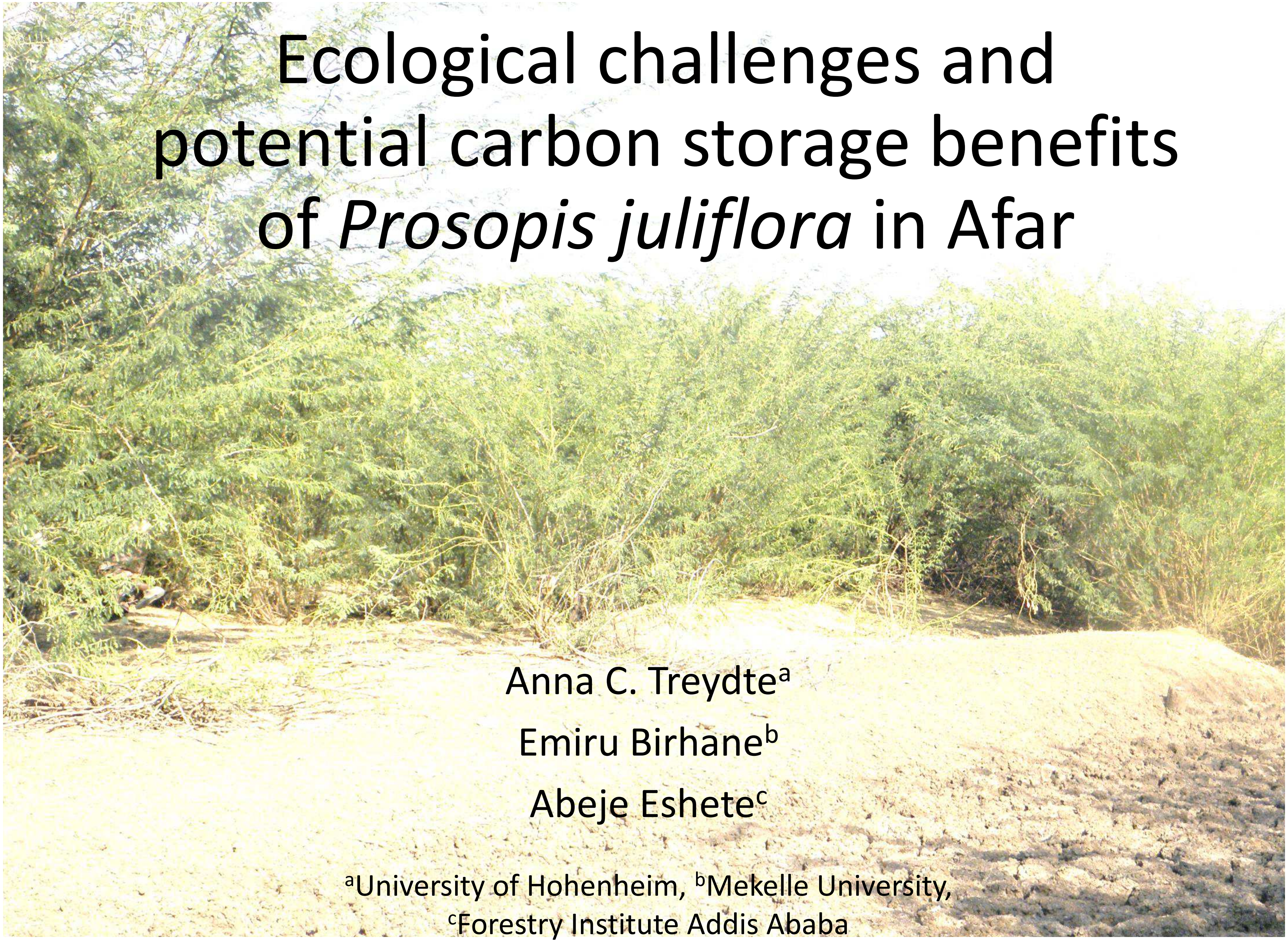

Ecological challenges and potential carbon storage benefits of *Prosopis juliflora* in Afar

