STRATEGIC GRAZING FOR RESISTANCE TO EXTREME WEATHER EVENTS

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Abstract. A greater number of extreme weather events such as drought and hurricanes, are predicted in coming decades, due to changing global climate, and they have significant impacts on agricultural systems. Runoff losses of nitrogen (N) can be exaggerated during hurricanes due to much intense precipitation. The other extreme, drought reduces forage productivity which in turn increases hay requirement. Our study was conducted in Southern Piedmont of Georgia to develop a grazing system that is more resistant to extreme weather events such as hurricanes and droughts. Runoff collectors were established to collect surface runoff in eight "Conventionally" managed beef-pastures in Southern Piedmont, Georgia, USA. Runoff samples were collected immediately after runoff events and filtered (< 48 hours; 0.45 µm filter) and analyzed for nitrate (NO_3^-) and ammonium (NH_4^+). In May 2016, "Strategic-Grazing" was devised and implemented in four pastures and the remaining four pastures were continuously grazed with rolling out of hay (Continuous-Rolling). "Strategic-Grazing" includes excluding and over seeding vulnerable areas (concentrated flow paths), strategic placement of shade, hay, and water, and moderate rotational grazing. During a prolonged drought in 2016 (8 months), the Strategic pastures produced more forage and required less hay feeding as compared to Continuous-Rolling pastures. During a wet period in 2017 (June-October), which included a Category-5 hurricane (Irma), the runoff-NO_3^- per unit soil nitrate in Strategic pastures was 1/3 times lower as compared to the Continuous-Rolling pastures. This was mainly attributed to forage growth in the excluded areas, lower bulk density, and the cattle-rotation that allowed forage shoot and root regeneration. These results indicated that "Strategic-Grazing" could be a useful management tool in developing resistance to extreme weather events while increasing forage productivity in beef pastures.

INTRODUCTION

Conventional/Continuous grazing system, common in Southeastern USA for beef production, involves continuous grazing of pasture without control over grazing time and intensity. This system is more vulnerable to ongoing climatic changes and extreme weather events because most of the beef-pastures are in sloped, fragmented and marginal lands not suitable for row cropping (Drouillard, 2018). In Georgia, more land is being converted to pastures (Machmuller et al. 2015) and extreme events such as drought and hurricanes are occurring more frequently in recent decades (IPCC, 2012). Loss of soil and nutrients from slope and marginal pastures, in surface runoff, has detrimental effect on both stream water quality and farm productivity. In conventional grazing system, authors (Dahal et al. 2018; Hendricks et al. 2019) have reported high nutrient deposition near pasture equipages and in areas vulnerable to erosion. This study aims to develop a grazing system that will improve beef-pasture system's resistance to extreme weather events such as hurricanes and droughts.

METHODS

This study was conducted in eight historically (>10 years) continuously grazed pastures, four in J. Phil Campbell Sr. Conservation Research and Education Center (33.887487° N, 83.420966° W), Watkinsville, GA, and four in Animal and Dairy Science Beef Cattle Farm (33.420759° N, 83.476555° W), Eatonton, GA. Three to four Pour-point runoff collectors were established in each pasture to collect surface runoff and soil-samples were collected yearly (2015, 2016, and 2017) Runoff samples were collected immediately after runoff events and filtered (< 48 hours; 0.45 µm filter) and analyzed for nitrate (NO_3^-) and ammonium (NH_4^+).

Inside each contributing watershed soil samples were analyzed for nitrate and ammonium. We also recorded number of haybales fed per year in each pasture to calculate hay requirement. NDVI maps (Normalized Difference Vegetation Index), as a proxy for forage production, were created for Eatonton pastures using Sentinel-2 satellite images.

