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Plant and soil carbon-nitrogen sequestration and isotope ratios in relation to land management systems and seasons in Mopane savannah, Namibia

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Outline

- Introduction
- Study objectives
- Materials and methods
- Data analysis
- Results and discussion
- Conclusion and recommendation
- Acknowledgements

Introduction

- In Sub-Saharan Africa, rangelands support livestock and wildlife production.
- And also serve as sources of livelihood and income generation for the majority of the human population.
- Rangelands represent the largest potential carbon sink that could be managed to increase carbon-nitrogen sequestration at a landscape level.

Introduction cont….

- At present, in Namibia, rangeland ecosystems are used for animal production purposes practiced under three main land management systems, namely:
  - communal-continuous,
  - commercial-rotational and,
  - wildlife-continuous
- As a result, impact of land management on the ecosystems stability and functions differ greatly.
- The stable $\delta^{13}C$ and $\delta^{15}N$ isotope ratios of soil and vegetation components serve as a useful tool for examining ecosystem responses to environmental changes as altered by land management systems (Farquhar *et al*., 1989).

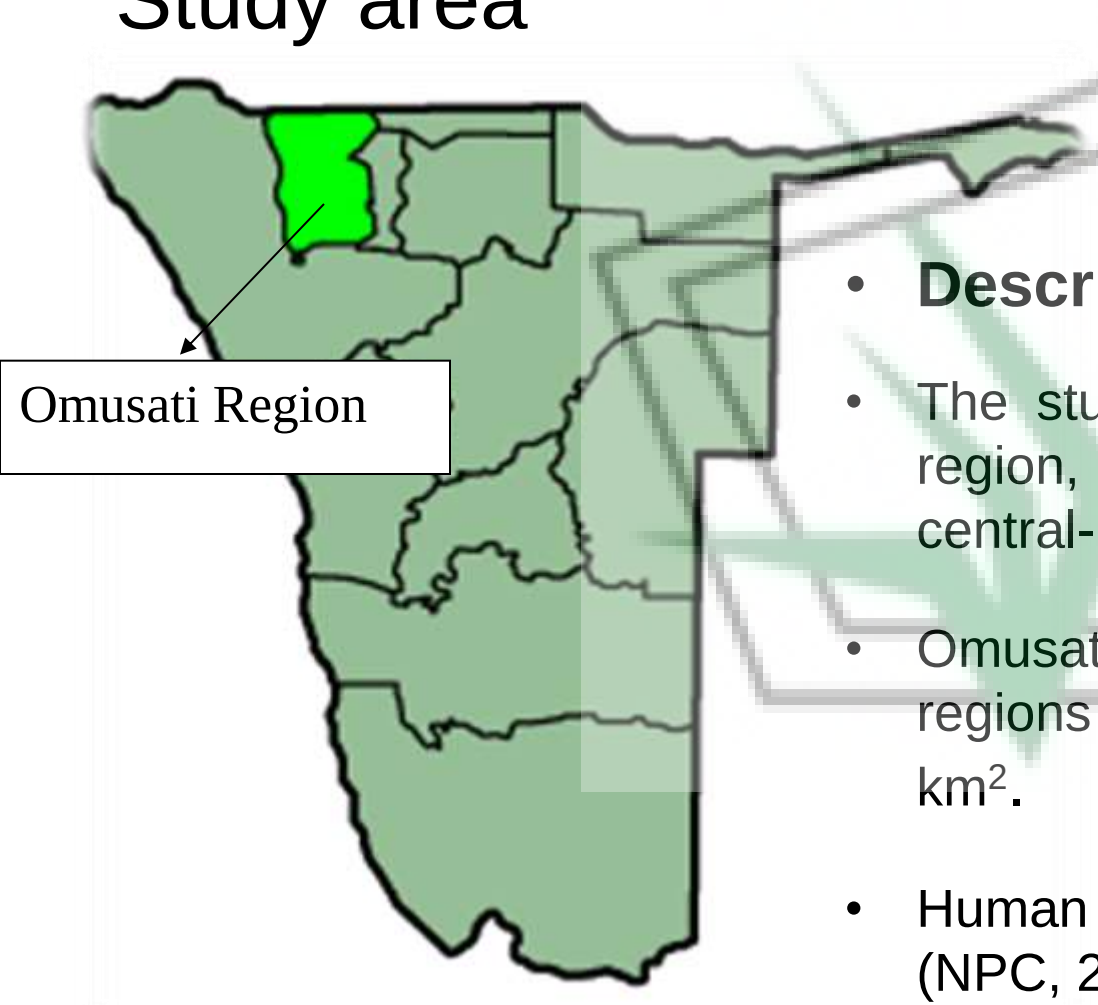
Study objectives

- 1) To determine total plant and soil carbon-nitrogen under three land management systems in two seasons.