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Introduction

Invasive species *Prosopis juliflora* threatens Afar:

- Rapid spread through livestock feces, vegetatively
- Colonization along roadsides and riverbeds
- Replacing valuable vegetation rangeland areas
- Poisonous for animals and humans
- Difficult to control (coppicing insufficient, resprouting, large efforts)

Introduction

Expected consequences for Afar

- Grass layer and other native trees will be disappearing
- Soil seed bank might become depleted
- Soil microorganism community might change drastically
- Soil nutrients and organic matter might shift
- Browsing biomass available for livestock will decline
- Carbon storage potential of the ecosystem might increase

Introduction

Aims

- Quantify woody species abundance, diversity and biomass in areas of different *Prosopis juliflora* infestation
- Quantify potential above- and below-ground Carbon stocks
- Investigate soil properties (compaction, water holding capacity, nutrients)
- Address soil microbial communities under various infestation rates
- Assess recruitment potential of *Prosopis juliflora* (seedling numbers under various infestation densities and in restored areas)
- Record seed bank potential of differently infested areas

As from kick-off:

Component	Focus of each component	Information relevant for other components
Ecological	• Woody species for browsing animals • Different level of encroachment and its impact on herbaceous layer, land use, animals, etc. • Soils and soil quality (nutrient and water, water retention) • Microbial aspect of the soil • Soil seed bank • etc.	• Biomass quality under different Prosopis level • Reaction of pastoralists • Impact on social behavior of pastoralists • Expansion of Prosopis over time • Economic value on pasture quality • Success of restoration measures • Areas where Prosopis localized • Drivers of Prosopis invasion • Alternative options for management of Prosopis

Methods

Study sites:

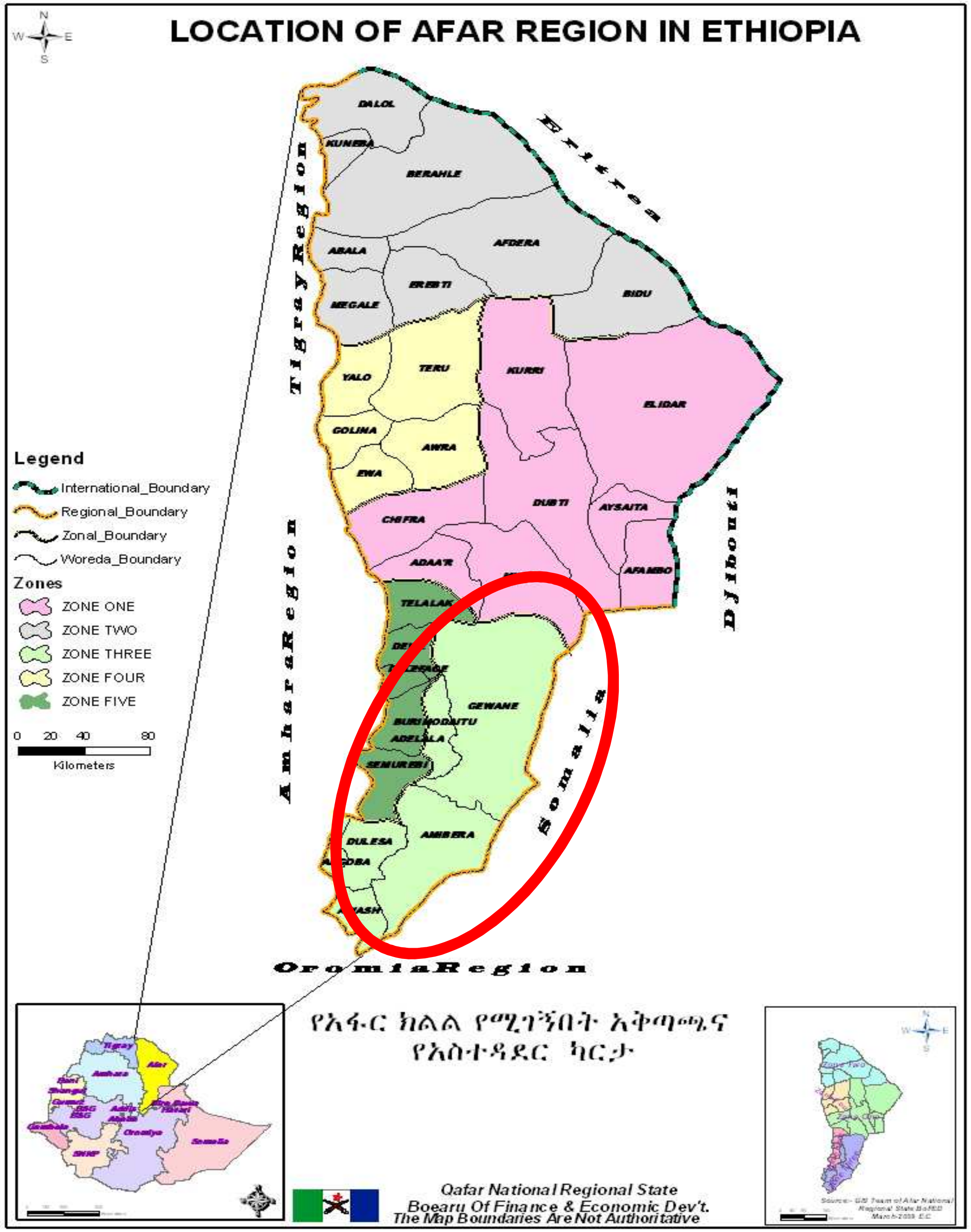
Amibara

Gewane

Mostly flat land

Temperature: 25°C - 48°C

Average annual rainfall: 336 - 818 mm



Methods

- Woody vegetation (composition and structure) and soils were analysed
- Soil seed bank was established
- Setup was along roadsides, riverbeds
- Sites of different *Prosopis* encroachment (none, low, medium, high)
- Plus one restoration site

Main vegetation / land use

Zone No.	Cultivated land	Grassland	Shrubland	Woodland	Natural forest	Riverine forest	Exposed soil / rock
1	1.2	15	24	2	0	0	55
2	0.1	10	27	0	0.4	0	62
3	**0.4**	**19**	**38**	**4**	**0**	**1**	**36**
4	0	16	45	2	0	0	38
5	0	26	56	2	9	1	15

Land cover as % of total zonal and regional area. Our study sites were located in Zone 3 (bold). Source: Afar National Regional State (ANRS, 2004)

