Tree-Species Effects on Forage and Microclimate in a Silvopasture System of the Southeast USA

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Introduction

Silvopastures have potential to serve as multiple-income source enterprises for land managers benefiting from the integration of trees, livestock, and forages. The tree-component of silvopastures is usually cited for its ability to provide shade for the grazing livestock and to modify the understory microclimate. However, low light environments can negatively impact understory forage productivity.

The temperature-humidity index (THI) has been associated with animal responses. In North Carolina, USA, about a third of the year there are days with THI ≥ 72 which would negatively affect animal responses (Fig. 1). There is limited information about THI in silvopasture systems. In addition, the microclimate under the trees may vary as a function of time (month of the year or time of the day) and as a function of tree-species.

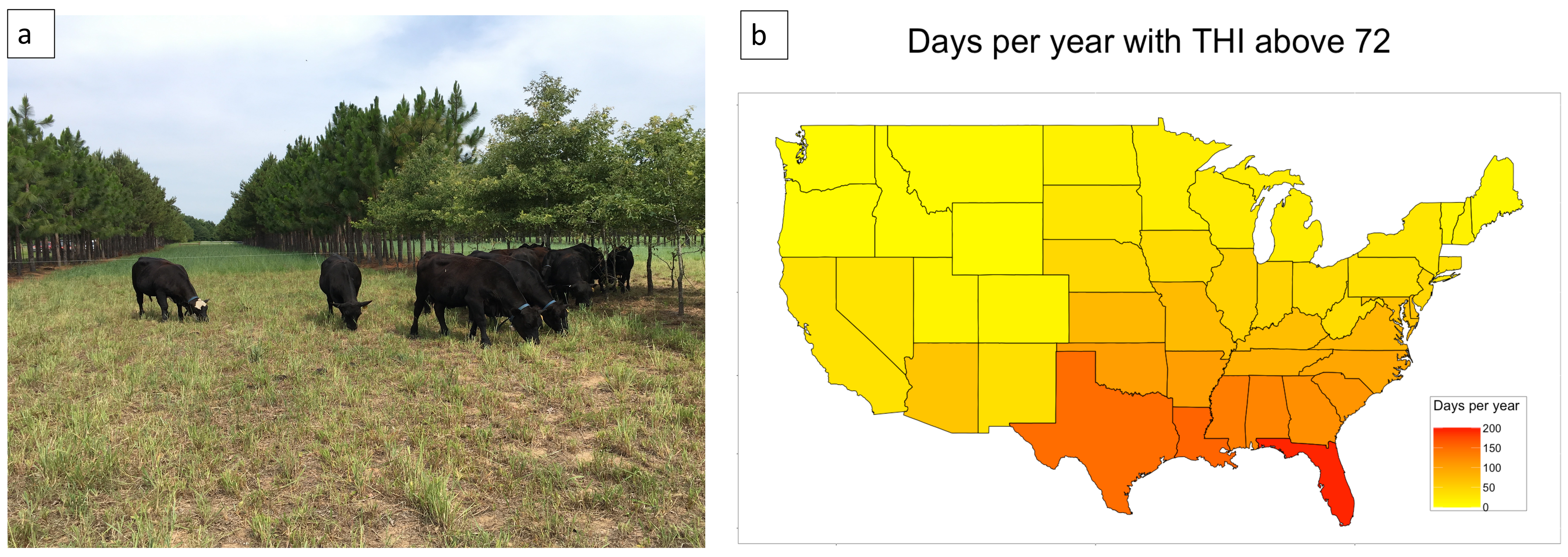

Fig. 1. (a) Picture of the silvopasture system in North Carolina, USA and (b) USA map with number of days per year per state with THI values above 72.

Objectives

The objectives were to characterize and compare **1)** light environment, **2)** forage dry matter yield, and **3)** to determine a mitigation parameter (defined as the ability to modify the THI), as a function of tree-species in silvopasture vs. open-pasture.

