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The combined effect of slash burning and repeated disc harrowing on changes in fuel loading, soil properties, root growth and stand productivity of Eucalypts in Mpumalanga: South Africa

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DISC HARROWING



Agri expo (2019)





INTRODUCTION



- In SA about 1 143 116 ha has some form of damage: **fire 669 439 ha (59%)** and 473 677 ha (41%) other abiotic and biotic factors
- Unmanaged fuels contribute significantly to occurrence, spread, and intense damage caused by **wildfires**
- Disc harrowing breaks fuel **horizontal continuity** = reduce surface fire rate of spread and reduce **fuel loading** = less fire intensity
- **Problem:** There is not enough evidence to quantify the effects and support the effectiveness of this practice



STUDY OBJECTIVES



- Effectiveness of disc harrowing throughout stand rotation on **fuel load reduction** for wildfire management.
- Investigate effect of harvest slash burning incorporated with repeated disc harrowing on soil **bulk density & available nutrient pools**.
- Determine potential impact of slash burning incorporated with disc harrowing throughout the rotation on *Eucalyptus grandis x nitens* **growth**.
- Investigate if prescribed burning incorporated with disc ploughing has any effect on **root distribution patterns** of *Eucalyptus grandis x nitens*.



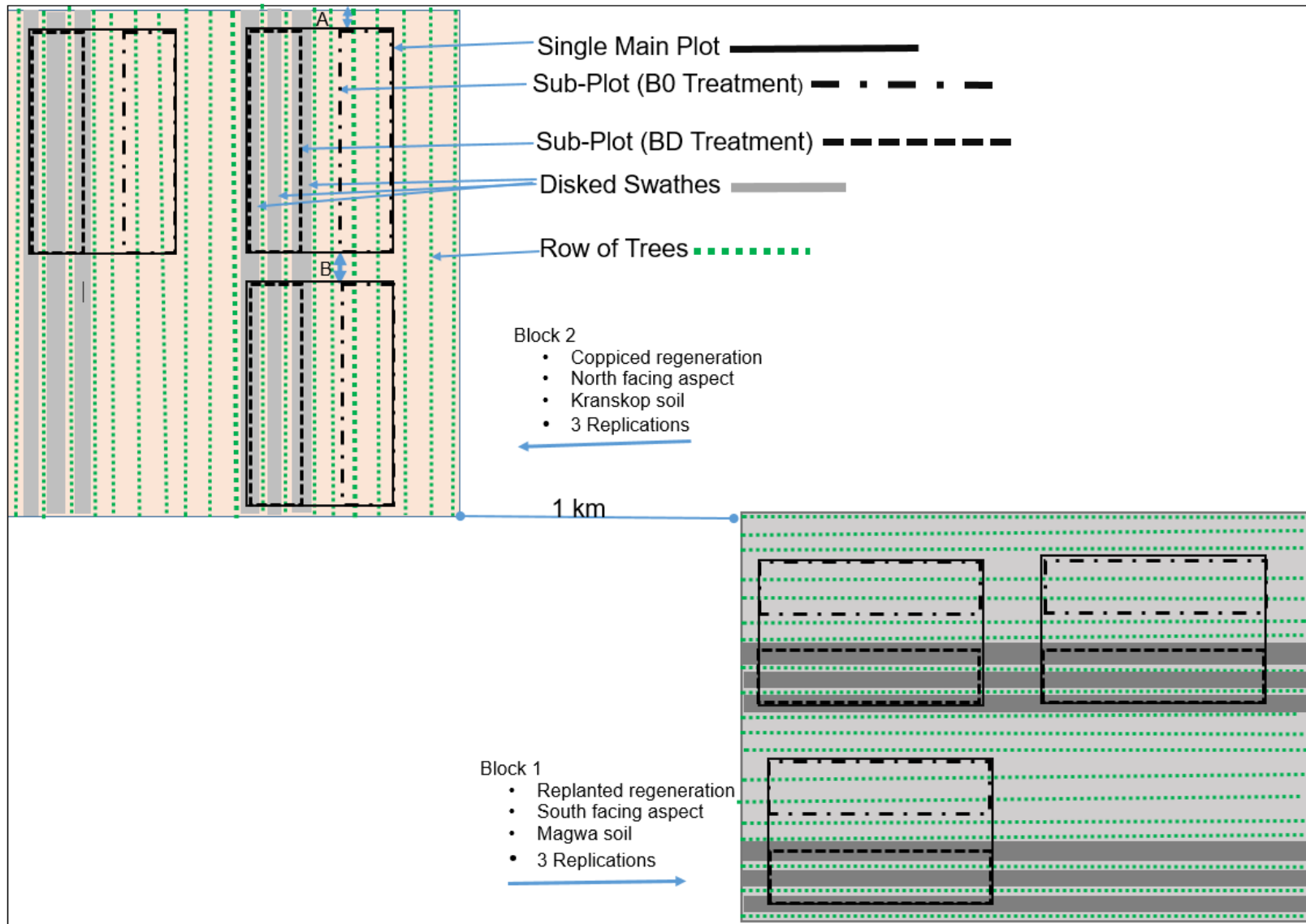
L. REVIEW: PROS AND CONS TO BURNING OR RETENTION OF HARVEST RESIDUES



- **Fires & harvest residue** management impact sites' long-term productivity (du Toit and Scholes, 2002)
- **Bark, branches and foliage** constitute roughly 68% (N) , 54% (P), 70%(K), 80%(Ca) and 82%(Mg) of aboveground nutrient pools (du Toit, 2003)
 - Litter fall is a major pathways for nutrient return to soil (Fisher and Binkley, 2000)
- However, slash retention limits site access for planting, growth suppression, and **fire hazard**
- Slash burn reduce fire hazard, allelopathy (Águas et al, 2017)
- Ash bed effect (pH & P availability), **low to medium intensity**



METHODOLOGY: Study Design





METHODOLOGY: Study Design



Island

Actual disk swathe

“Non- Disking”

