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Atta texana, Texas Leaf-cutting Ant, on Typic Quartzipsamments: Ecological Considerations

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Atta texana, ***Texas Leaf-cutting Ant, on Typic Quartzipsamments: Ecological Considerations***

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ABSTRACT *Pine plantations on Typic Quartzipsamments in East Texas are difficult to establish. Forest management options following clearcutting are limited. An 8-year regeneration study of the growth and survival of loblolly,* Pinus taeda, *L. shortleaf,* P. echinata *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 Quartzipsamments. Successful regeneration provides new opportunities for insects and pathogens. Impacts of the Nantucket pine tip moth,* R}iyacionia frustrana *(Comstock), the Deodar weevil,* Pissodes nemorensis, *Germar, Annosus root rot,* Heterobasidion annosum *(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,* Atta texana, *(Buckley) will be discussed in the context of droughty site management.*

IN THE UPPER Gulf coastal plains of East Texas, sandhills are droughty where alluvial and marine deposits of relatively recent geological origin occur (Burns and Hebb 1972). These droughty sites occur on broad, slightly convex interstream divides at elevations ranging from 100 to 250 meters above sea level and range in depths from 2 to 9 meters. In Nacogdoches and Rusk counties, these sandhills are characterized by 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 5000 ha 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 incana Bartr.), commonly called scrub oaks, and pineland three-awn (Aristida stricta Michx.), commonly known as wiregrass (Hebb 1957). The primary land use on Tonkawa soils today is woodlands (site index averages 55 at 50 years for shortleaf pine, Pinus echinata Mill.), although the potential for pine is low due to the droughty and infertile nature of the sand. Watermelons can be grown, but potential is low for any other cultivated crops. Sand.hills are resistant to erosion and are considered important ground water recharge areas.

From 1973 to 1975, approximately 1400 ha 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.

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From 1983 to 1990, a study was conducted (Tracey et al. 1991) on the site to determine the survival and growth of seven species/treatment combinations. These included: I) untreated loblolly pine, Pinus taeda L., 2) Terra-Sorb-treated loblolly pine, 3) kaolin clay slurry-treated loblolly pine, 4) untreated slash pine, P. elliotii Engelm, 5) Terra-Sorb-treated slash pine, 6) kaolin clay slurry-treated slash pine, and 7) 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 pine yielded the highest survival (> 50%) throughout the study, followed by Terra-Sorb-treated loblolly pine (38%); all other treatments were unacceptable (below 30% by the end of the eighth year). Tracey et al. (1991) recommended:

I) 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 resources, including wildlife, limited recreation and groundwater protection.

Successful regeneration provides new opportunities for 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, in combination with soil characteristics have caused undue stress to trees. Minor impacts caused by insects and pathogens on the Tonkawa series include the Nantucket pine tip moth (NPTM), Rhyacionia frustrana, (Comstock), the deodar weevil, Pissodes nemorensis Germar, annosus root rot Heterobasidion annosusm (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. The moisture content of these soils ensured 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 oviposition occurs in the fall and the larvae feed on terminals during the winter. Adults emerge in the spring and remain inactive during the summer. Adult weevils feed on the inner bark, often girdling a stem or twig. Weevil damage to terminals and the main stem of planted 4-5-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 is a larval feeder on the 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 is a major forest insect pest in pine plantation management, on the Tonkawa study site it is a secondary pest compared to the impacts caused by the Texas leaf-cutting ant, Atta texana (Buckley).

Atta 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 Cruz.

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 (Moser 1967, 1984). Atta texana overturns the soil when excavating 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. texana constructs in the soil are numerous and extend deeper than those of vertebrate animals. The nest area is usually marked by crescent-shaped mounds about 15 to 30 cm in height and about 30 cm in diameter. Nests are conspicuous and abundant, reach sizes of 15 to 25 m 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 tum enrich the soil (Holldobler 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) 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 enable 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).

Objectives

The objectives are to:

1. Determine the overall effects of Atta texana on soil texture and organic matter within the mound and adjacent areas;
2. Estimate the landscape area affected by Atta texana on different sites within an area on the Tonkawa soil series of thermic coated Typic Quartzipsamments; and
3. Discuss educational activities

Methods

The study area is located along the FM 1078 road corridor (right of way) and an area of regeneration north of camp Tonkawa, located in northern Nacogdoches and southern Rusk Counties, 10 km west of Garrison, Nacogdoches County, Texas. Distribution of the known nesting areas of A. texana was examined on this ecosystem. This study area encompasses many sandy soils and loams that are capable of sustaining A. texana. Atta texana shows 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 15 and 50 cm 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 affected 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 percentage of organic matter lost to the nearest 0.01%. Bouyoucos analysis (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 trothing, all mounds and foraging openings were located in the regeneration study area. All nesting mounds and created forage openings were measilred 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, by overturning the soil when excavating tunnels and chambers, has a profound effect upon organic matter and texture of the Tonkawa soil series. The tunnels and chambers that A. texana constructs in the soil are numerous and extend deeper than those of any vertebrate animals. Materials transported to the surface during tunnel and chamber building by ants are mixed with body fluids to form uniform pellets of soil.