- 2) To investigate the responses of C and N isotope ratios to land management systems.

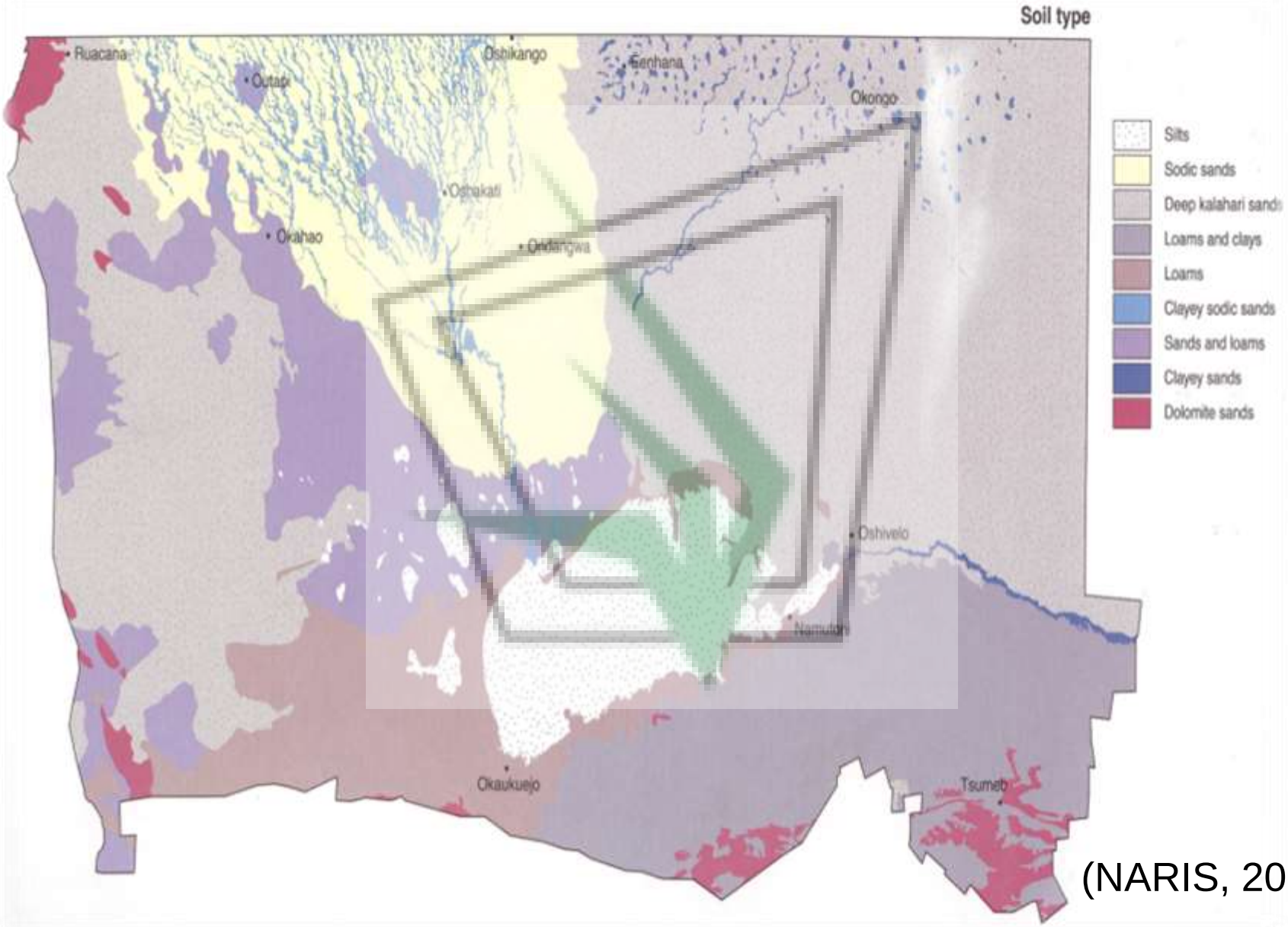
Materials and methods

Study area



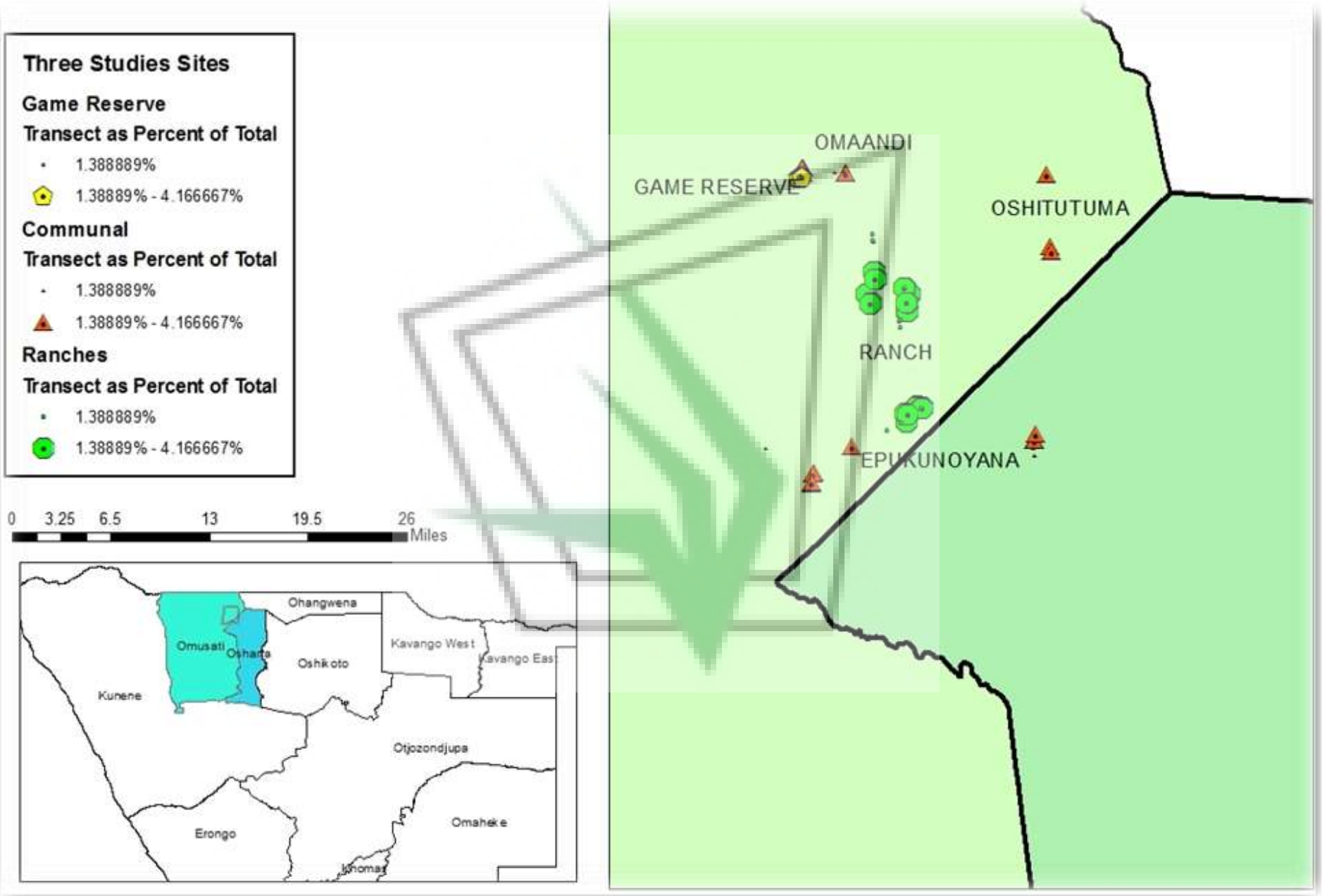
- **Description of the study areas**
- The study was conducted in Omusati region, particularly, Ogongo District, central-northern Namibia.
- Omusati is one of the 14th political regions of Namibia and covers 26573 km^2.
- Human population of about 229000 (NPC, 2011)