Materials and Methods

Location:

North Carolina (35°22'N; 78°2'W), in the Coastal Plains physiographic region of eastern USA

Experimental Site:

An alley-cropping system established in 2007 transitioned to silvopasture when the forage component was planted in 2014. The system consists of three tree-species (*Pinus palustris*, PP; *Pinus taeda*, PT; and *Quercus pagoda*, QP) and two alley-widths (12 and 24 m between lines of trees). Each tree-line has three rows of trees planted in a diamond-shaped spacing of 1.8-m between trees in each row and 1.8-m between tree-rows within each tree-line. The overall experimental design is a randomized complete block design replicated five times (Fig. 2). The forage component consist of a four-way forage mixture of perennial native warm-season grasses [big bluestem (*Andropogon gerardi*), gamagrass (*Tripsacum dactyloides*), indiangrass (*Sorghastrum nutants*), and switchgrass (*Pannicum virgatum*)].

Data Collection:

Sampling areas for the forage were located at 3, 6, and 12 m from each tree-line in the 24-m wide alleys from experimental blocks 2, 3, and 4 (Fig. 2).

Light environment was characterized during Winter (Jan 2018 and 2019) and Summer (June 2017 and 2018) once per day at solar noon time using two wirelessly-synchronized sensors that measure photosynthetically active radiation (PAR). One sensor was positioned under the canopy (under the trees and in the middle of the alley) and the other sensor in the open-pasture.

Twelve sensors ("X" in Fig. 2) recorded TEMP and RH every 5 min from Apr. 2018 to Aug. 2019. The THI was calculated as THI = (1.8 x TEMP + 32) – [(0.55 - 0.0055 x RH) x (1.8 x TEMP – 26.8)] and it was computed creating 6-hr overlapping windows categorized for Day (between sunrise and sunset time) and Night.

