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FINAL PROGRESS REPORT ON MODEL-BASED DIAGNOSIS OF SOIL LIMITATIONS TO FOREST PRODUCTIVITY

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MODEL-BASED DIAGNOSIS OF SOIL LIMITATIONS TO FOREST PRODUCTIVITY

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Contents

Abstract

This project was undertaken in support of the forest industry to link modeling of nutrients and productivity with field research to identify methods for enhancing soil quality and forest productivity and for alleviating soil limitations to sustainable forest productivity. The project consisted of a series of related tasks, including (1) simulation of changes in biomass and soil carbon with nitrogen fertilization, (2) development of spreadsheet modeling tools for soil nutrient availability and tree nutrient requirements, (3) additional modeling studies, and (4) evaluation of factors involved in the establishment and productivity of southern pine plantations in seasonally wet soils. This report also describes the two Web sites that were developed from the research to assist forest managers with nutrient management of Douglas-fir and loblolly pine plantations.

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1. INTRODUCTION

Significant gains in forest productivity have been demonstrated in field research, particularly through nutrient management and by vegetation control during plantation establishment. Examination of such treatments on a broader range of soil types is needed as well as the ability to extrapolate from field sites to multiple sites and for different species. Methods to extrapolate results of this type of field research over a wide range of soil and climate conditions are needed to identify practices that can improve soil quality and tree crop productivity. The development and testing of spreadsheet modeling tools provides a practical means to meet this need. Ultimately, the application of such tools by forest managers will enhance the efficient use of nutrients, increase forest productivity in sustainable forest management operations, and reduce the production costs by matching site and tree crop nutrient requirements.

The objective of this project was to link modeling of nutrients and productivity and field research in support of the forest industry to identify methods for enhancing soil quality and forest productivity and for alleviating soil limitations to sustainable forest productivity. The project included a series of tasks involving both field experiments and development of modeling tools that can be used for assessing fertilization requirements for forest management of loblolly pine plantations in the Southeast and Douglas-fir (*Pseudotsuga menziesii*) stands in the Pacific Northwest. As part of the project, a field experiment exploring the potential production of loblolly pine (*Pinus taeda*) on seasonally wet soils was implemented in 1999 to examine mechanisms for establishment and management to enhance tree growth in soils typical of the western Gulf Coastal Plain. In addition to research reports and peer-reviewed publications, the tools and information developed by this project have been made available to forest managers and researchers through the development of two Web sites (see Sect. 2.5).

2. RESULTS

The project supported a series of related tasks, including (1) simulation of changes in biomass and soil carbon with nitrogen (N) fertilization, (2) development of spreadsheet modeling tools for evaluating soil nutrient availability and tree nutrient requirements, (3) additional modeling studies, and (4) evaluation of factors involved in the establishment and productivity of southern pine plantations in seasonally wet soils. Two Web sites have been developed to make the results of the project available to forest managers and researchers.

2.1 OPTIMUM YIELD POTENTIAL OF SOUTHERN PLANTATIONS

Changes in biomass and soil carbon with N fertilization were simulated for a 25-year loblolly pine plantation and for 3 consecutive 7-year, short-rotation cottonwood stands at 17 locations in the southeastern United States. The LINKAGES model was used and results were compared on a thermal basis of growing-degree-days for the 17 locations that ranged in mean annual temperature from 13.1 to 19.4°C. Loblolly pine stands increased in biomass with N fertilization and warming (increasing growing-degree-days) showing additive responses. An interaction response was found for cottonwood. Unfertilized cottonwood stands tended to decline (not significantly) in biomass at warmer locations, whereas a large biomass response to fertilizer N in all cottonwood rotations at cooler locations declined significantly at warmer sites. Soil carbon tended to increase with warming in both loblolly and cottonwood plantations. Nitrogen fertilizer effects on soil carbon were small or not significant.

The loblolly pine version of the 3PG growth model has been implemented as an Excel® spreadsheet simulator. The model was previously calibrated with loblolly pine information from the SETRES site in North Carolina by J. Landsberg and K. Johnsen. This spreadsheet model is made available on the project's two Web sites for use in the estimation of target forest production for loblolly pine and Douglas-fir.

A paper by Luxmoore et al. (2002), "Addressing Multi-Use Issues in Sustainable Forest Management with Signal-Transfer Modeling," was published in *Forest Ecology and Management*. This contribution describes a method for making management decisions using signal-transfer through a hierarchy of simulation models. The integrated responses (signal) from a smaller scale physiological model are transferred and incorporated into larger spatial- and temporal-scale models of forest growth. Use of the approach for sustainable forest management is outlined in the paper.

2.2 SOIL NUTRIENT AVAILABILITY AND TREE NUTRIENT REQUIREMENTS

The Nutrient Cycling Spreadsheet (NuCSS), a spreadsheet-based model that simulates cycling of C, N, P, S, K, Ca and Mg in forest ecosystems with simple, often empirically derived relationships, has been developed as an intermediate approach between highly complex, process-based simulation models and nutrient bookkeeping. The latest versions of NuCSS have been modified so that the modeling results regarding vegetation as generated by the Nutrition Requirement Spreadsheet (REMSS) can be entered into the model—there is no direct feedback between the NuCSS and REMSS models so biomass production is imposed on the NuCSS model.

A version of NuCSS has been developed where vegetation growth and litterfall are calculated using simple logistic growth functions. The NuCSS model was applied to a mixed-oak forest near Oak Ridge, Tennessee, and a loblolly pine stand near Durham, North Carolina (Verburg and Johnson 2001), as part of the calibration process for this version. Simulated nutrient distribution generally corresponded with measurements for both stands. However, NuCSS simulated much lower soil N accumulation for the mixed-oak stand. The measured accumulation was much higher than could be explained by known inputs through deposition, suggesting a measurement error or an unknown input of N (e.g., N fixation). The simulated forest floor mass for the loblolly pine stand was much lower than field measurement values—the difference was ascribed to the presence of a forest floor prior to planting. The NuCSS simulations suggested that there was not enough inorganic N available to sustain the imposed biomass production in either the oak or pine stands. Either the model underestimated N mineralization, or an additional N input (e.g., N fixation) was present and not captured in the simulations. Although the model was useful to assess fertilizer requirements and to provide guidance for fertilization, a quantitative use of NuCSS for fertilizer recommendations may not be justified given the uncertainties in the representation of some of the ecosystem processes. These same uncertainties also apply to more complex nutrient cycling models. These limitations of the models based on simulations with available information serve to identify data needs to support model predictions of production needs and to identify potential limitations.

Versions of REMSS for loblolly pine and Douglas-fir have been developed and calibrated. Initial parameters for the Douglas-fir model have been identified. Testing against published nutrient cycle components for Douglas-fir has been completed. Several scenarios—some based on growth and yield models, some based on empirical data—have been run for both the Douglas-fir and loblolly pine versions of REMSS. In addition, some limited testing of the loblolly version against what its predecessor model predicts for loblolly pine stands where more is known about the nutrient cycle has been completed. The comparison of the different models is difficult because the spreadsheet version to date can be run only for rotation-length, and there are no rotation-length studies of the complete nutrient cycle in loblolly pine. The Douglas-fir simulations have been run using data bases from three sites in the Pacific Northwest, but results overall are constrained because insufficient published information is available to adequately parameterize the model, much less adequately test the outputs against independent data. This data gap was identified early on in the process of the spreadsheet development. A paper describing the loblolly pine model, "Nutrient Supply and Fertilization Efficiency in Midrotation Loblolly Pine Plantations: A Modeling Analysis," has been published in *Forest Science* (Ducey and Allen 2001).

Development of fertilizer application modeling with the NuCSS spreadsheet model for Douglas-fir and loblolly pine has been completed. The DIAGNOSIS spreadsheet model for estimation of the nutritional status at forest sites is available on the two Web sites.

NuCSS, its predecessors, and successors are meant to be complementary and modular—not a single comprehensive model that would fill all needs but a series of simpler models that would address specific needs. Previous versions have attempted to assess growth response to fertilization in a Douglas-fir forest (Johnson and Harrison 1998) using a model that was very specifically calibrated to a certain forest ecosystem.

Currently, there are three versions of the NuCSS model: one version includes very simple growth functions and allows for feedback between N limitations and plant growth (NuCSS.1x); a second version uses vegetation biomass, nutrients, and litterfall as calculated by the Nutrition Requirement Spreadsheet (REMSS) model (NuCSS.2x). In this second version, there is no feedback between nutrient availability and plant growth/litter production. The main aim of this version is to assess potential fertilization requirements to match the imposed nutrient demand by the vegetation.

