Long-term Pasture under Elevated CO_2 and N Management: CO_2 Flux Patterns upon Return to Cultivation

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ABSTRACT

Soil CO_2 efflux patterns associated with converting pastures back to row crop production remain understudied in the Southeastern U.S. A 10-year study of bahiagrass (*Paspalum notatum* Flüggé) response to elevated CO_2 was conducted using open top field chambers on a Blanton loamy sand (loamy siliceous, thermic, Grossarenic Paleudults). Plants were subjected to ambient or elevated (ambient plus 200 ppm) CO_2 and grown under managed ([$(NH_4)_2SO_4$] at 90 kg ha^{-1} 3x yr^{-1}) and unmanaged conditions (no added N), both of which are common in the Southeast. At study termination, soil CO_2 flux was continuously monitored (automated carbon efflux system or ACES) following glyphosate applications and tillage to document CO_2 loss associated with pasture conversion to row crop production. Concurrent measures of the herbicide termination process were documented with an active light sensor (Greenseeker® meter). Following the initial herbicide application, managed plots showed higher vigor which declined and became similar to unmanaged plots after 3 weeks; there was no CO_2 effect during this period. After the second herbicide application, no GreenSeeker differences were detected, and monitoring was discontinued one week later. Cumulative soil CO_2 flux was higher under elevated CO_2 only for the week prior to the first herbicide application and for the period between the second herbicide application and the tillage event. The only N effect occurred during the second week after tillage (coinciding with rainfall) where daily CO_2 flux was higher in managed plots. For the entire sampling period, total cumulative CO_2 loss was not affected by either N or CO_2 level. These findings suggest that conversion of pasture to row crop systems will not be greatly impacted by N management or atmospheric CO_2 level.

Keywords: carbon dioxide, pasture, nitrogen fertilization, herbicide, CO_2 flux, tillage

INTRODUCTION

The level of carbon dioxide (CO_2) in the atmosphere is increasing at an unprecedented rate due primarily to fossil fuel burning and land use change (Keeling and Whorf, 2001). Plant responses to elevated CO_2 are well documented, showing increased photosynthesis and resource use efficiencies that lead to increased growth for most plants (Amthor, 1995). In some instances, plants do not respond to increased atmospheric CO_2, particularly when soil resources such as N are limiting. Nitrogen is the element most limiting to biomass production and is key to both plant and soil C dynamics. Understanding CO_2-induced changes in plant/soil N interactions will be critical to N management for both profitable and environmentally sound agricultural systems of the future.

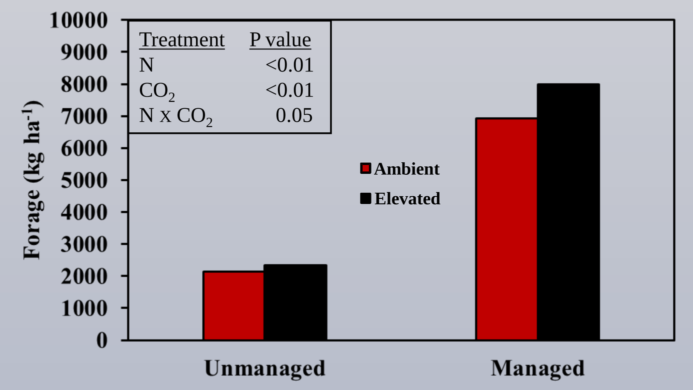
Pastures occupy 80 million acres in the southeastern U.S., which is about 75% of the total pasture acreage in the eastern U.S (Ball et al., 2002). While the effects of elevated CO_2 on natural grasslands have received some attention, pastures in the southeastern United States remain an understudied agroecosystem. A 10-year study examining the response of a southeastern pasture system (bahiagrass, *Paspalum notatum*) to current and elevated levels of CO_2 (ambient and plus 200 ppm CO_2) with a nitrogen management treatment (no N = unmanaged and plus N = managed) was recently terminated.

