

SPATIAL EVALUATION OF NITROGEN EMISSIONS FROM POULTRY OPERATIONS AND THEIR INFLUENCE ON THE IMPACT OF PITCH CANKER IN SLASH PIN (*Pinus elliottii*) PLANTATIONS

Executive Summary

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Acknowledgements

This project has been and continues to be, in every sense of the word, "a team effort." The authors of this executive summary report express their sincere appreciation to David Morse, Brian Cobble, Tim Wilkinson, Jon Handrick, Bud Mayfield, Andrea Van Loan, and Barry Brown for their invaluable field assistance. We extend our thanks to the landowners who provided access to their pine stands for evaluation. Lastly, we thank the many other individuals from the Florida Division of Forestry and the University of Florida who provided assistance with sample collection, processing, and/or other aspects of technical assistance.

Introduction

Pitch canker, a sometimes serious fungal disease of *Pinus* spp., caused by *Fusarium subglutinans* (Wollenw. & Reinking) Nelson, *et al.* [f. sp. *pini* Correll *et al.* = *F. circinatum* Nirenburg and O'Donnell sp. nov. (Nirenburg and O'Donnell 1998)?] is strongly influenced by the physiological (esp. nutritional) status of its host pines. Severe outbreaks of the disease can cause significant stem and crown damage as well as mortality of infected trees. For decades, casual observations and limited research in Florida have noted elevated levels of both incidence and severity of pitch canker in susceptible pines subjected to high and/or imbalanced levels of fertility (Anderson and Blakeslee 1984, Claeson and Smith 1977, Fisher, Garbett and Underhill 1981, Fraedrich and Witcher 1982, Meyers 1989). Above "normal" levels of damage caused by this disease have been observed in 1) fertilized pine plantations, 2) pines in high maintenance landscapes (golf courses, etc.), 3) pines used experimentally as a nutrient filter to extract nutrients from industrial wastewater for purposes of aquifer protection, 4) pines surrounding a commercial sod farm irrigated with nutrient-rich brewery wastewater, and 5) pines adjacent to a chemical plant emitting aerosol ammonia (Barnard and Blakeslee 1987). In 1977, Claeson and Smith reported a strong relationship between nutrient gradients and the incidence of pitch canker in slash pine (*Pinus elliottii* Englem.) along radii from a poultry farm in Baker County, Florida. Repeated episodes of damaged pines proximal to poultry farms in Florida, increasing acreages of susceptible pines, and recent changes in poultry production practices are combining to signal an important and potentially expanding problem for both pine growers and poultry producers. Accordingly, we initiated a study to 1) quantify periodic N emissions from a tunnel-ventilated poultry house, 2) spatially assess N (and other nutrient) accumulation in soils and pine foliage in slash pine plantations adjacent to poultry production facilities, 3) assess associated pitch canker-related impact, and 4) develop baselines for "safe" distances between poultry houses and planted pines. This executive summary provides an overview of our findings. All data and procedural details are compiled and presented in a similarly titled summary document, subtitled "Interim Summary Report." That report is on file with the U.S.D.A. Forest Service, Cooperative Forest Health Protection offices in Asheville, NC and Atlanta, GA, as well as the Florida Division of Forestry's Forest Health Section in Gainesville, and the University of Florida (departments indicated with authors – above). Interested parties may request access to the full report from any of these sources.

Procedures

Ten plantations of slash pine (*Pinus elliottii* Engelm.) in north central Florida, ranging in age from 11 to 17 years, were selected for study. Seven plantations were proximal to operational poultry (chicken) production facilities. Three plantations, regarded as "controls", were distant from such operations (Table 1). At least 75 1/40th–acre plots were established and GPS-located in each plantation; 64 on a grid distributed throughout each plantation, and 11 randomly located within each plantation (Figure 1). All trees in each plot were evaluated for status (living or dead), and all live trees were assessed for symptoms of pitch canker; incidence (present or absent) and severity (1 = trace to 10% crown affected, 2 = >10 – 33% crown affected, 3 = >33 – 50% crown affected, 4 = >50% crown affected). Diameters at breast height were recorded for all live trees and heights of two plot-corner trees and one plot-center tree were measured.

Foliage, forest floor ("litter"), and soil samples were collected from all plots and analyzed for nitrogen content. In addition, in one "intensive study plantation" rain throughfall was collected from all plots on certain dates corresponding to routine poultry farm activities, and gaseous ammonia was evaluated using passive diffusion tubes (Table 2, Figure 2).

Results

Nitrogen levels were compared to reported background levels for comparable slash pine plantations, and evaluated spatially in relationship to poultry houses, as well as pitch canker incidence and severity, tree mortality, and wood volume. All results are reported in detail in the Interim Summary Report. For purposes of this Executive Summary, key findings are reported in summary fashion to facilitate distribution to and consumption by interested parties. Overall, the data set produced by this project is voluminous. Analyses are ongoing at the University of Florida, and funding has been provided to include analyses of other nutrients besides N (e.g., P, K, Ca, Mg) that may be important and related to pitch canker development.

The following pages provide a series of interpolation maps for selected study plantations as illustrations of the spatial trends observed and recorded during this work (Figures 3-34). Similar maps for all study plantations and all variables assessed are included in the Interim Summary Report. In addition to the selected maps, this Executive Summary includes a series of graphic presentations of certain variables (foliar N, forest floor N, soil N, soil C, pitch canker incidence, pitch canker disease index, tree mortality, and wood volume) as stand medians and ranges (Figure 35:A-H) and stand means with standard deviations (Figure 36: A-H). Lastly, average predicted values (10m intervals) from the interpolation maps for the various parameters are presented in Figures 37 – 44.

In summary, this study provides strong evidence of nitrogen influence from poultry operations on neighboring slash pine plantations. This influence is directly related to elevated levels of pitch canker infection, severity, and related tree mortality, and inversely related to wood volume. Such trends were evident in all of the seven plantations evaluated next to poultry operations.

Despite the strong trends clearly evident and documented in this study, there were the not unexpected irregularities. For example, the general trends observed in the seven plantations adjacent to poultry operations were not as strongly reflected in the data for study sites 2 and 7. This is perhaps not surprising. Study plantations were selected, not only on the basis of certain qualifying criteria (age, proximity to poultry operations, ease of access, owner cooperation), but in some cases simply because of availability and access. In this regard, study plantation number 2 was relatively distant from its “influencing” poultry operation, it spanned distinctly different soil types, it was bordered by a powerline right-of-way (influencing air currents?), a graded road, a cattle pasture, and, on its poultry-side, an intermittent oak “buffer”. Study plantation number 7 was essentially two plantations (separated in space and in age by a year; differing seedling/seed sources), part of one section of the plantation was traversed by a powerline right-of-way (influencing air currents?), the two sections traversed obviously variable soil types, and they were separated from their “influencing” poultry operation by a serpentine highway and intermittent oak “buffer”. In addition, study plantation number 7 was the youngest of the plantations evaluated, and there is some question regarding possible influences from an additional soil amendment in part of the plantation.

Management Considerations

This study documents and partially quantifies a very real and expanding problem. It also raises the issue of management to mitigate undesirable effects. In short, without validating research, options are limited. Possible courses of action might include the following:

1) Establishment and maintenance of adequate “safe distances” between poultry operations and pine plantations. On the basis of the present work, a safe distance might be as much as 500 meters, although this could vary with poultry production practices, size of poultry operations, prevailing winds and weather, etc.

2) Establishment and maintenance of vegetative “buffers” (oaks, redcedars, etc.) to block and/or filter or absorb aerosols from poultry house fans.

3) Replacement of susceptible pines with alternative tree species unaffected or possibly positively affected by the nutrient deposition.

4) Identification and utilization of potential genetic resistance to pitch canker infections in slash and other pine species.

5) Conversion of land use from pine production to some alternative agronomic crop (hay, corn, etc.) which might both benefit from the nutrient deposition and act as a capture crop to mitigate possible ground water contamination.

6) Develop engineering solutions (filters, scrubbers, etc.) to remove nutrients from poultry house fan emissions.

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Table 1. Description of the seven slash pine plantations used in this study including age, location and details on soils and poultry houses.

Site	Age (years)	Number of Poultry Houses	Closest Distance from Poultry Houses to Stand Edge (m)	Closest Distance from Poultry House Fans to Stand Edge (m)	Ventilation System	Soils	Previous Site Usage
1	15	4	44	195	Tunnel	Blanton fine sand	Pasture and Crops
2	15	4	97	113	Tunnel	Blanton fine sand	Pasture and Crops
3	15	3	27	40	Tunnel	129Ac.Alpine Fine Sand 20Ac.Blanton sand 1Ac.Wampy Loamy sand	Crops
4	13	8	20	20	Tunnel	50% Penney sand 35% Blanton-Ortega 15% Ortega Fine sand	Hay and Crops
5	17	8	67	67	Tunnel	Penney sand	Crops
6	16	8			Tunnel	Blanton fine sand	Crops and Pine
7	11-12	5	70	80	Tunnel	Blanton 08,09, Bonneau 13	Crops
CHECK STANDS							
C-1	14	N/A	N/A	Not applicable	N/A	90% Penney Sand 10% Ortega fine Sand	Crops/Fallow
C-2[b]	14	N/A	N/A	Not applicable	N/A		Crops
C-3	14	N/A	N/A	Not applicable	N/A	Blanton & Chiefland fine sands	Crops

Table 2: Throughfall collection and rainfall amounts for the four collections made at Site 1.

Collection Date	Dates Collectors in Field	Chicken Production Cycle	Rainfall amount (during collection)	Rainfall amount one week previous to collection
June 24	June 19 – June 24	Second week of cleaning	0.90 cm (0.35 in)	3.96 cm (1.56 in)
July 8	July 2 – July 8	Chickens 12 days old	5.21 cm (2.05 in)	1.91 cm (0.75 in)
July 24	July 21 – July 24	Chickens 28 days old	2.79 cm (1.10 in)	1.98 cm (0.78 in)
September 2	August 26 – Sept 2	Chickens 8 days old	4.85 cm (1.91 in)	Not available

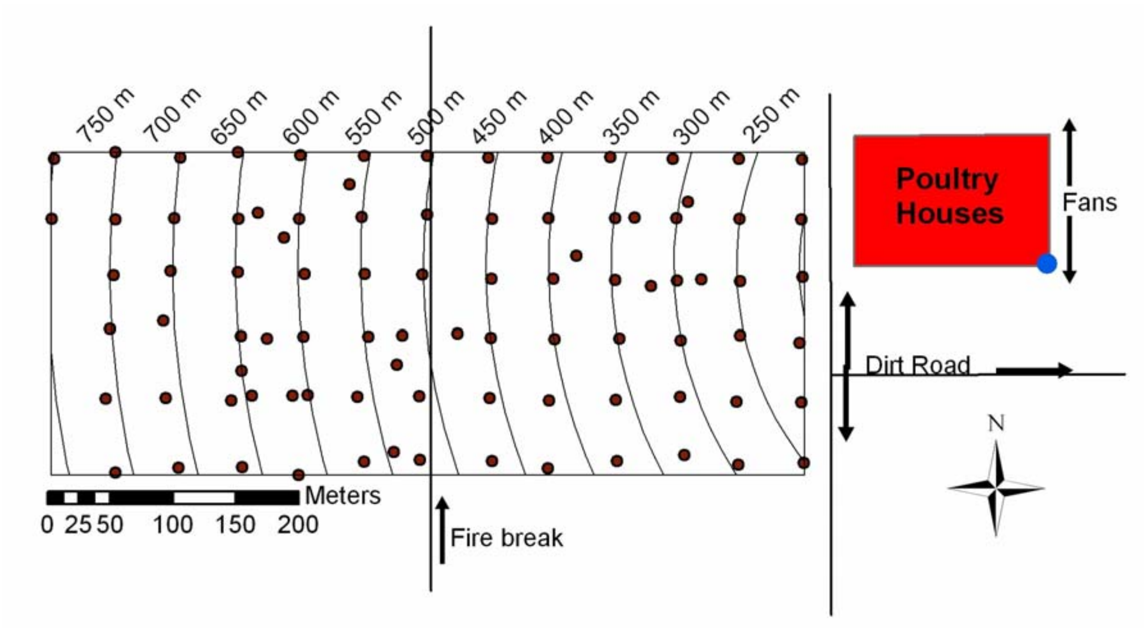


Figure 1. Schematic of plot/sampling locations (74 on grid, 15 random) for study site 1. Labeled arcs within plantations indicate distances from poultry houses fans as measured from fan located by ● on poultry house clock. All study stands located proximal to poultry houses were similarly plotted and assessed.