Soil type of the central-northern Namibia



(NARIS, 2001)

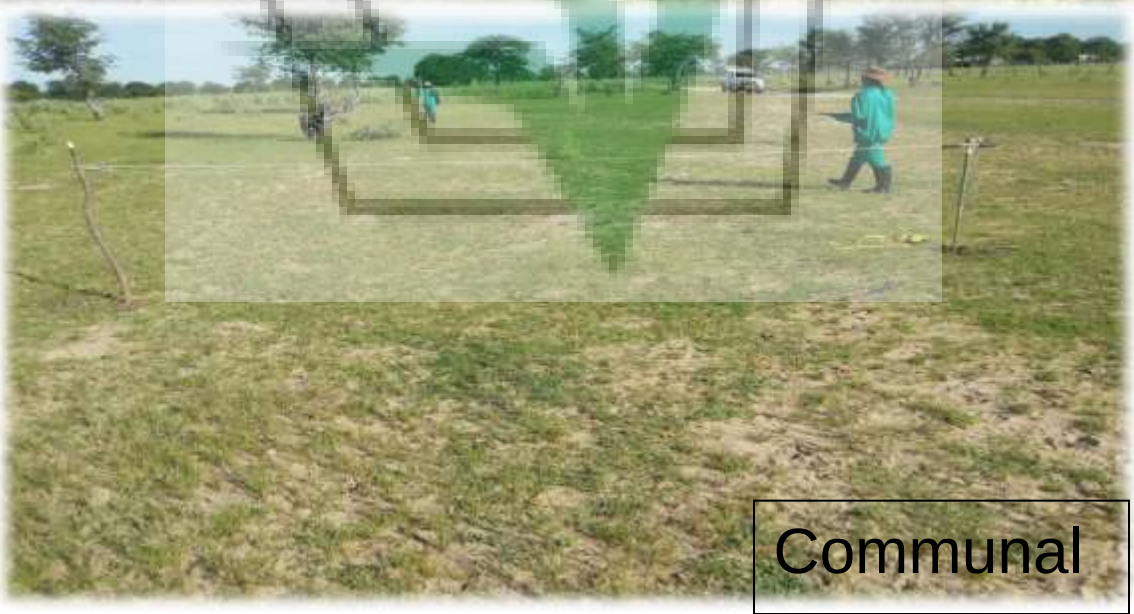
Sample site selection and layout



Data collection (Field Sampling)

Game reserve

Ranch



Communal

Data collection cont….

- Three 250 m^2 belt transects randomly laid in each of the 3 camps per land management system.
- Woody plant sampling:- Leaves and twigs
  - bulked and oven-dried at 65 ^oC
- Herbaceous plant sampling:- five (0.25 m^2) quadrats
  - bulked and oven-dried at 65 ^oC
- Soil sampling:- 3 soil samples per belt transect
  - depth of 20 cm using a soil auger
  - and a soil core sampler for soil bulk density

Data analyses

C and N. analyses (Plant and soil)

- TC: - determined through the dry combustion in ovens at 750 ^{o}C for 2 hours.
- TN: - performed by the standard Kjeldahl method.

The $\delta^{13}C$ and $\delta^{15}N$ isotopes analyses

- Carried out at the Stable Light Isotope Unit of the University of Cape Town in South Africa.

Statistical analyses

- Soil and plant TC, TN, $\delta^{13}C$, $\delta^{15}N$ and C:N ratio:- General Linear Model (GLM) procedure of SAS (2007).
- The soil and plant C, N, $\delta^{13}C$, $\delta^{15}N$, C:N ratios and bulk density:- subject to a two-way ANOVA according to the GLM procedure of SAS to test variations between land management systems as well as between season

Results and discussion

Total organic carbon, total nitrogen (%) and C:N ratios of the herbaceous

Sites	Herbaceous plants					
	TOC		TN		C:N	
	Summer	Winter	Summer	Winter	Summer	Winter
Game	37.0^{bA}	43.3^{aA}	1.0^{aA}	0.5^{bB}	38.7^{bA}	109.9^{aA}
Ranch	36.0^{bA}	42.2^{aA}	1.1^{aA}	0.7^{bA}	34.0^{bA}	83.5^{aB}
Communal	32.9^{B}	-	1.1^{A}	-	30.1^{A}	-
SE	1.1		0.07		4.9	

(a, b) compare means between seasons in each site, (ABC) compare site means in each season.