The latest version of the model, NuCSS.3x, builds on the previous versions through a consolidation of user inputs and has been modified to integrate the nutrient and vegetation results generated by REMSS into the model. Using the vegetation production results from REMSS, NuCSS calculates if nutrient supply through deposition, mineralization, and mineral weathering is sufficient to sustain the imposed biomass production. If demand is greater than supply (i.e., if exchangeable base cations or N become negative), fertilization is required.

Consequently, fertilizer has to be added until base cations or N become positive. A user manual has been prepared for NuCSS (Verberg and Johnson 2000) and is available on the Douglas-fir and loblolly pine Web sites (see Sect. 2.5).

In a related effort supported by the Nevada Agricultural Experiment Station,[1] the NuCSS model has also been tested and modified to a simpler format for use in assessing the effects of fire on forests of the southwestern United States. Because of past fire suppression, excessive fuel buildups in forests of this region have produced conditions conducive to catastrophic wildfire, and prescribed fires combined with mechanical biomass removal are needed to mitigate this problem. Forest fires in the southwest within the past several years and the issues surrounding salvage harvesting continue to show the need for these models to assess nutrient effects. Since these forests are N-limited, there are concerns over the effects of these harvesting practices on N removal, and NuCSS can be used to help assess these effects. Modifying NuCSS to assess natural forest yields and biomass loading can assist industry with management of their natural forest lands as well as intensive tree crops to ensure sustainable site and nutrient management while meeting fiber needs.

2.3 MODELING STUDIES

The NuCM model was developed in the early 1990s to explore potential effects of atmospheric deposition, fertilization, and harvesting in forest ecosystems. As a stand-level model, NuCM incorporates all major nutrient cycling processes (uptake, translocation, leaching, weathering, organic matter decay, and accumulation). NuCM simulates the cycling of N, P, K, Ca, Mg, Na, and S based on expected optimal growth rates (input by the user and reduced in the event of nutrient limitation), user-defined litterfall, weathering, N and S mineralization rates, soil minerals composition, initial litter and soil organic pools, and C/N ratios. NuCM has been applied to forest ecosystems covering a large range in vegetation, soil, and climate conditions to simulate the effects of changing atmospheric deposition, harvesting, species change, precipitation, increased temperature, elevated $C0_2$, and liming.

Long-term patterns in nutrient cycling in regrowing Douglas-fir and red alder on both Douglas-fir and red alder soils were simulated using NuCM (Verburg, Johnson, and Harrison 2001). These simulations indicated that

1. prolonged presence of red alder causes a depletion in soil base cations as a result of increased nitrification and nitrate leaching;
2. lower base cation availability under red alder ultimately causes biomass production to decline;
3. high N availability in red alder soils favors regrowth of Douglas-fir;
4. higher base cation and P status of the Douglas-fir soils favors growth of red alder both in the short and long term since N is not limiting to red alder; and
5. in regrowing red alder, nitrate leaching increases with time as a result of increased N fixation.

[1] Johnson, D. W., R. B. Susfalk, R. A. Dahlgren, and J. M. Klopatek 1998. "Fire is More Important than Water for Nitrogen Fluxes in Semi-Arid Forests," *Envir. Sci. and Pol.* **1**:79-86.

The effect of soil type on biomass production was very small both for red alder and Douglas-fir. NuCM did not fully elucidate differences in P cycling between Douglas-fir and red alder. NuCM overestimated weathering rates under Douglas-fir and overestimated H^+ input resulting from N fixation in red alder because of the way in which N fixation must be simulated (as atmospheric ammonium input).

NuCM was used to investigate the effects of increased temperature [air and soil (+4°C) and soil only (+4°C soil)] and changing precipitation (increased and decreased) on biogeochemical cycling at five forest sites: a *Picea rubens* forest at Noland Divide in the Great Smoky Mountains, North Carolina; a mixed deciduous at Walker Branch, Tennessee, and Coweeta, North Carolina; a *Pinus taeda* forest at Duke, North Carolina; and a *P. eliottii* at Bradford, Florida (Johnson et al**.** 2000). Simulations of increased air temperature and reduced or increased precipitation caused changes in soil water flux, but increased soil temperature alone had no effect. Both increased temperature scenarios caused N release from forest floors at all sites. At the N-saturated Noland Divide site, this resulted in no change in N uptake or growth but increased nitrate leaching. Among the four N-limited sites, increased temperature stimulated growth at only two (Coweeta and Duke) but did cause increased nitrate leaching at three (Coweeta, Duke, and Bradford), indicating that N released from the forest floor was not efficiently taken up by the vegetation. Reduced precipitation caused long-term increases in soil exchangeable base cations as well as adsorbed phosphate at all sites. Both increased temperature scenarios and reduced precipitation increased soil solution mineral acid anion and Al concentrations at the Noland Divide site.

A review of the lessons learned from various NuCM applications (Johnson, Sogn, and Kvindesland 2000) led to the conclusion that the model has been more successful in matching decadal-scale changes in nutrient pools and soils and less successful in capturing intra-annual variations in soil solution chemistry. The NuCM model, like all models, can use improvements and these have been suggested; however, the current model has provided valuable insights into nutrient cycling in forest ecosystems, including the potential for short-term soil change and the great importance of nutrient translocation in N cycling.

Modeling of biosolids applications to three forest types with the LINKAGES model showed gains in productivity that were greatest for Douglas-fir, intermediate for loblolly pine, and smallest for eastern hardwood forest. Biosolids can be a beneficial resource for enhancing forest productivity (Luxmoore, Tharp, and Efroymson 1999). The forest industry is encouraged to expand cooperation with municipalities for enhancing the recycling of biosolids on commercial forest land.

2.4 PLANTATION ESTABLISHMENT AND PRODUCTIVITY IN SEASONALLY WET SOILS

There is a significant area of seasonally wet, somewhat poorly drained soils in southern Arkansas, Texas, and Louisiana with good potential for intensive production of southern pines. However, cultural practices are required to optimize growth and to sustain productivity in these areas. The objectives of the research are to clarify some of the factors important in promoting growth and sustaining productivity. Ten research sites were established in southern Arkansas (four in 1998 and six in 1999). Each of the four sites established in 1998 has four plots (all bedded with a combination plow—noted as BED below) treated with one of the following treatments:

1. control (BED-N) received no treatment,
2. continuous complete vegetation control (BED-CV) until canopy closure,
3. continuous fertilization (BED-F) as per needle nutrient analysis, and
4. continuous fertilization and continuous vegetation control (BED-CVF).

In 1999, six new sites were established with the above four treatments and two additional plots with no bedding (FP for flat planting) in each site with the following treatments:

1. control (FP-N) received no treatment and
2. fertilization and vegetation control at year of planting (FP-CVF). The following data are being collected since the establishment of the sites:

- height and root collar diameter (RCD) growth at the end of each growing season;
- needle nutrient analysis for macro- and microelements;
- leaching loss of nutrients to the fragipan by means of suction cup lysimeters;
- fine root growth from minirhizotron color video monitoring;
- xylem pressure potential diurnally at five different periods (0400, 0900, 1200, 1500 and 1800 hours) at different sampling sessions in each growing season;
- water relations data (stomatal conductance, transpiration, vapor pressure deficit) at the same time and session as water stress data by using a Li-Cor 6200;
- gas exchange data such as CO_2 assimilation rate, stomatal conductance for $C0_2$, and intercellular CO_2 concentration using a Li-Cor 6250.

In 1999, a herbicide labeled for loblolly pine release was unintentionally used to reduce competition; however, conditions at the time of application caused unacceptable mortality of study seedlings in some sprayed plots. Nevertheless, observations in the 2000 growing season indicated that damaged seedlings were regaining vigor. Seedling mortality was difficult to determine for certain sprayed plots as a result of confounding of natural factor and chemical spray impacts. An assessment of seedling vigor in December 1999 revealed spray damage ranging from no damage of certain plots to almost complete seedling mortality in other plots.

The study continued on all plots in all sites and treatments in 2000. Of the seedlings that survived the spray, the height growth was greatly reduced and the expected increased seedling height in CV and CVF plots over that in the control (N) was not observed. However, fertilized plots showed increased height growth over that in the control in both the 1998 and 1999 planted sites. Root collar diameter growth was significantly higher ($P < 0.0001$) for all treatments than the control in the 1999 sites and for the CVF treatment in the 1998 sites.

Minirhizotron video images were taken at the end of 1999 growing season to estimate fine root growth and root turnovers from different treatments. Needle samples were taken in January 2000 for nutrient analysis. Mean foliar nutrient values were not significantly different in the 1998 sites and most of the 1999 sites, although nutrient concentrations may possibly decrease in foliage of fertilized plots in association with increased leaf area (i.e., a dilution effect).