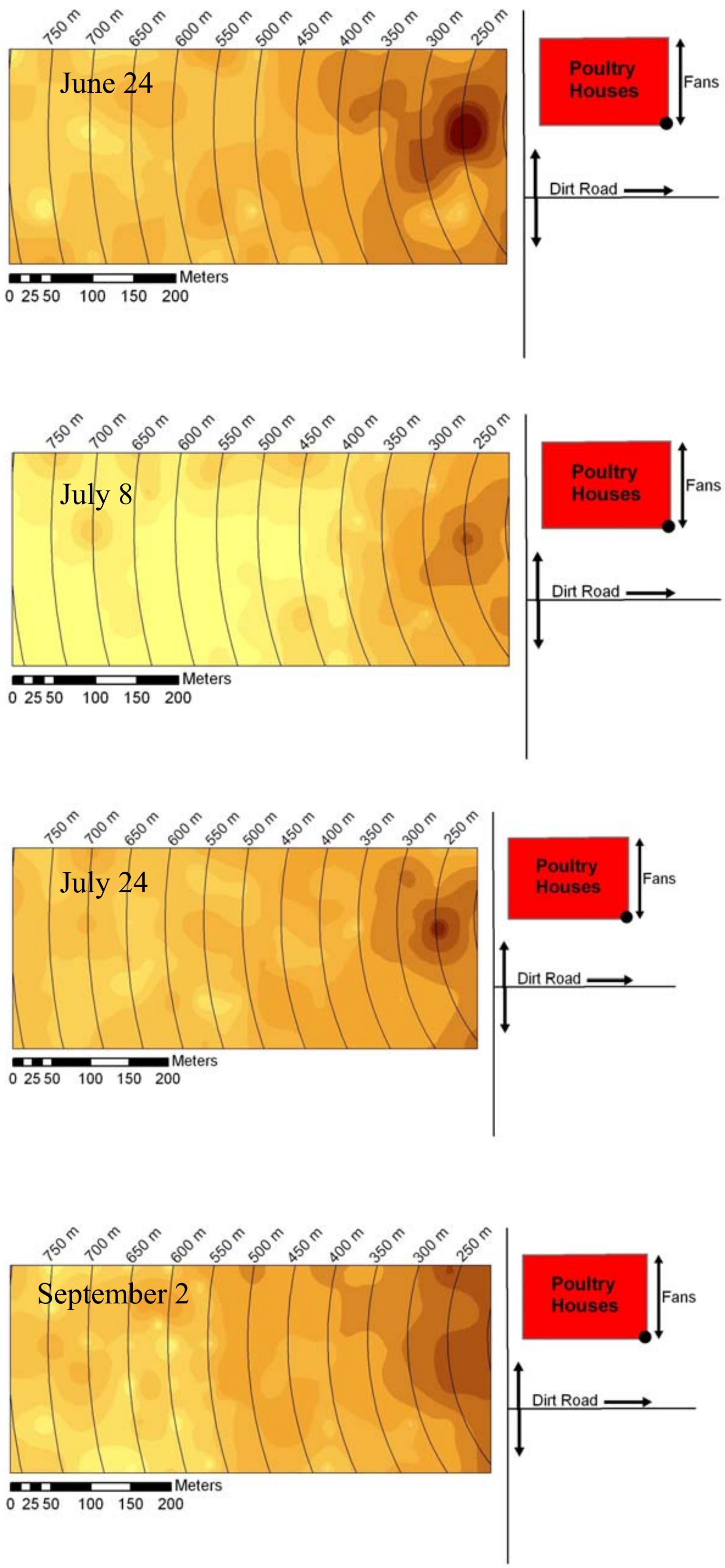
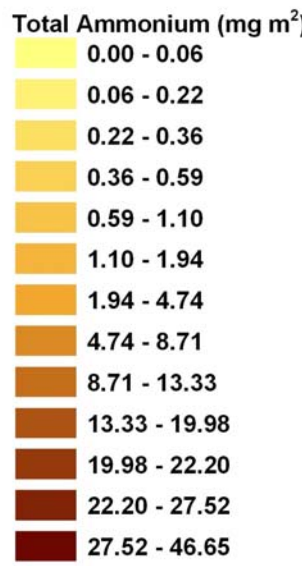


Figure 2. Ammoniacal throughfall collections in study plantation number 1 on selected dates associated with routine poultry production operations (ref. table 2).



Figures 3 - 10. Spatial distributions of foliage N, forest floor N, soil N, soil C, pitch canker incidence, pitch canker disease index, tree mortality, and tree volume for study site 1 in relationship to adjacent poultry production operation.

