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FOREST PEST MANAGEMENT ON TYPIC QUARTZIPSAMMENTS: A MANAGEMENT DILEMMA [1]

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Abstract. Pine plantations on Typic Quartzipsamments in East Texas are difficult to establish. Forest management options following clearcutting are limited. A eight year regeneration study of the growth and survival of loblolly, ***Pinus taeda,*** L. shortleaf, ***P. echinutu*** Mill., slash, ***P. elliotii*** Engelm and **longleaf** pines ***P. palustris*** Mill. was conducted to determine optimum tree species and treatments for reforestation; and to recommend practical alternative land uses and management strategies for Typic Quartzipsamrnents. With successful regeneration also comes insects and pathogens. Impacts of the Nantucket pine tip moth, ***Rhyacionia frustrana,*** (Comstock) the Deodar weevil, ***Pissodes nemorensis,*** Germar, ***Annosus*** root rot, ***Heterobusidion annosusm*** **(Fr:** Fr) Bref, fusiform rust, ***Cronartium quercuum*** **(Berk.)** Miyabe ex Shirai f. sp. ***fusiforme*** (Hedge and N. Hunt) Burdsall and G. Snow and the Texas leaf-cutting ant, ***Attu texana,*** (Buckley) will be discussed in the context of droughty site management.

Introduction

The sandhills are droughty, alluvial and marine deposits of relatively recent geological origin that are found from the barrens of New Jersey along the Atlantic Coastal Plain to Florida and then westward along the Gulf Coastal Plain to Texas (Burns and Hebb 1972). In the upper Gulf coastal plains of East Texas, Quartzipsamments occur on broad slightly convex interstream divides at elevations ranging from 300 to 700 feet above sea level and range in depths of 6 to 20 feet. In Nacogdoches and Rusk counties Quartzipsamments developed on outcrops of the Carrizo formation, continental stream deposits formed during the Eocene series of the Tertiary system. The Tonkawa soil series is classified as thermic coated Typic Quartzipsamments, and accounts for approximately 23,000 acres in Nacogdoches, Rusk, Panola, and San Augustine counties (Dolezel 1980). These soils are characterized by low fertility, rapid permeability and extreme acid reaction.

The original vegetation on the sandhills was an association of **longleaf** pine (***Pinus palustris*** Mill.), turkey oak (***Quercus laevis*** Walt.) and **bluejack** oak (***Quercus incunu*** Bartr.), commonly called scrub oaks and **pineland** three-awn ***(Aristidu strictu*** Michx.), commonly known as wiregrass (Hebb 1957). The primary land use on Tonkawa soils today is woodlands (site index averages 55 for shortleaf pine ***Pinus echinutu*** Mill.) althought the potential for pine is low due to droughty and infertile nature of the sand. Watermelons can be grown, but potential is low for any other cultivated crops. Sandhills are resistant to erosion and are considered important ground water recharge areas.

From 1973 to 1975 approximately 6,000 acres on Tonkawa were **clearcut** followed by extensive site preparation. Removal of all organic matter and surface litter from the site exposed the bare mineral soil to the sun and wind, which greatly decreased the moisture holding capacity of the soil and increased surface temperatures (Kroll et al. 1985). Repeated attempts were made to regenerate the area without success. Intensive management on this sensitive site provided incentive for a regeneration study.

From 1983 to 1990 a study was conducted by Tracey et al. (1991) on the site to determine the survival and growth of seven species/treatment combinations. Species/treatment combinations were: untreated **loblolloy** pine ***Pinus taeda,*** L., Terra-Sorb@ treated loblolly, kaolin clay slurry treated loblolly, untreated slash pine ***P. elliotii*** Engelm, Terra-Sorb@ treated slash, kaolin clay slurry treated slash, and containerized **longleaf** pine. The objectives of this study were to determine optimum tree species and treatments for reforestation; and to recommend practical alternative land uses and management strategies for Typic Quartzipsamments.

Containerized **longleaf** yielded the highest survival (> 50%) throughout the study followed by

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loblolly Terra-Sorb@ treated pine (38%) all other treatments were unacceptable (below 30% by the end of the eighth year). **Tracey** et al. (1991) recommended: 1) Encourage harvest systems that minimize site exposure and leave residual overstory; underplant pine; avoid clearcutting. 2) Site preparation on previously **clearcut** sites must be accomplished with minimal site disturbance and topsoil displacement. 3) Reforest droughty sites in East Texas with **longleaf** pine using container grown seedlings or loblolly pine treated with Terra-Sorb@. 4) Manage for non-timber **resouces,** including wildlife, limited recreation, and groundwater protection.