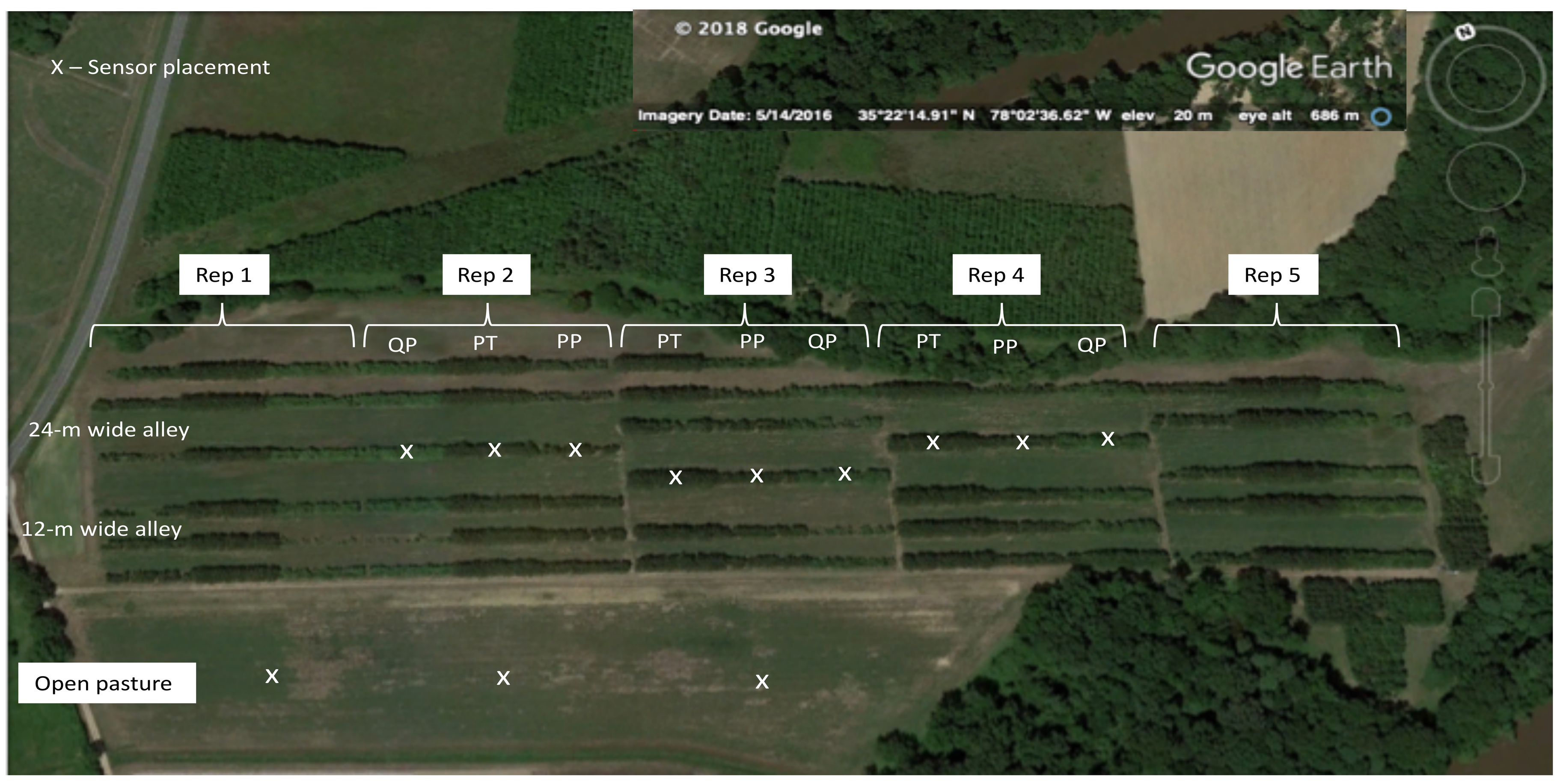

Fig. 2. Field layout of trees (PP = *Pinus palustris*; PT = *Pinus taeda*; QP = *Quercus pagoda*), alleys, silvopasture and open-pasture, and sensors ("X" for temperature and humidity) for the agroforestry site in North Carolina, USA.

Results and Discussion

Understory Light Environment (ULE)

In general, ULE was lower under the trees (0-m) compared to the middle of the alleys (12) (Fig. 3). At the 0-m location, differences in ULE due to tree-species occurred mainly during Winter; however, ULE was lowest during Summer and there were no differences due to tree-species. The ULE values ≤ 20% during Summer will impact forage productivity but at the same time will provide a desirable shade-shelter for grazing livestock preventing direct exposure to solar radiation.