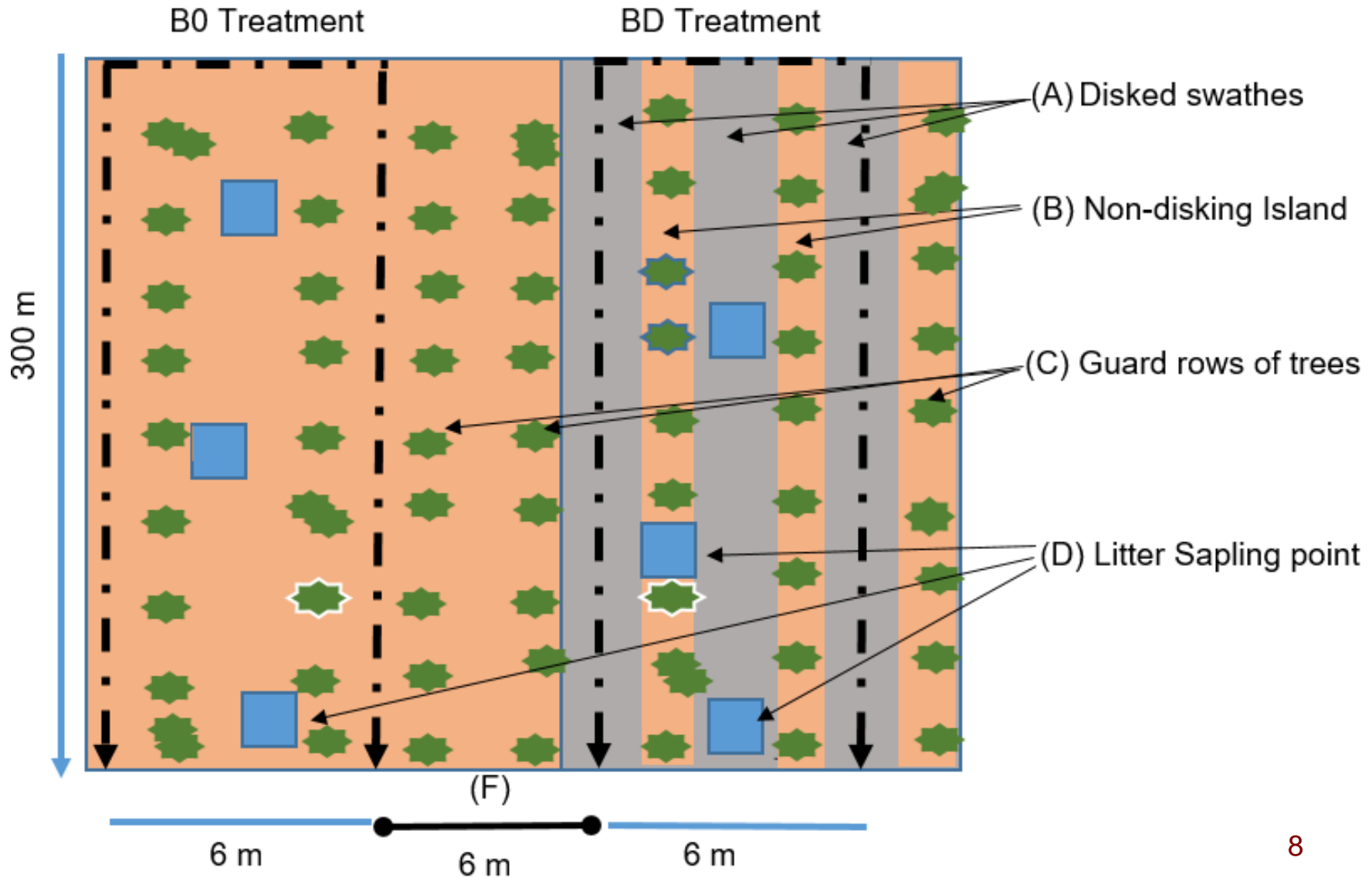
“Mounding”





METHODOLOGY: Data Collection

Litter Sampling





METHODOLOGY: Data Collection



Step 1



Step 2



Step 3



Step 4





METHODOLOGY: Data Collection



The Above Ground Tree Growth

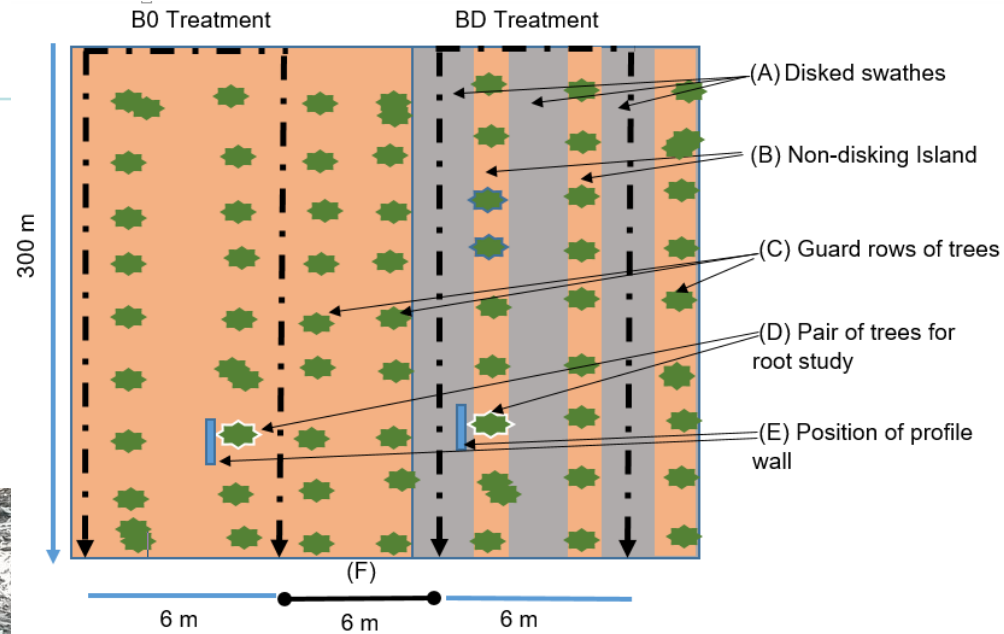
- Tree DBH and heights
- Tree growth variables:
 - Individual tree
 - Density stems/ha
 - Stand level
 - Volume $\text{m}^3 \text{ha}^{-1}$,
 - Basal Area $\text{m}^2 \text{ha}^{-1}$, and
 - Above-ground Biomass t ha^{-1}



METHODOLOGY: Data Collection

Root distribution Patterns

partner



	B0										DBH 10 cm										Count	%
0	20	23	20	14	19	18	23	18	20	15	190	19										
10	11	7	10	8	12	7	11	13	8	10	97	10										
20	7	8	6	5	9	11	9	5	15	11	86	9										
30	17	9	10	18	23	14	11	19	16	18	155	16										
40	8	6	10	8	9	10	11	21	15	18	116	12										
50	6	9	10	12	10	13	13	9	10	18	110	11										
60	11	6	15	10	6	19	12	11	10	3	103	10										
70	3	8	9	8	6	8	6	7	3	5	63	6										
80	1	1	4	7	4	3	3	4	3	4	34	3										
90	0	4	5	5	0	2	2	2	5	2	27	3										
100											981	100										