Methods

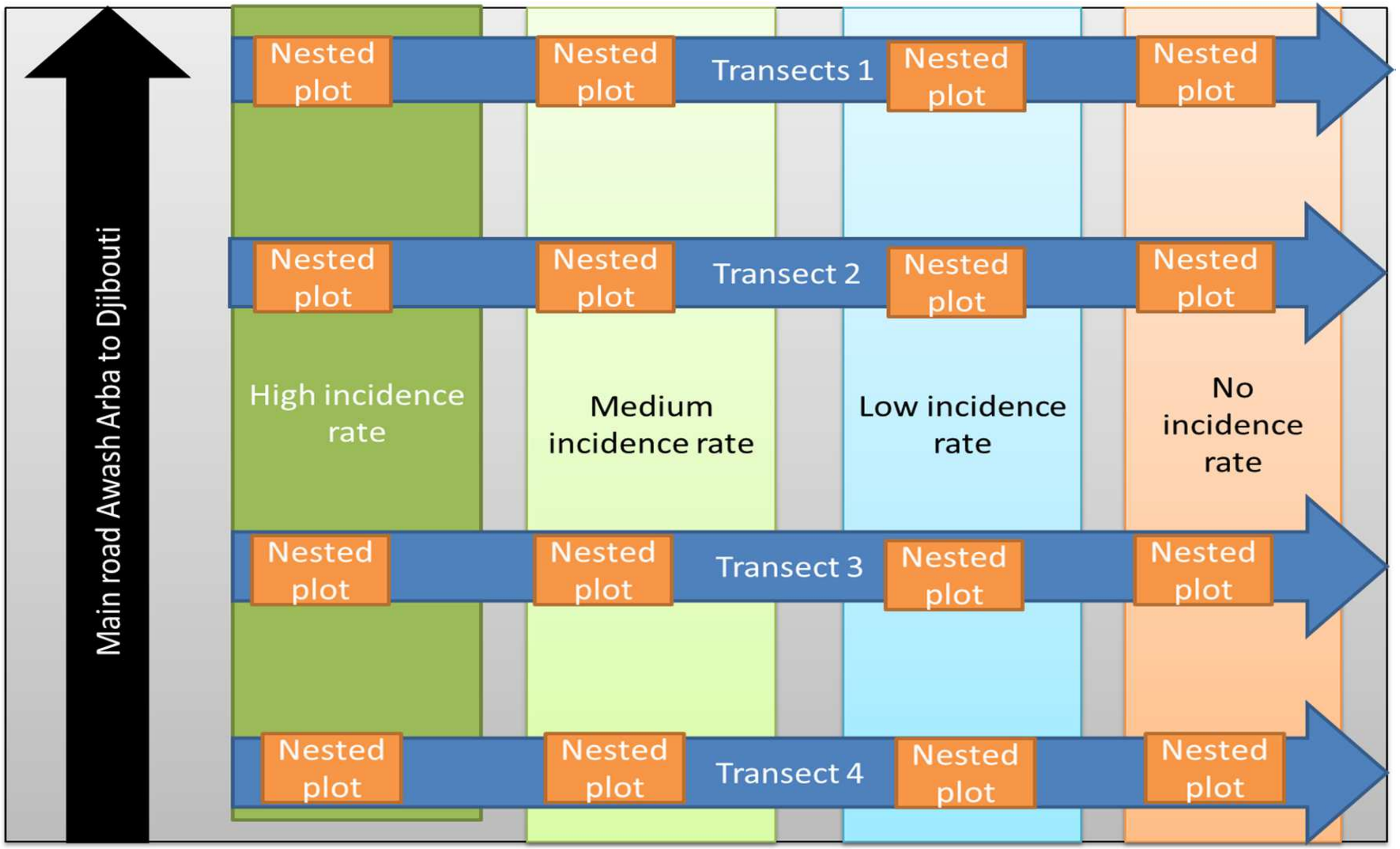
Study was conducted from December 2013 –March 2014 (dry season)

Preliminary *Prosopis* invasion categories classified during reconnaissance survey

Study setup

Vegetation data

- 8 transects per site (< 2 km apart) and 4 plots (.0025 – 0.04 ha) per transect
- All woody plants were identified and measured (diameter, height, crown diameter)



Methods

Soil sampling

- Quadrants of 1 m X 1m from main plots
- Soil samples collected at 0-15 cm and 15-30 cm
- Soil seed bank from same quadrats

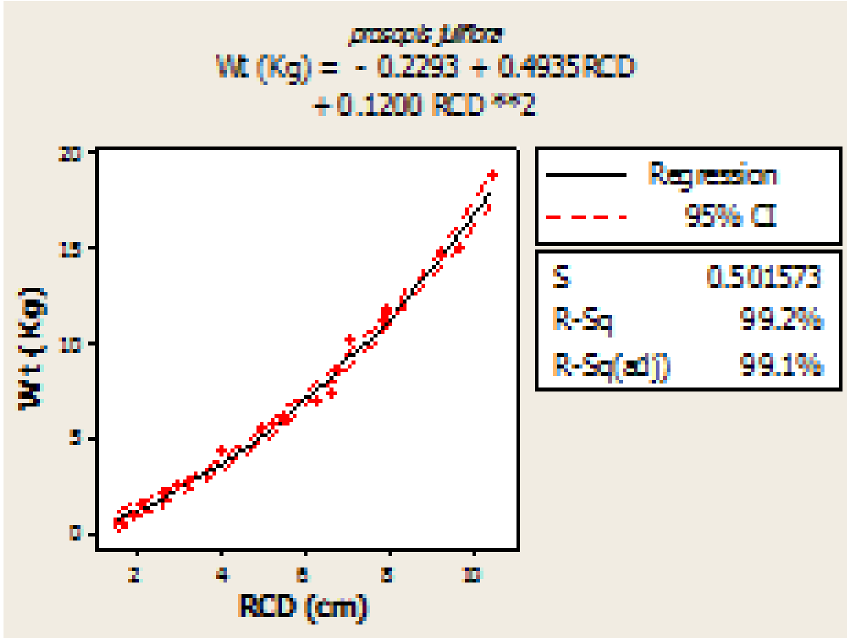
Results & discussion: Vegetation composition

