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Impact of the Texas Leaf-Cutting Ant (*Atta texana* (Buckley))
(Order Hymenoptera, Family Formicidae)
on a Forested Landscape

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**ABSTRACT** *Atta texana* (Buckley), the Texas leaf-cutting ant, rapidly expanded in a harvested forested landscape on sandhills characterized by droughty soils, causing mortality of planted loblolly pine (*Pinus taeda* (L.)). The site, composed primarily of Quartzipsamments soils classified as thermic coated Typic Quartzipsamments in the Tonkawa soil series, accounts for approximately 5,000 ha in Nacogdoches, Rusk, Panola, and San Augustine Counties in eastern Texas, USA (Dolezel 1980). These soils are characterized by low fertility, rapid permeability, and extreme acid reaction. These sandhills are resistant to erosion and are considered important ground water recharge areas. The distribution of *A. texana* central nest mounds and foraging areas was examined using aerial photography, digital orthophotographic quarter quadrangles (DOQQ) (scale 1:6000), and global positioning satellite (GPS) data. Plant nutrition of *A. texana* nesting areas was examined. Previous soil texture analysis of the central nest mound and adjacent landscapes is presented.

From 1973 to 1975, approximately 1,400 ha in the Tonkawa soils (Typic Quartzipsamments) were clearcut, followed by extensive site preparation (Tracey et al, 1991). Removal of all organic matter and surface litter from the site exposed the bare mineral soil to the sun and wind, decreasing the moisture holding capacity of the soil and increasing surface temperatures (Kroll et al. 1985). The clearcutting disturbance of the study site quickly resulted in ideal *Atta texana* habitat.

*Atta* species densities are normally higher in secondary than in primary vegetation (Haines 1978). Nest dimensions are significantly correlated with distances foraged by leafcutters (Fowler and Robinson 1979) and *Atta* species foraging patterns are influenced by the availability and locations of preferred plant species in its territory (Waller 1986). Adaptations in their pattern of nest distribution enable ants to use the food available in the habitat more effectively and reduce the unfavorable results of competition among societies, which limit their reproduction and numbers (Cherrett 1968).

Though long considered serious pests in both natural and plantation ecosystems, the basic biology of leaf-cutting ants is not completely understood. Leaf-cutting ants are exclusively New World species, ranging from Argentina in the south to Texas in the north. The northernmost species is *A. texana*, the Texas leaf-cutting ant (Hölldobler and Wilson 1990).

*A. 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). *A. texana* overturns the soil when excavating tunnels and chambers. When building tunnels and chambers, materials transported to the surface by ants are mixed with body fluids to form
uniform pellets of soil (Weber 1966). *A. texana* constructs tunnels and chambers in the soil that are numerous and extend deeper than those of vertebrate animals. The nest area is usually marked by crescent-shaped mounds 15 to 30 cm tall and about 30 cm in diameter.

*A. texana* shows a decided preference for grasses, weeds, and hardwood leaves. Leaf parts are gathered and used to cultivate their food fungus. They prune the vegetation, stimulate new plant growth, break down vegetable material rapidly, and, in turn, enrich the soil (Hölldobler and Wilson 1990). *A. texana* is a forest pest because it cuts needles from both natural and planted pine seedlings. Though ant foraging occurs year round, the industrial forest impact is felt in the winter months when pines are defoliated in the absence of other forage (Moser 1967). In East Texas, this situation causes considerable loss to timber producers, especially in young plantations on droughty sites.

**Methods**

*A. texana*, by overturning the soil when excavating tunnels and chambers, has a profound effect upon organic matter and texture of the Tonkawa soil series. *A. texana* utilized created openings and disturbances to create nesting areas and benefitted from the wintering foraging on pines in their expansion. *A. texana* is found along the FM 1087 road corridor and along the edges of stream side corridors. In regeneration areas, *A. texana* reacted to the monocultural habitat and dispersed in all directions, causing massive destruction to the loblolly plantation.

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, USA. The distribution of *A. texana* central nest mounds and foraging areas was examined using aerial photography, digital orthophotographic quarter quadrangles (DOQQ) (scale 1:6000), and global positioning satellite (GPS) data. Plant nutrition of *A. texana* nesting areas was examined. Previous soil texture analysis of the central nest mound and adjacent landscapes is presented. This study area encompasses sandy soils and loams capable of sustaining *A. texana* populations.

**Results and Discussion**

Currently, there are 52 openings found throughout the study area. The total study area was 78 ha, or 78,000 square meters. Total defoliation attributed to *A. texana* accounted for 16,380 square meters (21.5%) of the total study area. The immediate nesting areas or mounds accounted for 1.25% of the total area affected by *A. texana*. Not all disturbance areas contained mounds due to natural mound mortality or chemical treatment with methyl bromide.

Repeated efforts at regeneration and control of *A. texana* in the Tonkawa site have met with limited success. Low site productivity makes intensive forest silvicultural practices marginal. Plantation forestry, particularly involving pines on droughty sites, is adversely affected by *Atta* species defoliation (Cherrett 1968) with the most disastrous outbreaks of *Atta* species occurring in monoculture systems (Hölldobler and Wilson 1990).

The impact of *A. texana* nests is evident following timber harvests as nests become the dominant feature on landscapes with deep sandy soils. *A. texana* is the primary soil-
improving organism in the droughty environment of the Typic Quartzipsamments or Tonkawa landscape in northern Nacogdoches County, Texas (Cahal 1993, Cahal et al. 1993). Nests extend underground to a depth of 8 m with hundreds of subterranean chambers (Moser 1963) and up to 61 cm of excavated subsoil on the nest’s surface (Cahal 1993, Cahal et al. 1993, Kulhavy et al. 1998). *A. texana* significantly increases the percent clay; the percent clay in the pellets of nest mound craters was significantly higher than at the intermound surface and the control surface. When comparing percent clay by depth, the mound surface had a significantly higher percentage of clay (5.6% clay for the pellets of the nest mound crater compared to 3.9% and 3.6% at 50-cm depths and the internest surface, respectively) (Cahal 1993, Cahal et al. 1993, Kulhavy et al. 1998).