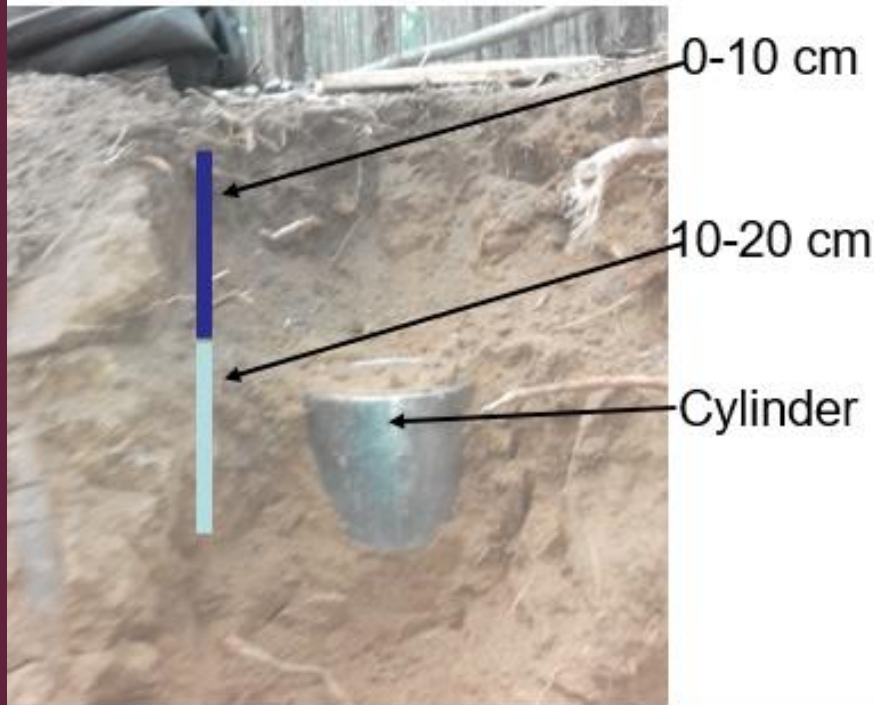
Profile wall root study method (Böhm W, 1979)



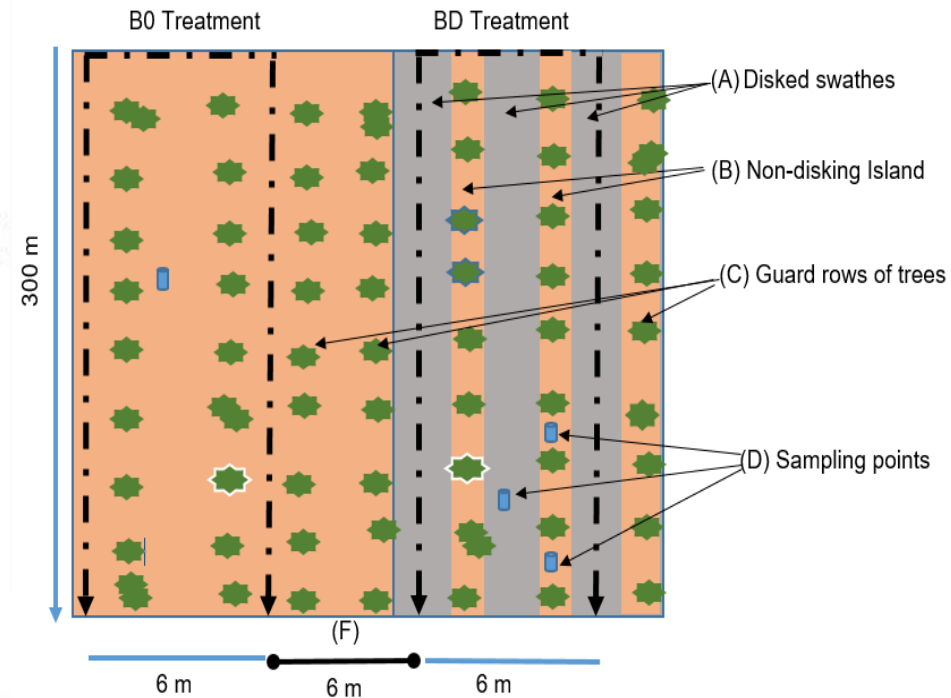
METHODOLOGY: Data Collection



Soil Sampling



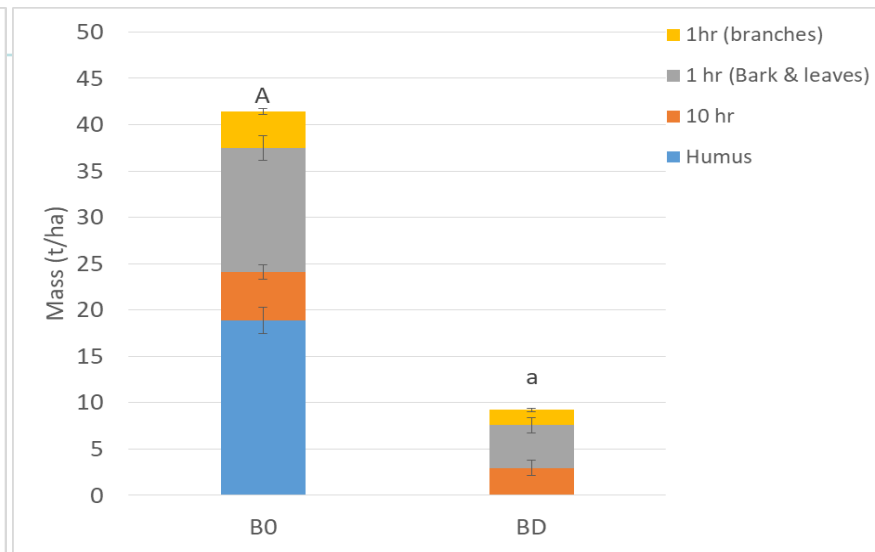
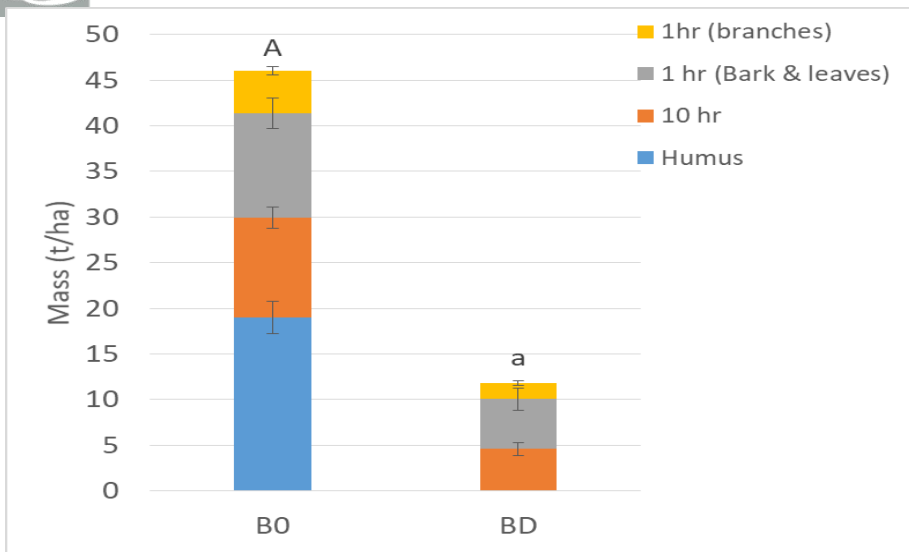
Bulk density