Figure 3. Site 1 - Foliar N

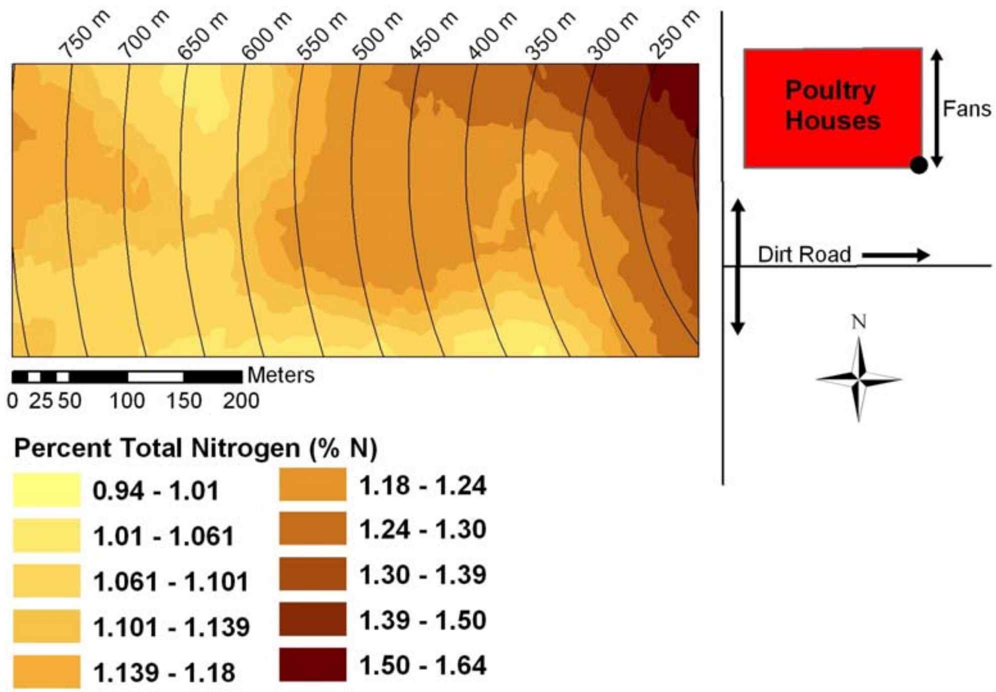


Figure 4. Site 1 - Forest Floor N

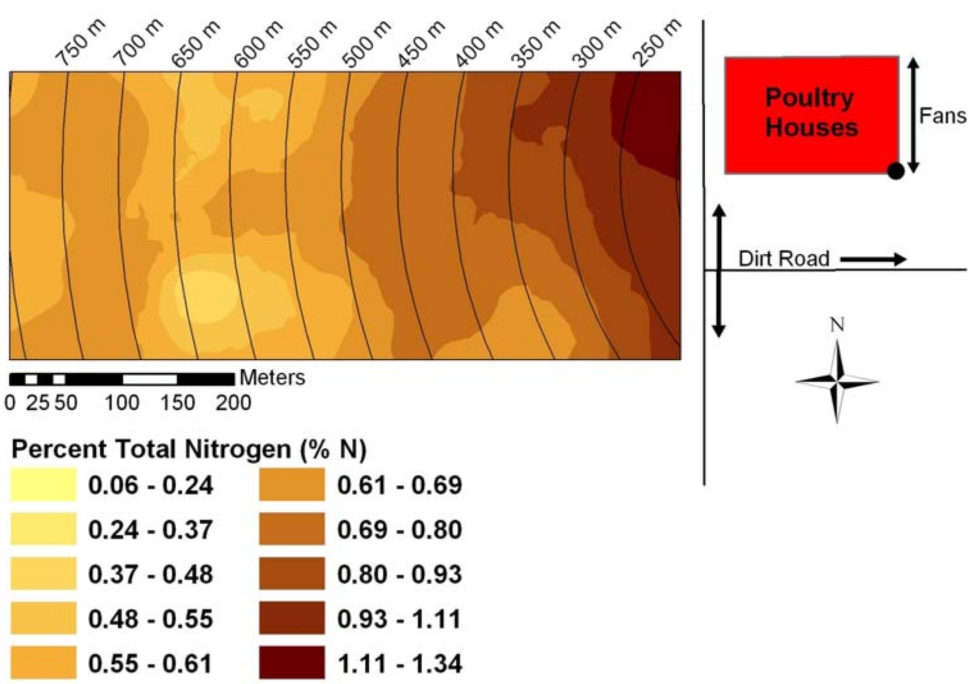


Figure 5. Site 1 - Soil N

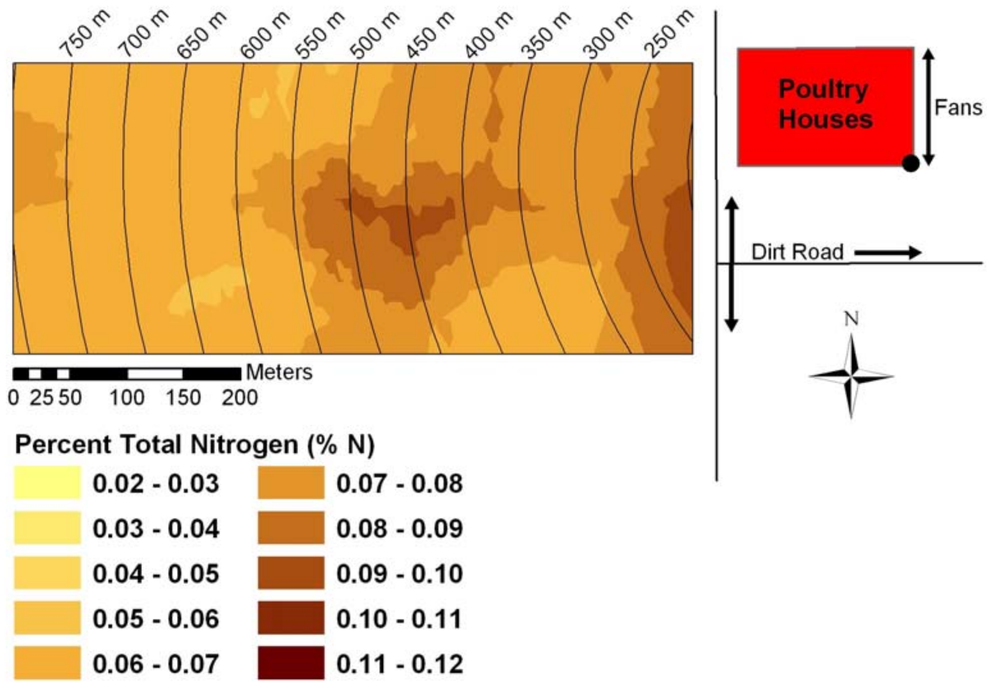


Figure 6. Site 1 - Soil C

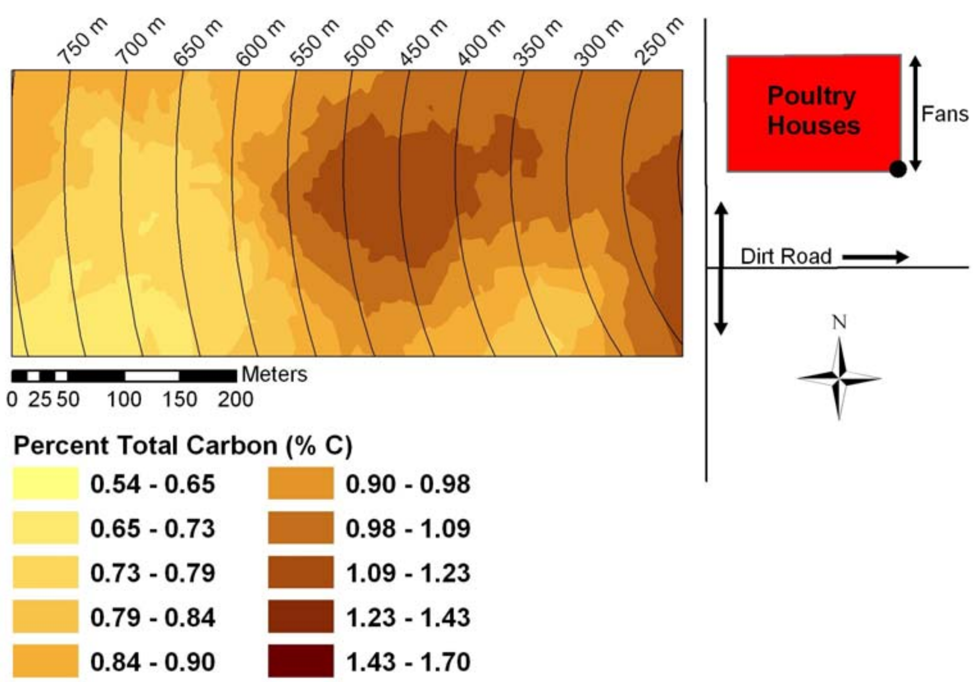


Figure 7. Site 1 - Pitch Canker Incidence

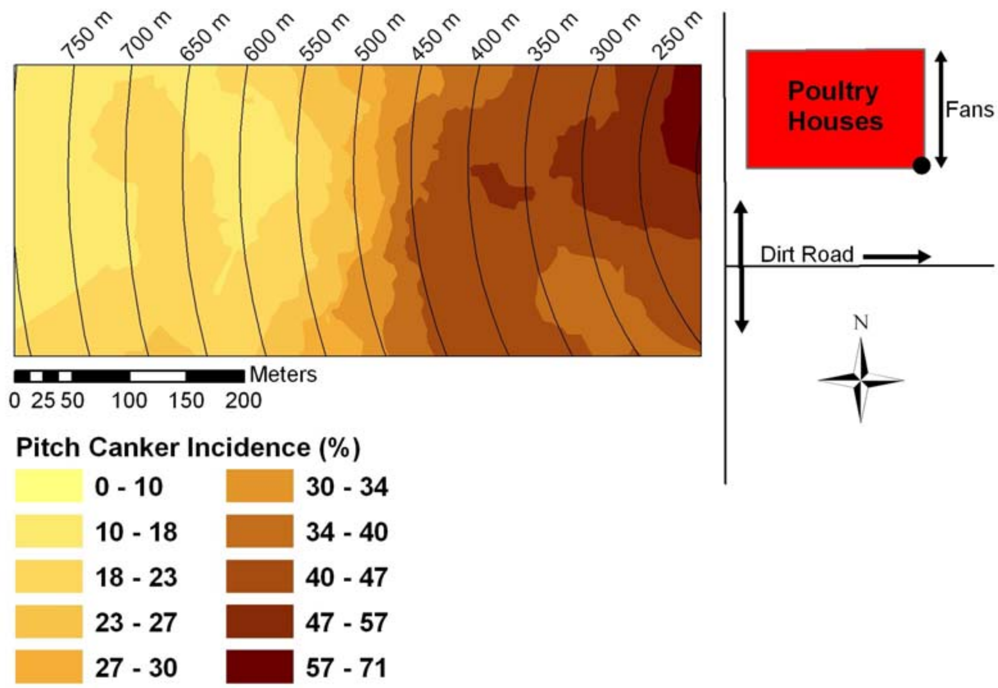


Figure 8. Site 1 - Pitch Canker Disease Index

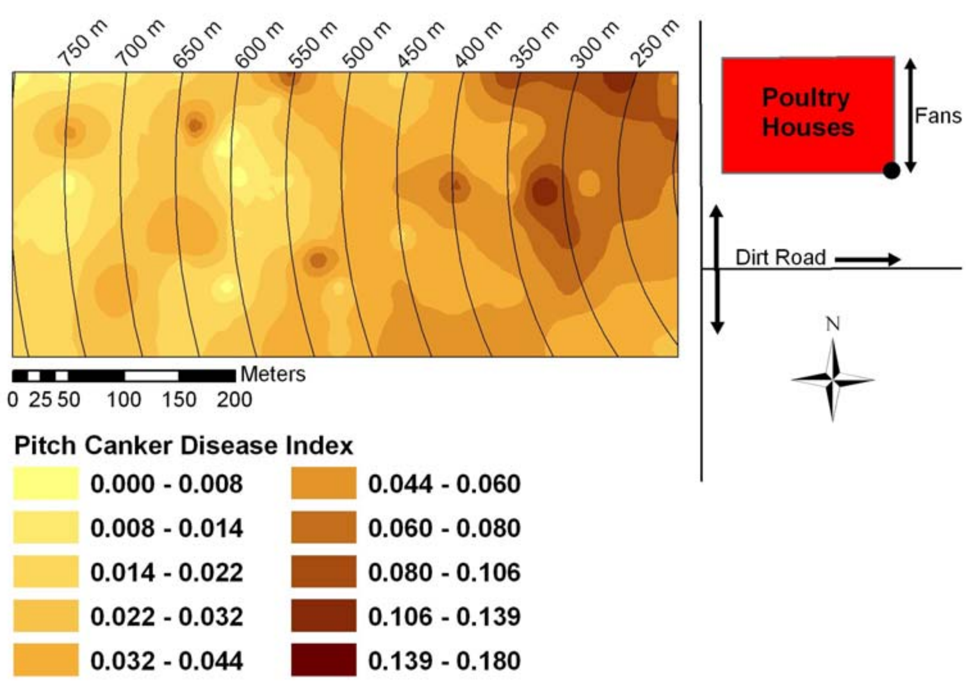


Figure 9. Site 1 - Tree Mortality

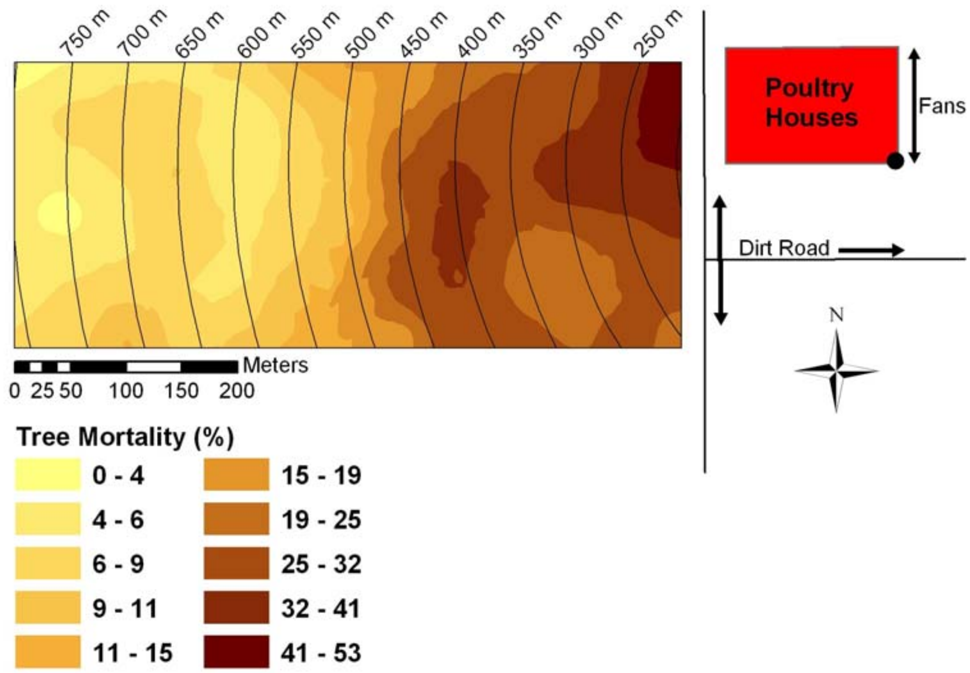
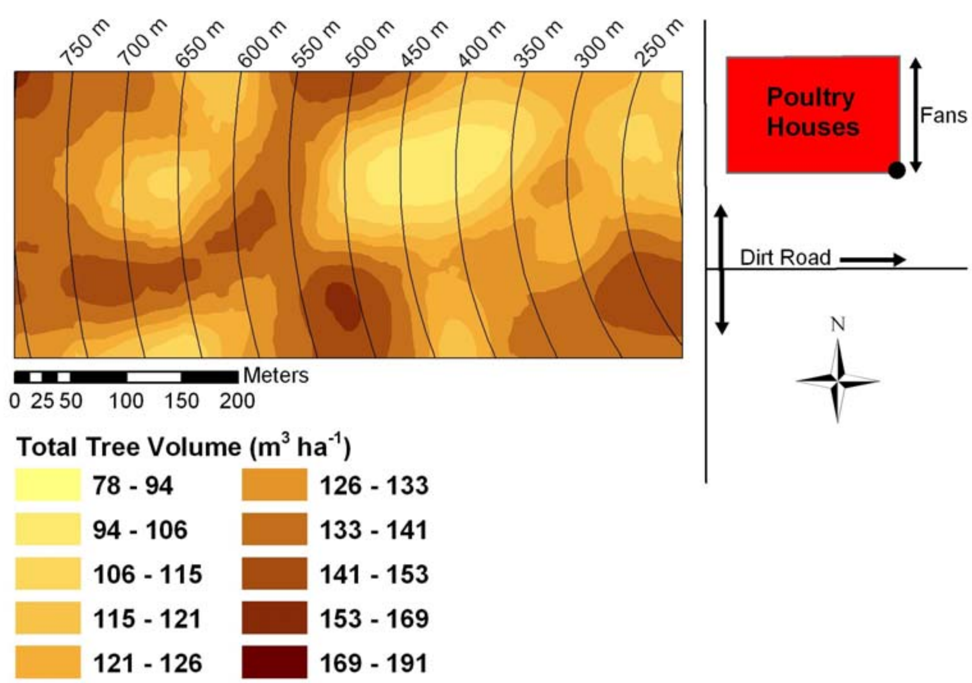


Figure 10. Site 1 - Tree Volume



Figures 11 - 18. Spatial distributions of foliage N, forest floor N, soil N, soil C, pitch canker incidence, pitch canker disease index, tree mortality, and tree volume for study site 3 in relationship to adjacent poultry production operation.