Site	Species	Invasion rate			
		High	Medium	Low	None
Amibara	*Acacia melifera*	0	9	25	0
	Acacia senegal	0	0	0	928
	Dobera glabra	50	22	3	0
	Prosopis juliflora	4200	503	325	44
	Total	**4250**	**534**	**353**	**972**
Gewane	*Acacia melifera*	0	0	0	13
	Acacia senegal	0	0	0	863
	Acacia seyal	0	0	25	0
	Acacia species	0	0	50	0
	Acacia tortolis	0	0	0	13
	Balanaytes aegyptica	0	0	13	0
	Dobera glabra	0	0	0	12
	Prosopis juliflora	3850	1775	1513	13
	Total	**3850**	**1775**	**1600**	**913**

Prosopis juliflora dominates most categories while *Acacia senegal* dominates in areas not infested

Low species diversity & richness in highly infested areas in an already low diversity system (3-4 species)

Allometric equations



Prosopis biomass weight can easily be predicted using allometric measurements, e.g., root collar diameter (RCD)

Hence, if we are interested in knowing how much biomass is available as forage / for firewood production / as C storage potential, some simple tree measurements are sufficient

Woody biomass

Invasion rate	High	Medium	Low	None	Rehabilitated	Canals
Above ground biomass (t/ha)	61	42	28	12	13	30
Below ground biomass (t/ha)	16	11	7	3	3	8
Total biomass	77	53	35	15	16	38

Overall vegetation biomass declines with decreasing invasion rate

Low infested sites and areas close to water ways (canals) show half the biomass than highly infested sites

The trend is similar for above and below ground biomass

Rehabilitated sites show biomass as low as areas without any infestation

Reduced basal cover of native herbaceous vegetation under high *Prosopis*

Two most dominant species and their structure

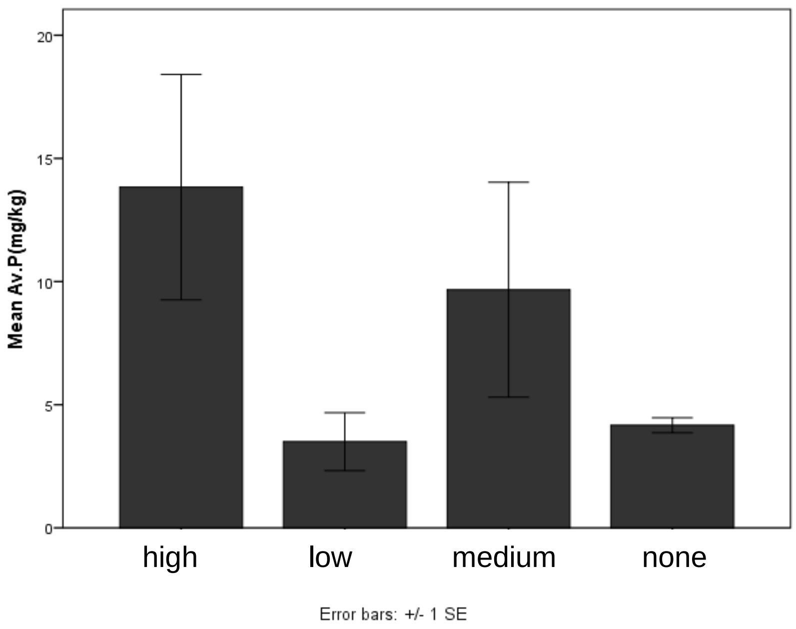
	Root collar diameter & Diameter at stump height (cm)	Height (m)	Crown diameter (m)	Stem weight (kg)	Branch weight (kg)	Total weight (kg)
Prosopis juliflora	5.4±0.6	4.2±0.3	5.0±0.3	3.6±0.6	3.3±0.7	6.8±1.2
Acacia senegal	6.7±0.8	3.4±0.3	3.8±0.4	5.4±0.8	5.1±1.1	10.4±1.9