Chemical analysis

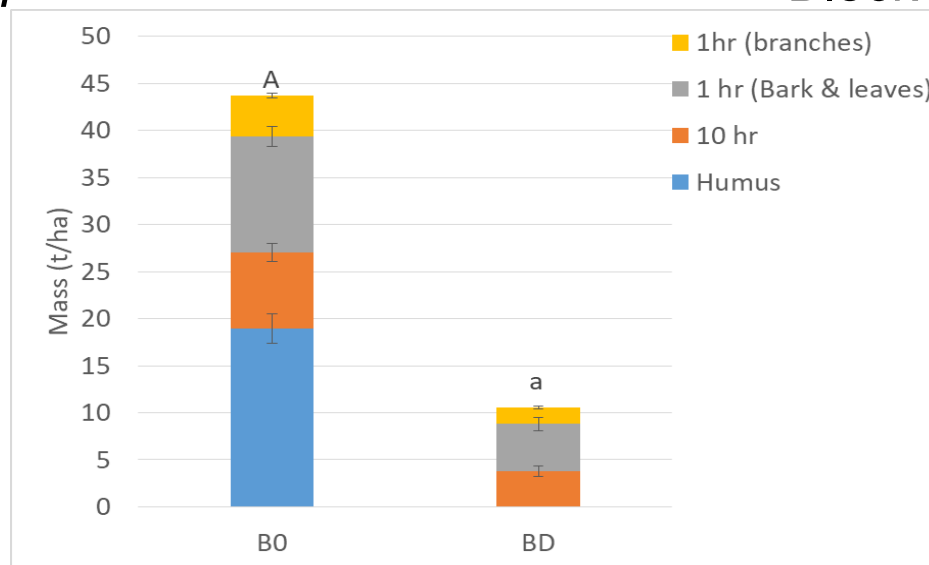


Results: Litter & Fuel Loading



Block 1: All sig at $p < 0.05$

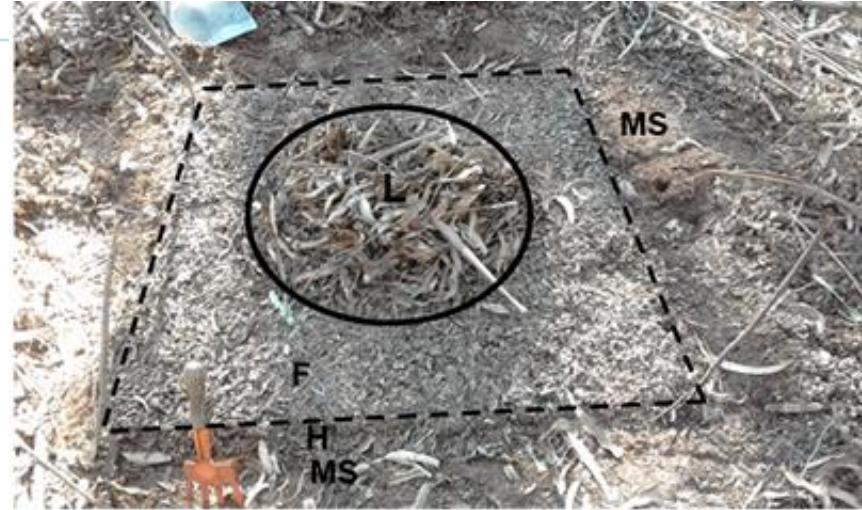
Block 2: All sig at $p < 0.05$



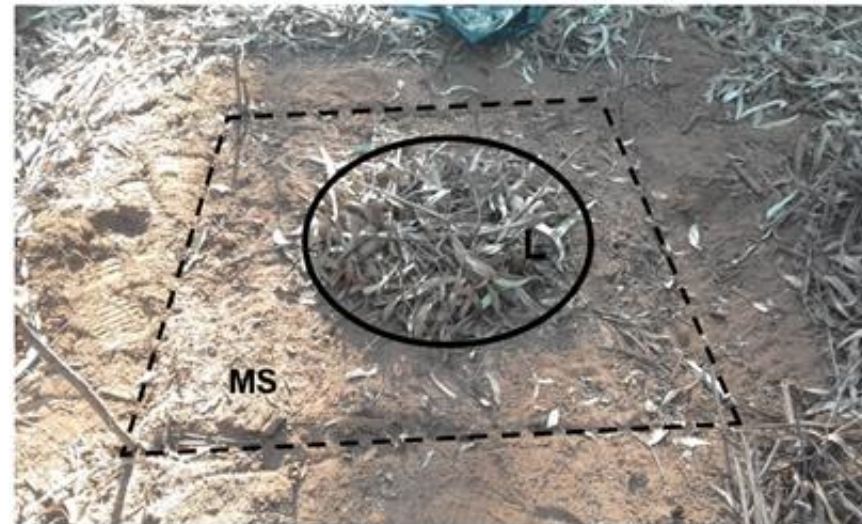
Blocks combined: All sig at $p < 0.05$



Results: Forest Floor Structure



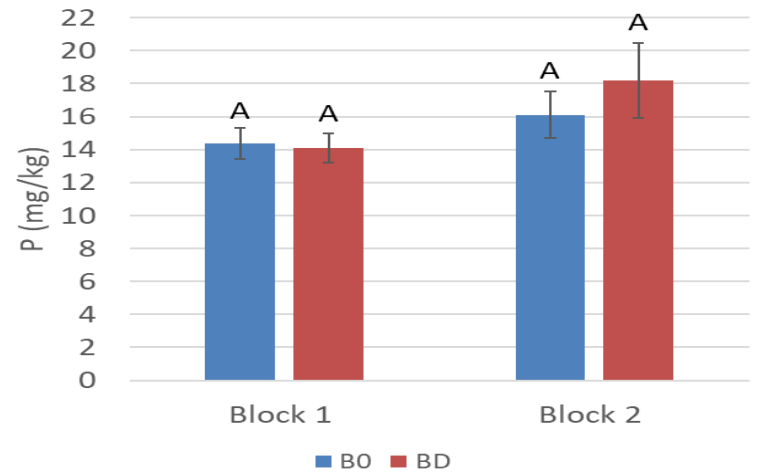
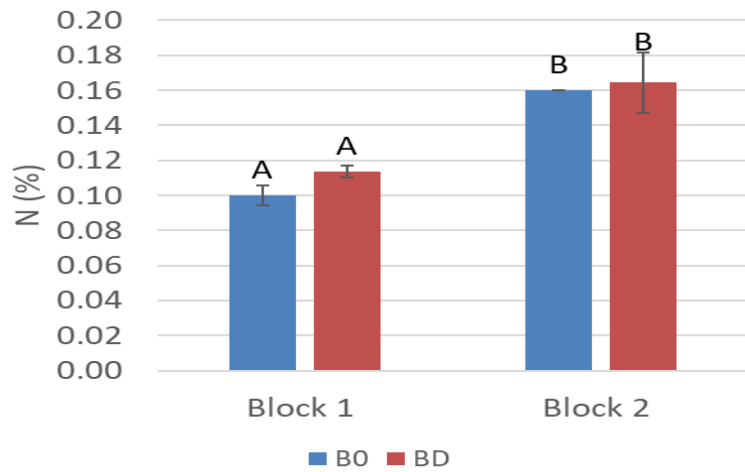
Non-disc harrowed forest floor