Figure 11. Site 3 - Foliar N

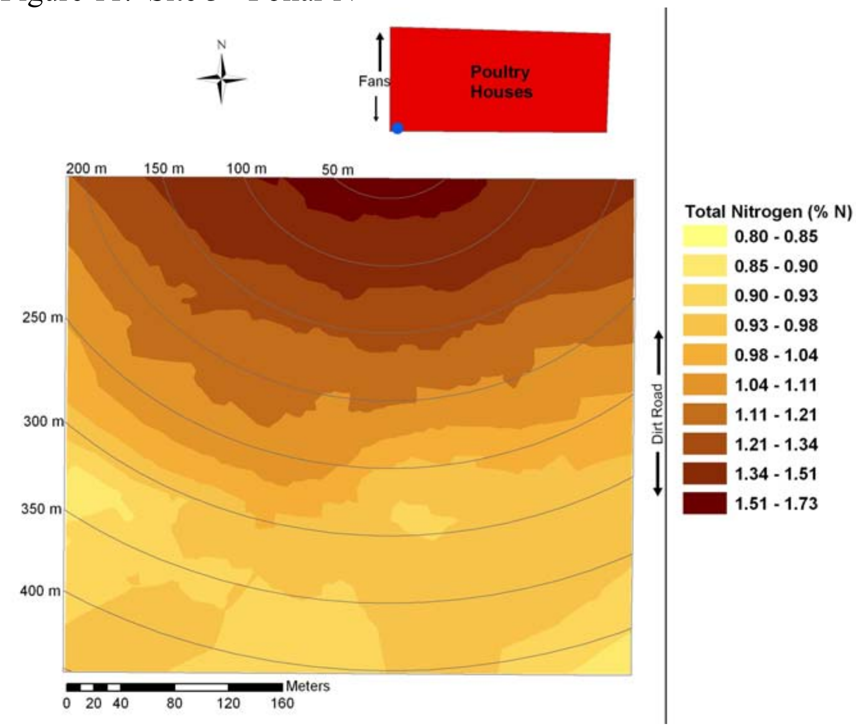


Figure 12. Site 3 - Forest Floor N

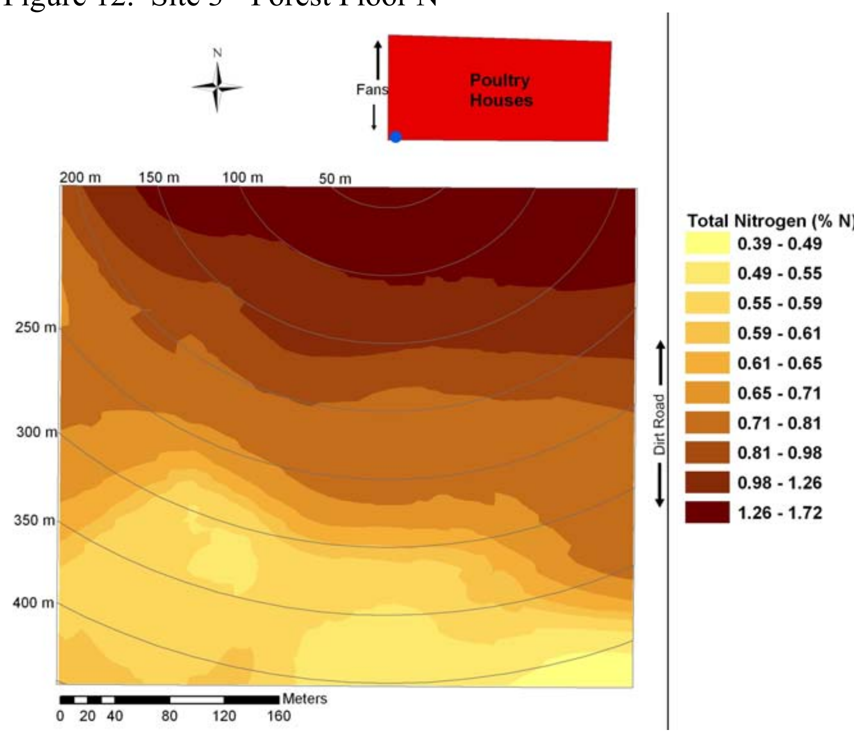


Figure 13. Site 3 - Soil N

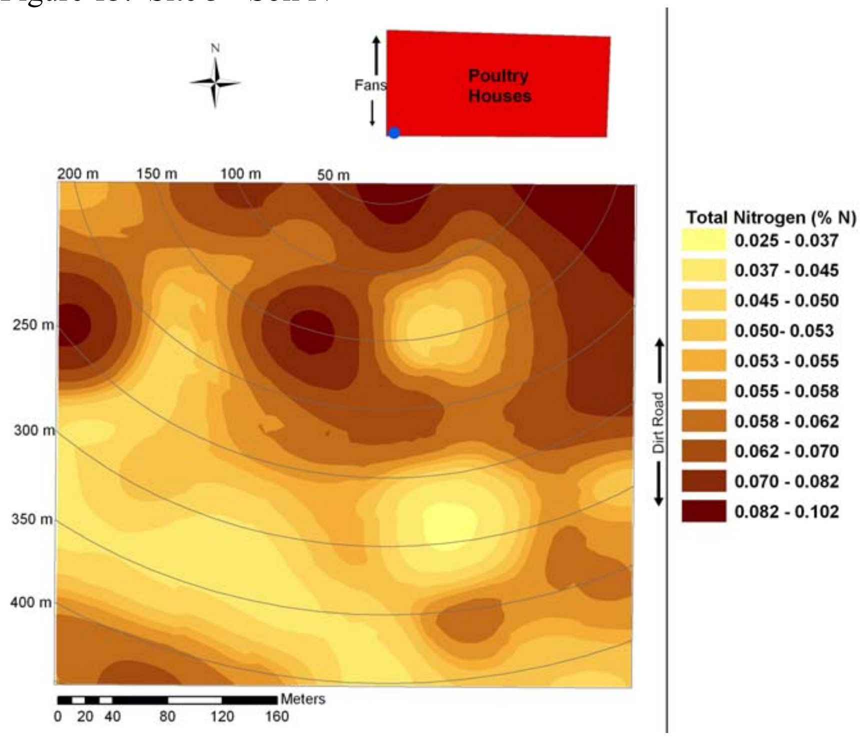


Figure 14. Site 3 - Soil C

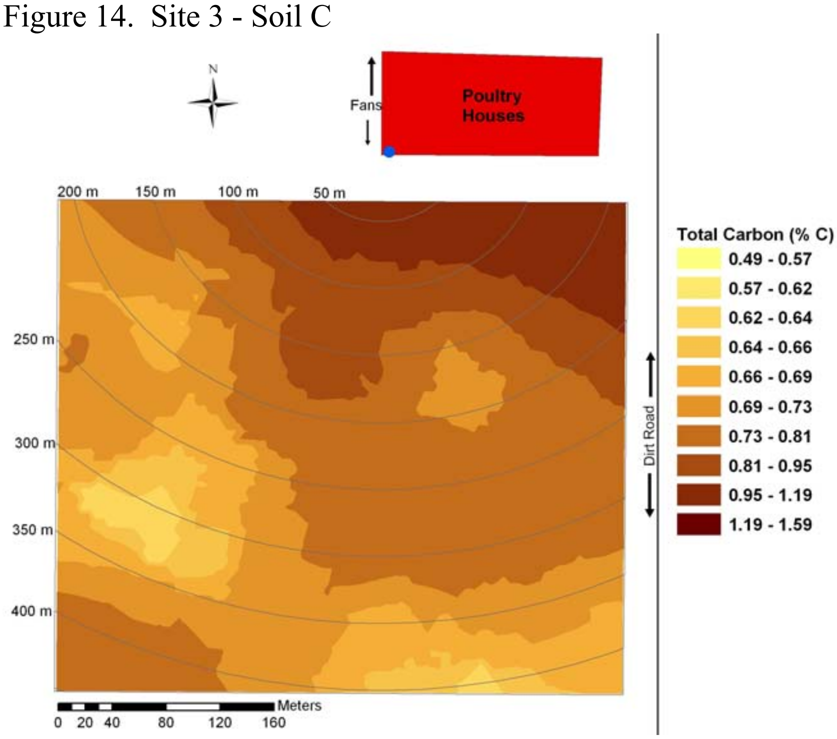


Figure 15. Site 3 - Pitch Canker Incidence

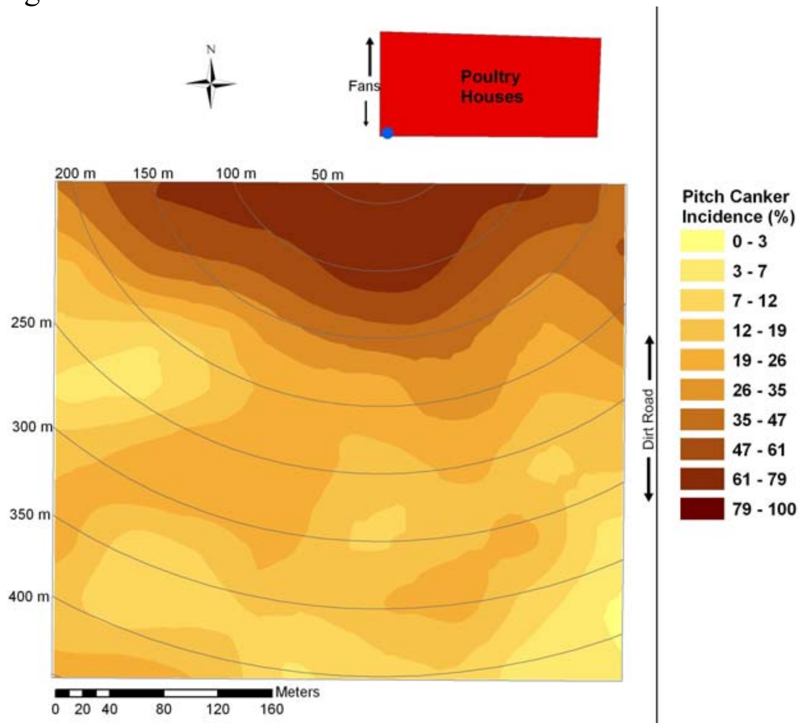


Figure 16. Site 3 - Pitch Canker Disease Index

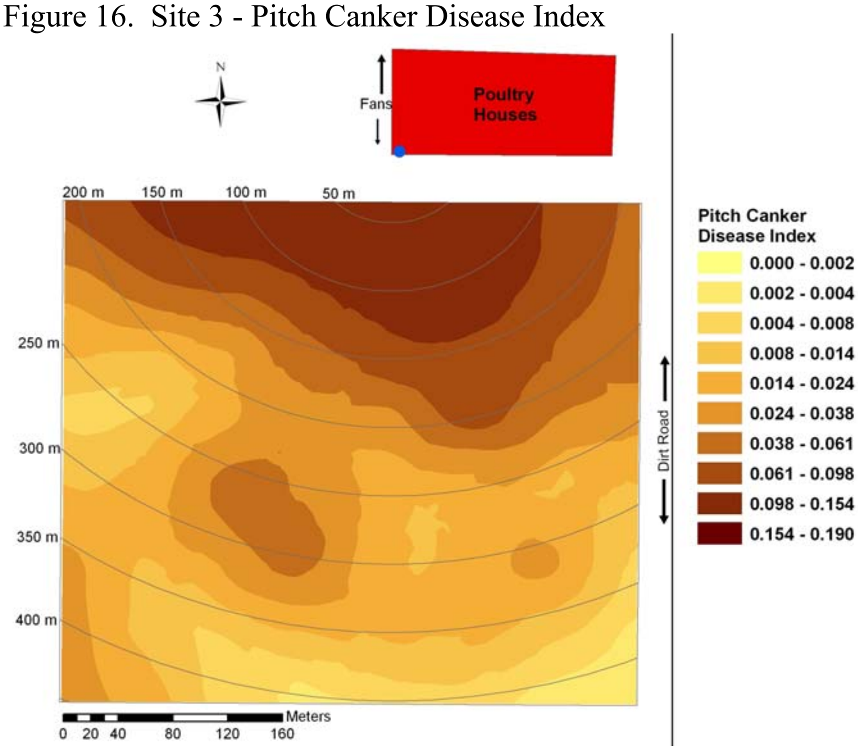


Figure 17. Site 3 - Tree Mortality

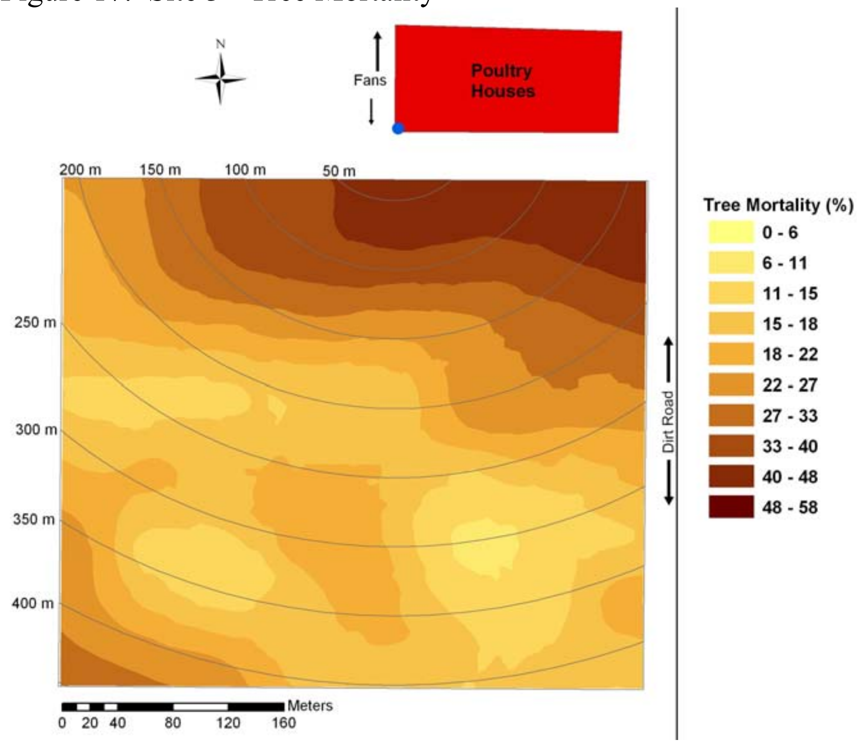
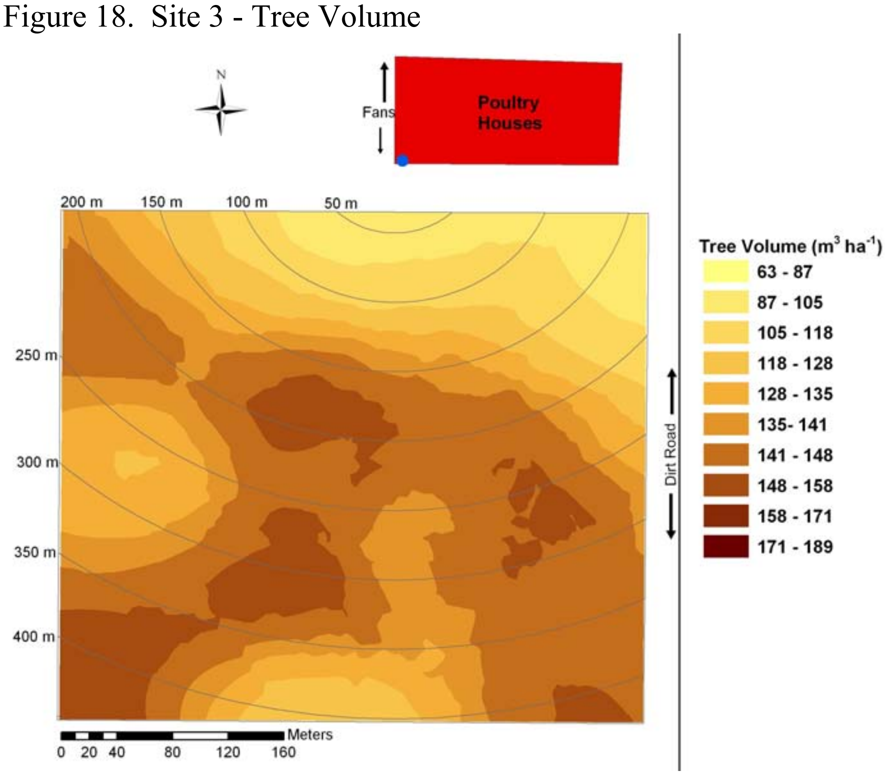


Figure 18. Site 3 - Tree Volume



Figures 19 - 26. Spatial distributions of foliage N, forest floor N, soil N, soil C, pitch canker incidence, pitch canker disease index, tree mortality, and tree volume for study site 4 in relationship to adjacent poultry production operation.