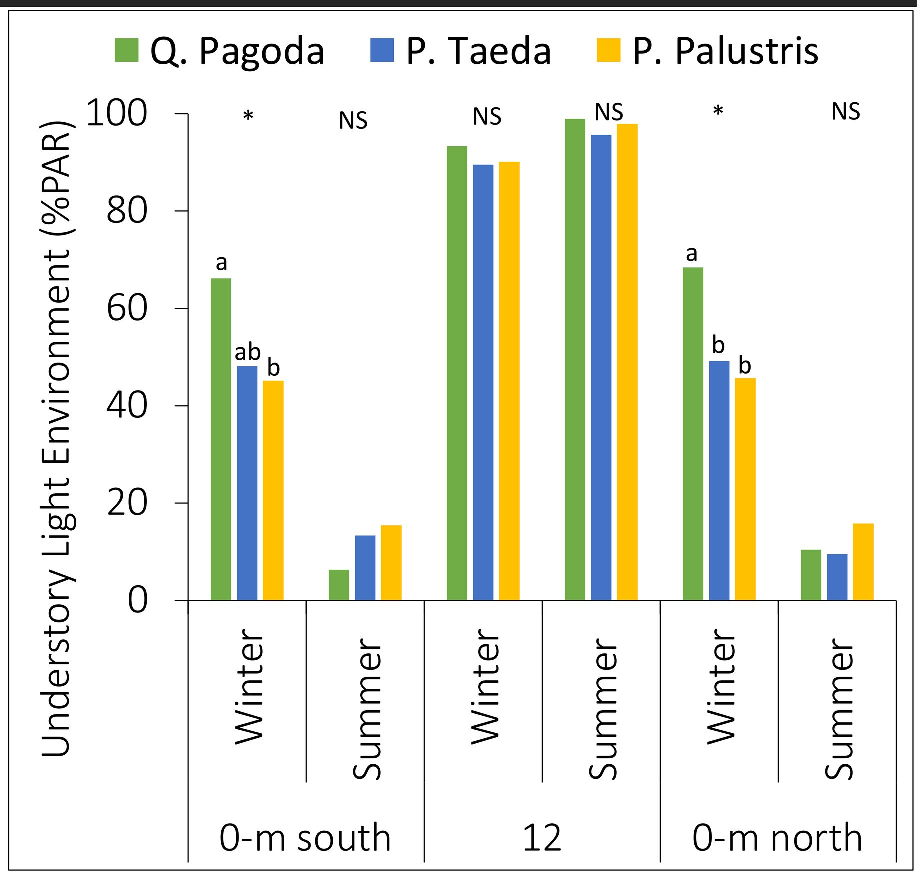

Fig. 3. Understory light environment (SE = 4.1). NS = not significant, * = P ≤ 0.05.

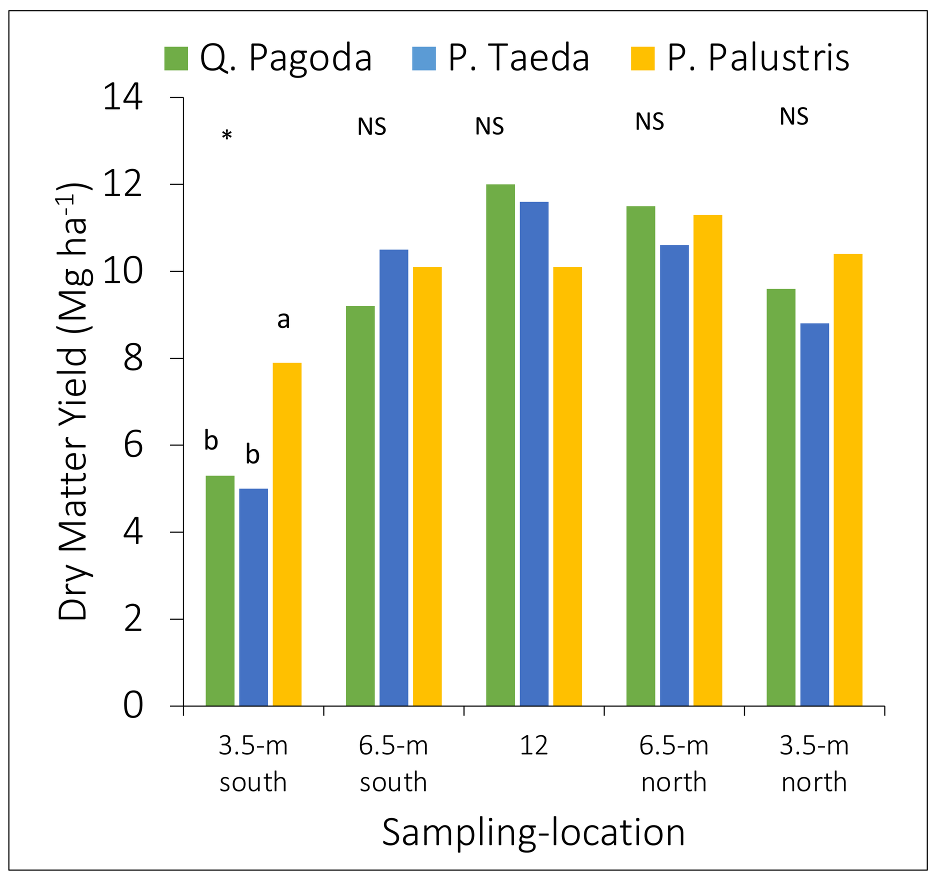

Fig. 4. Total seasonal dry matter yield (SE = 2.3). NS = not significant, * = P ≤ 0.05.

Total Forage Dry Matter Yield (TDMY)

The TDMY was greater at the *P. palustris* system only a the 3.5-m south sampling location and it was not different for the other 4 sampling locations within the system (Fig 4). However, the total system TMDY (integrated across sampling locations) was not different among tree-species systems (~6.6 Mg ha^{-1} yr^{-1}). Differences in TDMY among sampling locations were not as striking as expected because the forages were planted starting 3-m away from the tree-lines.