Repeatedly disc harrowed forest floor

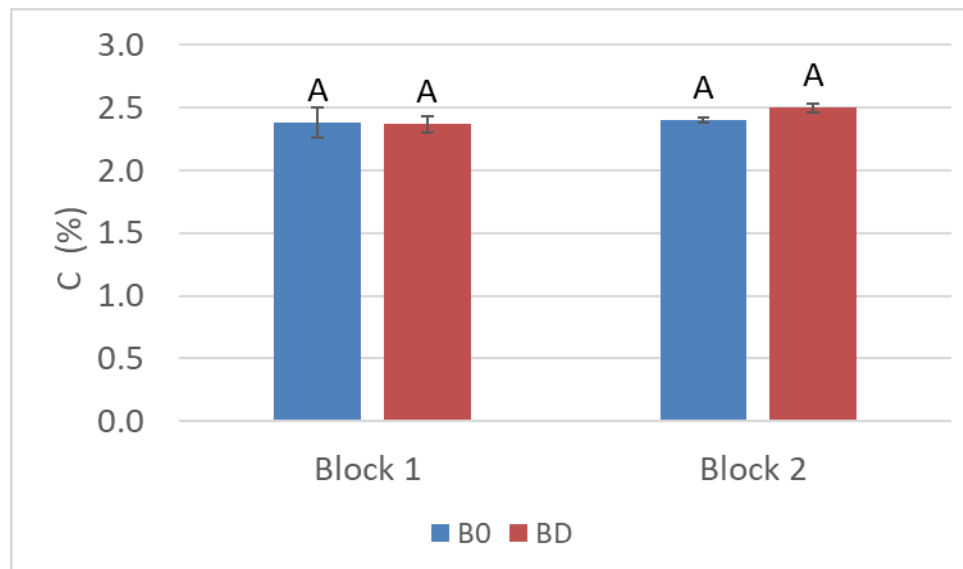


Results: Total N, Bray 2 P, & Organic C



N: sig at $p < 0.05$ between blocks

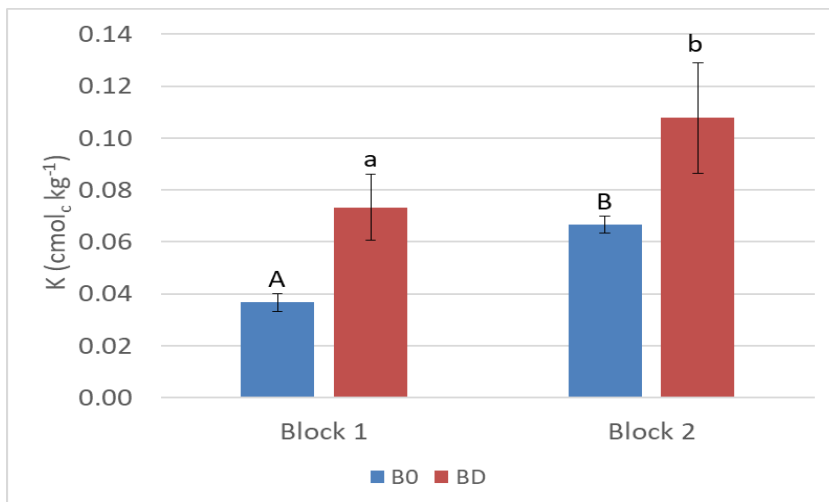
P: All non-sig at $p < 0.05$



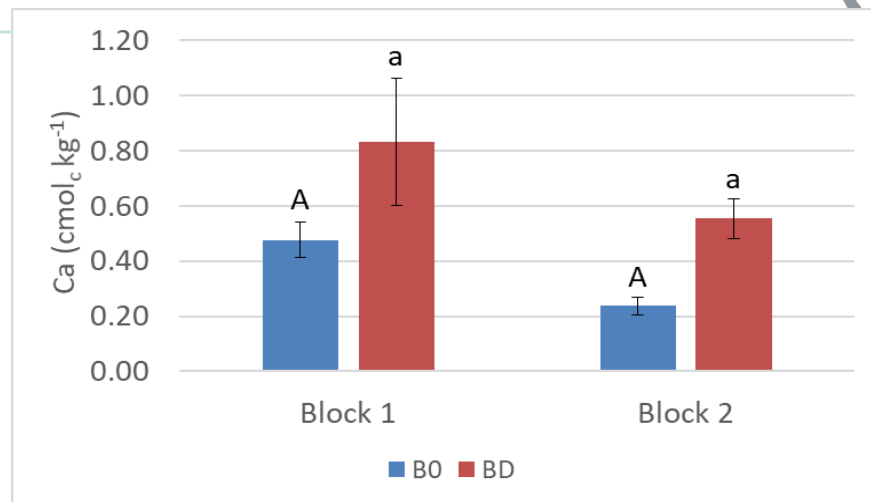
C: All non-sig at $p < 0.05$



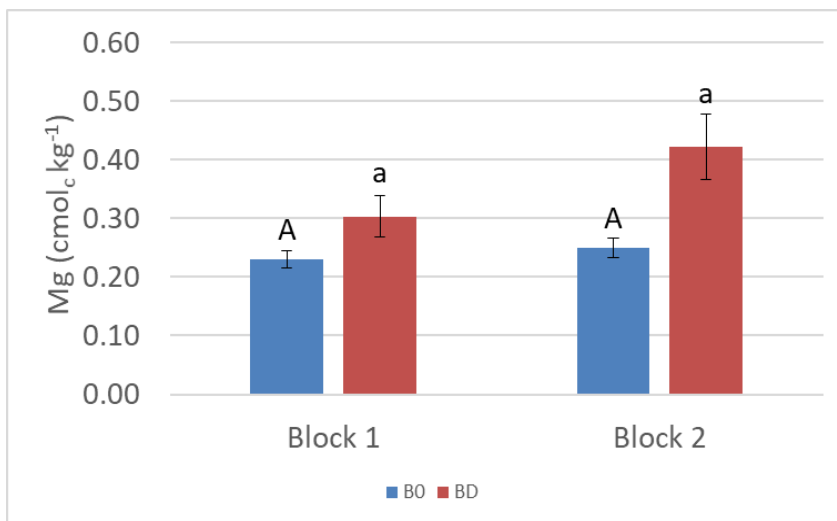
Results: Exchangeable Base Cations



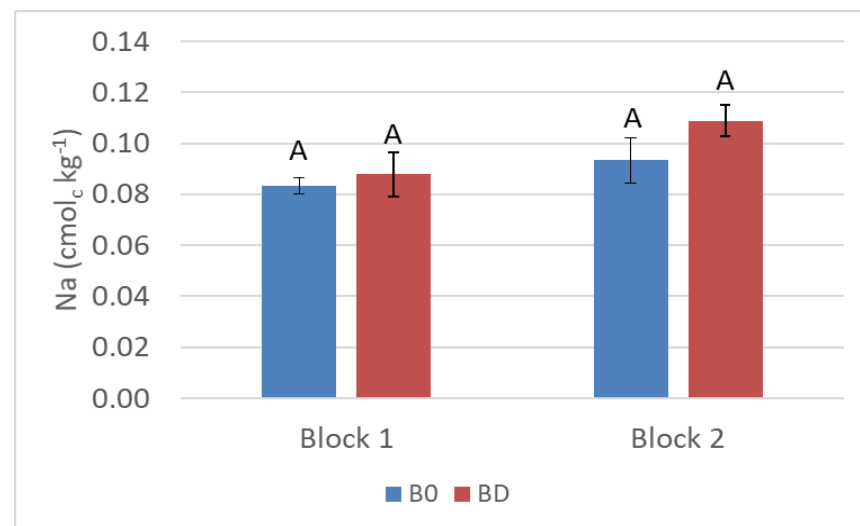
K: sig at $p < 0.05$ between blocks & treatment