Following defoliation and mortality of the pine plantation matrix, the patches are maintained by *A. texana* and eventually become a permanent component of the landscape. These patches can vary in size from a few hundred square meters to 6 hectares.

A single *A. texana* nest is a marvel of engineering and the dimensions are staggering. The central nest mound may be 30 m in diameter, have numerous 0.3-m diameter feeder mounds extending outwards to a radius of 80 m (Moser 1967, Cahal 1993, Kulhavy et al. 1998), and may occupy 30 to 600 square meters (Hölldobler and Wilson 1990, Cahal 1993). Larvae are raised in brood chambers, fungus is cultivated in fungal chambers, and waste material is deposited in detrital chambers. Removal of vegetation covering *A. texana* nests reduces soil moisture. *Atta* species are prodigious foragers and a large colony is capable of gathering several kilograms of leaves per day (Weber 1966).

On the Tonkawa study site, the matrix was composed of pine plantations and post oak savannas. Selective foraging by *A. texana* created patches readily apparent on aerial photography. Nest emigration (new patches) occurs by new-founding queens or translocation of existing colonies (Fowler 1981). Combining GPS and GIS with aerial photography quantifies the impacts these ants have on the forested landscape.

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. 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 8 meters (Moser 1967, Cahal et al. 1993). Generally, *A. texana* mounds are located between 1.5 m and 8 m from the water table (Moser 1963, Cahal et al. 1993).

Vegetation on active ant mounds in the Tonkawa soils (Typic Quartzipsamments) are species not preferred by *A. texana*. Post oak (*Quercus stellata*), bluejack oak (*Q. incana*), shining sumac (*Rhus capillina*), yucca (*Yucca louisiana*), mockernut hickory (*Carya tomentosa*), sassafrass (*Sassafrass albidum*), muscadine grape (*Vitis rotundifolia*), and dog fennel (*Eupatorium caprifolia*) predominate on *A. texana* nests. This vegetation flourishes following site colonization by *A. texana*. To examine foliar nutrition, samples were collected
on *A. texana* central nest mounds and on adjacent non-mound areas, oven dried, and ground with a Wiley mill to prepare the samples for nitric acid digestion (Mills and Jones 1991). Concentrations of a suite of nutrients associated with plant productivity (N, P, K, Ca, Mg, Mn, Cu, S, Na, Fe, As) were determined by ICP (inductively coupled argon plasma emission spectrometry), sensitive to <1 mg kg\(^{-1}\) (Walsh 1983). Each plant species was compared individually based on location (either on-mound or off-mound), mound size, and ant activity level.

*A. texana* serves an important ecological function of soil amelioration and increases biodiversity, especially on the very sensitive ecosystem of the Tonkawa study area. Impact of leaf-cutting ants was greatest on planted loblolly pine. Repeated efforts at regeneration and control of *A. texana* in the study area have met with limited success. Regeneration studies on Typic Quartzipsamments indicated the best survival with Terra-Sorb\(^{®}\)-treated loblolly pine followed by longleaf pine (Tracey et al. 1991).

Currently, the primary land use on Tonkawa soils is pine and wildlife management, 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. Recommendations include (1) encouraging native plants in openings created by *A. texana*, (2) managing for wildlife and limited recreation, (3) allowing *A. texana* to continue its biological function of soil improvement, and (4) utilizing this area for teaching forest pest management and forest entomology (Tracey et al. 1991).

Aerial photography is used to measure landscape impacts, vis-a-vis soil formation of *A. texana* (Cahal 1993, Cahal et al. 1993). Stereoscopic color infrared photographs (1:5000) of a 36- by 36-km area were used to estimate both numbers of mounds present and percentage of area defoliated by *A. texana* in the Tonkawa soil series of the Typic Quartzipsamments. Nest mound location and identification of soils, vegetation associations, and changes in mound size and location were measured and entered into a Geographic Information System using ArcView\(^{®}\). Central nest mounds of *A. texana* were located by using the soil survey of Nacogdoches County (Dolezel 1980), aerial observation using fixed-wing aircraft, extensive ground checking, color infrared aerial photography at a scale of 1:6000, and digital orthophotographic quarter quadrangles (DOQQ). Moser (1986) estimated timber losses due to leaf-cutting ants by examining aerial photographs of individual mounds.

For each mound, the center was identified, marked with a sequentially numbered pole, and located with a Trimble\(^{®}\) TDC-1 GPS receiver. One-meter accuracy was obtained by taking a minimum of 100 locational positions tracking a minimum of four satellites with a positional dilution of precision (PDOP) maximum of 6. Differentially corrected GPS data were transferred to the GIS Laboratory of the Arthur Temple College of Forestry and transferred onto 1996 DOQQ imagery (1:12000). These images were georeferenced, rectified, and parallax and distortion free, which allowed GPS positions to be overlaid with location accuracy. The integration of GPS and DOQQ imagery enhance the investigation of *A. texana* because mound movement can be mapped over time and landscape patterns discerned.

Accurate mapping coupled with an interactive GIS system (ArcView\(^{®}\)) details the landscape-wide ecological process of patch formation, change in the matrix, and alteration of the structure and function of the forest landscape on Typic Quartzipsamments soils. A thorough investigation of central nest mound changes in size and location, coupled with
analysis of the associated vegetation productivity and nutrition, is essential in assessing the ecology of *A. texana* in the forested landscape.

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