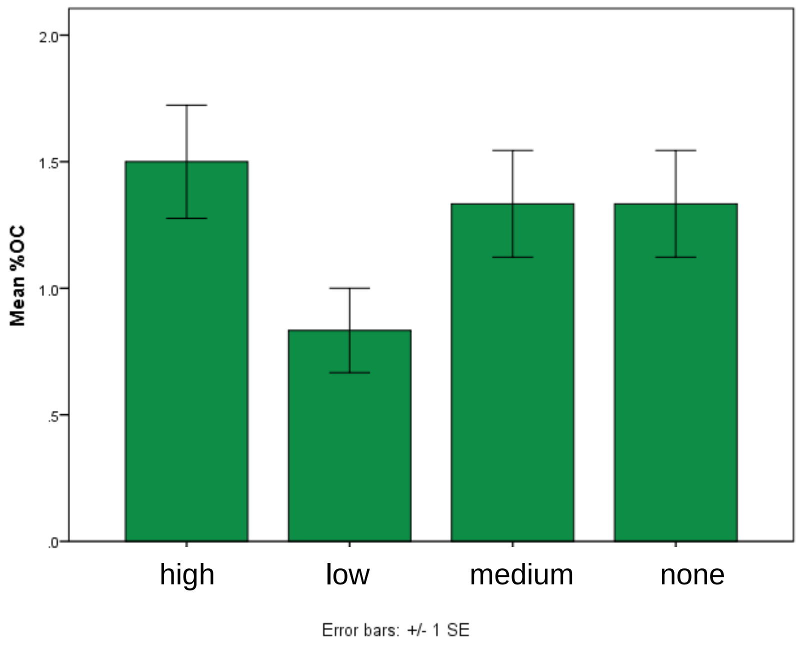
Prosopis and *Acacia* showed similar structure and rather low variations

Acacia had lower heights and smaller crown diameter than *Prosopis*

Total weight of *Acacia* was by 30% higher than that of *Prosopis* (higher stem and branch weight) – important for Carbon stocks

Soil organic Carbon & Phosphorus





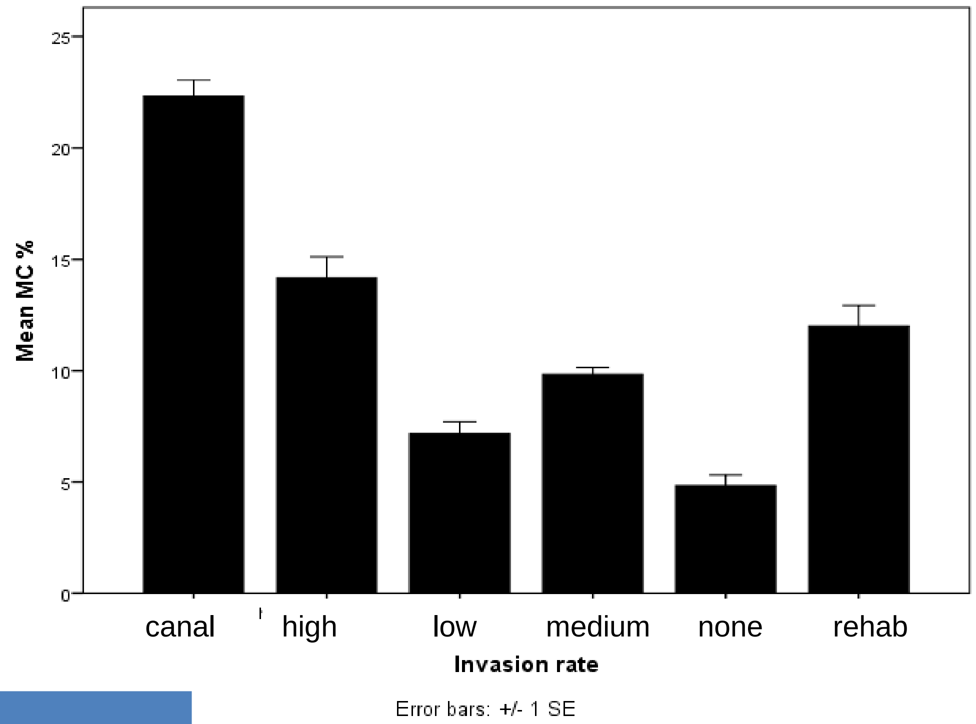
Soil available Phosphorus high in highly and intermediate infested sites