In May 2016, four pastures were converted to "Strategic-Grazing" and Four were "Continuously grazed with rolling out of hay in various places in pasture" (Continuous-Rolling). Strategic-Grazing is a collection of better grazing practices; (i) Manure distribution in pasture through Lure-management of cattle by strategic placement of Shade,

Hay and Water, (ii) Exclusion of compacted areas (with high cattle activity) vulnerable to erosion losses, (iii) Over-seeding excluded areas with Legume-Grass mix to improve cover and minimized sediment and nutrients losses, (iv) Strategically planned Flash/Mob grazing of the excluded areas, and (vi) Moderate rotational grazing in the sub-paddocks to control grazing intensity and duration for facilitating forage recovery.

RESULTS

Nitrate in Runoff

This portion reports runoff results obtained during the Summer/Fall 2017 (June-October), when the pastures were affected by a hurricane ("Irma"; category-3 in Georgia). The regression equation for each treatment are presented in Table 1 which shows the relationship between runoff nitrate and soil nitrate.

The ratio of two slopes (Strategic/Continuous-Rolling) shows that less nitrate was lost in runoff (one-third), per unit increase in soil nitrate, in Strategic pastures as compared to Continuous-Rolling pastures (Figure 1).

Forage Productivity and Hay Requirement

This portion reports forage results obtained during the Spring/Fall 2016. Hay requirement during a severe drought (2016) for Eatonton pastures, measured as number of hay-bales fed, in Strategic pastures was 1/3 of the requirement in the Continuous-Rolling pastures (Figure 2).

The NDVI maps in Figure 3 were created as a proxy of forage biomass in pastures.

Higher NDVI, indicates higher forage biomass whereas lower values indicate lower biomass. We can clearly see the gradual reduction in greenness of the pastures, following May 2016, which was an impact of an 8-month-drought. The green patches in the Strategic pastures, outlined by purple line, delineate the exclusions. The biomass measured as NDVI during July and August 2016, clearly illustrates the reason for lower hay requirement in the Strategic pastures.

DISCUSSION

Less nitrate was lost in runoff, per unit soil-nitrate, in Strategic pastures as compared to Continuous-Rolling pastures which shows the ability of Strategic system to resist N loss during extreme weather events such as hurricanes. The lower runoff-nitrate in Strategic pastures was attributed to reduced/controlled cattle-access in the concentrated flow paths (exclusions), greater cover and biomass of the excluded areas and plant uptake of the soil nitrogen (over-seeding of exclusions).

Table 1: Comparison of relationship between soil-nitrate vs. runoff nitrate by grazing-system. The P-value column compares the slope between two grazing systems during baseline and during the Summer/Fall 2017.

Treatment	Runoff-NO_3^-	Slope	P-value
Baseline – Conventional	-0.05+Soil-NO_3^- x 0.0134	0.0134	NS
Baseline - Strategic	0.019+Soil-NO_3^- x 0.0114	0.0114	
Continuous - Rolling (Summer/Fall 2017)	-0.17+Soil-NO_3^- x 0.0074	0.0074	0.0205
Strategic (Summer/Fall 2017)	-0.03+Soil-NO_3^- x 0.0022	0.0022	

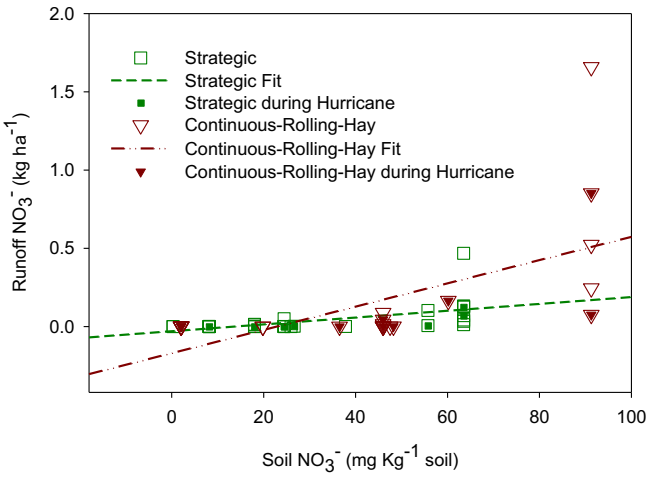

Figure 1: Comparison runoff-nitrate in Strategic vs. Continuous-Rolling pastures during Summer/Fall 2017. The regression lines show the change in runoff-nitrate per unit increase in soil nitrate. The solid squares and triangles indicate the events during hurricane "Irma".