Lysimeter water samples were collected periodically to evaluate nutrient leaching. Soil solution volumes were measured and nutrient concentrations were determined. Soil solution N concentrations in the 1998 sites were relatively high in the complete vegetation control plots (CV and CVF). Nitrogen concentration was lowest in the fertilized only (F) treatment, perhaps because of greater uptake and immobilization associated with enhanced growth of vegetation than in the control (N) plots. This result was not found in the 1999 sites, where fertilization and vegetation control treatments leached more N than the control plots. Phosphorus in soil solution showed no significant treatment effect. Base cations (K, Ca, and Mg) generally leached more in the fertilized plots (F and CVF) in both 1998 sites and 1999 sites. Bedding did not significantly affect soil solution nutrient concentrations. Reduced competition and evapotranspiration from the vegetation control plots (CV and CVF) resulted in more available water in both the 1998 and 1999 sites.

Water relations data were collected at three different sampling sessions in the 1999 growing season. Soil water content increased with vegetation control, resulting in improved plant water status in these plots. Transpiration and stomatal conductance were at a minimum level early in the day and increased until 1500 hours for all treatments. Seedlings from the CVF treatment showed maximum transpiration and stomatal conductance throughout the day, while the control seedlings showed the least.

Seedlings from all treatments showed significantly higher ($P < 0.0001$) net photosynthesis than the control. Vegetation control and fertilization showed an additive effect on net photosynthesis assimilation. Also, CVF seedlings had higher intercellular CO_2 concentration and stomatal conductance than the control (N).

Data collection continued until project termination in December 2000. All data were then analyzed to evaluate treatment effects, resulting in the following conclusions:

- fertilization increased height and RCD of seedlings,
- height and RCD growth and seedling survival on vegetation control plots cannot be determined due to spray damage,
- no significant differences in needle nutrient concentrations were observed,
- treatment effects on nutrient concentrations in soil solution were variable,
- vegetation control increased soil water status and improved seedling water relations, and
- continuous vegetation control and fertilization increased net photosynthesis of seedlings.

Overall maximum height has been attained on sites where fertilizer alone (F) was applied. Significantly ($\alpha=0.05$) more height growth has been observed due to bedding (BED-N) compared with no-bedding (FB-N). Substantial increases in survival (67% vs 97%, respectively) have occurred with bedding compared with no bedding. Decreases in soil moisture availability, presumably as the result of changes in soil physical parameters and soil drainage, have occurred with bedding. This decreased soil moisture affects survival. Presence of subsoil moisture was determined to be more critical to survival during droughts than presence of soil moisture in the upper 15 cm. Vegetation control without nutrient addition or bedding did not increase productivity.

A related study by Texas A&M University in 2001 involved laboratory analyses of lysimeter soil solution samples and needle digests for nutrients. In addition, a complete analysis of seedling height and groundline diameter (GLD) growth was done for all sites established in 1999. The results showed that sites and treatments significantly ($P < 0.0001$) affected both height and GLD, and there was a strong site/treatment interaction ($P < 0.0001$). Bedding significantly ($P < 0.0001$) increased height and GLD on all sites. Within any site preparation class (bedding or flatplanting), fertilization significantly ($P < 0.0001$) increased height and GLD. Chemical vegetation control reduced tree growth in the first year; however, this effect disappeared in the second growing season.

Treatment responses were variable among sites. Some sites showed expected growth responses—such as increased height and growth from both chemical vegetation control and fertilization—and an additive response from both applied together. However, at others, there was reduced growth from chemical vegetation control and fertilization applied separately but increased growth from both applied together, reflecting a strong additive effect. The variation in responses can most likely be explained by soil-site physical characteristics such as depth to fragipan, bedding stability, duration of waterlogging, and other pertinent variables. The scope of the study did not permit measurement of these factors.

2.5 LOBLOLLY PINE AND DOUGLAS-FIR WEB SITES

Two Web sites were developed to make the models and related information available to potential users. The project has been used to explore use of existing general nutrient data to support the Douglas-fir and loblolly pine models because of the limitations in existing data to generate desired site specific map units. Both the Douglas-fir and loblolly pine Web sites are available for access and trial by industry, recognizing that the models and Web sites are still in need of refinement and require beta testing with the forest industry users. The Douglas-fir Web site (http://depts.washington.edu/nitrogen/), is hosted at the University of Washington, while the loblolly pine Web site hosted at Oak Ridge National Laboratory can be found at http://loblolly.esd.ornl.gov/. Pages from the loblolly pine Web site are reproduced in Appendix A.

The Web sites provide background information on the project, an overview of the models available, a detailed description of the NuCSS and REMSS spreadsheet models, discussion of several other models that can be used to provide some of the input needed, guidance regarding use of the models and data input, links to sources of publicly available information that may provide some of the input data needed, and directions for downloading the spreadsheets. The REMSS and NuCSS models have been linked on the loblolly pine Web site so that the user is provided with a single set of input data sheets. Once the input data are entered, the output from the REMSS spreadsheet is automatically input to the NuCSS spreadsheet. Appendix B of this report provides documentation for the macro that was developed to link these two spreadsheet models.

Site-specific input data are generally needed for the site being modeled, but some of the data may be available from public databases such as the State Soil Geographic Database

(STATSGO) and from the literature. The loblolly pine Web site provides links to STATSGO and other useful data sources. As in all models of its type, there are uncertainties in NuCSS, including weathering (the release of nutrients from soil minerals to the exchanger and soil solution), fertilizer N retention in soils, and atmospheric N_2 fixation. The model is designed such that the user sets weathering rates and other uncertain parameters during calibration. Atmospheric N_2 fixation is not accounted for in the current version of the model.

One of the most attractive features of the model is the ease of calibration. The users can immediately view the results of their adjustment of various parameters in a series of conveniently located charts and can do multiple runs to assess the options for obtaining target growth. Users may also produce their own charts from spreadsheet information. This spreadsheet model is designed to be applicable to a wide variety of soil/vegetation types. Some of the data required to run the model may be obtained from publicly available data sources, while other data may need to be sampled for the specific site. As a tradeoff, the spreadsheet offers less in the way of prediction than more complex models requiring much more detailed data. The continuing challenge is to achieve a balance between mechanistic realism and user-friendliness and generality.

3. PROJECT PUBLICATIONS

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Appendix A

PAGES FROM THE LOBLOLLY PINE STANDS WEB SITE

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Welcome to the **Nutrient Management for the Enhanced Productivity of Loblolly Pine Stands** site. This site contains information and management tools related to modeling nutrient requirements and growth patterns of Loblolly Pine stands. The site will be of particular interest to forest managers and researchers involved in modeling or increasing the productivity of Loblolly Pine stands.

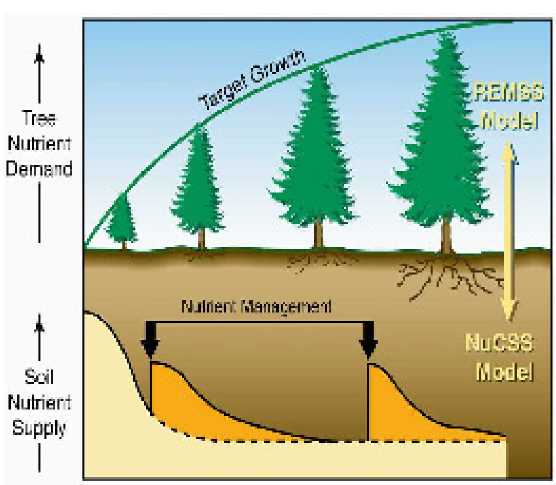
Background

The U.S. Department of Energy, Office of Industrial Technologies, the American Forest and Paper Association and the National Council for Air and Stream Improvement have established a Government and Industry partnership to increase the productivity and energy efficiency of the forest products industries. A cooperative agreement for this partnership is established through the Agenda 2020 Program.

A project on "Model-based Diagnosis of Soil Limitations to Forest Productivity," supported by the U.S. Department of Energy, Office of Industrial Technologies, is a contribution to the "Sustainable Forestry" component of the Agenda 2020 Initiative in Forest Products. Scientists from three universities (University of New Hampshire, Durham; University of Nevada at Reno and the Desert Research Institute; University of Washington, Seattle) and Oak Ridge National Laboratory are cooperating with Weyerhaeuser Co. scientists in this Agenda 2020 project to provide methods for determining site-specific nutrient management protocols for enhanced productivity of Loblolly Pine stands in the Southeastern U.S. This web site is provided as an aid to forest managers for development of nutrient management protocols that support enhanced sustainable forest production. The term "enhanced sustainable" is used to indicate the goal of sustained high productivity from forest land through intensive management. Spreadsheet tools, using Microsoft® Excel(tm)* software, are provided along with data sources to supplement site-specific data available to managers from their company databases. The spreadsheet tools can be downloaded from this web site. Links to additional information and data are also provided. Explanations are given on the selection of input data, spreadsheet calculations and display of results. Alternative calculations for various target productivity and nutrient management scenarios may be compared.