Figure 19. Site 4 - Foliar N

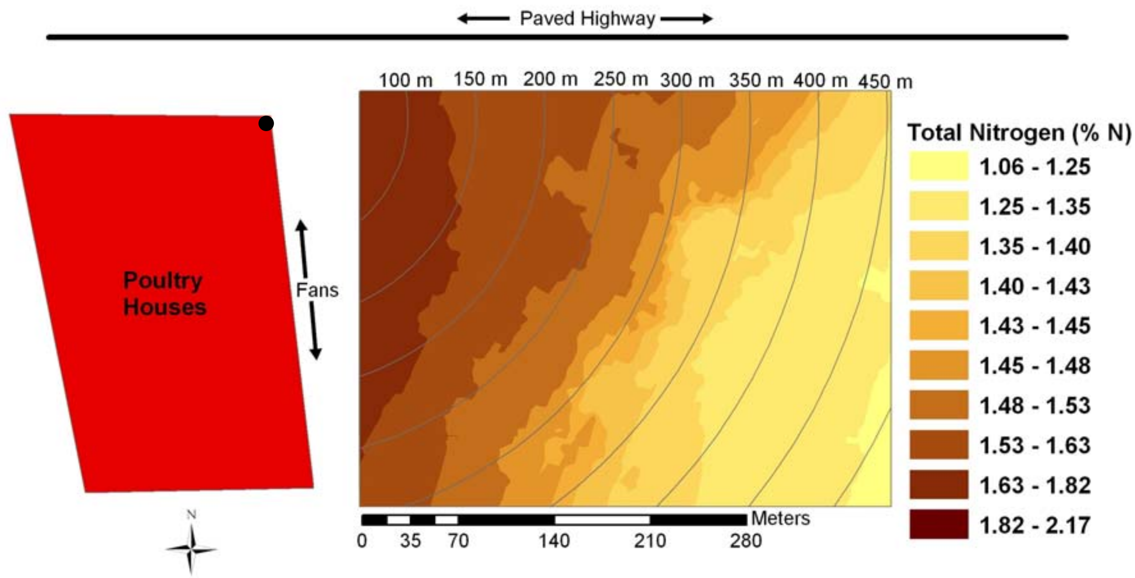


Figure 20. Site 4 - Forest Floor N

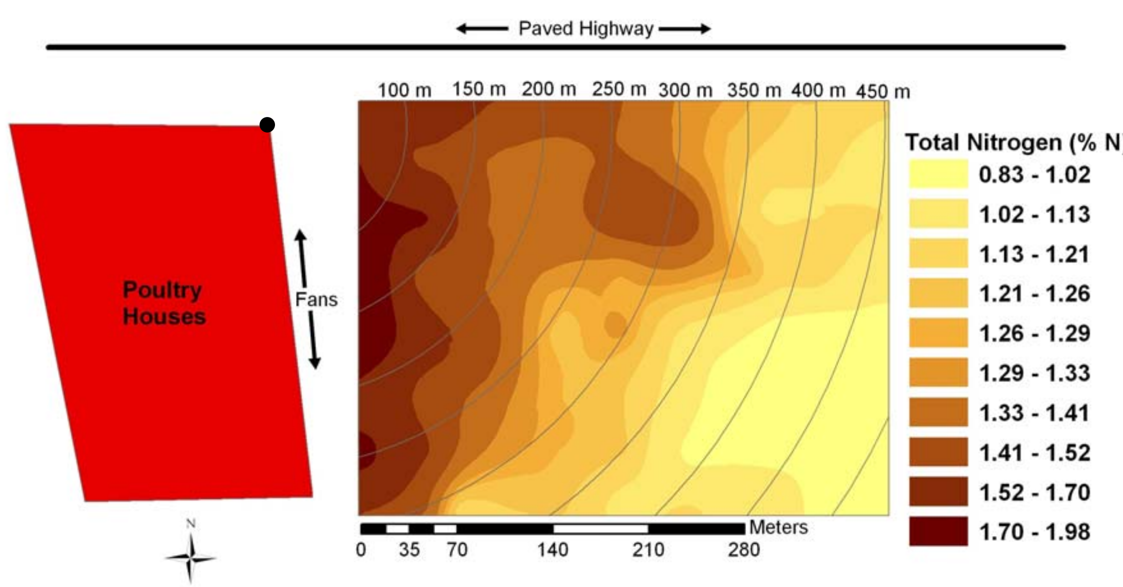


Figure 21. Site 4 - Soil N

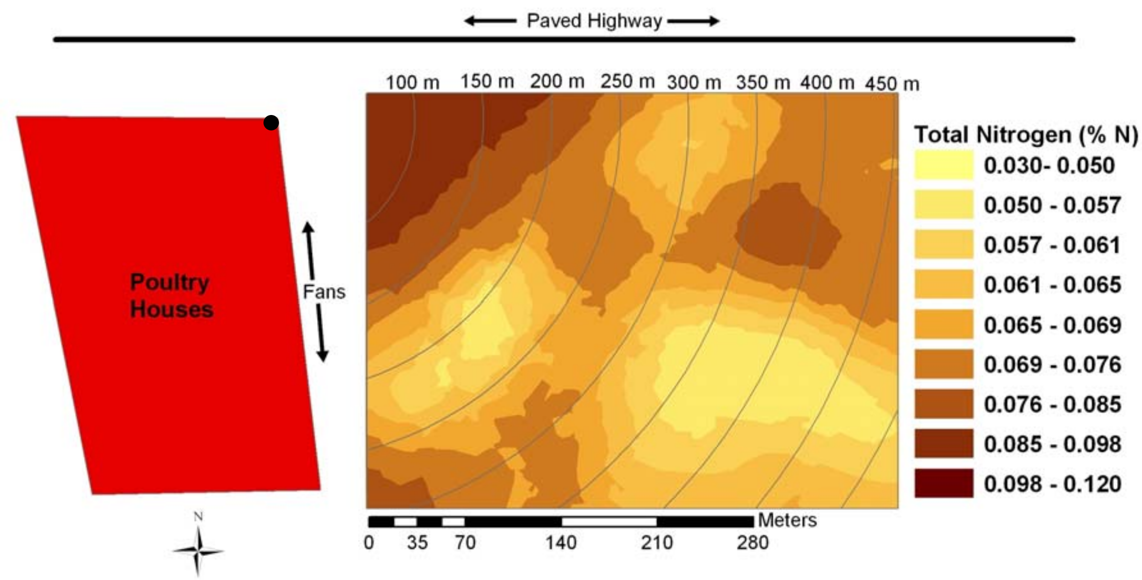


Figure 22. Site 4 - Soil C

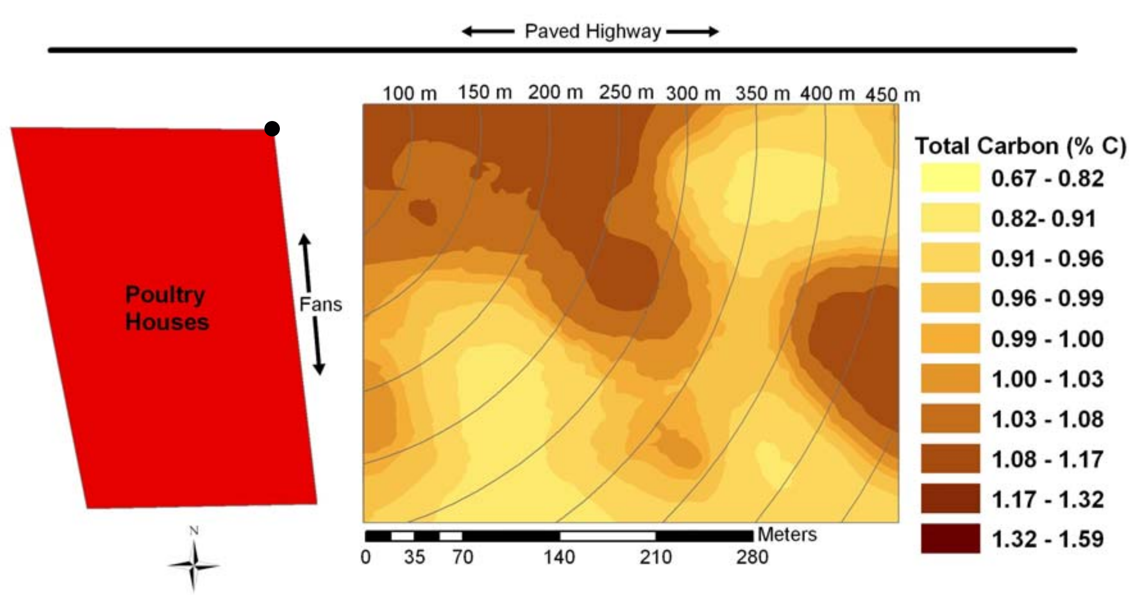


Figure 23. Site 4 - Pitch Canker Incidence

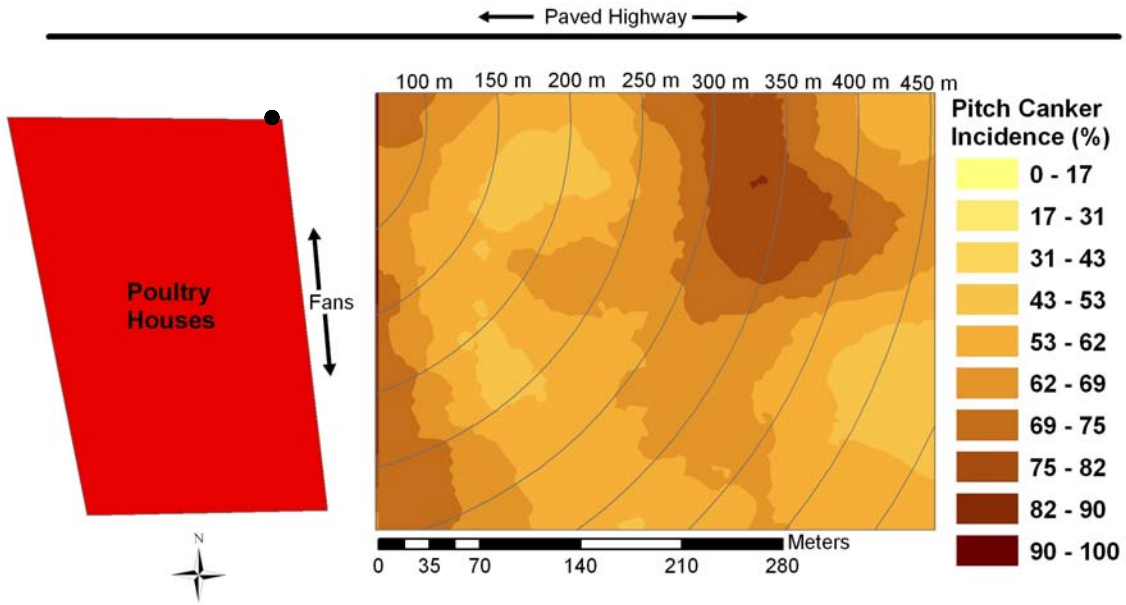


Figure 24. Site 4 - Pitch Canker Disease Index

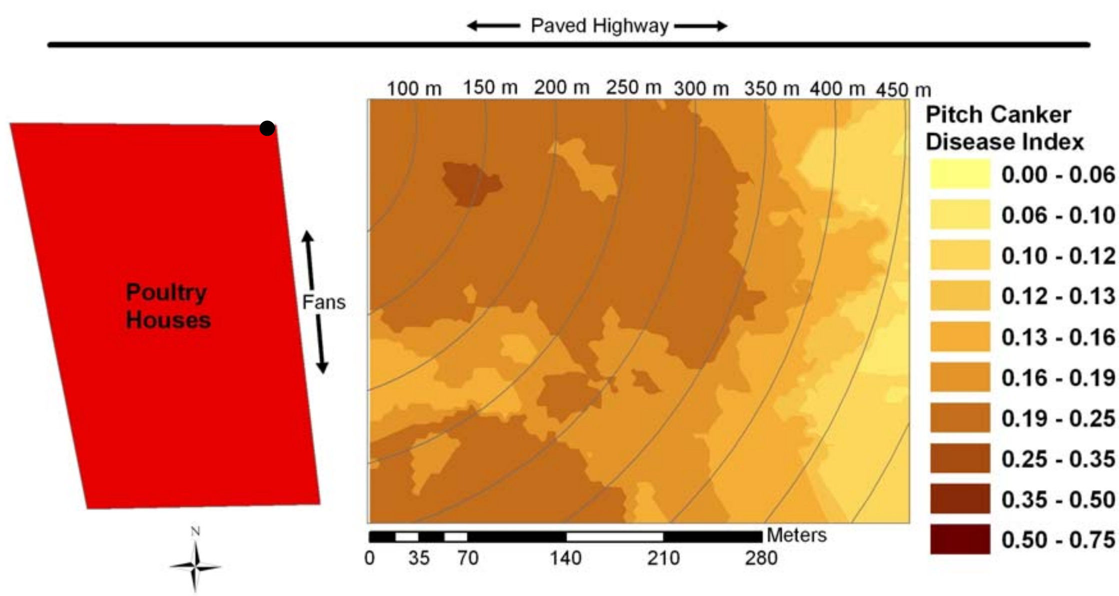


Figure 25. Site 4 - Tree Mortality

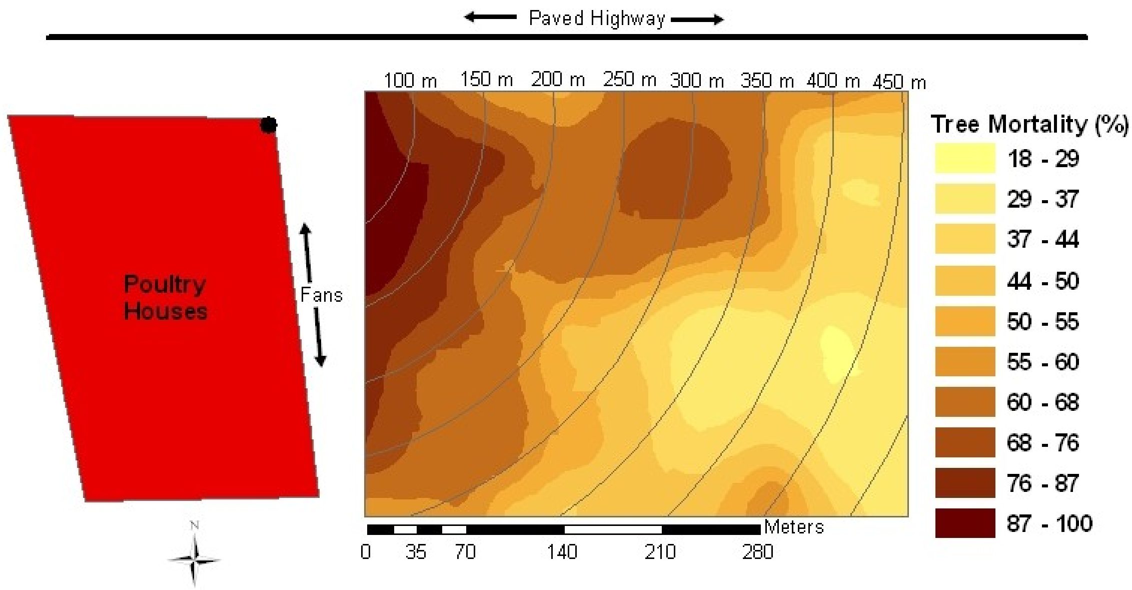
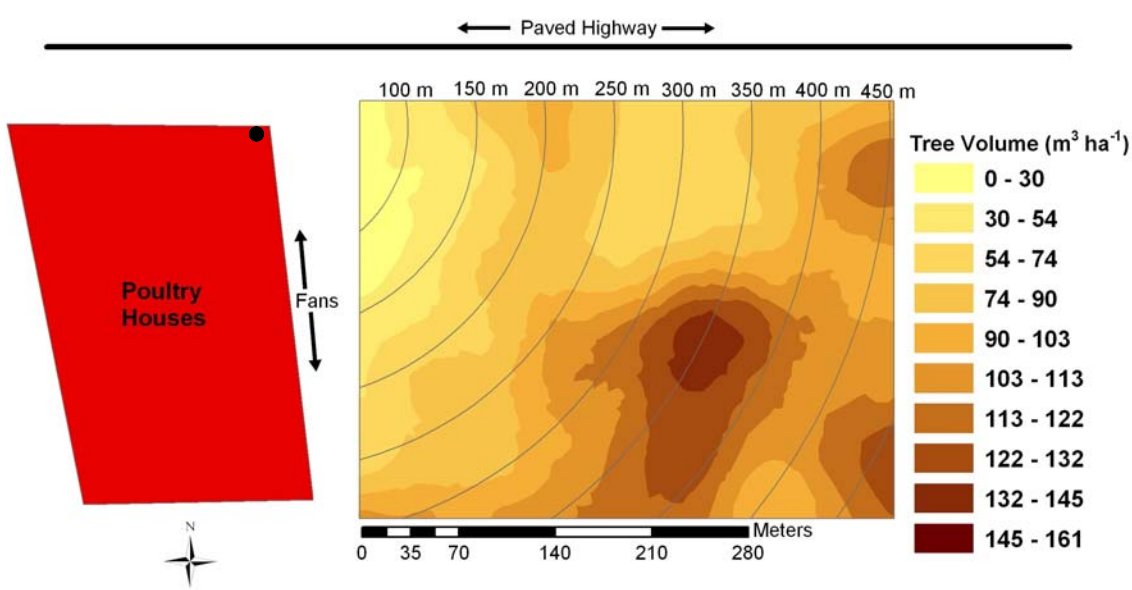