With successful regeneration also comes insects and pathogens. Artificial **monocrop** systems in forestry are of recent origin and their effects on the emergence of new pests and diseases are more likely to be the direct result of environmental change (Way 1981). Heavy winter and spring precipitation followed by periods of drought during the summer for the past two years and characteristics of the soil has caused undue stress to trees. Minor impact caused by insect and pathogens on the Tonkawa series include the Nantucket pine tip moth (NPTM), ***Rhyucionia frustrana*****,** (Cornstock), ***the*** deodar weevil, ***Pissodes nemorensiss*** Germar, ***annosus*** root rot ***Heterobasidion annosus*****m (Fr** : Fr) Bref, and **fusiform** rust, ***Cronartium quercuum*** **(Berk.)** Miyabe ex Shirai f. sp. ***fusiforme (Hedge*** and N. Hunt) Burdsall and G. Snow.

Slash pine found scattered throughout the study area grows well on low lying soils with characteristics of Aquic Quartzipsamments. Moisture content of these soils insured excellent regeneration. Pathogens associated with slash pine, such ***as Annosus*** root rot and fusiform rust, are problematic.

The deodar weevil is a minor insect pest on the Tonkawa soil series. The weevil is found throughout the study area in low lying areas. The life cycle of this weevil differs from others in that the ovipostion occurs in the fall and the larvae feed on terminals during the winter. Adults emerge in the spring and remain inactive during the summer. Adults weevils feed on the **inner** bark often girdling a stem or twig. Weevil damage to terminals and the main stem of planted four to five year old loblolly pines was documented in areas of increased surface moisture due to record precipitation throughout the Tonkawa study site.

The Nantucket pine tip moth (NPTM) is widely distributed throughout the eastern and southern United States. NPTM are larval feeders of meristematic tissue of young pines causing significant damage, particularly in areas where forest regeneration practices favor its proliferation (Yates et al. 1981). Larval feeding severs the conductive tissue in the tip, causing it to turn brown and die. Infestations can result in growth loss, excessive branching, multiple terminals and deformed bushy trees and is of primary importance in even-age management of loblolly and shortleaf pines. While NPTM are a major forest insect pest in pine plantation management, on the Tonkawa study site they are secondary pests compared to the impacts caused by the Texas leaf-cutting ant, ***Attu texana*** (Buckley).

Attu texana confined to Texas and Louisiana, is the northernmost representative of this most specialized genus of Attini, a New World tribe of fungus-growing myrmicine ants. The range of the ant occupies much of the area of Texas and Louisiana lying between 92.5 and 101 degrees of longitude. In Texas, the range extends from near the Oklahoma border to the extreme southern border, with an extension into northeastern Mexico as far south as Vera Crux.

Atta texana shows a decided preference for nesting in sandy or sandy loam soils, but is also capable of nesting in heavy soils and those of limestone origin (Smith 1963). These nesting areas (mounds) are most often found on the tops and sides of ridges where the water table is deep and nests can reach depths of 25 feet (ft) (Moser **1967,1984).** ***Atta texana*** overturn the soil in excavating their tunnels and chambers. In building these tunnels and chambers, materials transported to the surface by ants are mixed with body fluids to form uniform pellets of soil **(Weber** 1966). The tunnels and chambers that ***A. texunu*** construct in the soil are numerous and extend deeper than those of vertebrate animals. The nest area is usually marked by crescent shaped mounds about 6 to 12 inches in height and about 12 inches in diameter. Nests are conspicuous and abundant, reach sizes of 50 to 75 feet across, and have a decided impact on the forest landscape.

Atta texana shows a decided preference for grasses, weeds, and hardwood leaves. These leaf parts are gathered and used to cultivate their fungus. They prune the vegetation, stimulate new plant growth, break down vegetable material rapidly and in turn enrich the soil **(Hölldobler** and Wilson 1990). ***Atta texana*** is a forest pest because it cuts the needles from both natural and planted pine seedlings. The pines usually escape destruction as long as there is other green vegetation, but in the winter pine needles satisfy the ants' need for green plant material (Moser 1967). Spatial distribution of A. *texana* is based on suitable habitat availability. The clearcutting disturbance of the study site quickly became a matrix (the most extensive and most connected landscape element type present, which plays the dominant role in landscape functioning (Forman and Gordon 1979)) of ideal ant habitat. Ant densities are normally higher in secondary than in primary vegetation (Haines 1978). Nest dimensions are significantly correlated with distances foraged by various species of leafcutters (Fowler and Robinson 1979). *Atta* foraging patterns are influenced by the availability and locations of preferred plant species in its territory (Waller 1982). Adaptations in their pattern of the nest distribution enables ants to use the food available in the habitat more effectively and to reduce the unfavorable results of competition among societies, which limit their reproduction and numbers (Cherrett 1968).