The primary tools available on this site include the REMSS (Nutrition Requirement Spreadsheet) and the NuCSS (Nutrient Cycling Spreadsheet) models.

Publications which report the results of this project can be found in the Project Publications section on the Links page.



The REMSS spreadsheet model has been calibrated with data relevant to loblolly pine stand nutrient requirements (also known as LobREMSS) and provides an input to the NuCSS spreadsheet. Users may modify the REMSS spreadsheet parameters if they wish to set their own target growth levels. The NuCSS spreadsheet contains a macro that links to the REMSS spreadsheet and provides data entry screens for soil and fertilization data. Graphs are generated in the NuCSS spreadsheet that identify any anticipated shortfall in fertilization requirements. The user can use the spreadsheet tools to vary the fertilization values over a period of years in order to meet targeted minimum levels.

Links to data resources and guidance are provided on this web site for the soil and atmospheric data that are required for the NuCSS spreadsheet. While the site focuses primarily on the REMSS and NuCSS spreadsheets, additional links to models, resources, and data related to forest management are provided in the Nutrient Management Tools section of the web site.

A related site devoted to the management of Douglas-fir stands in the Pacific Northwest has been developed at the University of Washington. Both sites host spreadsheet models that can be used to identify nutrient, and therefore fertilization requirements to achieve target stand growth rates.

** Identification and use of specific commercial software is provided for user convenience and does not represent unique endorsement of the named products.*

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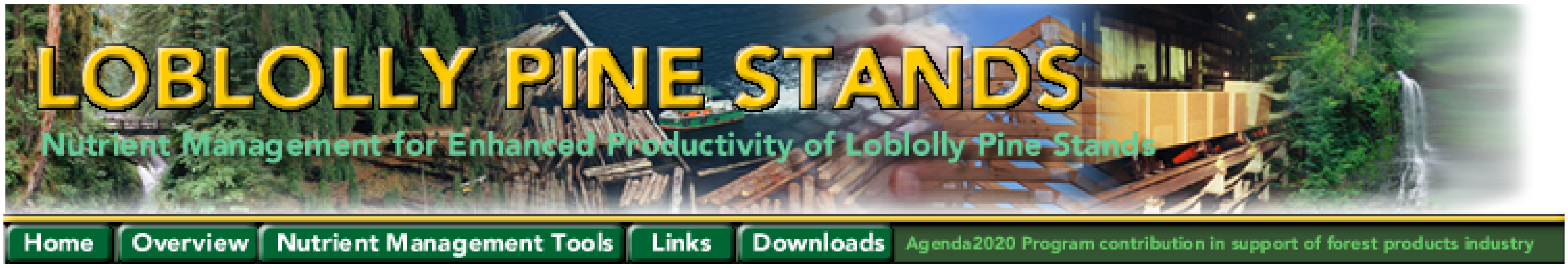
Nutrient Management for Enhanced Productivity of Loblolly Pine Stands

Agenda2020 Program contribution in support of forest products industry



Overview

Introduction

Guidance on the nutrient management requirements to support enhanced productivity goals for plantations of loblolly pine *(Pinus taeda)* in the southeastern United States or of Douglas-Fir (*Pseudotsuga menziesii*) in the northwestern United States has been developed. A suite of Excel spreadsheet calculations, derived by simplification of simulation models, is posted at two Internet web sites for use in stand management planning. A three-step procedure is involved.

First Step: Target Growth-REMSS

The REMSS model on the web site has been customized with general values for loblolly pine growth parameters (LobREMSS). A user may also provide estimates for the target productivity of a forest plantation at a specific site of interest (Fig. 1) Determination of target growth can be based on growth and yield data or modeling projections.

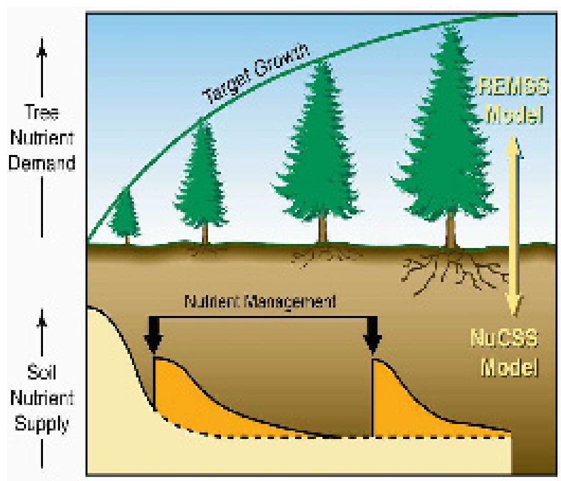


Fig. 1

Second Step: Nutrients Required-NuCSS

Annual values for trees/ha, basal area/ha, dominant height and stem wood volume or weight are inputs to the REMSS spreadsheet model **(Fig. 2a and b)**. REMSS calculates the nutrients (N, P, K, Ca, Mg) required to support the target growth, including the uptake of nutrients needed from soil **(Fig. 3a)** Annual results from REMSS (standing biomass, detritus inputs, and nutrient uptake from soil, **(Fig. 4a)** are next copied as a table of inputs to the NuCSS spreadsheet model. This transfer of data may be performed manually or may be initiated by the user from a macro on the NuCSS spreadsheet.

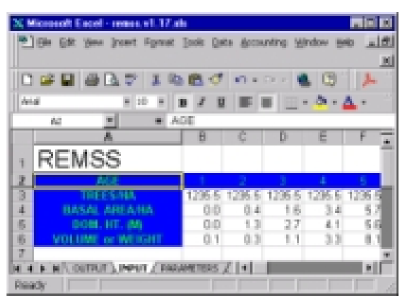


Fig. 2a. Input menus for REMSS and NuCSS

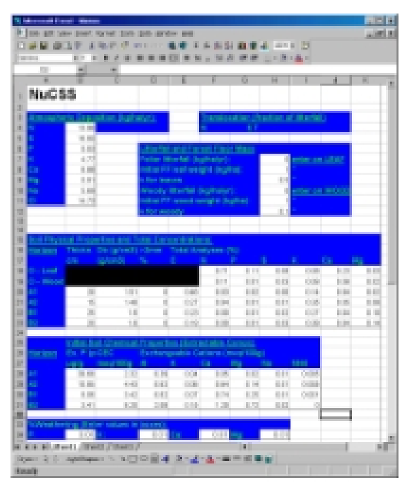


Fig. 2b. Input menus for REMSS and NuCSS

Third Step: Soil Nutrient Supply and Fertilizer Guidance

The NuCSS model **(Fig. 3b)** initially requires soil data for the selected site **(Fig. 4b)** that may be supplied from site measurements or estimated from site-specific analyses and published data sources. Using the fertilizer menu of NuCSS, the deficit between soil nutrient supply and tree nutrient requirements may be eliminated **(Fig. 4b)**. This provides guidance on the quantity and timing of fertilizer needed to sustain the target growth. The feasibility of enhancing target growth may be explored.

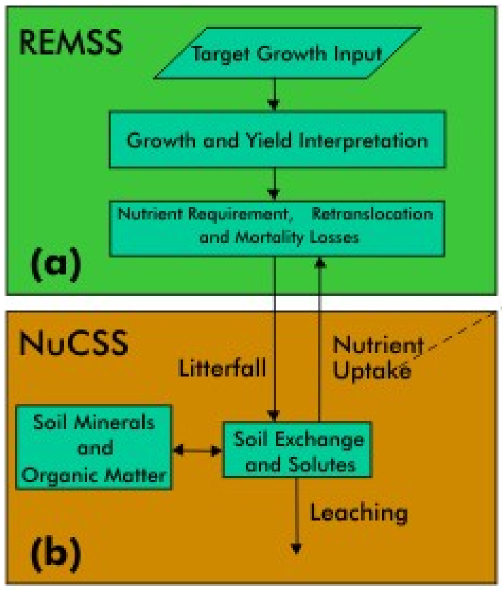


Fig. 3a,b. Spreadsheet models.