Figure 26. Site 4 - Tree Volume



Figures 27 - 34. Spatial distributions of foliage N, forest floor N, soil N, soil C, pitch canker incidence, pitch canker disease index, tree mortality, and tree volume for study site 4 in relationship to adjacent poultry production operation.

Note: Distance relationships at this sites (ref. Figures 27-34) have so far been analyzed only from a single point (fans on the northern set of poultry houses). When analyses are adjusted to include the fans on the southern set of poultry houses, distance functions will be stronger than reflected in this report.

Figure 27. Site 6 - Foliar N

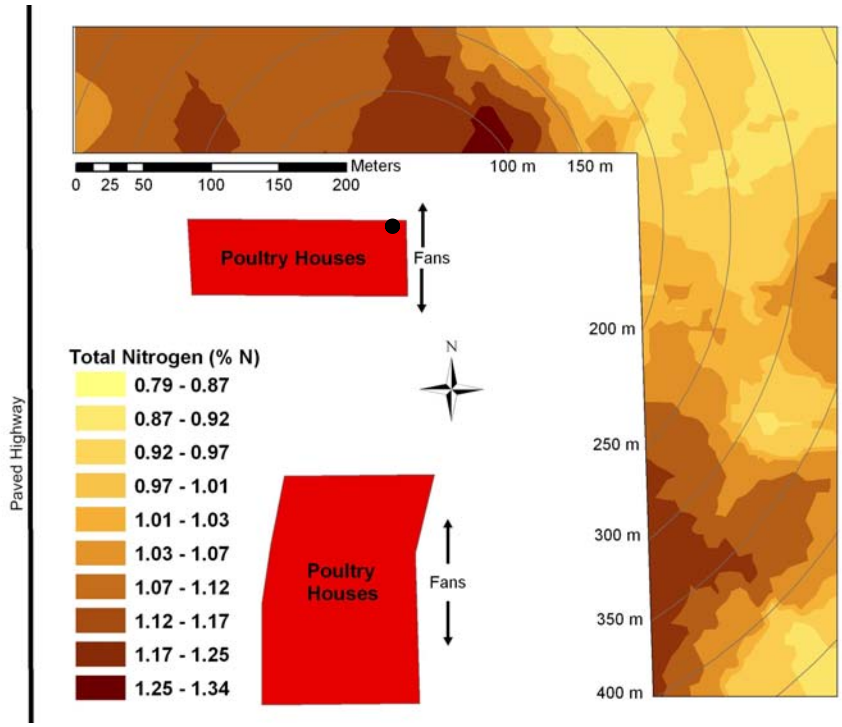


Figure 28. Site 6 - Forest Floor N

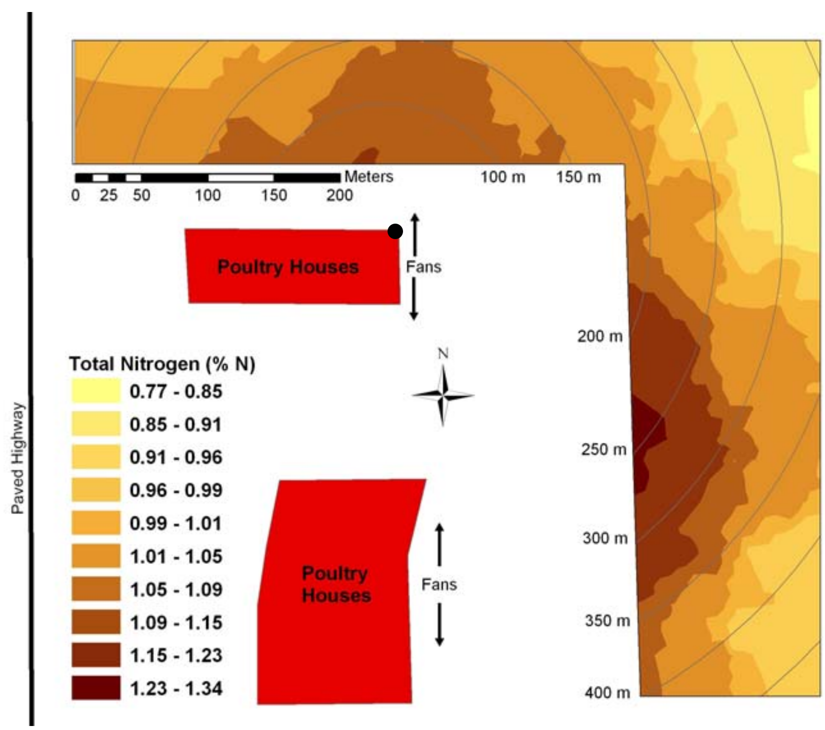


Figure 29. Site 6 - Soil N

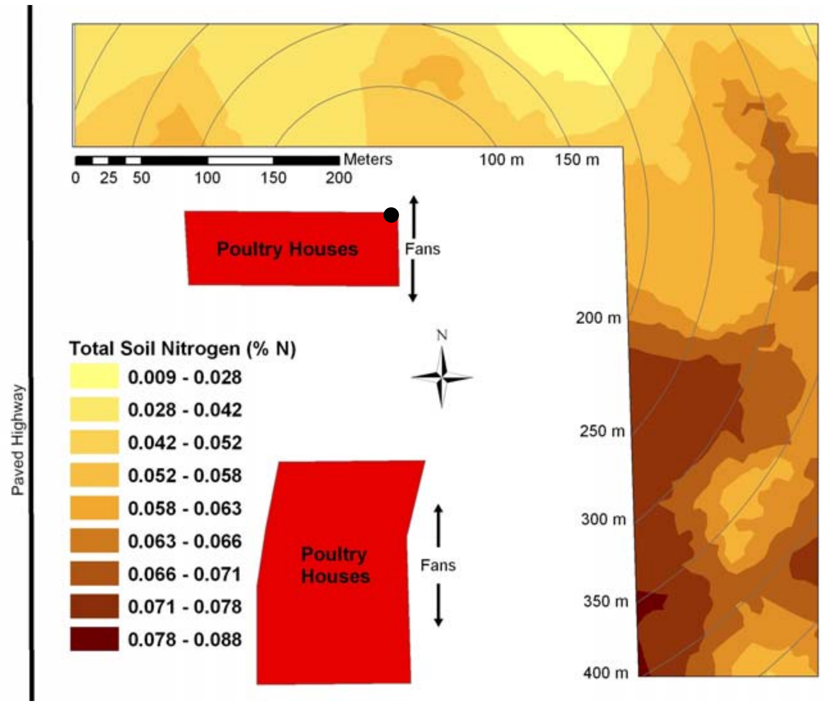


Figure 30. Site 6 - Soil C

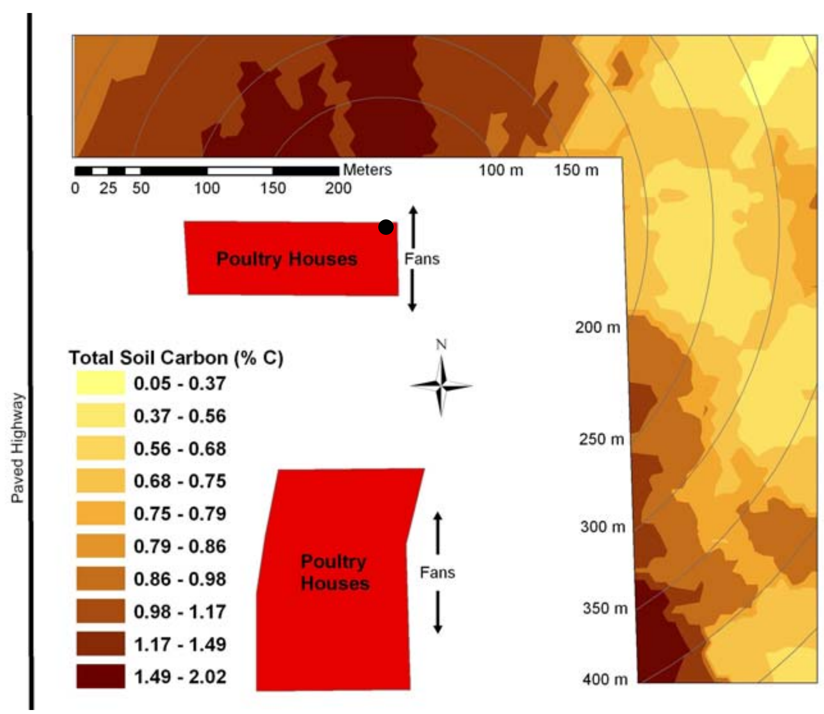


Figure 31. Site 6 - Pitch Canker Incidence

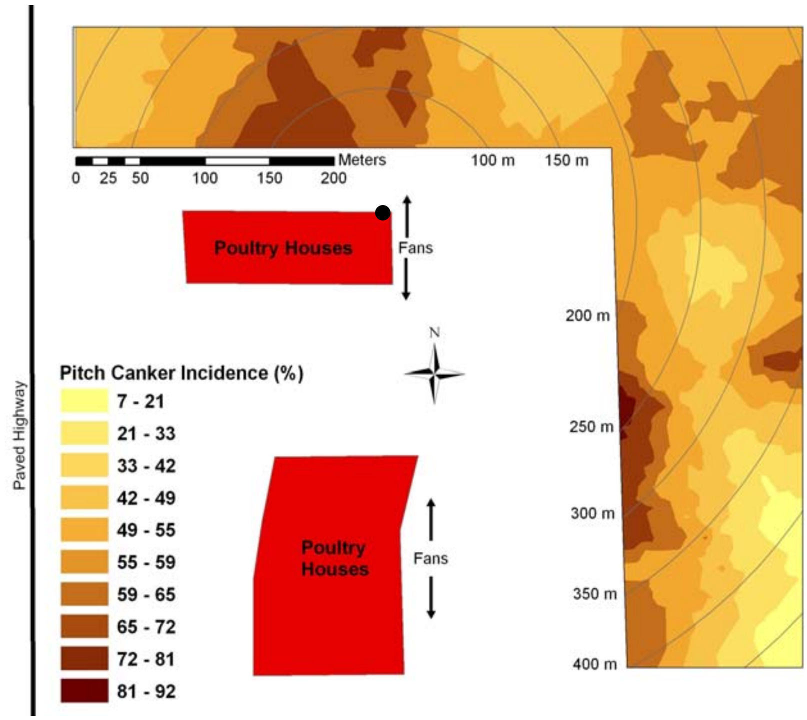


Figure 32. Site 6 - Pitch Canker Disease Index

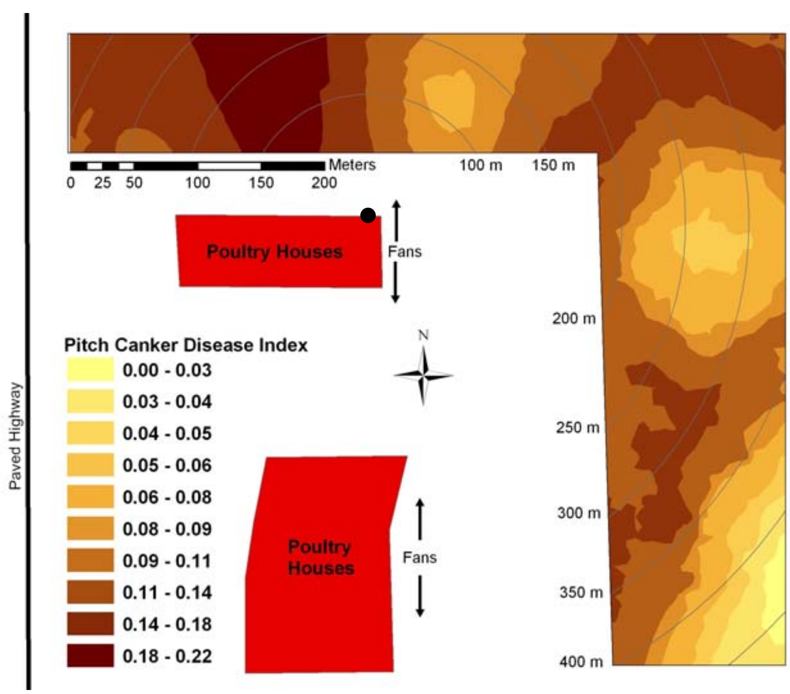