Using Bouyoucos analysis to determine soil texture, it was found that Atta texana significantly increases the percent clay. The percent clay in the pellets of nest mound craters was statistically more significant than at the inter-mound surface and the control surface (Table 1) at the a = .05 level. In comparing percent clay by depth, the mound surface was statistically more significant than the 15-or 50-cm depths at the a = .05 level.

Soil brought to the mound surface by A. texana is significantly lower in percent organic matter than the percent organic matter present in the soil at the inter-mound and control surfaces (Table 2). Organic matter for the mound at 15-cm and 50-cm is statistically higher than the same depths in the inter-mound and the control areas at a = .05 confidence interval.

Atta texana utilized created openings and disturbances (an event or events that cause.a significant change from the normal pattern in an ecological system, Forman and Godron 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. Atta texana 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.

Table 1. One-way analysis of variance for mean texture percents of Tonkawa soils (Typic Quartzipsamments) tested by site and depth (means ± standard deviations) using the Bouyoucos method

Site	N	Sand	Silt	Clay
Pellets of Nest Mound Craters	30	90.7 ± 3.7	3.7 ± 1.3	5.6 ± 3.0 a
50 cm Beneath Nest Mound Surface	30	92.0 ± 2.4	4.1 ± 1.8	3.9 ± 1.0 b
Intemest Surface	30	91.9 ± 2.5	4.4 ± 1.8	3.6 ± 1.2 b

Currently, there are 52 openings found throughout the study area. The total area of the study is 78 ha, or 78,000 sq. m. Total defoliation attributed to A. texana accounts for 16,380 square m 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.

Table 2. One-way analysis of variance for mean percent organic matter of Tonkawa (Typic Quartzipsamments) tested by site and depth (means ± standard deviations)

Site	Tonkawa Soils (n = 30 sites)

Pellets of Nest Mound Craters
15 cm Beneath Nest Mound Craters 50 cm Beneath Nest Mound Craters Nest Mound Surface
15 cm Beneath Nest Mound Surface 50 cm Beneath Nest Mound Craters lntemest Surface
15 cm Beneath lntemest Surface 50 cm Beneath Intemest Surface

0.92 ± 0.49 de
1.48 ± 0.68 ab
0.89 ± 0.39 e
1.45 ± 0.66 b
1.27 ± 0.51 be
0.71 ± 0.29 e
1.72 ± 0.61 a
1.14 ± 0.50 cd
0.71 ± 0.28 e

Within columns, means followed by the same letter are not significantly different (P<0.05) using Duncan's
multiple range test.

Current research includes color infrared photographic coverage at a scale of 1:5000 over a 36 by 36 km area to estimate both numbers of mounds present and percentage of the area defoliated by A. texana. The photography includes 60 percent end lap and 30 percent side lap for use as stereo pairs. The relationship of A. texana to topography and depth above the water table is being examined to develop a landscape model to ascertain the effects of both terrain and location of the ant mounds and the influence of A. texana on the forest landscape. Educational activities for the area include its use in teaching forest entomology, landscape ecology, environmental science and teacher education in environmental science. Evaluation of the influence of A. texana on the landscape includes using the components of structure, function and change to evaluate corridors, patch dynamics and the influence on the forest matrix in long-term evaluation of a droughty landscape. The measurement of change on the forest matrix by A. texana gives a graphic example of the influence of social insects on the landscape. Critical thinking skills are honed by evaluating the influence of both soils and openings on the landscape as sculpted by the ants.

Recognition that soil color is indicative of soil texture change and perhaps nutrition raises questions of why the pellets are concentrated in the central nest mound area and what are the influences on the ecology of the landscape? The structure of the ant mound, with its integral tunnels and precise angles of these tunnels to both the surface and to the central nest mound (Moser 1984), add to the overall examination of the impact of A. texana on the landscape. Questions arise as to why the central nest mound is large (15 to 25 m across with a depth of 15 to 50 cm of soil deposited on the mound surface). Environmental education and natural history interpretation of the site lead to development of education modules and educational sequences that both intrigue and fascinate all ages and levels of education. As an educator, it is imperative that we stimulate those we are entrusted to teach.

Conclusions

While most consider Atta texana 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 outweigh its pest status. Atta texana is unique with regard to soil preference, its nesting mounds, foraging areas and spatial distribution.

Plantation forestry, particularly pines on droughty sites, 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 (Holldobler and Wilson 1990). Repeated efforts at regeneration and control of Atta texana in certain areas of the study area have failed. Low site productivity makes intensive forest silvicultural practices unprofitable. Therefore, our recommendations are 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 its biological function of soil improvement and 4) the area be utilized as an important teaching aid for forest pest management and forest entomology laboratories because of the unique nature of the area with regard to the presence of pathogens and insects.

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