The Temperature-Humidity Index (THI) and Mitigation Parameter by Trees

The THI is consistently greater during the Summer months (Fig. 5a) with values ≥ 72 for both Day and Night in open pastures. Relative to open pastures, the areas under the trees showed greater mitigation potential (~ -1 degree for THI) for the Day time and up to ~ +0.5 degrees during Night time specially during Summer months.

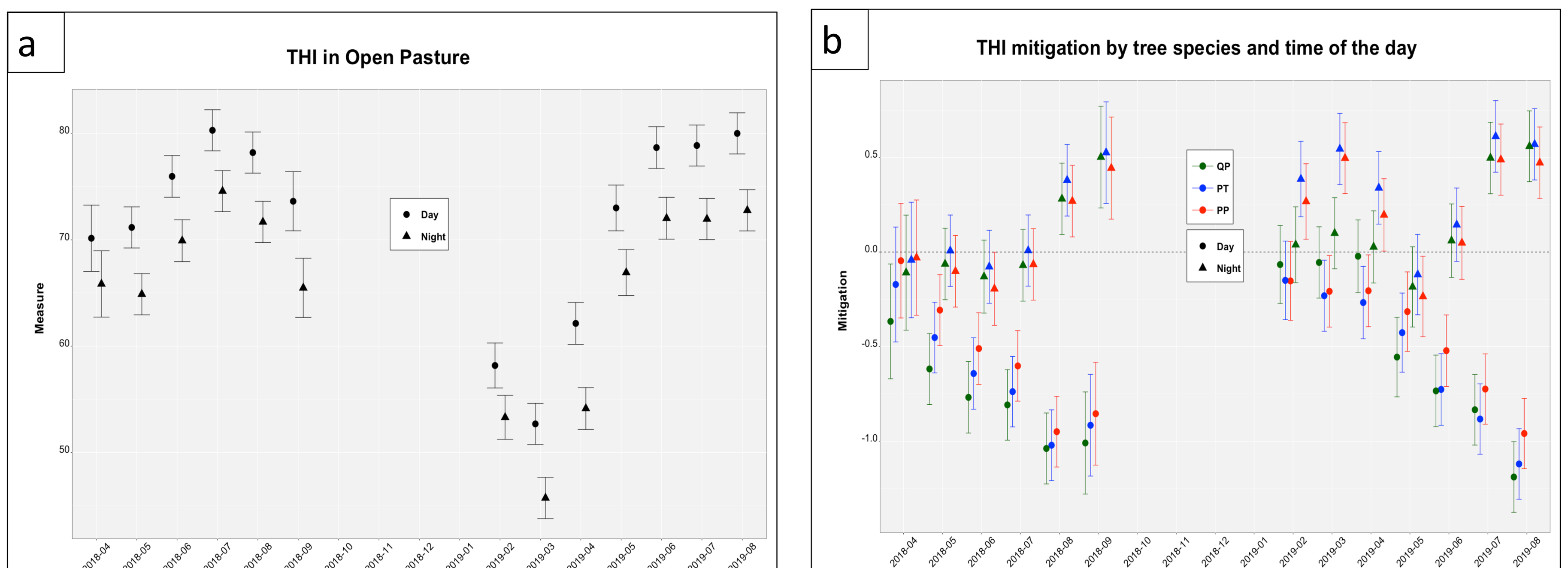

Fig. 5. Temperature-humidity index for (a) open pasture and (b) mitigation potential by tree-species (QP = *Quercus pagoda*, PT = *Pinus taeda*, and PP = *Pinus palustris*)

Conclusions and Implications

- The current design of the silvopasture system provided areas with significant shade (~20% of incident PAR) for grazing livestock and full sun for forage production (in the middle of the alleys).
- Total dry matter yield of forages was not impacted by tree-shade because the forages were planted 3-m away from the tree-lines; however, as the trees grow they may potentially start impacting forage production.
- Areas under the trees had different temperature-humidity index values compared to open-pastures; however, it is not known at this point if the extent of the mitigation potential by the trees will have an effect on animal responses.

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