The objectives of the study were to: (1) determine the overall effects of *Atta fexana* on soil texture, and organic matter within the mound and adjacent areas; (2) estimate the landscape area affected by *Atta texana* on different sites on an area on the Tonkawa soil series of thermic coated Typic Quartzipsamments; and (3) determine the distribution of *Atta texana* on a known area of Typic Quartzipsamments.

Methods

The study area is located along the FM 1078 road corridor (right of way) and an area of regeneration north of the Camp Tonkawa Boy Scout Camp, located in northern Nacogdoches and southern Rusk counties, 10 km west of Garrison, Nacogdoches Country, Texas. Distribution of the known nesting areas of *A. texana* were examined on these two different ecosystems. This study area encompasses many soil types that are capable of sustaining *A. rexana*. These include Tonkawa, Darco, Tenaha and Briley soil series. *Atta texana* show a decided propensity for the Tonkawa soil series of thermic coated Typic Quartzipsamments for their mounds.

Soil samples were collected from 30 *A. texana* mounds found on the Tonkawa soil series. Samples were taken on the surface, and at depths of 6 inches (in.), and 50 in. on the *A. texana* mounds (an area currently being impacted by *A. texana*). This procedure was replicated on the inter-mound area (an area once effected by *A. texana*) and from a control area of similar physical characteristics away from the area of influence for a total of nine samples per mound. All soil samples were catalogued, oven dried, and sifted with a 10 gauge soil sieve. Loss on ignition methodology of each soil sample was processed in a Muffle furnace at a temperature of 500° C. This determines the percent of organic matter lost to the nearest 0.01%. Bouyoucos analyses (Bouyoucos 1962) was performed on 100 grams of each soil sample to determine the percent clay, percent silt and percent sand.

Using aerial photographs and ground truthing, all mounds and foraging openings were located in the regeneration study area. All nesting mounds and created forage openings were measured in the four cardinal directions (north, south, east, and west). This was done to measure the overall impacts of the nesting and foraging territories on the forest landscapes.

Results and Discussion

Atta texana in overturning the soil in excavating their tunnels and chambers have a profound effect upon organic matter and texture of the Tonkawa soil series. The tunnels and chambers that *A. texana* construct in the soil are numerous and extend deeper than those of any other vertebrate animals. In building these tunnels and chambers materials transported to the surface by ants are mixed with body fluids to form uniform pellets of soil.

Using Bouyoucos analysis to determine soil texture, it was found that *Atfa texana* significantly increases the percent clay. In testing the percent clay by site it was found that percent clay at the mound surface was statistically more significant than at the intermound surface, which in turn was found to be statistically more significant than the control surface (Figure 1) at the a = .05 percent level. In comparing percent clay by depth (Figure 2) it was found that the mound surface was statistically more significant than *than the 6* in. or 20 in. depths at the a = .05 level.

Soil brought to the mound surface by *Atta texana* is significantly lower in percent organic matter than the percent organic matter present in the soil at the intermound and control surfaces (Figure 3). Organic matter for the mound at 6 in. and 20in. is statistically higher than the same depths at the intermound and the control at a = .05 percent confidence interval. In testing the percent organic matter by site (Figure 4) it was found that percent organic matter for the mound at the 6 in. depth was