Over the course of the study there was a strong effect of N addition on forage production, while effects of elevated CO_2 were lower; CO_2 level had no impact on forage production when no N was added (see graph below). A somewhat similar pattern was seen in belowground rhizome biomass production (see graph below). Given that some evidence has shown that elevated CO_2 may increase herbicide tolerance in some plants (Ziska et al., 1999), we were interested in determining if the extensive nature of the rhizome belowground system would impact herbicide efficacy when converting a pasture back to a row crop production system.

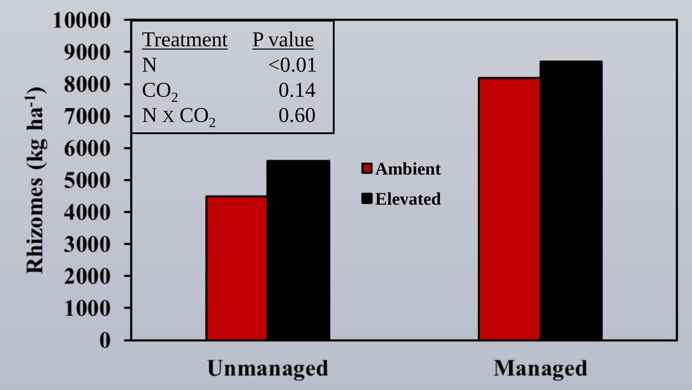
MATERIALS AND METHODS

- ✓ The response of a southeastern pasture system (bahiagrass, *Paspalum notatum*) to current and elevated (current plus 200 ppm) levels of CO_2 and nitrogen management (no N = unmanaged and plus N = managed) was investigated on an outdoor soil bin (7m x 76 m) at the USDA-ARS National Soil Dynamics Laboratory in Auburn, AL, USA.
- ✓ Extension fertility recommendations were used only in plus N plots. Nitrogen [$(NH_4)_2SO_4$] was applied to plus N plots three times per year (2 months before first harvest and after June and August harvests) at 90 kg ha^{-1} per application. No N plots received no fertilizer. These treatments represent managed and unmanaged pastures that are both common in the Southeast.
- ✓ The study used a split-plot design replicated three times with N as main plots and CO_2 level as subplots within open top field chambers (Rogers et al., 1983) on a Blanton loamy sand (loamy, siliceous, thermic Grossarenic Paleudult) and was terminated after 10 years.
- ✓ Aboveground forage biomass was harvested three times per year (June, August, and October). At each harvest, plants were mowed (to simulate a haying operation) and total dry weights determined (55^{o}C). For background information, the 10-year average for the yearly cumulative forage biomass is shown below. In addition, rhizome biomass that was determined at termination is also shown below.
- ✓ Following study termination, plots were sprayed with glyphosate at recommended rates (DOY 132); a second application was used 20 days later (DOY 152). Crop vigor was monitored using a handheld GreenSeeker® optical sensor (DOY 130-161). The plots were rototilled (15-20 cm depth) 20 days after the second glyphosate application (DOY 172). Soil CO_2 efflux was continuously monitored using Automated Carbon Efflux Systems (ACES) throughout this period (DOY 127-207).
- ✓ Data analyses were conducted using the using the Mixed Models Procedure (Proc Mixed) of the Statistical Analysis System (Littell et al., 1996). Error terms appropriate to the split-plot design were used to test the significance of main effects and their interactions. A significance level of ($P \leq 0.10$) was established *a priori*.

