Microbial Indices Response to Prescribed Burning and Thinning in a Managed Forest Ecosystem

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ABSTRACT

Prescribed burning and thinning is used to maintain fire dependent species, improve wildlife habitat, and preparing areas for forest regeneration after timber harvest. Fire is a powerful and instantaneous modifier of the environment, and potentially has a profound long-term influence on nutrients cycles in ecosystems by changing the form, distribution and amount of nutrients as well as species composition and processes. We assessed the effect of low intensity burning (two circles of 3-year burn) and thinning on microbial indices (microbial biomass carbon, microbial biomass nitrogen, microbial respiration, enzymes activities, and adenosine triphosphate) and carbon fractions. Results show that thin + burn increased MBC and MBN compared to thin only and burn only soil. PCM decreased in thin + burn plots than in thin or burn only plots. POC and PON were higher in thin only, reference, and burn only plots than in thin + burn plots. LFC and LFN were greater in thin + 10yr burn than in reference, thin + 3yr burn, and burn only plots. Glutaminase activity increased in thin + burn plots than in thin and burn only plots. Acid phosphatase was the most dominant enzyme in this soil, and its activity was suppressed by 50% thin + 3yr burn and no thin + 3yr burn.

INTRODUCTION

- For almost a century fire was viewed as destructive force in terrestrial ecosystem.
- Because of this mentality, fire was seriously suppressed.
- Recent scientific studies have depicted some usefulness of fire in the ecosystem management.
- Nowadays, prescribed fire is often used as a land management tool.
- Prescribed burning has been used to:
  - Restore forest ecosystem
  - Maintain species composition and richness
  - Avoid catastrophic wild fire
  - Enhance nutrients cycling
  - Alter soil physiochemical properties
- The intensity and frequency of fire is an important factor influencing ecosystem functions.
- Although it is well known that prescribed fire exerts strong influence on forest ecosystem, the relationship between low intensity fire, thinning and the ecosystem in the Bankhead National Forest is still poorly understood.

REFERENCES

Cambardella, C.A., and E.T. Elliott. 1992. Particulate soil organic matter changes across a grassland cultivation sequence. Soil Sci. Soc. Am. J. 56:777-783.

Haney, R.L., A.J. Franzluebbers, E.B. porter, F.M. Hons, and D.A. Zuberer. 2004. Soil carbon and nitrogen mineralization: Influence of drying . Soil Sci. Soc. Am. J. 68:489-492.

Howath, W.T., and E.A. Paul. 1994. Microbial biomass. In Methods of soil analysis, part 2: Microbial and biochemical properties, R.W. Weaver et al. (eds.), 753-774. Madison, WI: Soil Science Society of America.

Janzen, H.H., C.A. Campbell, S.A. Brandi, G.P. Lafond, and L. Townley-Smith. 1992. Light-fraction organic matter in soils from long-term crop rotations. Soil Sci. Soc. Am. J. 56:1799-1806.

Martins, R. 2001. Estimation of ATP in Soil: extraction methods and calculation of extraction efficiency. Soil Biol. Biochem. 33:973-982.

Tabatabai, M.A. 1994. Soil enzymes. In method of soil analysis, part 2: Microbial and biochemical properties, R.W. Weaver et al. (eds.), 903-947. Madison, WI: Soil Science Society of America.

OBJECTIVES

To compare the impact of thinning and burning (low intensity) on microbial indices, carbon fractions and enzymes biochemical reactions.

MATERIALS and METHOD

- Soils were sampled at the 0-10 cm depth in Fall of 2011 at the Bankhead National Forest (BNF) in Northwest Alabama.
- Two burning patterns (no burn and burn) and three levels of thinning (no thin, thin to 17.22 m^2 ha^{-1} basal area and to 11.46 m^2 h^{-1} basal area) were applied to nine treatment plots.
- Two circles of a 3-year burn was completed before soil sampling in 2011.
- Microbial biomass carbon and nitrogen, potential carbon mineralized were determined based on the methods of Horwath and Paul, 1994; Haney et al. 2004.
- Adenosine triphosphate (ATP) determined according to Martins, 2001.
- Light Fraction carbon and nitrogen was extracted using the methodology described by Janzen et al. 1992.
- Particulate organic carbon and nitrogen was extracted based on the procedure described by Cambardella and Elliott, 1992.
- Enzymes biochemical reactions were assayed according to Tabatabai, 1994.

CONCLUSION

- Thinning and burning increased MBC and MBN than in reference soil, thin, and burn only.
- PCM decreased in Thin and burn plots than in reference or thin only or burn only plots.
- LFC and LFN are in the order thin only > thin + burn 10yr > reference > thin + burn 3yr > burn only 10yr > burn only 3yr.
- POC and PON are in the order thin only > reference > burn only 10yr > burn only 3yr > thin + burn 10yr > thin + burn 3yr.
- Among the amidohydrolases, amidase activity was the least and affected by burning and thinning.
- Glutaminase activity increased in thin + burn plots than in thin and burn only plots.
- Acid phosphatase was the most dominant enzyme in this soil, and its activity was suppressed by 50% thin + 3yr burn and no thin + 3yr burn.