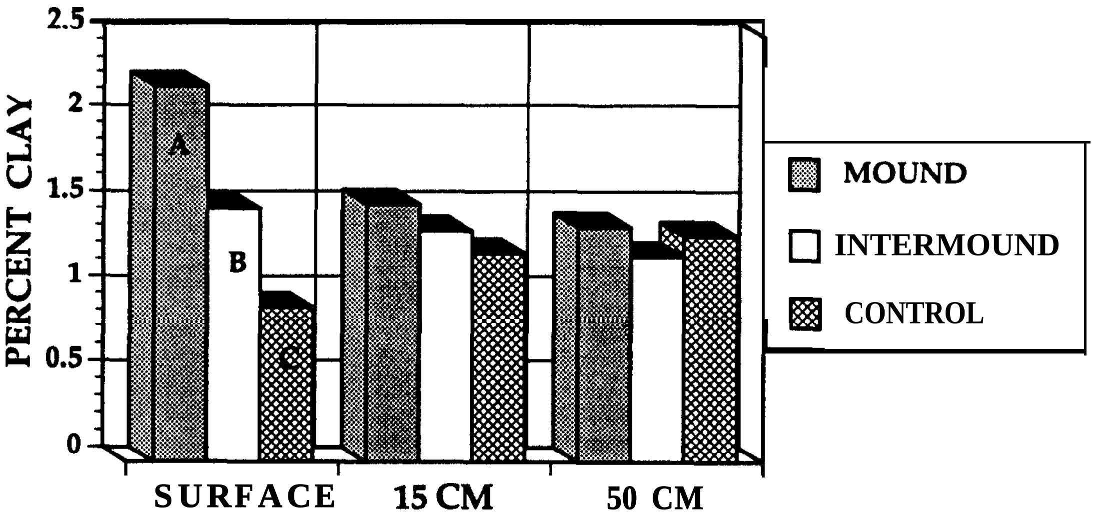

Figure 1. *Percent clay by site for Tonkawa soil series tested using Bouyoucos analysis method.*

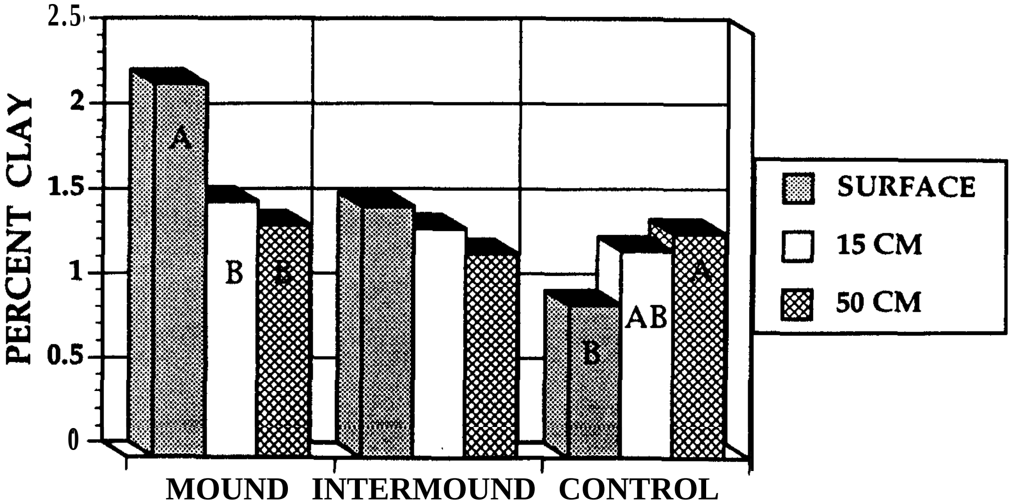

Figure 2. *Percent clay by depth for Tonkawa soil series tested using Bouyoucos analysis method.*

significantly higher than the surface and 20 in. at a = .05 percent confidence interval.

Attu texana intrinsically utilize created openings and disturbances (an event or events that causes a significant change from the normal pattern in an ecological system, Forman and Godon 1986) to create nesting areas and benefit from the use of corridors (a narrow strip of land that differs from the matrix on either side) in their expansion. ***Attu texunu*** is found along the FM 1087 road corridor and along the edges of stream side corridors. In the regeneration areas ***Atta texana*** reacted to the monocultural habitat and dispersed in all directions causing massive destruction to the loblolly plantation in the area. Currently there are 52 openings found throughout the study area. The total area of the study is 320 acres or 13939200 sq. ft. Total defoliation attributed to ***A. texunu*** accounts for 2970870 sq. ft or 21.5 % of the total landscape area. The immediate nesting areas or mounds account for 1.25% of the total area affected by ***A. texana.*** Not all disturbance areas contain mounds due to natural mound mortality or chemical treatment with methyl bromide.

Conclusions and Recommendations

While most consider ***Attu texunu*** an economic pest, in nature they are of fundamental ecological importance. ***Atta texana*** serves an important ecological function of soil amelioration and increases biodiversity, especially on the very sensitive ecosystem of the Tonkawa study area. Its soil-enriching capabilities outway its pest status. ***Atta texunu*** is unique in regards to soil preference, its nesting mounds, foraging areas and spatial distribution.