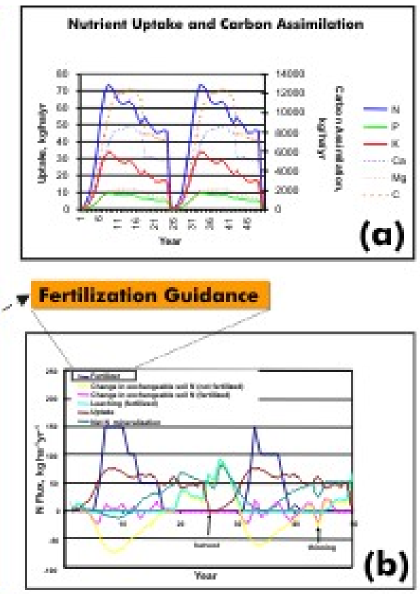


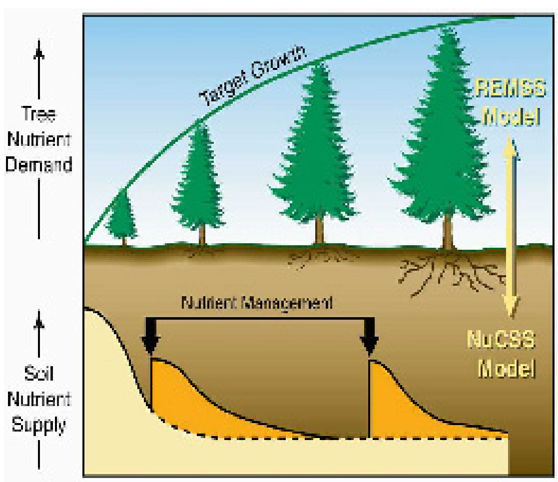
Fig. 4a,b. Results.

Research sponsored by the Office of Industrial Technologies and the Office of Biological and Environmental Research, US Department of Energy, in cooperation with the Pacific Northwest Stand Management Cooperative and North Carolina State Forest Nutrition Cooperative.

Fertilization management tools and resources for loblolly pine

Several steps may be taken to enhance forest productivity and successfully maintain the long-term nutritional requirements of intensively managed forests. These steps can result in economic benefits for loblolly pine management.

This site describes two spreadsheet models that can assist forest managers in assessing potential nutrient limitations and determining fertilization requirements to sustain target growth rates. The Nutrition Requirement Spreadsheet (REMSS) uses calibrated values for loblolly pine to calculate desired productivity, and the Nutrient Cycling Spreadsheet (NuCSS) simulates cycling of C, N, P, S, K, Ca, and Mg. REMSS calculates a desired biomass production level that is then exported to NuCSS, which calculates values for fertilization requirements. The forest manager may then enter fertilization values for a range of years to view whether nutrient requirements will sustain the target growth rate.



The versions of REMSS and NuCSS on this web site have been linked so that only one set of input values need to be entered. The user has the option, however, of modifying the calibrated values in REMSS in order to calculate alternative growth targets. Use of this model involves three steps.

Site characterization

- Collection of data on soil characteristics, climate, and landscape attributes for input to REMSS and NUCSS using data from the site itself and/or data sources such as the National Soils Characterization Database (NSCD), STATSGO, and atmospheric data from the National Atmospheric Deposition Program

Tree nutrient demand

- The Nutrient Requirement Spreadsheet (REMSS) models the above- and below-ground construction, nutrient content, and nutrient use associated with prescribed levels of stand growth

Tree nutrient supply

- The Nutrient Cycling Spreadsheet (NuCSS) model uses the output from REMSS and input of data from site characterization to estimate the available nutrients from the soil and the additional nutrients needed from fertilization to attain the desired level of growth

Additional tools and resources

The following tools and procedures are available for estimating the nutrient management requirements for enhanced sustainable productivity of loblolly pine stands.

Site diagnostics

- The Diagnosis spreadsheet can be used with data from foliar nutrient analysis and litter analysis from a loblolly pine site in a previous rotation or current stand to identify possible soil fertility limitations for enhanced growth at a site. These site measurements are inputs to the Diagnosis spreadsheet for determining nutrients in low supply and for evaluating potential fertilizer requirements.
- Download the Diagnosis spreadsheet and the user's manual.

Sustainable target

- Sustainable target productivity can be estimated for a specific site using available growth and yield data, predictions from complex models, or empirical estimates from experimental work such as that conducted by the North Carolina State Forest Nutrition Cooperative
- Important issues for obtaining enhanced sustainable forest productivity are site preparation, competition control, fertilization during establishment and mid-rotation fertilization.
- Target productivity can also be estimated with the 3PG model developed by Waring and Landsberg (1977, Forest Ecol. Manage. 95:209-228). This spreadsheet model has been calibrated for loblolly pine applications with data from The Southeast Tree Research and Education Site (SETRES) research. The spreadsheet simulates forest growth based on climatic data, site factors, and initial conditions.
- Download the 3PG model.

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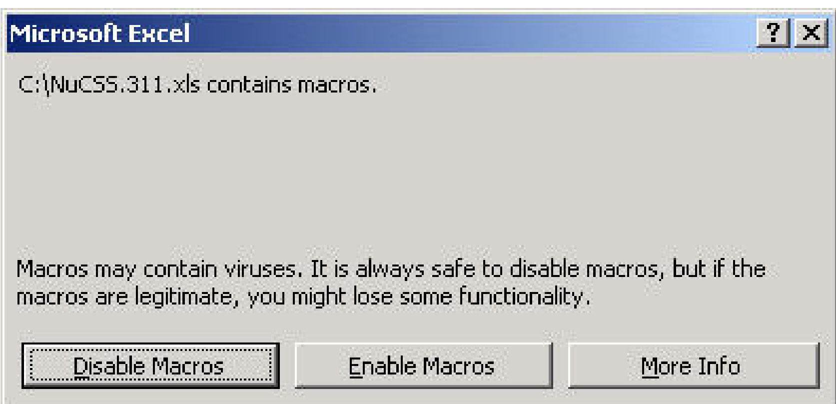
The Process - Using the NuCSS and REMSS Spreadsheets

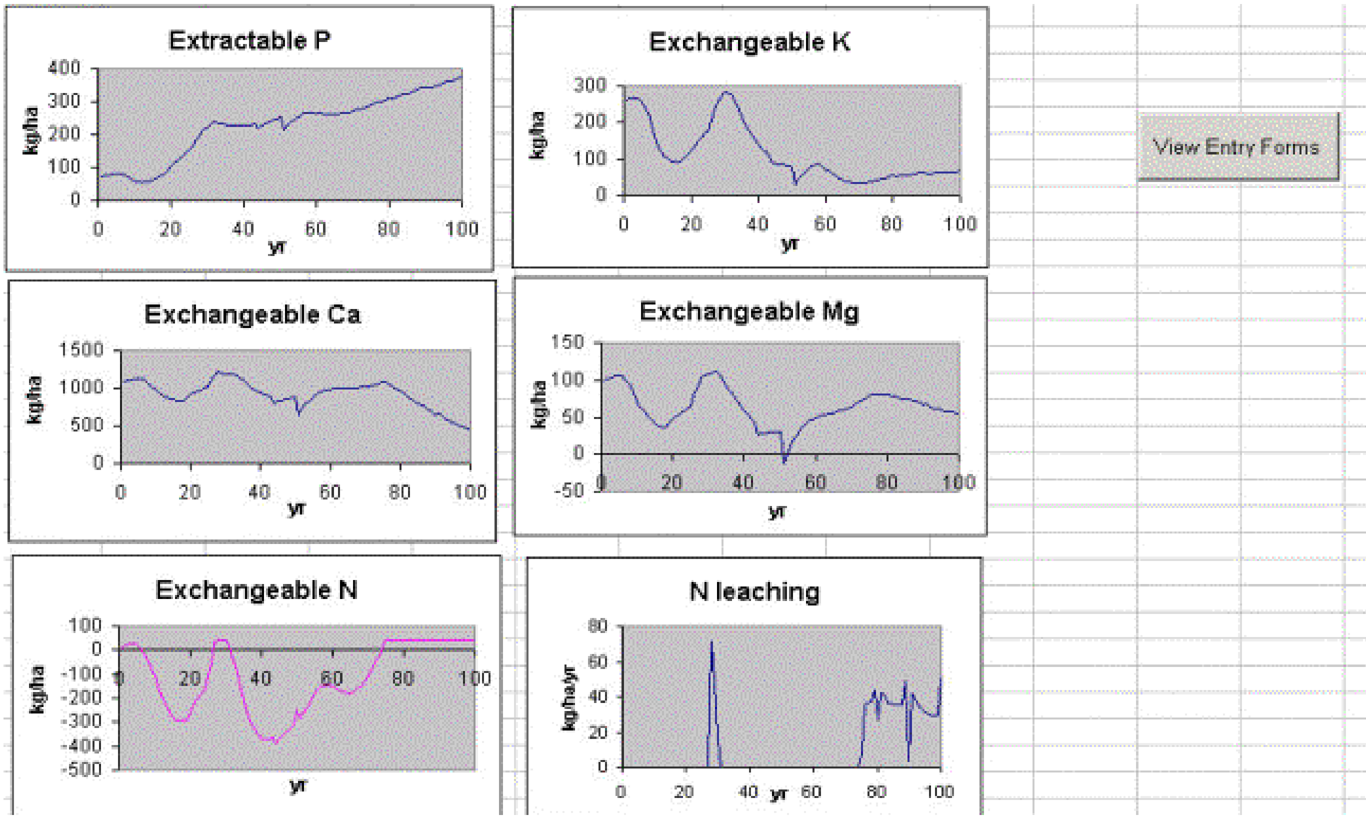
The following section describes the process for entering data into the NuCSS spreadsheet and importing the loblolly pine-calibrated REMSS (LobREMSS) data to establish target nutrient requirements. Downloads of the spreadsheet tools can be found in the downloads section of this web site. The downloadable NuCSS spreadsheet already contains the LobREMSS data. Modified REMSS data can be imported as needed if new assumptions or site-specific data have been entered into the REMSS spreadsheet.