Total organic carbon, total nitrogen (%) and C:N ratios of woody vegetation (means)

Sites	Woody vegetation					
	TOC (%)		TN (%)		C:N	
	Summer	Winter	Summer	Winter	Summer	Winter
Game	50.2^{aA}	50.1^{aA}	2.1^{aA}	1.5^{bA}	25.3^{bB}	34.9^{aB}
Ranch	49.9^{aA}	43.2^{bB}	1.4^{aC}	1.0^{bC}	40.1^{bA}	48.1^{aA}
Communal	49.9^{aA}	50.2^{aA}	1.8^{aB}	1.2^{bB}	28.1^{bB}	49.8^{aA}
SE	0.5		0.1		1.5	

(a, b) compare means between seasons in each site, (ABC) compare site means in each season.

Carbon and nitrogen isotopes (‰) of the herbaceous and woody plants (means)

Sites	Herbaceous plants				Woody vegetation			
	$\delta^{13}C$		$\delta^{15}N$		$\delta^{13}C$		$\delta^{15}N$	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Game	-13.6^{aA}	-13.8^{aA}	3.8^{aB}	2.8^{aA}	-25.8^{aB}	-25.8^{aB}	5.4^{aA}	4.8^{aA}
Ranch	-14.9^{aAB}	-15.6^{aB}	3.2^{aB}	3.2^{aA}	-25.0^{aA}	-17.3^{bA}	3.9^{aB}	2.6^{bB}
Communal	-15.1^{B}	-	8.7^{A}	-	-24.8^{bA}	-25.9^{aB}	5.0^{aA}	4.2^{aA}
SE	0.5		1.2		0.2		0.3	

(a, b) compare means between seasons in each site, (ABC) compare site means in each season.

Total organic carbon, total nitrogen of the vegetation (kg ha^{-1}) (mean).

Sites	TOC		TN	
	Summer	Winter	Summer	Winter
Game	44201.1^{aA}	34533.0^{bA}	1504.3^{aA}	661.5^{bA}
Ranch	37693.8^{aB}	30985.8^{bB}	1310.8^{aB}	625.2^{bA}
Communal	24461.1^{aC}	16136.3^{bC}	787.5^{aC}	424.0^{bB}
SE	3499.3		103.6	

(a, b) compare means between seasons in each site, (ABC) compare site means in each season.

Mean soil TOC, TN, C:N ratios in relation to land management systems and seasons

Sites	TOC (%)		TN (%)		C:N	
	Summer	Winter	Summer	Winter	Summer	Winter
Game	0.3^{aA}	0.3^{aA}	0.03^{aB}	0.03^{aB}	10.9^{aA}	10.8^{aA}
Ranch	0.3^{aA}	0.2^{bB}	0.05^{aA}	0.06^{aA}	10.5^{aA}	10.5^{aA}
Communal	0.2^{bB}	0.3^{aA}	0.02^{aB}	0.03^{aB}	9.7^{aB}	10.5^{aA}
SE	0.01		0.02		0.5	