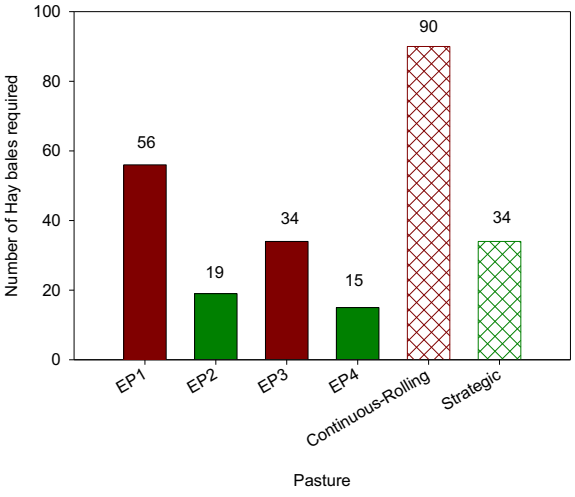

Figure 2: Comparison of hay fed in Eatonton pastures (2016) during extend drought. The Continuous-Rolling and Strategic bars show the cumulative hay requirement in each treatment.

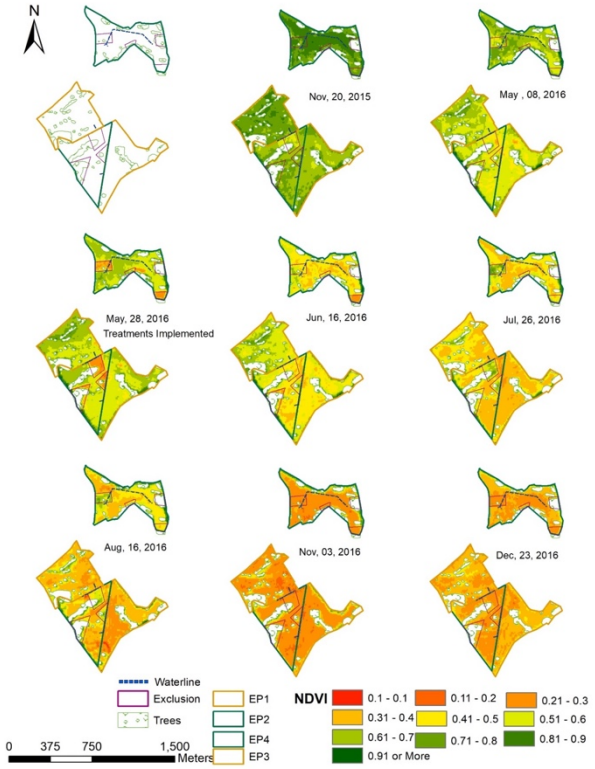

Figure 3: NDVI (Normalized Difference Vegetation Index) maps of Eatonton pastures (Nov 2015- Dec 2016). EP1 and EP3 are Continuous-Rolling and EP2 and EP4 are Strategic pastures. The areas enclosed by purple lines in Strategic pastures are the excluded vulnerable areas.

The nutrient-rich excluded areas in Strategic pastures, over-seeded with productive grass-legume mix, utilized the soil nutrients to produce a better forage biomass, as compared to the Continuous-Rolling system, which was utilized by cattle during the times of drought. Rather than losing the nitrogen, accumulated in vulnerable areas, in runoff, it was utilized by plants to produce forage biomass. That biomass ultimately contributed to a longer grazing period thereby reducing hay requirement. Also, the moderate rotation of cattle in Strategic pastures allowed forage regeneration ultimately helping to reduce the hay requirement.

CONCLUSIONS

Our results indicate that strategic grazing reduced nitrate in runoff as compared to Continuous-Rolling grazing during extreme rainfall event such as hurricane and prolonged forage availability during extreme drought which reduced hay requirement. Overall, Strategic grazing can be a useful tool to develop resistance to extreme weather events in beef-pasture system.

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