After downloading and opening the NuCSS spreadsheet, the following dialog box may appear. To enable the data entry forms and import of the REMSS spreadsheet data, click the enable macros button.



Disable/Enable Macros Dialog

After Macros have been enabled, you will be directed to the input forms. Once data entry has been completed and the forms have been closed, you may reactivate the forms by selecting the View Entry Forms button on the inputs worksheet.



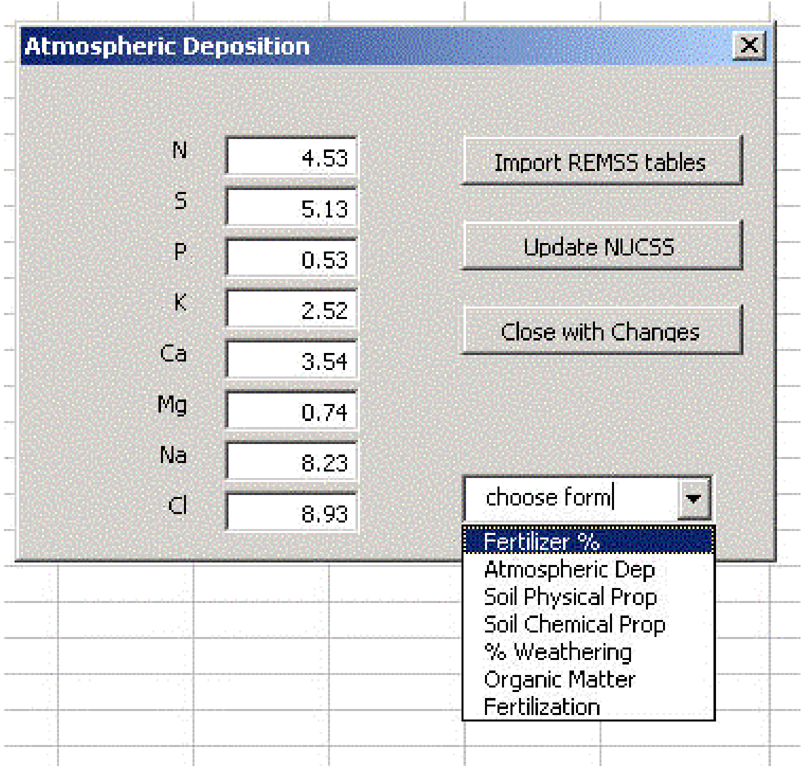
Inputs Worksheet Image

Upon opening the NuCSS data entry screen, the initial form will be displayed for data entry. The first form that will be visible is the Atmospheric Deposition form. Specific forms can be selected on the drop-down menu in the bottom right corner of a screen.

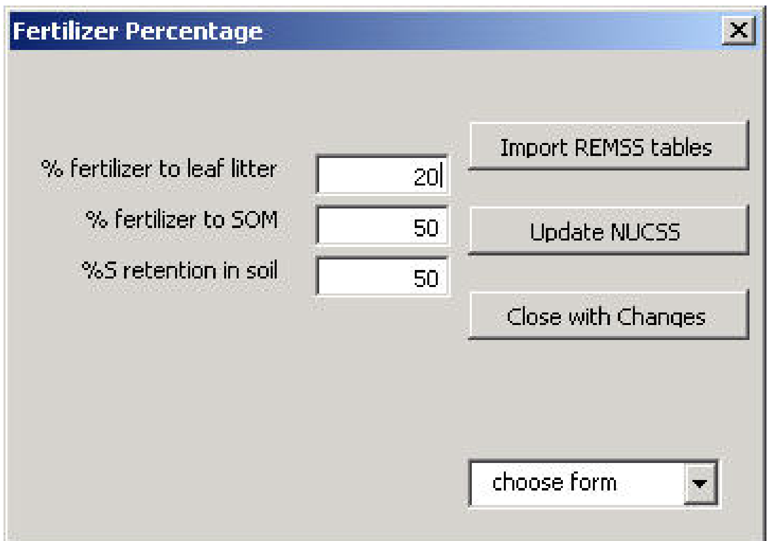
The 'Import REMSS tables' button will open the REMSS spreadsheet and copy the current values into the corresponding cells on the NuCSS spreadsheet. The NuCSS spreadsheet contains the current version of LobREMSS data. If changes are made to REMSS input values, click the button to import the updates.

If you have made changes to any screen and wish to update the spreadsheet with the new values, you should select Update NuCSS before switching forms. Depending on the speed of your processor, the update may take some time to perform the spreadsheet calculations. The status of these calculations can be seen in the bottom left corner of your spreadsheet application as shown in the following figure. Remember that the calculations are not instantaneous.

The initial entry screen requires atmospheric deposition data in kg/ha/yr. Much of this data may be available through resources identified in the links section of the web site. One potential resource for some of this data is the National Atmospheric Deposition Program. Default values may not correspond with values for your location.

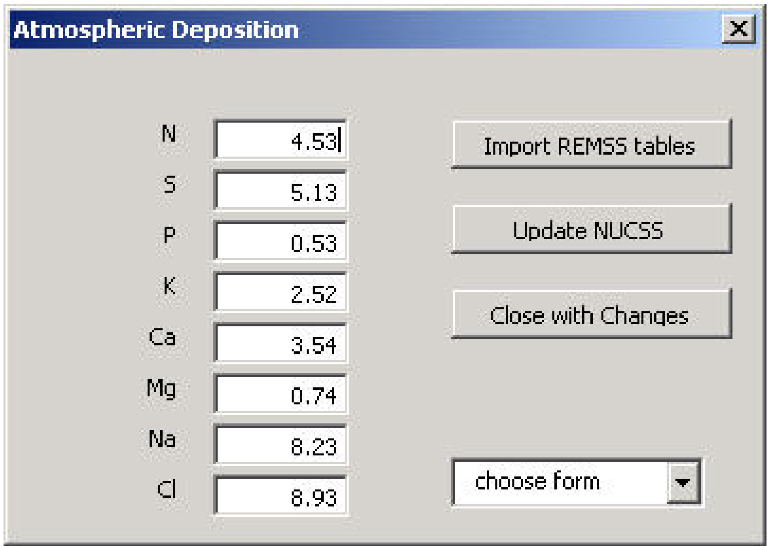


Drop-Down List Example

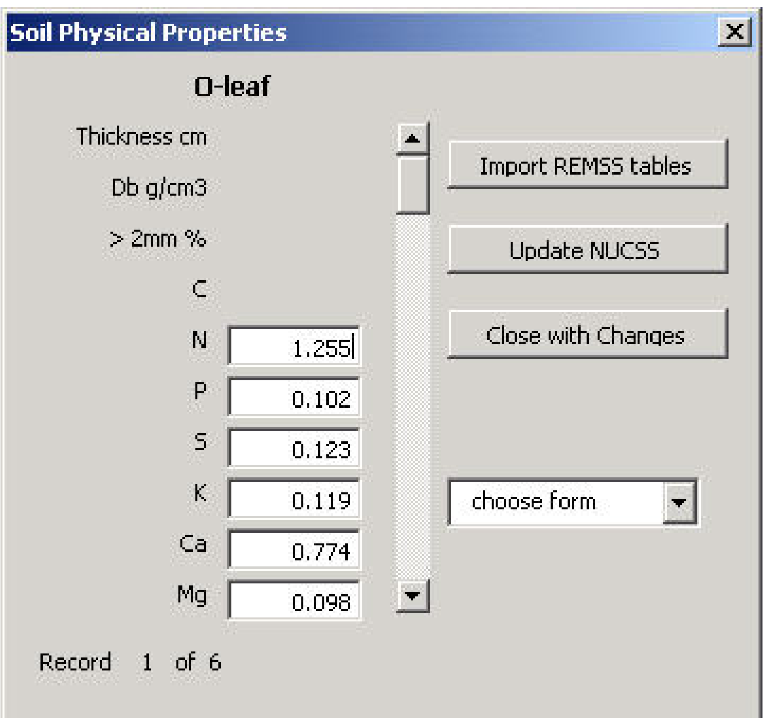


Fertilizer Percentage Form

Default values may be left for fertilizer percentages. If site-specific values are known, they may be entered.