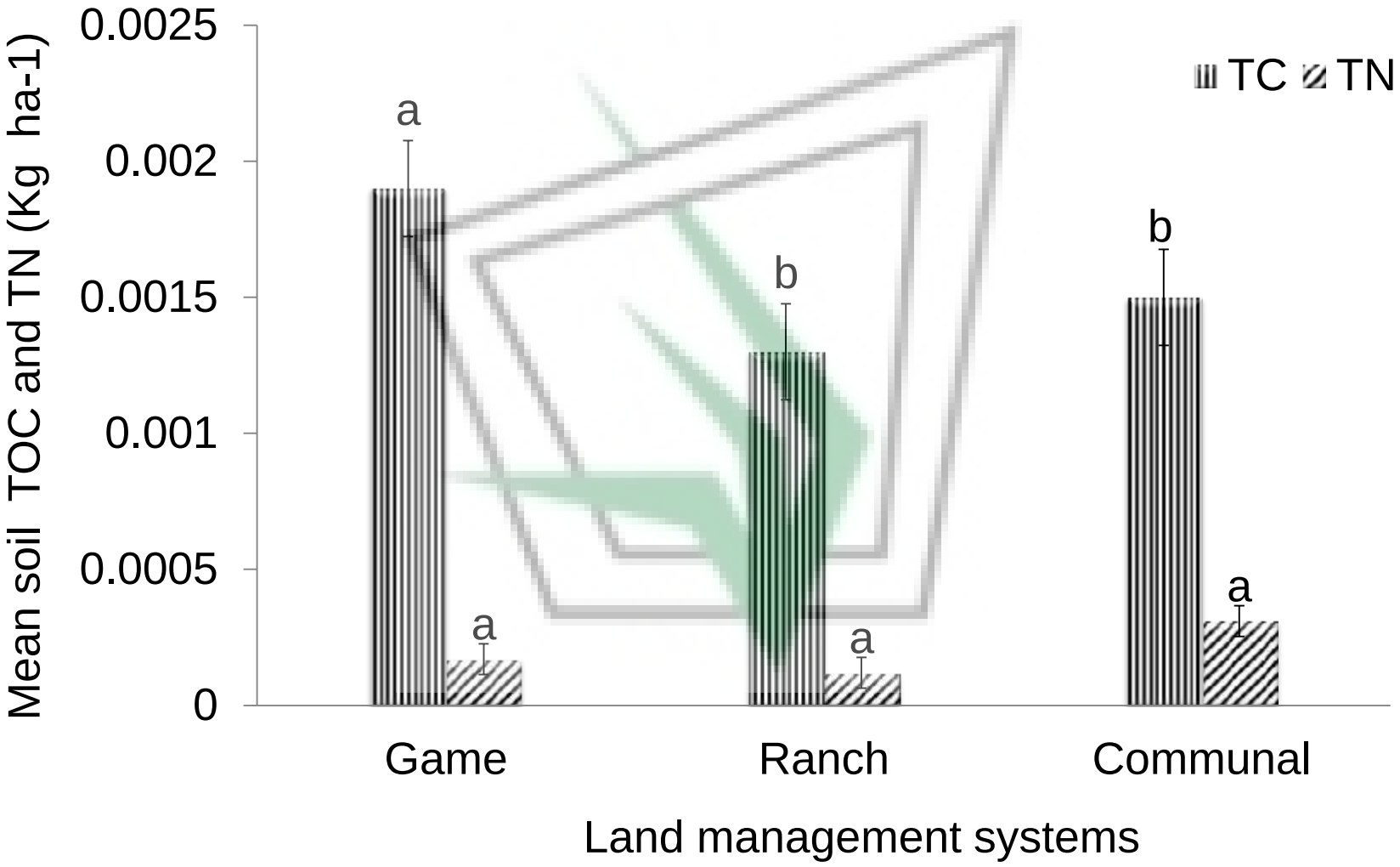
(a, b) compare means between seasons in each site, (ABC) compare site means in each season.

Soil $\delta^{13}C$, $\delta^{15}N$ in relation to land management systems and seasons

Sites	$\delta^{13}C$		$\delta^{15}N$	
	Summer	Winter	Summer	Winter
Game	-18.5^{aC}	-18.8^{aC}	5.2^{aC}	5.3^{aC}
Ranch	-17.8^{aB}	-18.1^{aB}	6.4^{aB}	6.0^{aB}
Communal	-17.2^{aA}	-17.4^{aA}	7.3^{aA}	7.5^{aA}
SE	0.2		0.2	

(a, b) compare means between seasons in each site, (ABC) compare site means in each season.

Total soil organic carbon (kg ha^{-1})



Conclusion and recommendation

- The study concludes that game reserve sequester more TOC and TN (kg ha^{-1}) in the total vegetation than the other two land management systems in both summer and winter.
- The game reserve also stored more soil TOC (kg ha^{-1}) than the ranch and communal.
- Research to be conducted by including land management systems in different agro-ecologies and for a prolonged period to ascertain the impact of land use practices and seasonal dynamics of the measured variables.

Acknowledgements

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Thank you very much for
your attention!!