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Management of droughty site: Typic Quartzipsamments, ecological considerations

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MANAGEMENT OF DROUGHN SITE: 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. A 12 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. With successful regeneration also comes insects and pathogens. Impacts of the Nantucket pine tip moth, *Rhyacionia frustrana*, (Comstock) and the Texas leaf-cutting ant, *Atta texana*, (Buckley) will be discussed in the context of droughty site management.

INTRODUCTION

In Nacogdoches and Rusk counties, sandhills are characterized by Quartzipsamments. 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* Barb.), 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 pine and wildlife management although 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 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 and others 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 (Tracey and others 1991) on the site to determine the survival and growth of seven species/treatment combinations. Species/treatment combinations were: untreated loblolly 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 percent) throughout the study, followed by loblolly Terra-Sorb@ treated pine (38 percent) all other treatments were unacceptable (below 30 percent by the end of the 12 year). Tracey and others (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 resources, 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), *Rhyacionia frustrana*, (Comstock). 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 and others 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, *Affa* fexana (Buckley).

Atta fexana, 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,

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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 6 m (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. texana* 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 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 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) 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).

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 on an area on the Tonkawa soil series of thermic coated Typic Quartzipsamments; and

METHODS

The study area is located along the FM 1078 road corridor (right of way) and an area of regeneration north of the Tonkawa camp, located in northern Nacogdoches and southern Rusk counties, IO km west of Garrison, Nacogdoches Country, Texas. *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 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 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 IO 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 percent. 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 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

Regeneration studies on the Typic Quartzipsamments indicate the best survival with Terra-Sorb@ treated loblolly pine followed by longleaf pine. Impact of leaf-cutting ants was greatest on loblolly pine. 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 percent of the total landscape area. The immediate nesting areas or mounds account for 1.25 percent 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. *Atta texana* in overturning the soil in excavating their tunnels and chambers has an effect on organic matter and texture of the Tonkawa soil series. In building these tunnels and chambers materials transported to the surface by ants are mixed with body fluids to form uniform pellets of soil. *Atta texana* significantly increases the percent clay; the percent clay in the pellets of nest mound craters was statistically more significant than at the intermound surface and the control surface at the a = .05 percent level. In comparing percent clay by depth, the mound surface was statistically more significant (5.6 percent clay for the pellets of the nest mound crater compared to 3.9 and 3.6 percent for 50 cm depths and the internest surface, respectively. 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 intermound and control surfaces. Organic matter for the mound at 15 cm. and 50 cm. is statistically higher than the same depths at the intermound and the control at a = .05 percent confidence interval.

Atta texana uses created openings and disturbances (an event or events that causes a significant change from the normal pattern in an ecological system, Forman 1997) 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* reacted to the monocultural habitat and dispersed in all directions loss to the loblolly plantation in the area.

The relationship of *A. texana* to topography and depth above the water table are 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. fexana* on the forest landscape. Each central nest mound of A. fexana are being located use GPS systems and transferred to rectified photography for the area. Each mound is located in relation to the topography of the site. Generally, *A. fexana* is located more that 1.5 m and less than 8 m from the water table. Vegetation on active ant mounds are generally dominated by species not preferred by A. *fexana.* Our current research indicates a predominance of post oak, bluejack oak, sumac, yucca, hickory, sassafras, grape vine and dog fennel on the sites. This vegetation flourishes following the colonization of the site by *A. fexana.* Educational activities for the area include use in teaching forest entomology, landscape ecology, environmental science and teacher education in environmental science. The importance of teaching in the area includes the inclusion of management of a forest resource; ecology of an organism; and inclusion of teaching constructs from environmental science. Evaluation of the influence of A. *fexana;* on the landscape includes using the components of structure, function and change to evaluate corridors, patch dynamics and the influence on the matrix in long-term evaluation of a droughty landscape. The measurement of change on the forest matrix by *A. fexana* gives a graphic example of the influence of social insects on the landscape.

Atta fexana serves an important ecological function of soil amelioration and increases biodiversity, especially on the very sensitive ecosystem of the Tonkawa study area. *Atta fexana* is unique in regards to soil preference, its nesting mounds, foraging areas and spatial distribution. Repeated efforts at regeneration and control of *Atta* fexana in certain areas of the study area has failed. Therefore, recommendations include 1) native vegetation be allowed to grow in the openings created by *Atta fexana 2)* the area be managed for wildlife and limited recreation 3) *Atta fexana* be allowed to continue their biological function of soil improvement and 4) the area could be utilized as an important teaching aid for forest pest management and forest entomology laboratories because of the unique nature of the area in regard to the pathogens and insects present.