Atmospheric Deposition Form

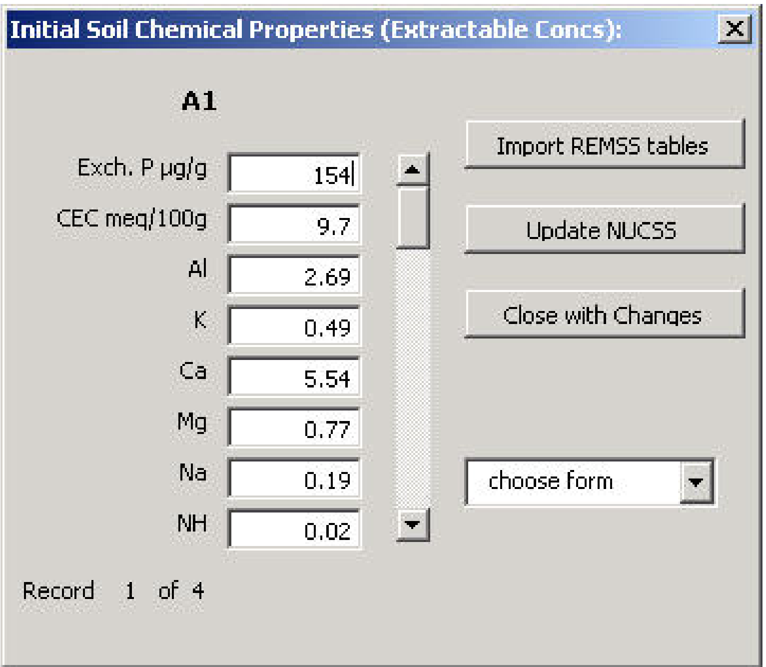


Soil Physical Properties Form

Soil physical properties may vary greatly from site to site. The default values entered in the spreadsheet may not correspond to the values at your location. For more specific values, sampling and analysis of soils from the site may be required.

Soil testing laboratories for loblolly-region states have been identified in the links section of this website. Data from the National Soils Characterization Database (NSCD) and the STATSGO database may also be useful for some of the input values.

The scroll bar in the middle of the form changes between soil horizons. Select the Update NUCSS button to update the values that you have entered. Values will not be retained between forms or when scrolling between soil horizons without performing these updates.

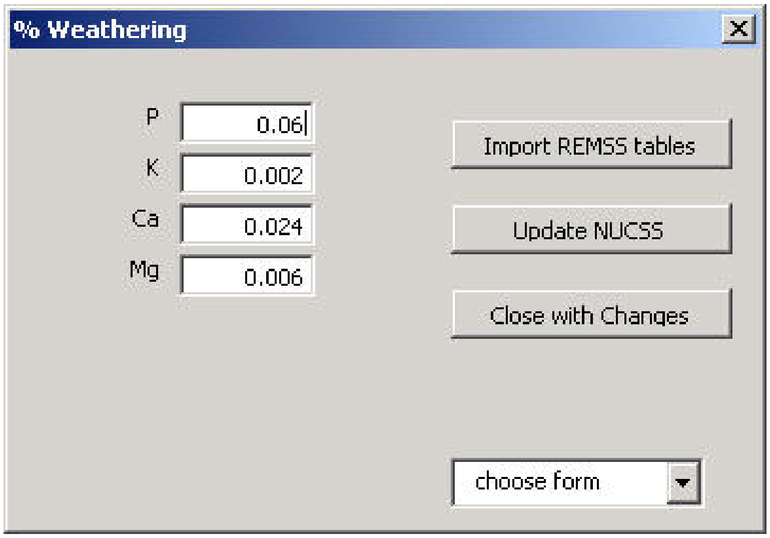


Initial Soil Chemical Properties Form

As in the soil physical properties form, soil chemical properties may vary greatly from site to site. The default values entered in the spreadsheet may not be appropriate for your site. For more specific values, sampling and analysis of soils from the site may be required.

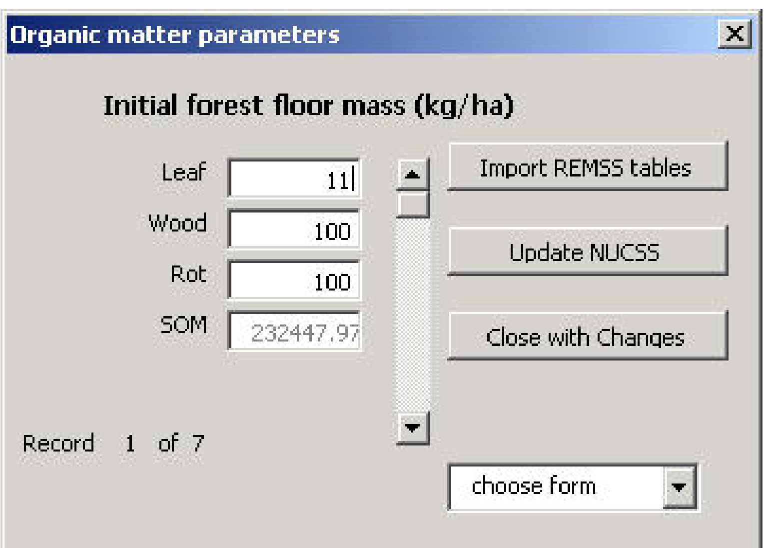
Soil testing laboratories for loblolly-region states that may be able to perform appropriate analyses have been identified in the links section of this web site. Data from the National Soils Characterization Database (NSCD) and the STATSGO database may also be useful for some of the input values.

The scroll bar in the middle of the form changes between soil horizons. Select the Update NUCSS button to update the values that you have entered. Values will not be retained between forms or when scrolling between soil horizons without performing these updates.



% Weathering Form

The NuCSS spreadsheet is calibrated for weathering rates. The values on this sheet represent weathering values by % per year. By adjusting these values, simulation can include long-term cation trends. If long-term data are unavailable, weathering rates should be set so that the amount of exchangeable cations in the soil do not become negative. Default values may or may not apply to your site.



Organic Matter Parameters Form

The organic matter parameters form allows you to enter site-specific data on organic matter. If data are not immediately available for your site, the following guidance, based on literature and measurements, may be followed (in order of scroll)

Initial forest floor mass

If no initial forest floor mass is present, a small, non-zero number should be entered to initialize forest floor nutrient content.

Initial forest floor N (%)

Default values may be used if no site-specific data is available.

Fraction C in litter

This value may remain at the default value of 0.47 if no other data are available.

Decomposition rate

Litter decomposition rate has been determined from the literature. If no site values are available, the following values may be used:

0.5 for deciduous leaf litter, 0.2-0.3 for coniferous leaf litter, 0.5 for fine root litter, 0.1 for woody litter, and 0.001 for SOM (soil organic matter).