Ca: sig at $p < 0.05$ between blocks & treatment



Mg: sig at $p < 0.05$ between blocks & treatment



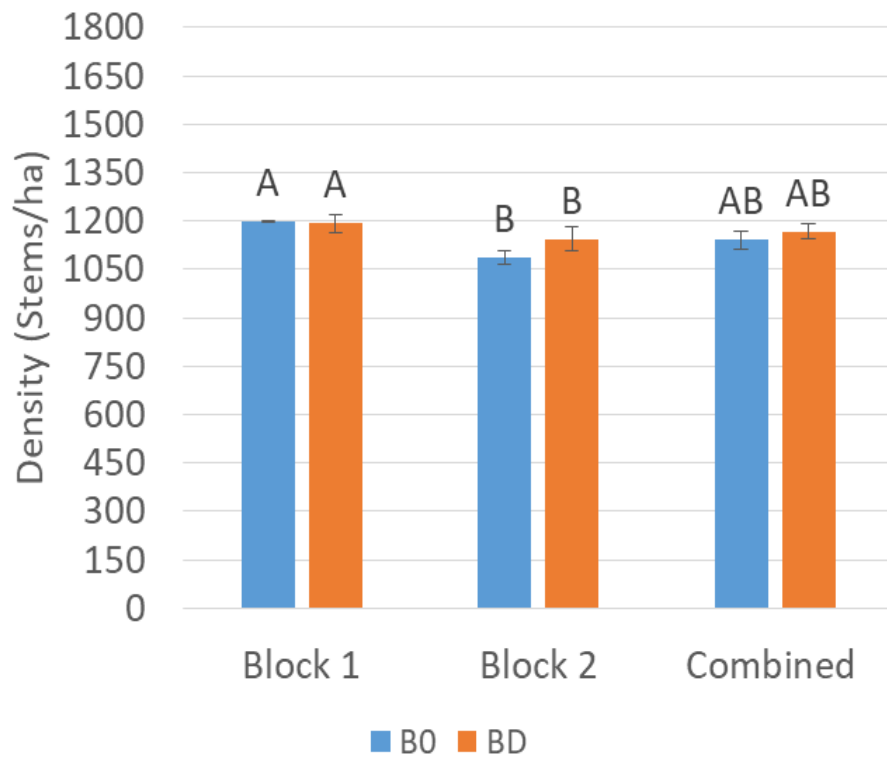
Na: All non-sig at $p < 0.05$



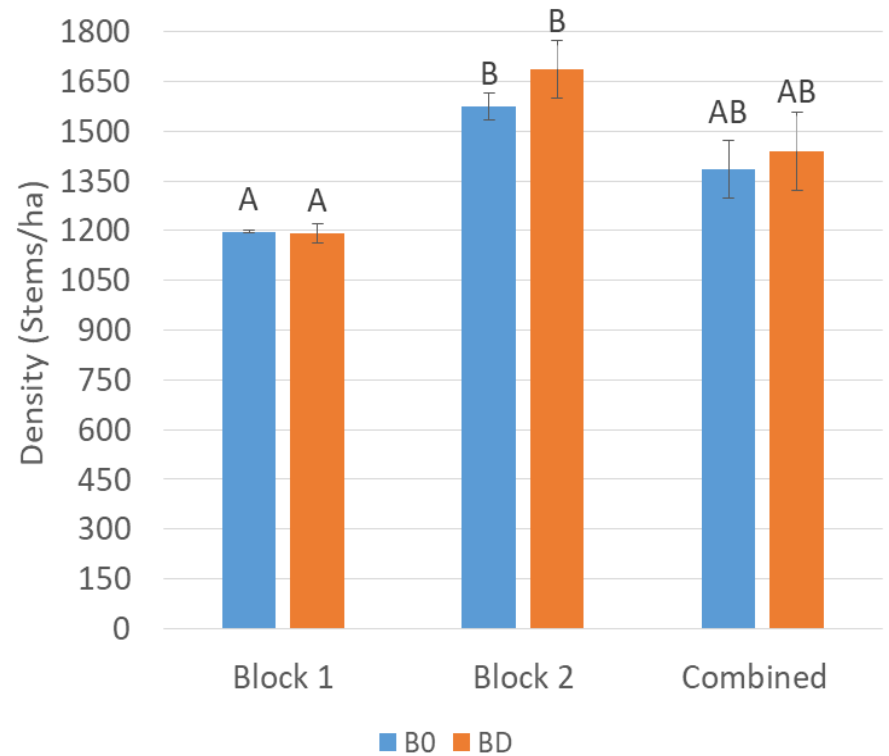
Results: Stand Density



Density (stump)



Density (stem)

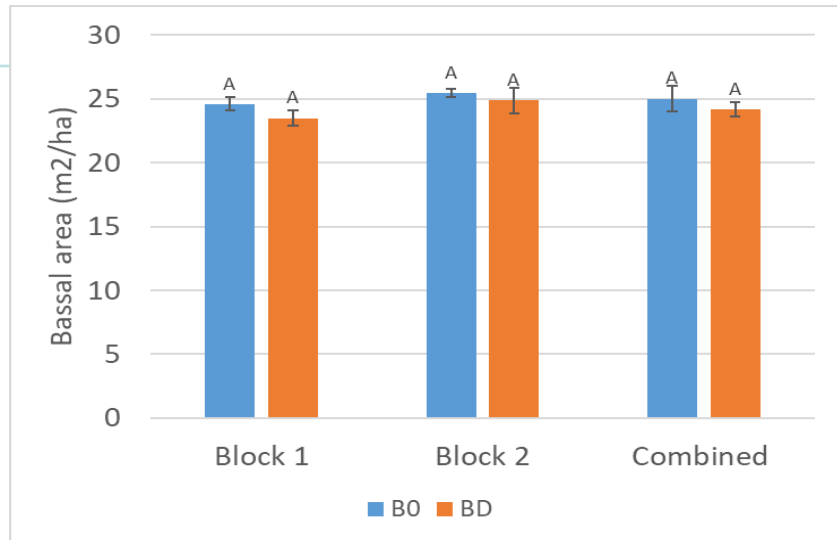
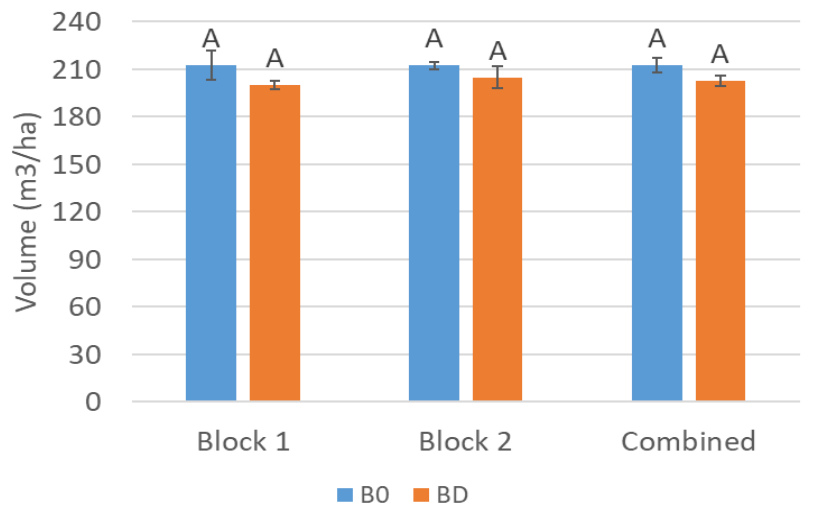