REFERENCES

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analyses of soils. Agronomy Journal. **54(5):** 464-465.

Burns, R.M.; Hebb, E.A. 1972. Site preparation and reforestation of droughty, acid sands. Agric. Handb. 426. U.S. Department of Agriculture, Forest Service. 60 p.

Cherrett, J.M. 1986. The interaction of wild vegetation and crops in leaf-cutting ant attack, pp 315-325. In: J.M. Thresh (ed.), 1986 Pests, Pathogens, and Vegetation. Pitman, Boston Massachusetts.

Cherrett, J.M. 1968. The foraging behavior of *Atta cephalotes* (L.) (Hymenoptera: Formicidae). I. Foraging pattern and plant species attacked in tropical rain forest. Journal of Animal Ecology. 37: **387-403.**

Dolezel, R. 1980. Soil survey of Nacogdoches County Texas. U.S. Department of Agriculture, Soil Conservation Service and Forest Service. In cooperation with: Texas Agriculture Experiment Station. Washington, DC: Superintendent of Documents, U.S. Government Printing Office.

Forman, R.T.T. 1997. Land mosaics, Oxford Univ. Press.

Fowler, H.G.; Robinson, S.W. 1979. Foraging by *Atta sexdens*: seasonal patterns, caste, and efficiency. Ecological Entomology. *4: 239-247.*

Haines, B.L. 1978. Elements and energy flows through colonies of the leaf-cutting ant *Atta colombica*, in Panama. Biotropica. 10: *270-277.*

Hebb, E.A. 1957. Regeneration in the sandhills. Journal of Forestry. *55: 210-212.*

Hölldobler, B.; Wilson, E.O. 1990. The ants. Cambridge, MA: Harvard University Press: 596-732.

Kroll, J.C.; Deauman, W.C.; Foster, C.D. [and others]. 1985. Survival of pines on droughty soils: two year results. In: Shoulders, E., ed. Proceedings of the third biennial southern silvicultural research conference; 1984 November 7-8; Atlanta. Gen. Tech. Rep. SO-54. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 128-l 31.

Moser, J.C. 1967. Mating activities of *Atta fexana* (Hymenoptera: Formicidae). Insectes Sociaux. **14:3:** 295-312.

Moser, J.C. 1984. Town ant. In: Payne, T.L.; Billings, R.F.; Coulson, R.N.; Kulhavy, D.L., eds. Proceedings of the 10th anniversary of the east Texas forest entomology seminar. Misc. Publ. College Station, TX: Texas Agricultural Experiment Station: 47-52.

Smith, M.R. 1963. Notes on the leaf-cutting ants, *Atta spp.,* of the United States and Mexico. Proceedings of the Entomological Society of Washington. **65:4:** 299-302.

Tracey, W.D.; Kulhavy, D.L.; Ross, W.G. 1991. Land and resource management on Typic Quartzipsamments. In: Coleman, Sandra S.; Neary, Daniel G., comps., eds. Proceedings of the sixth biennial southern silvicultural research conference; 1990 October 30-November 1; Memphis, TN. Gen. Tech. Rep. SE-70. Asheville, NC: U.S. Department of Agriculture, Forest Service Southeastern Forest Experiment Station: 475-484.

Vilela, E.F.; Howse, P.E. 1986. Territoriality in leaf-cutting ants, *Atta spp.* In: Lofgren, C.S.; Vander Meer, R.K., eds. Fire ants and leaf-cutting ants, biology and management. Boulder, CO: Westview Press: 147-158.

Waller D.A. 1982. Foraging ecology of the Texas leaf-cutting ant, *Atta fexana* (Buckley) (Formicidae; Attini); host choice and forager size polymorphism. Austin, TX: University of Texas. 188 p. Ph.D. dissertation.

Way, M.J. 1981. Pest disease status in mixed stands vs. monocultures the relevance of ecosystem stability. In: Cherret, J.M.; Sagar. G.R., eds. 1981, origins of pest, parasite, disease, and weed problems. Oxford London Edinburgh and Melbourne: Blackwell Scientific Publications: 127-138.

Weber, N.A. 1966. The fungus growing ants and soil nutrition. Progresos en Biologia del Suelo Actas Del Primer Coloquio Latinoamercano de Biologia del Suelo Monografias 1. Centro de Cooperacion Cienifica de la UNESCO para America Latina (UNESCO, Montevideo): 221-225.

Yates, H.O.; Overgaard, N.A.; Koerber, T.W. 1981. Nantucket pine tip moth. U.S. Department of Agriculture, Forest Service Insect and Disease Leafl. 70.7 p.