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RESULTS

Table 1. Soil physical and chemical properties at treatments site in Bankhead National Forest, AL.

Treatment #	Application	pH_H_2O	C (%)	N (%)	S (%)	C/N Ratio	NH_4 (ppm)	NO_3 (ppm)	Conductivity (µS/cm)	CEC meq/100g soil
T1	Reference (no treatment)	4.66±0.22	3.11±1.02	0.126±0.033	0.016±0.004	24.42±1.83	11.12±5.09	9.37±13.35	51.77±6.37	3.03±0.35
T2	Burn only- 10 yr	4.34±0.45	2.99±0.46	0.122±0.022	0.014±0.002	24.72±2.58	4.35±0.25	2.22±1.94	48.77±9.41	3.51±0.76
T3	Burn only- 3 yr	4.72±0.24	2.37±0.25	0.101±0.004	0.012±0.001	23.48±1.65	6.29±1.60	1.60±0.70	40.87±5.50	2.30±0.89
T4	Thin to 11.46 m^2 ha^{-1} basal area	4.85±0.23	2.47±0.45	0.104±0.018	0.011±0.001	16.47±13.66	9.87±0.60	4.94±1.32	42.07±4.65	2.32±0.53
T5	Thin 17. 22 m^2 ha^{-1} basal area	4.57±0.28	3.49±1.38	0.129±0.028	0.013±0.003	26.54±5.17	4.86±1.9	5.70±0.34	40.13±6.99	3.40±1.15
T6	Thin 11.46 m^2 ha^{-1}basal area + 3yr burn	5.06±0.1	1.97±0.24	0.085±0.005	0.012±0.001	23.18±2.13	6.71±0.79	1.38±0.29	38.33±4.11	2.21±0.32
T7	Thin 17.22 m^2 ha^{-1} basal area + burn	4.74±0.22	1.90±0.16	0.090±0.011	0.012±0.001	21.35±1.71	5.68±1.38	2.66±0.96	37.17±8.35	2.71±0.69
T8	Thin 11.46 m^2 ha^{-1} basal area + 10yr burn	4.73±0.48	1.59±0.54	0.081±0.021	0.011±0.003	19.30±1.99	5.92±0.52	2.75±2.84	33.70±2.12	1.92±0.63
T9	Thin 17.22 m^2 ha^{-1}basal area + 10yr burn	4.86±0.16	2.38±0.32	0.113±0.025	0.017±0.010	21.37±2.06	12.91±4.68	6.98±1.29	42.33±13.75	1.73±1.13