Sig at $p < 0.05$ between blocks

Sig at $p < 0.05$ between blocks

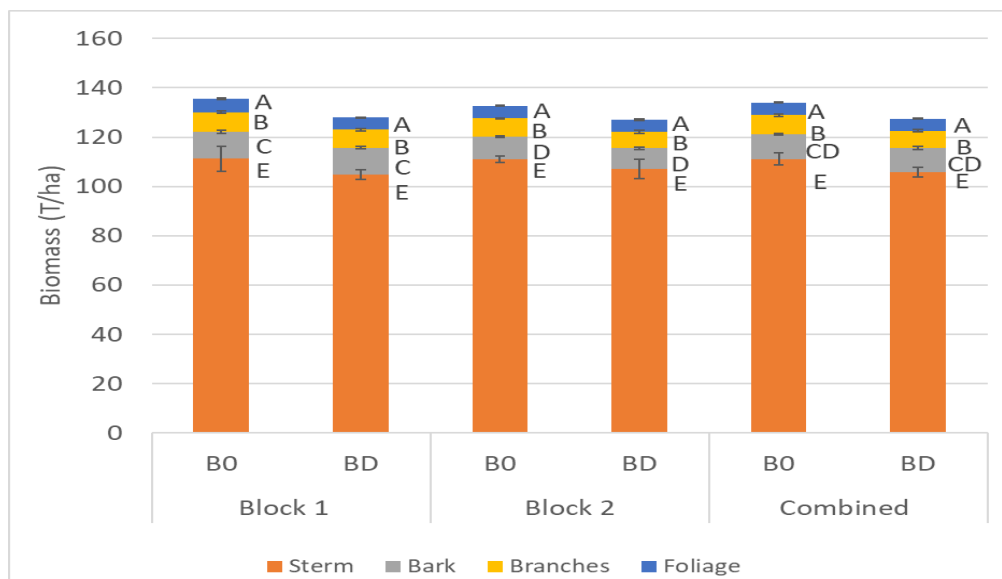


Results: Stand Volume & Biomass



Stand volume: All non-sig at $p < 0.05$

Stand basal area: All non-sig at $p < 0.05$



Biomass: All non-sig at $p < 0.05$ (except bark: blocks)



Results: Root Distribution Patterns (Block 1)

BD	DBH 10 cm										Count	%
0	15	12	21	23	19	22	29	21	27	16	205	31
10	8	10	6	7	5	13	15	8	11	7	90	13
20	8	6	7	9	12	9	10	11	8	9	89	13
30	6	9	7	5	3	4	6	5	7	8	60	9
40	11	8	13	10	20	9	19	11	12	5	115	17
50	1	5	3	5	3	0	2	7	6	4	36	5
60	0	4	5	1	2	0	2	2	1	1	18	3
70	0	1	3	0	0	0	2	3	3	2	14	2
80	1	5	0	0	1	1	3	2	0	6	19	3
90	0	4	1	0	3	0	2	0	7	4	21	3
100											667	100
	10	20	30	40	50	60	70	80	90	100		

BD	DBH 10 cm										Count	%
0	11	14	12	9	12	15	13	11	12	16	125	20
10	11	12	14	9	9	10	8	11	6	5	95	15
20	3	7	6	5	9	6	9	4	5	9	63	10
30	3	6	4	7	6	5	7	8	4	7	57	9
40	4	6	7	13	11	5	5	6	8	11	76	12
50	9	7	12	8	10	9	13	9	6	7	90	14
60	5	3	0	3	2	6	4	4	3	2	32	5
70	4	6	1	5	3	5	7	5	4	11	61	10
80	2	0	1	2	2	2	2	2	1	1	15	2
90	4	0	1	2	4	5	7	1	2	1	27	4
100											641	100
	10	20	30	40	50	60	70	80	90	100		

BD	DBH 15 cm										Count	%
0	21	18	13	15	17	14	12	18	23	12	163	30
10	6	4	8	12	8	9	6	5	9	7	74	14
20	5	8	6	11	9	10	5	4	8	3	69	13
30	2	1	0	2	4	2	6	5	7	5	34	6
40	3	6	5	4	2	3	3	5	2	2	35	6
50	5	4	7	2	2	6	3	5	8	12	54	10
60	2	4	6	7	3	2	5	4	2	13	48	9
70	0	2	4	3	2	1	3	4	14	1	34	6
80	0	0	6	0	0	0	2	3	6	1	18	3
90	1	2	0	2	1	0	0	2	2	3	13	2
100											542	100
	10	20	30	40	50	60	70	80	90	100		

BD	DBH 15 cm										Count	%
0	23	19	20	25	18	15	13	16	15	12	176	26
10	13	18	8	10	9	11	10	14	11	13	117	18
20	4	8	5	8	11	6	6	2	8	12	70	11
30	8	3	6	5	3	2	5	7	7	6	52	8
40	7	2	3	3	7	8	2	2	4	8	46	7
50	5	8	2	2	6	5	13	7	9	4	61	9
60	6	7	6	5	4	12	4	9	7	4	64	10
70	6	3	7	4	3	6	5	5	5	4	48	7
80	3	2	4	2	2	1	2	4	1	1	22	3
90	2	1	0	1	0	0	1	0	0	5	10	2
100											666	100
	10	20	30	40	50	60	70	80	90	100		

BD	DBH 20 cm										Count	%
0	21	13	18	21	14	17	19	17	25	25	190	32
10	7	11	11	7	10	10	8	8	8	8	90	15
20	9	8	9	7	5	11	11	5	7	6	78	13
30	3	5	4	15	12	4	12	7	3	1	66	11
40	2	3	6	5	5	3	5	5	3	1	38	6
50	6	8	3	9	6	3	3	4	6	5	53	9
60	3	2	7	2	1	4	1	3	2	4	29	5
70	1	3	9	1	2	4	1	5	1	3	30	5
80	1	0	3	0	0	1	0	1	1	2	9	2
90	0	1	3	0	0	3	0	2	2	1	12	2
100											595	100
	10	20	30	40	50	60	70	80	90	100		

BD	DBH 20 cm										Count	%
0	16	8	11	14	17	17	18	16	18	12	147	22
10	7	8	10	7	7	7	9	5	14	10	84	12
20	11	8	7	4	4	6	9	4	6	7	66	10
30	6	6	6	10	9	8	5	9	22	22	103	15
40	5	8	7	5	8	6	3	5	6	14	67	10
50	8	6	5	1	6	12	13	9	5	5	70	10
60	6	5	7	4	4	6	8	3	5	16	64	9
70	3	6	2	4	5	2	9	5	3	5	44	6
80	3	5	1	0	3	2	4	2	3	8	31	5
90	0	2	1	0	0	3	0	0	0	0	6	1
100											682	100
	10	20	30	40	50	60	70	80	90	100		