Soil organic Carbon highest in highly infested site but only slightly lower in medium and no infested sites

Hence, soils in densely and intermediate *Prosopois* encroached sites show good quality for plant growth

Soil moisture & Spore abundance

Moisture content in soils of canal areas, highly infested areas and rehabilitation sites was high



Invasion rate	Spore abundance	
	0-15 cm depth	15-30 cm depth
High	223.7 ± 64.5	92.2 ± 26.6
Medium	138.8 ± 37.1	136.7 ± 36.5
Low	193.8 ± 47.1	88.9 ± 21.5
None	192.8 ± 55.6	67.2 ± 19.4

Spore abundance twice as high in upper soil layers than lower soil layers

Lowest in medium high in dense *Prosopis* invasion sites; at medium sites similar in deep and shallow soils

Soil seed bank

Invasion rate	Number
high	18
medium	18
low	9
none	10

Most of the recovered species from the soil seed bank were grasses and herbs. So far only two *Prosopis* seedlings have germinated from the low and medium invaded soil seed banks. The soil seed bank is only 41 days old…

=> Highly and medium infested sites show the most beneficial soil properties for plant growth (moisture content, Phosphorus, SOC, seed numbers…);

=> Hence, these areas seem still reclaimable if *Prosopis* abundance was reduced

=> Other species than *Prosopis* will be able to sprout

Way forward

- Positive impact of *Prosopis* on the soil parameters (i.e., organic matter) can be used to rehabilitate degraded lands in a controlled manner.
- *Prosopis* invasion success seems to be supported by presence of mycorrhizae (though so far we know only the spore abundance).
- *Prosopis* growth has negative effect on other woody species (low browsing quality).
- Enhanced biomass and Carbon stocks can be positive in terms of climate change mitigation (micro-climate, soil moisture content, organic matter, C trade, alternative income generation?).
- Not too late for rehabilitation: high regeneration potential of native species as shown in soil seed bank, which is still „in order“.
- Investigation of genetic diversity needed to look for varieties/hybrids with less invasion characteristics
- Current management might not be sufficient / rather encouraging


Thank you!

Results & discussion

Invasion rate	High	Medium	Low	None	Rehabilitated	Canals
Above ground biomass (t/ha)	60.7±7.3^{A}	42.0±6.9^{AB}	28.3±4.2^{CB}	11.7±2.7^{C}	13.4±3.7^{C}	29.9±11.3^{CB}
Below ground biomass (t/ha)	15.7±1.9^{A}	10.9±1.8^{AB}	7.4±1.1^{CB}	3.0±0.7^{C}	3.4±1.0^{C}	7.7±2.9^{CB}
Total biomass	76.4±9.3^{A}	52.8±8.7^{AB}	35.6±5.3^{CB}	14.8±3.0^{C}	16.9±4.6^{C}	37.7±14.2^{CB}