Yearly forage production (10-yr average)



Rhizome production (at termination)



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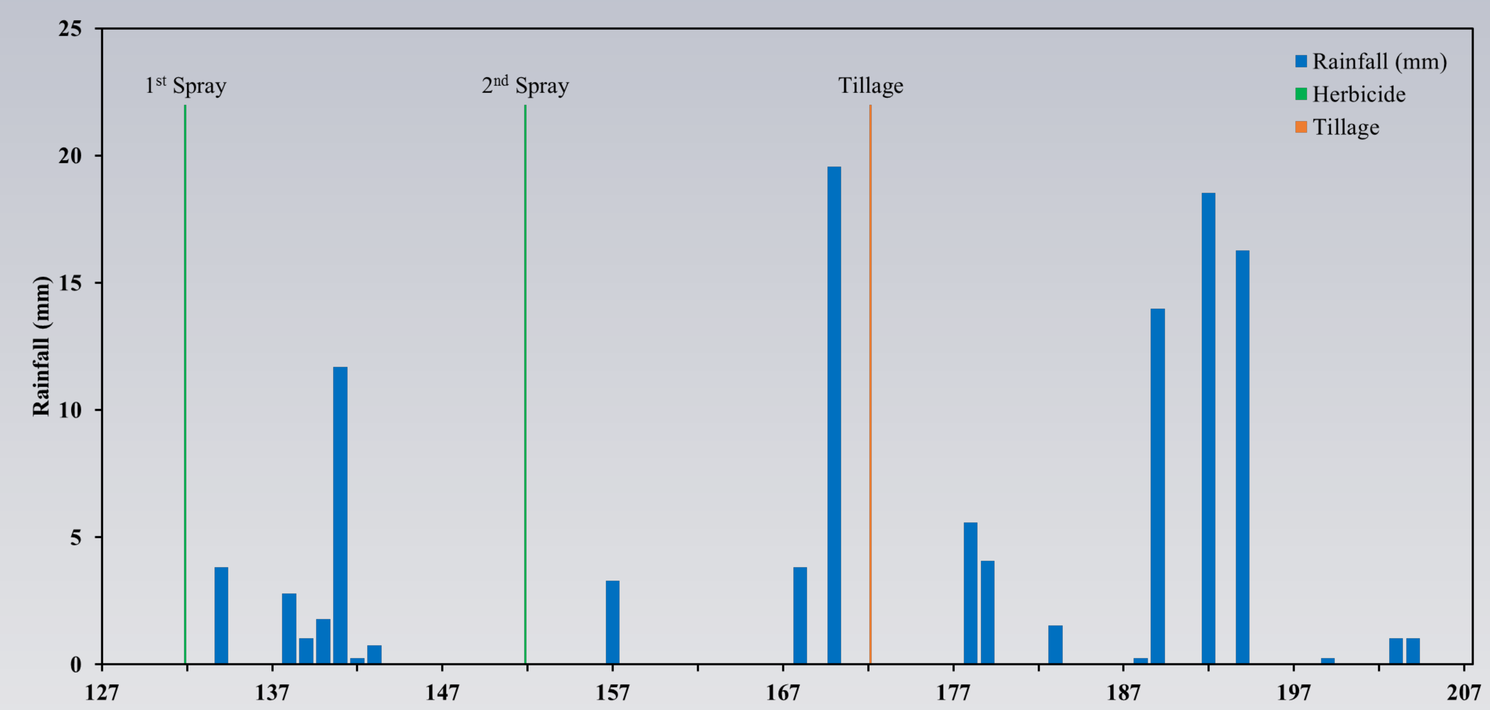
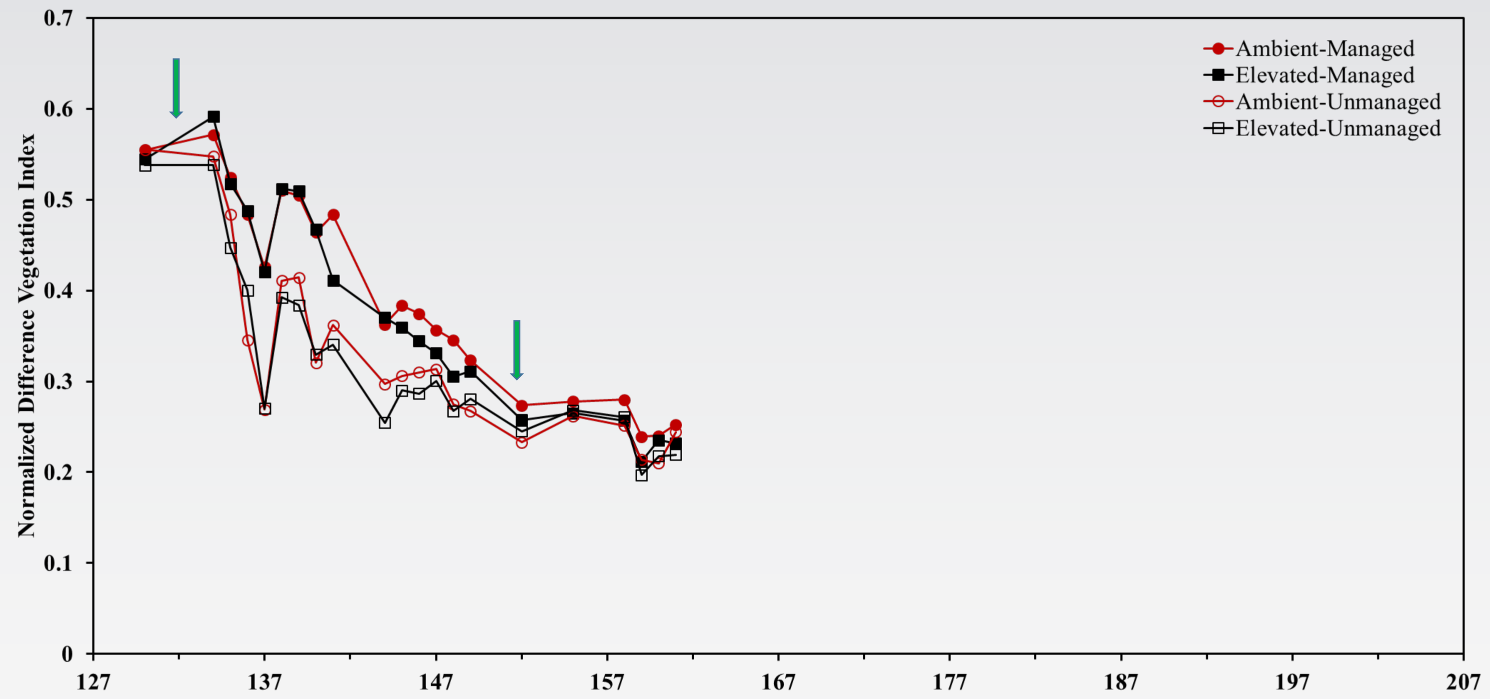
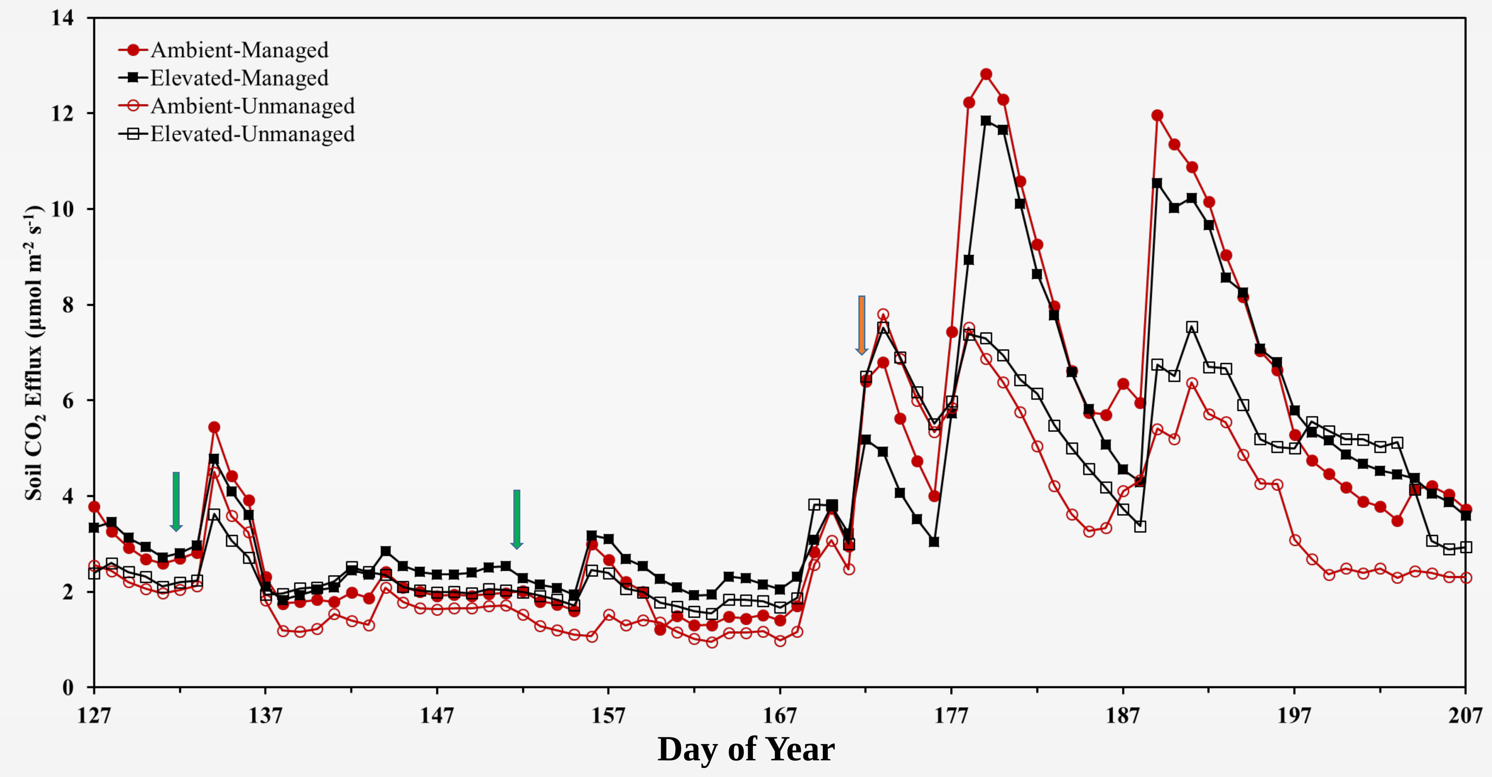
RESULTS







CONCLUSIONS

- ✓ Following the initial herbicide application, managed plots showed higher vigor which declined and became similar to unmanaged plots after 3 weeks; there was no CO_2 effect during this period.
- ✓ Following the second herbicide application, no treatment differences were detected with the GreenSeeker® and monitoring was discontinued one week later.
- ✓ Cumulative soil CO_2 flux was higher under elevated CO_2 only for the week prior to the first herbicide application and for the period between the second herbicide application and the tillage event. There was no N effect on cumulative CO_2 loss for any time interval.
- ✓ The only N effect occurred during the second week after tillage (coinciding with rainfall) where daily CO_2 flux was higher in managed plots.
- ✓ For the entire sampling period, total cumulative CO_2 loss was not affected by either N or CO_2 level.
- ✓ Findings suggest that conversion of pasture to row crop systems will not be greatly impacted by N management or atmospheric CO_2 level.
- ✓ Ongoing efforts are examining changes in soil organic carbon and nitrogen, including assessing the potential of this pasture system to sequester CO_2 as soil carbon and the influence on trace gas emissions (CO_2, CH_4, and N_2O).

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