Results: Root Distribution Patterns (Block 2)

BD	DBH 10 cm										Count	%
0	20	23	20	14	19	18	23	18	20	15	190	19
10	11	7	10	8	12	7	11	13	8	10	97	10
20	7	8	6	5	9	11	9	5	15	11	86	9
30	17	9	10	18	23	14	11	19	16	18	155	16
40	8	6	10	8	9	10	11	21	15	18	116	12
50	6	9	10	12	10	13	13	9	10	18	110	11
60	11	6	15	10	6	19	12	11	10	3	103	10
70	3	8	9	8	6	8	6	7	3	5	63	6
80	1	1	4	7	4	3	3	4	3	4	34	3
90	0	4	5	5	0	2	2	2	5	2	27	3
100											981	100

BD	DBH 10 cm										Count	%
0	25	21	18	25	30	28	29	23	27	22	248	22
10	15	15	11	7	17	20	19	25	29	12	170	15
20	8	11	10	8	8	6	11	8	13	18	101	9
30	6	5	5	7	6	5	6	8	12	9	69	6
40	18	13	16	18	16	22	16	10	11	14	154	13
50	14	18	13	14	23	22	15	13	5	12	149	13
60	9	9	7	11	9	13	14	6	7	7	92	8
70	5	8	6	8	13	6	4	6	10	8	74	6
80	7	3	10	7	6	6	6	5	7	2	59	5
90	5	1	7	4	3	2	2	2	4	1	31	3
100											1147	100

BD	DBH 15 cm										Count	%
0	12	20	11	13	20	16	23	25	11	19	170	27
10	3	11	5	10	8	10	15	14	4	12	92	15
20	4	8	4	5	9	15	13	10	3	8	79	13
30	11	7	4	5	5	9	8	6	6	9	70	11
40	4	7	8	7	4	7	4	4	3	10	58	9
50	11	4	3	4	7	7	8	5	4	8	61	10
60	3	3	2	3	3	6	3	7	7	3	40	6
70	3	6	0	4	3	6	3	3	4	0	32	5
80	4	2	2	2	4	2	3	2	1	0	22	3
90	0	0	2	0	3	1	2	0	0	0	8	1
100											632	100

BD	DBH 15 cm										Count	%
0	20	17	16	13	14	15	19	11	20	18	163	23
10	9	9	10	8	8	9	11	7	12	13	96	13
20	17	6	7	10	8	10	8	10	10	12	98	14
30	8	5	7	11	10	8	8	7	15	16	95	13
40	6	7	8	7	6	7	10	9	5	9	74	10
50	3	4	4	5	7	10	9	8	5	6	61	9
60	4	11	3	2	4	13	7	7	6	3	60	8
70	3	3	4	2	3	7	5	3	3	5	38	5
80	1	3	1	2	5	3	1	1	2	7	26	4
90	0	0	0	0	1	1	1	0	0	2	5	1
100											716	100

BD	DBH 20 cm										Count	%
0	36	17	20	26	20	21	19	16	24	21	220	42
10	7	6	5	7	3	4	6	5	0	0	43	8
20	4	5	7	6	6	8	9	15	8	6	74	14
30	10	8	7	0	2	3	5	4	3	7	49	9
40	5	4	3	3	5	9	7	5	3	5	49	9
50	3	7	3	5	2	9	6	3	4	3	45	9
60	3	7	0	0	0	6	4	3	0	3	26	5
70	3	0	2	0	2	1	3	2	3	0	16	3
80	0	0	0	0	0	0	0	3	0	0	3	1
90	0	0	1	0	0	0	0	0	0	0	1	0
100											526	100

BD	DBH 20 cm										Count	%
0	16	10	9	12	13	11	15	12	14	13	125	21
10	12	5	7	9	11	9	13	13	10	4	93	16
20	7	2	13	6	12	4	8	15	12	6	85	14
30	14	8	8	8	10	10	10	12	9	10	99	17
40	5	7	7	9	7	8	11	8	8	13	83	14
50	5	3	3	3	3	3	5	2	6	7	40	7
60	1	2	3	3	3	4	7	3	2	4	32	5
70	2	3	1	2	3	3	0	0	4	2	20	3
80	0	0	2	1	3	1	0	2	3	2	14	2
90	0	1	0	0	0	1	0	1	3	0	6	1
100											597	100





CONCLUSION



- Repeated harrowing incorporated organic material into soil and effectively reduces fuel loading.
- No effect on NPC, but improved exchangeable cations, as well as reduced soil bulk density.
- Change of root distribution & reduction on tree growth and stand productivity, but not significant.
- Benefit of fire risk reduction off set for the negative implication on the negligible reduction in tree growth and stand productivity.



Thank You!



your knowledge partner





METHODOLOGY: Lab Work



- **Bulk density**: Oven dry mass divided by volume of the cylinder
- Total N = **Kjedahl** technique (Buurman, Lagen and Velthorst, 1996)
- Available P = **Bray II** solution as an extractant (Hunter, 1974)
- **Organic C** fraction measured using potassium permanganate as an oxidising agent following Blair et al. (1995) procedure
- **Exchangeable cations (AMBIC), pH (in KCL)**



LITERATURE REVIEW: BIO CHARCOAL ON SOIL PROPERTIES & SITE PRODUCTIVITY



- **Bio charcoal** influence soil physical and chemical properties: **site-specific** (Kolb, Fermanich & Dornbush 2009).
- Biomass material: animal waste, municipal waste, and agriculture & wood residues (straws, thinning, and **harvest residues**) (Wróbel-Tobiszewska 2014).
- Bio charcoal characteristics determined by : **temperature, residence time**, & available **oxygen** during pyrolysis.
- Good qualities: prolonged chemically active time in soil, physical form (micro pores and a relatively large surface area), and negatively charged surface area (adsorption) (Carter et al 2018).



METHODOLOGY: Sorting, Followed by Milling and Analysis



Fuel Classes

10 hour fuel

1 hour fuel (bark and leaf fraction)

1 hour fuel (branch fraction)





METHODOLOGY: Data Analysis



- The following procedure was followed in SAS:
- One-Way ANOVA to test for homogeneity: Levene's and Bartlett's $p < 0.05$
 - If not then transform
- ANOVA linear model (**nested design**) at $p < 0.05$
 - Bonnferoni (Dunn) t-Test will be used to follow up where significant difference
- Normality (residuals): Shapio-Wilk test $p < 0.05$.



More Details



- Thesis like below
- <https://scholar.sun.ac.za/items/945e93f2-abdb-4ac3-b84b-b4ffdc87fe2b>
- Forsilvitech link below
- <https://www.forsilvitech.com/article/disc-harrowing-for-fuel-load-management-in-eucalyptus-stands/#:~:text=Repeated%20disc%20harrowing%20significantly%20increased,1%20respectively%20following%20repeated%20disking.>