Figure 33. Site 6 - Tree Mortality

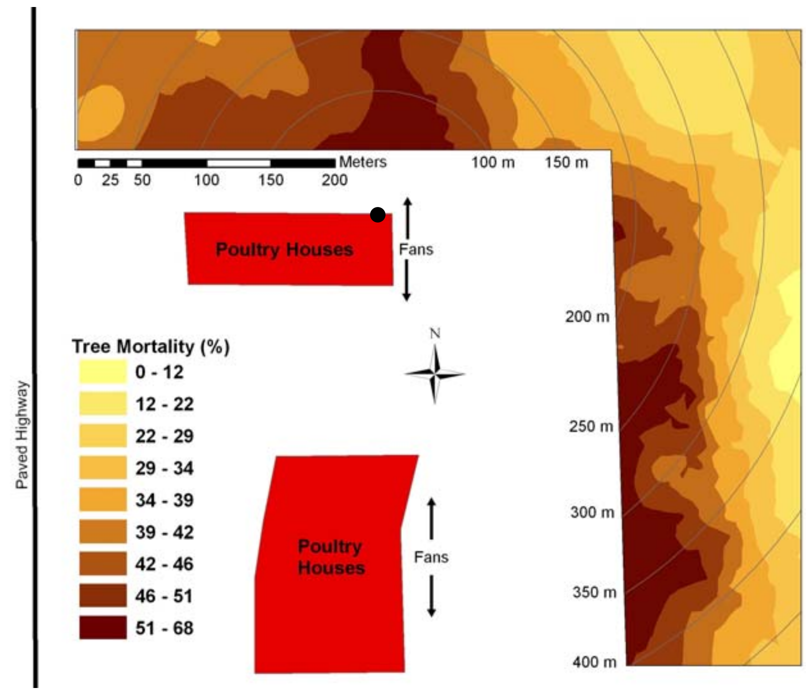


Figure 34. Site 6 - Tree Volume

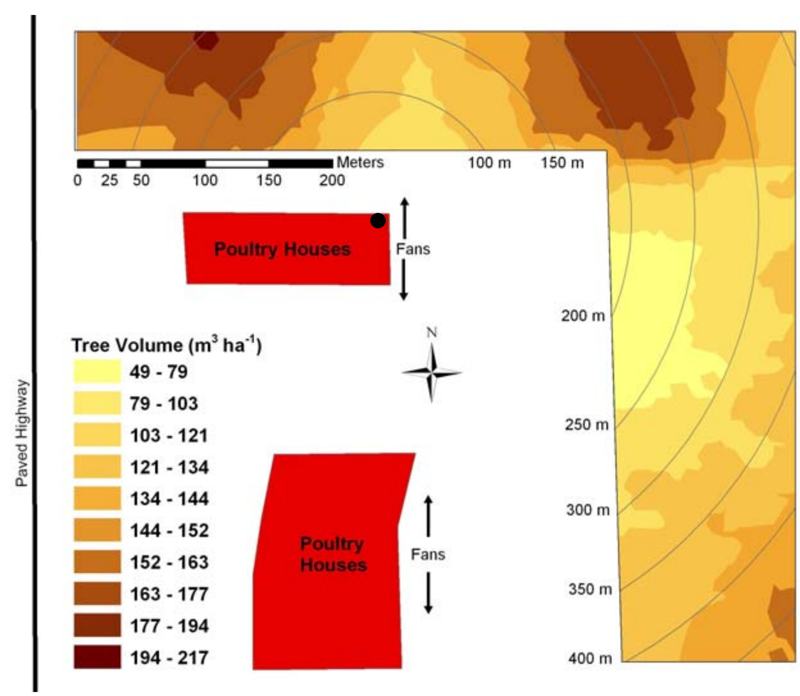
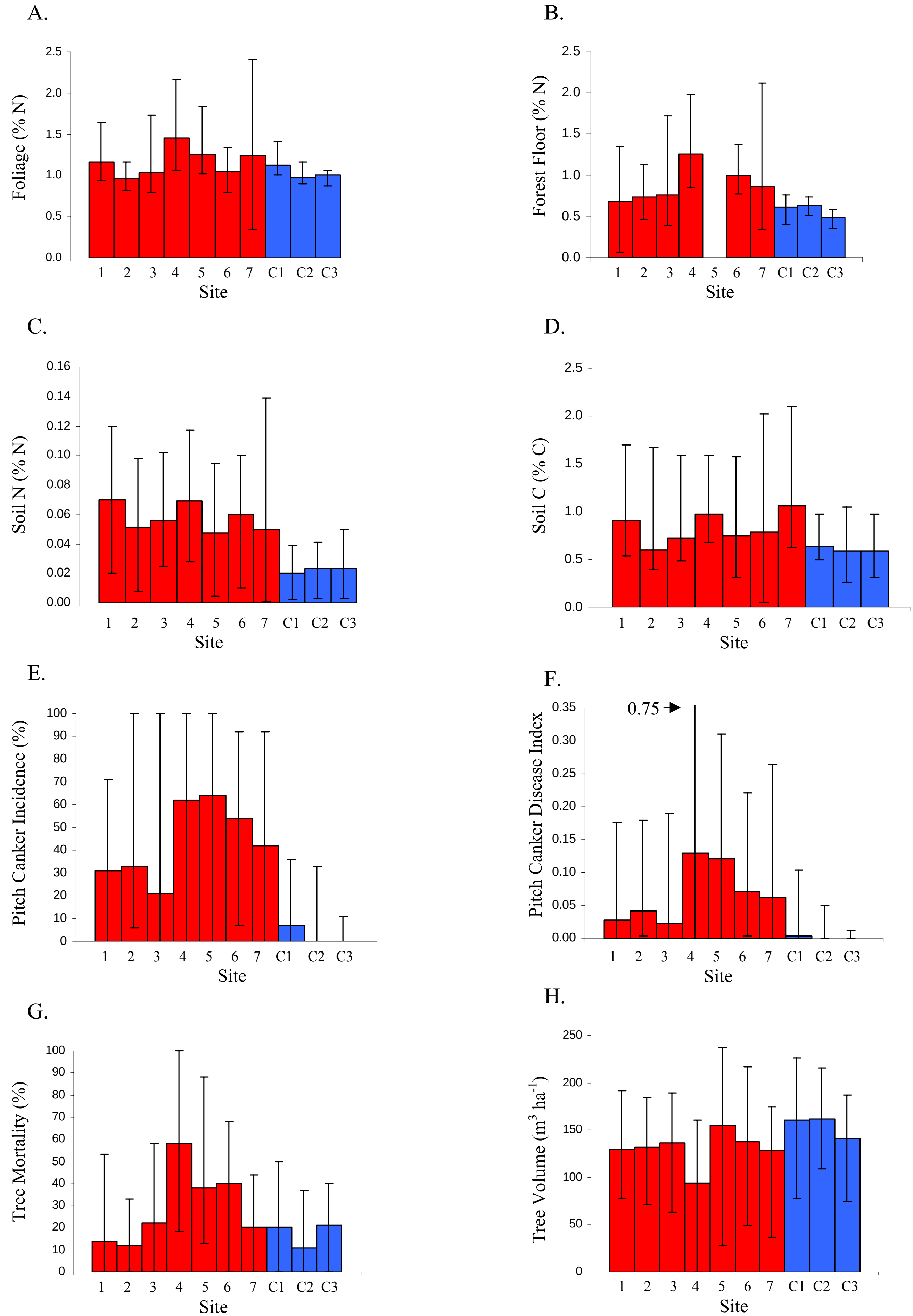


Figure 35. Study plantation median and range values for parameters assessed. Sites 1 - 7 denote plantations proximal to poultry houses. C1, C2, and C3 denote "control" plantations distant from poultry houses.

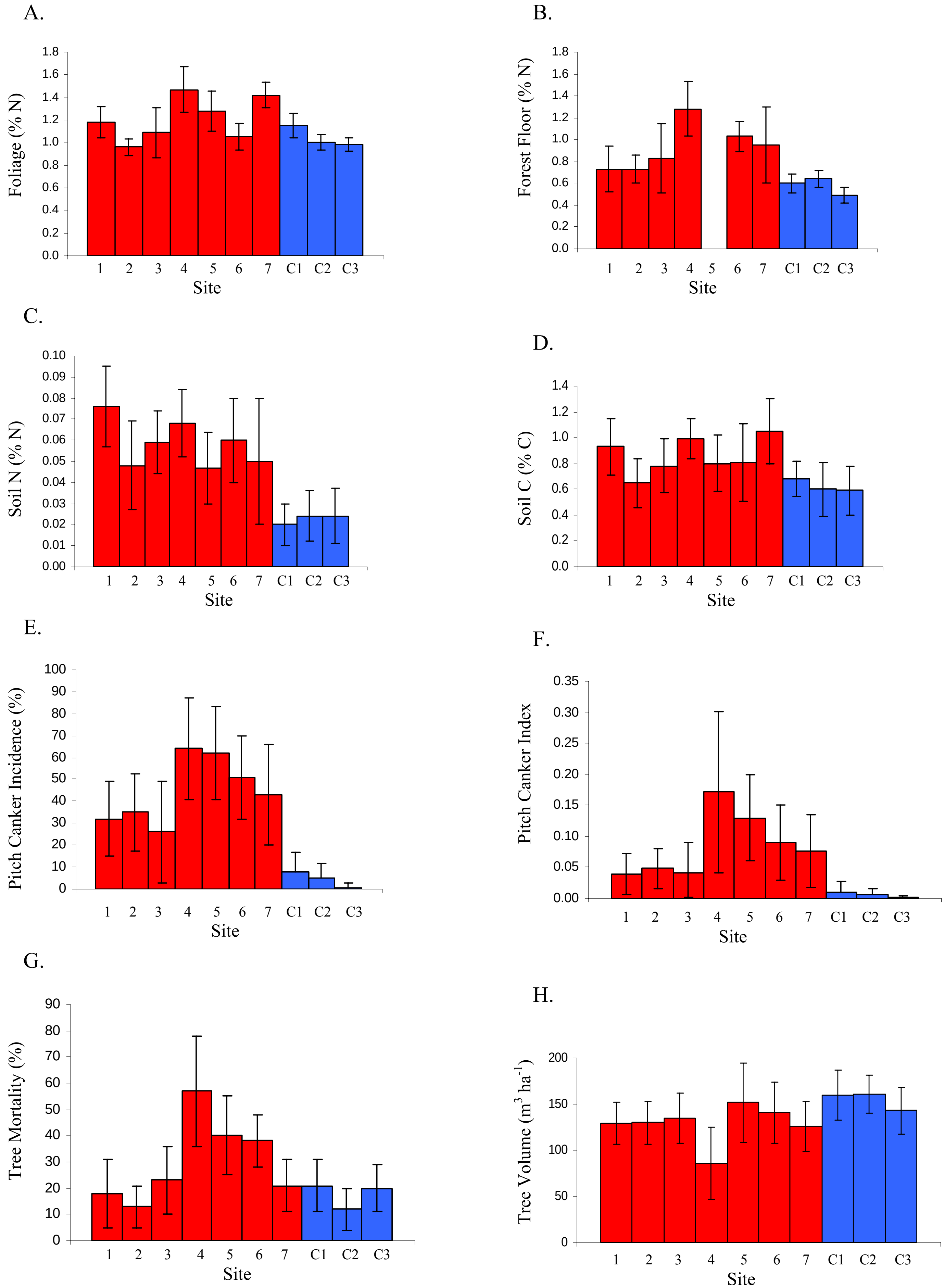
Figure 35.



A.
Foliage (% N)
Site
1 2 3 4 5 6 7 C1 C2 C3
B.
Forest Floor (% N)
Site
1 2 3 4 5 6 7 C1 C2 C3
C.
Soil N (% N)
Site
1 2 3 4 5 6 7 C1 C2 C3
D.
Soil C (% C)
Site
1 2 3 4 5 6 7 C1 C2 C3
E.
Pitch Canker Incidence (%)
Site
1 2 3 4 5 6 7 C1 C2 C3
F.
0.75
Pitch Canker Disease Index
Site
1 2 3 4 5 6 7 C1 C2 C3
G.
Tree Mortality (%)
Site
1 2 3 4 5 6 7 C1 C2 C3
H.
Tree Volume (m3 ha-1)
Site
1 2 3 4 5 6 7 C1 C2 C3

Figure 36. Study plantation means and standard deviations for parameters assessed. Sites 1-7 denote plantations proximal to poultry houses. C1, C2, and C3 denote "control" plantations distant from poultry houses.

Figure 36.