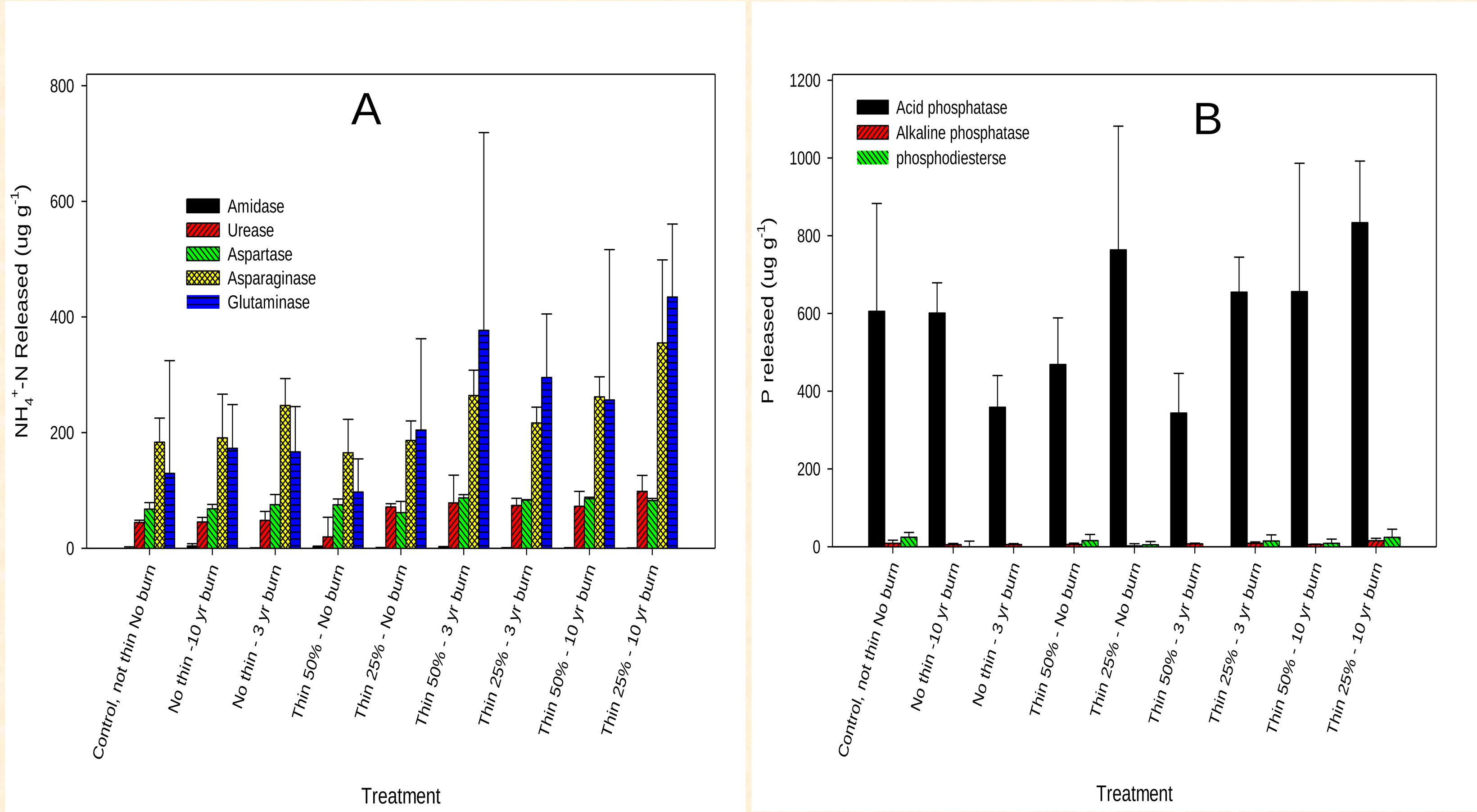

Fig. 1. Impact of burning and thinning on amidohydrolases (A) and phosphatases (B) activities

Table 2. Microbial indices at treatments site in Bankhead National Forest, AL.

Treatment #	Application	MBC mg kg^{-1}	MBN mg kg^{-1}	PCM mg kg^{-1}	ATP (ng g^{-1} soil)	MBC/ATP	ATP/MBC (%)
T1	Reference (no treatment)	285±199	51.78±15	754±101	4669±2866	69.37±40	0.010±0.007
T2	Burn only- 10 yr	822±205	57.1±22	658±66	4870±748	167.19±18	0.003±00.00
T3	Burn only- 3 yr	600±202	85.31±13	693±82	11053±7569	74.89±57	0.011±0.008
T4	Thin to 11.46 m^2 ha^{-1} basal area	234±117	58.95±15	703±120	22167±22578	26.72±15	0.019±0.023
T5	Thin 17. 22 m^2 ha^{-1} basal area	1773±2491	84.85±27	393±285	4576±3913	11080±19101	0.008±0.009
T6	Thin 11.46 m^2 ha^{-1}basal area + 3yr burn	2963±1947	70.23±25	754±256	9067±5462	389±366	0.002±0.002
T7	Thin 17.22 m^2 ha^{-1} basal area + burn	1605±1435	76.07±14	890±173	5875±1396	263.4±202	0.006±0.008
T8	Thin 11.46 m^2 ha^{-1} basal area + 10yr burn	2071±739	71.03±26	158±184	3935±1170	570±267	0.001±0.00
T9	Thin 17.22 m^2 ha^{-1}basal area + 10yr burn	2674±311	90.02±19	485±513	5207±1954	480±159	0.001±0.00

Table 3. Carbon, Nitrogen, and sulfur content of Light and particulate organic fractions in Bankhead National Forest, AL.

Treatment #	Application	Dry Wt. LF	LF C	LF N	LF S	POC	PON	POS
		---g kg^{-1} soil---						
T1	Reference (no treatment)	62.015±14.5	16.04 ±6.5	0.491±0.02	0.059±0.02	17.53±9.2	0.546±0.31	0.053±0.02
T2	Burn only- 10 yr	64.687±2.6	13.93 ±0.4	0.421±0.01	0.049±0.02	17.63±4.6	0.564±0.15	0.061±0.02
T3	Burn only- 3 yr	35.911±9.4	9.11±0.4	0.255±0.01	0.031±0.01	11.33±2.9	0.334±0.01	0.036±0.01
T4	Thin to 11.46 m^2 ha^{-1} basal area	40.503±7.9	9.16 ±0.3	0.253±0.01	0.028±0.01	14.25±4.2	0.427±0.18	0.044±0.01
T5	Thin 17. 22 m^2 ha^{-1} basal area	55.531±27.5	16.94±0.4	0.437±0.1	0.056±0.02	20.92±10.3	0.568±0.17	0.035±0.02
T6	Thin 11.46 m^2 ha^{-1}basal area + 3yr burn	30.121±6.8	7.67±0.1	0.184±0.04	0.020±0.01	7.66±1.9	0.188±0.01	0.044±0.00
T7	Thin 17.22 m^2 ha^{-1} basal area + burn	37.633±4.0	10.80±0.3	0.294±0.02	0.032±0.003	7.25±0.87	0.213±0.02	0.023±0.02
T8	Thin 11.46 m^2 ha^{-1} basal area + 10yr burn	31.783±13.3	8.92±0.3	0.281±0.01	0.033±0.02	6.06±5.5	0.204±0.22	0.026±0.02
T9	Thin 17.22 m^2 ha^{-1}basal area + 10yr burn	46.916±6.0	12.71 ±0.4	0.357±0.01	0.036±0.01	10.21±0.53	0.334±0.06	0.058±0.07