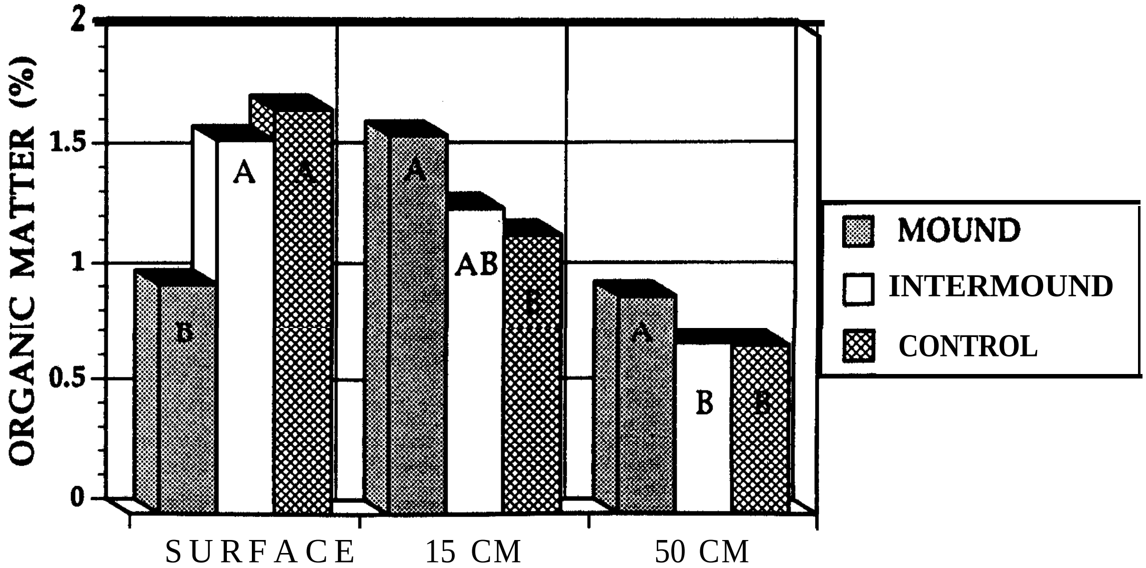

Figure *3. Mean percent organic matter by* ***depth for Tonkawa*** *soil* ***series*** *tested.*

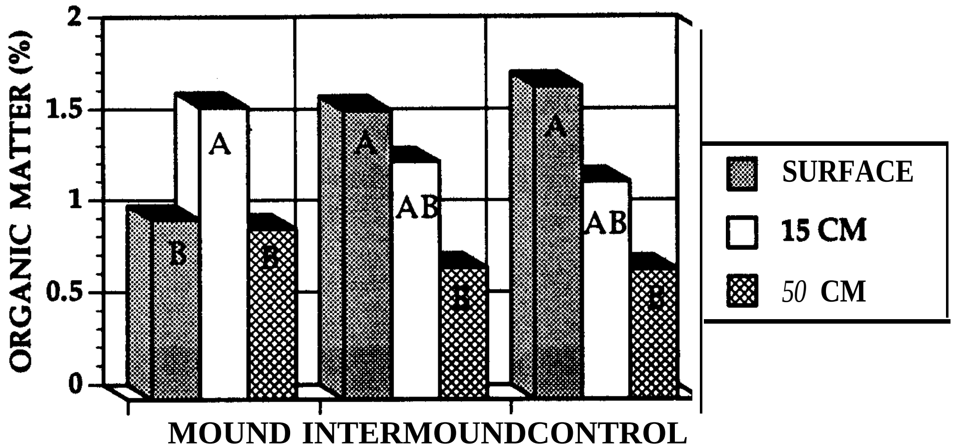

Figure 4. Mean ***percent organic matter by site for Tonkawa soil series tested.***

Plantation forestry, particularly eucalyptus and pines, is adversely affected by ***Atta*** defoliation (Cherrett 1986). They are well-adapted for attacking monocultures (**Vilela** and Howse 1986) and the most disastrous outbreak of ***Atta*** can be attributed to the introduction of monoculture systems (**Hölldobler** and Wilson 1990). Repeated efforts at regeneration and control of ***Atta texana*** in certain areas of the study area has failed. Low site productivity makes intensive forest silvicultural practices unprofitable. Therefore it is our recommendations that 1) native vegetation be allowed to grow in the openings created by ***Atta texana*** 2) the area be managed for wildlife and limited recreation 3) ***Atta texana*** be allowed to continue their biological function of soil improvement and 4) the area be utilized as an important teaching aid for forest pest management and forest entomology labs because of the uniqueness of the area in regards to the pathogens and insects present.

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