A.
Foliage (% N)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
1 2 3 4 5 6 7 C1 C2 C3
Site
B.
Forest Floor (% N)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
1 2 3 4 5 6 7 C1 C2 C3
Site
C.
Soil N (% N)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
1 2 3 4 5 6 7 C1 C2 C3
Site
D.
Soil C (% C)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1 2 3 4 5 6 7 C1 C2 C3
Site
E.
Pitch Canker Incidence (%)
0
10
20
30
40
50
60
70
80
90
100
1 2 3 4 5 6 7 C1 C2 C3
Site
F.
Pitch Canker Index
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
1 2 3 4 5 6 7 C1 C2 C3
Site
G.
Tree Mortality (%)
0
10
20
30
40
50
60
70
80
90
1 2 3 4 5 6 7 C1 C2 C3
Site
H.
Tree Volume (m3 ha-1)
0
50
100
150
200
1 2 3 4 5 6 7 C1 C2 C3
Site

Figures 37 – 44. Distance relationships between poultry house fans and foliar N, forest floor N, soil N, soil C, pitch canker incidence, pitch canker disease index, tree mortality and tree volume; presented as average predicted values from interpolation maps (10 m intervals).

Figure 37. Foliar N

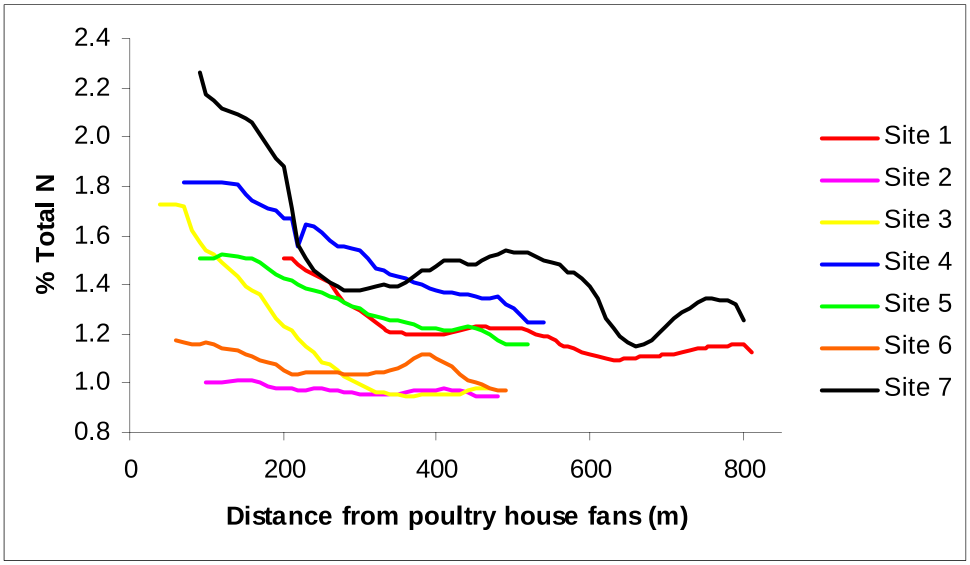


Figure 38. Forest Floor N

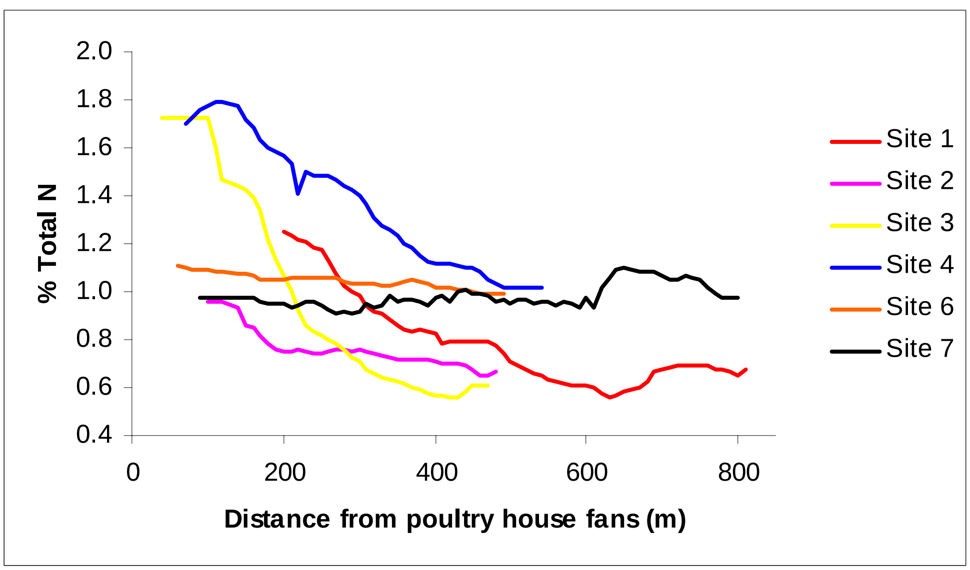


Figure 39. Soil N

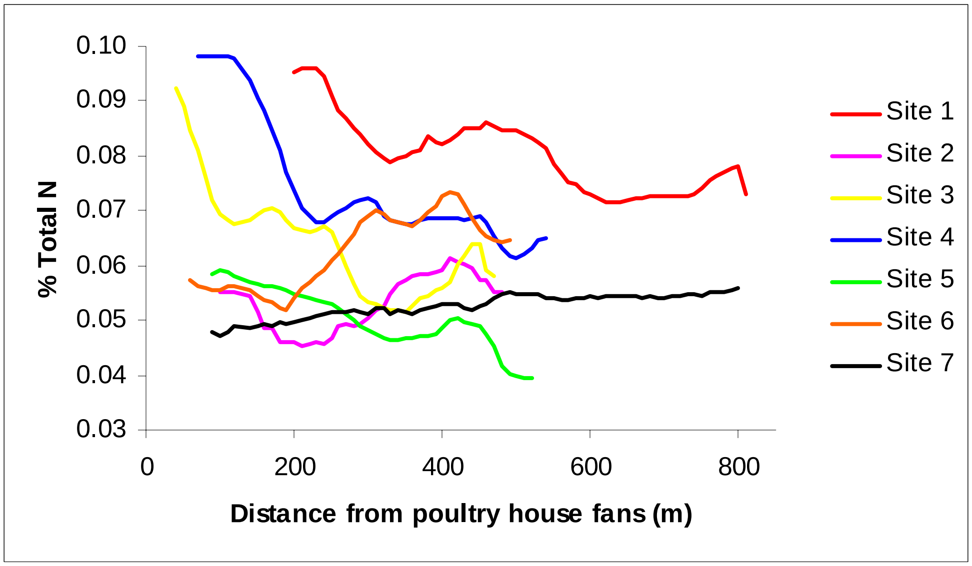


Figure 40. Soil C

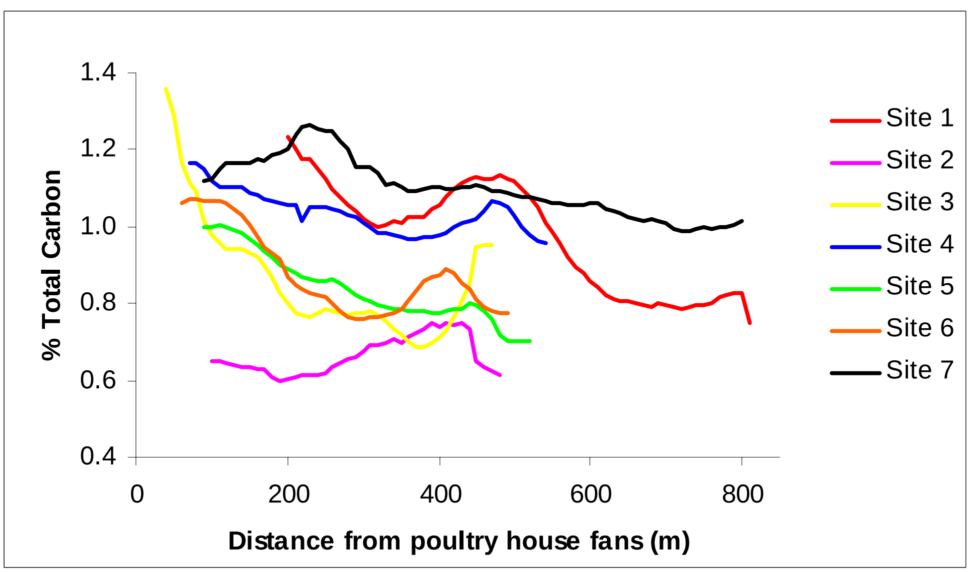


Figure 41. Pitch Canker Incidence

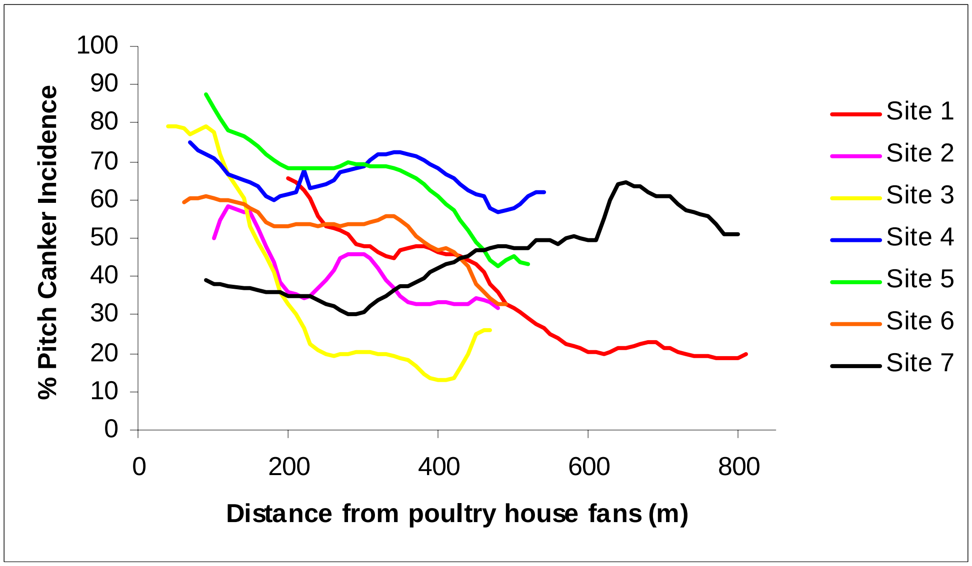


Figure 42. Pitch Canker Disease Index

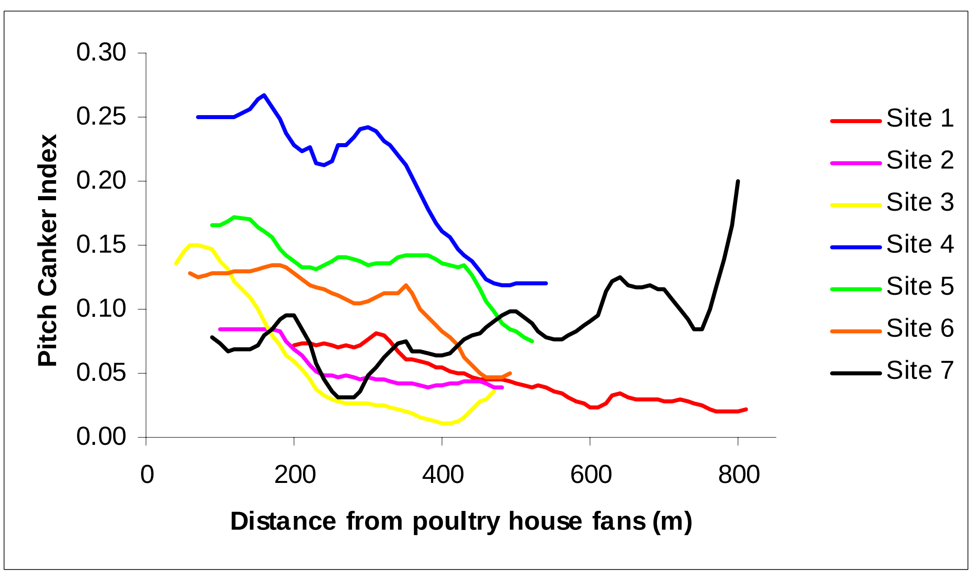


Figure 43. Tree Mortality

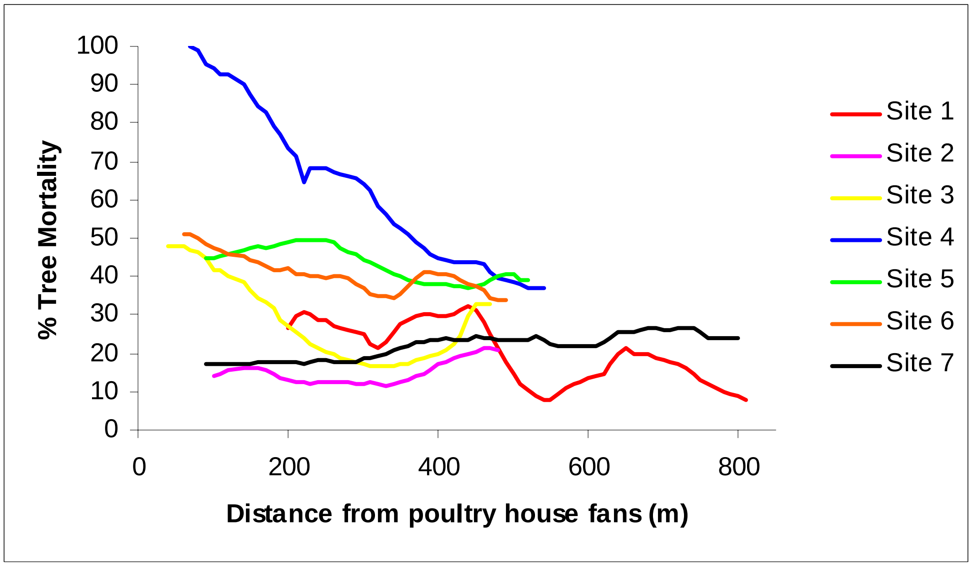


Figure 44. Tree Volume