Microbial C/N

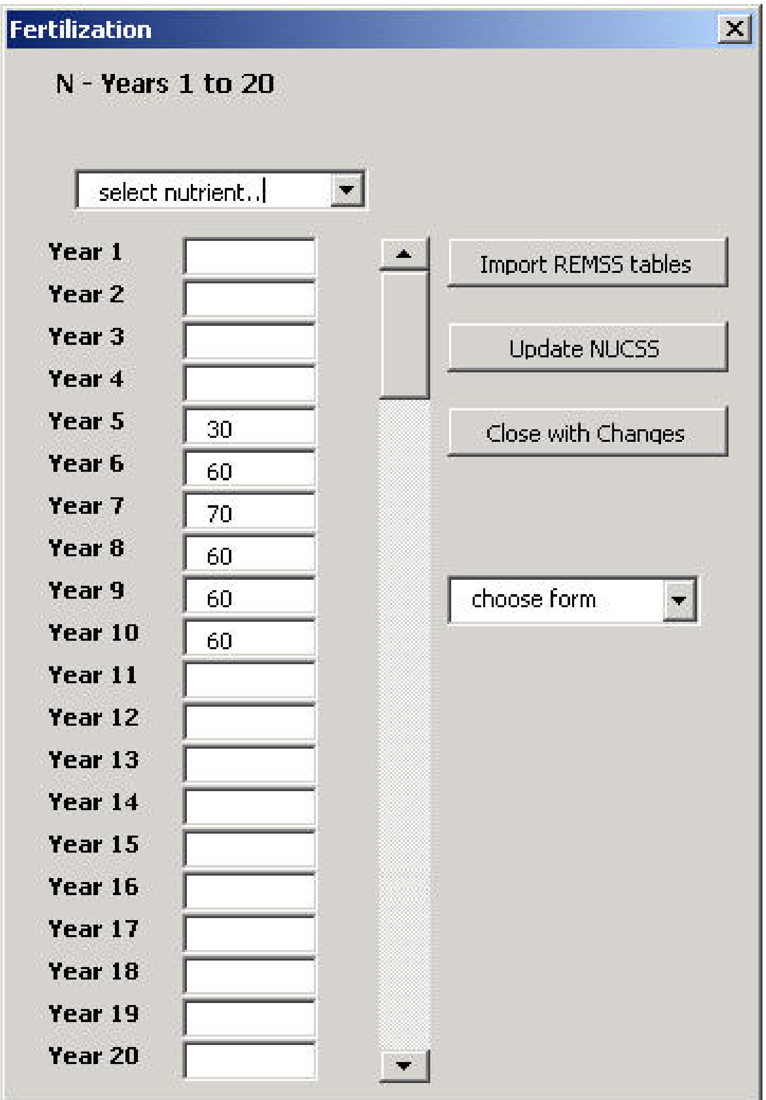
This data element is used to calculate N mineralization. If no data are present, the following guidelines may be followed—the C/N ratio for deciduous forests (bacteria dominated) may be set at 10, coniferous (fungi dominated) forests may be set to 20.

Microbial C use efficiency

The default values of 0.5 are generally accepted to be adequate estimates for all forest types.

Humification

The humification value represents the fraction of decomposing matter that enters the SOM pool. A reasonable default value to be entered is 0.05-0.1 for all components.



Fertilization Form

The fertilization form allows the user to enter fertilization quantities in kg/ha/yr and to view the effect of these values in the graphs on the input worksheet. The goal of this exercise is to maintain positive nutrient levels on the graphs and in the corresponding spreadsheet data. Updates to these values will be entered and can be observed in the graphs whenever the update NuCSS button is pressed. Be aware that there may be some delay in the updates as numerous calculations must flow through the spreadsheet. Press the NUCSS button after new values have been entered on the screen and before changing forms, changing fertilization type in the dropdown menu, or scrolling between time periods to record the update. This has been designed into the functionality of the forms to prevent long delays while an entire spreadsheet iterates through calculations.

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Nutrient Supply

NuCSS Spreadsheet

The Nutrient Cycling Spreadsheet (NuCSS) is a hybrid of simple empirical regressions and complicated stand or watershed simulation models. The model is written as a Microsoft® ExcelTM* spreadsheet, and includes an input macro to import data from REMSS (for baseline nutrient requirement values) and forms for growth parameters, litterfall, decomposition constants, nutrient concentrations (vegetation, litter and soil), soil physical properties, and other data.

Site-specific input data is generally needed for the site being modeled, but some of the data may be available from public databases such as the State Soil Geographic Database (STATSGO) and from the literature. As in all models of its type, there are many uncertainties in the NuCSS model, including weathering (the release of nutrients from soil minerals to the exchanger and soil solution), fertilizer N retention in soils and atmospheric N2 fixation The model is designed such that weathering rates and other uncertain parameters are set by the user during calibration. Atmospheric N2 fixation is not accounted for in the present version of the model.

One of the most attractive features of the model is the ease of calibration. The users can immediately view the results of their adjustment of various parameters in a series of conveniently located charts and can do multiple runs to assess the potions for obtaining target growth. Users may also produce their own charts from spreadsheet data.

NuCSS, its predecessors, and successors are meant to be complementary and modular in nature. We do not envision creating one final, comprehensive model that will fill all needs, but rather a series of simpler models that will fill specific needs. Previous versions have attempted to assess growth response to fertilization in a Douglas-fir forest (Johnson and Harrison, 1998) using a model that was very specifically calibrated to a certain forest ecosystem. Currently there are three versions of the NuCSS model; one version includes very simple growth functions and allows for feedback between N limitations and plant growth (NuCSS.1x); a second version uses vegetation biomass, nutrients and litterfall as calculated by the REMSS model (NuCSS.2x). In this second version there is no feedback between nutrient availability and plant growth/litter production. The main aim of this version is to assess potential fertilization requirements to match the imposed nutrient demand by the vegetation. NuCSS.3x, the current version, builds on the previous versions through a consolidation of user inputs and tighter integration with the REMSS spreadsheet. Data entry forms are now available on the spreadsheet and can be accessed by clicking a button.

This spreadsheet model is designed to be applicable to a wide variety of soil/vegetation types. Some of the data required to run the model may be obtained from publicly available data sources, while other data may need to be sampled for the specific site. As a tradeoff, the spreadsheet offers less in the way of prediction than more complex models requiring much more detailed data. The continuing challenge is to achieve a balance between mechanistic realism and user-friendliness and generality.

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Nutrient Requirements

REMSS Spreadsheet

The Nutrition Requirement Spreadsheet (REMSS) models the above- and belowground biomass construction, nutrient content, and nutrient use associated with prescribed levels of stand growth.

Stand growth, which in the downloadable version of REMSS on this web site is calibrated for loblolly pine, may also be input by the user. Stand growth data can either be a baseline (existing) level of growth, projected growth under intensive management, or a growth target. Outputs include nutrient uptake, litterfall, standing biomass and nutrient partitioning, and nutrient removals associated with partial and final harvests.

These outputs can be used for further modeling, or can be directly imported into the NuCSS nutrient cycling spreadsheet.

REMSS is a simplified spreadsheet implementation of NUTREM, a more complex model of tree growth and biomass and nutrient partitioning. REMSS is a straightforward Microsoft® ExcelTM* spreadsheet, and may be used in the current LobREMSS format (calibrated for loblolly pine) or can be modified by the user with annual values for tree density, basal area, dominant height, and stem cubic volume or weight starting from the beginning of the rotation. The user can also select management options relating to harvest timing and utilization, or choose other parameters, which govern leaf area development, tissue growth, and nutrient cycling.

In addition to instant creation of some commonly used graphs, REMSS provides numerical information on many aspects of biomass and nutrient accumulation and cycling in the stand.

For more information, view details on the REMSS Spreadsheet Model for Tree Nutrient Requirements.

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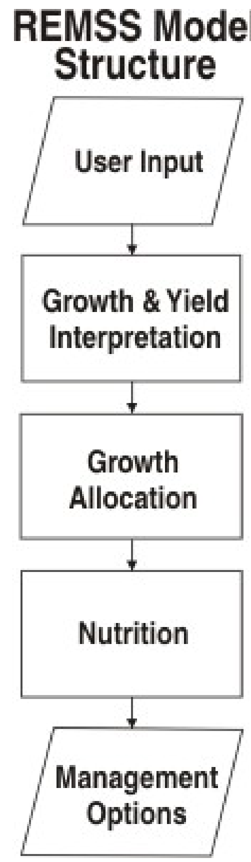
REMSS Spreadsheet Model for Tree Nutrient Requirements



User Input

REMSS uses conventional stand information as input: trees per acre or hectare, basal area per acre or hectare, dominant height in feet or meters, and total cubic volume outside bark in cubic feet per acre or cubic meters per hectare. Each variable occupies one row of the input sheet, and each year occupies one column. Data must be entered for each year up through the end of the rotation. Year 1 is, by definition, the year of stand initiation. Multiple rotations can be simulated easily: simply enter zero for all four input variables in the year after the first rotation is harvested, then begin entering the data for the next rotation.

Growth And Yield Interpretation

REMSS includes a growth and yield interpretation submodel to translate the user's input data into gross stemwood increment (net increment plus mortality and harvest) and crown coverage for each year of the model. Mortality is estimated using a simple rule base operating on the net change in tree density and some empirical coefficients describing the ordinary progress of self-thinning. Harvests are assumed to occur whenever the decline of tree number in a given year exceeds a user-specified threshold. Crown coverage is estimated using a simple crown-rise model. Taken together, these variables drive the next stage of the model: estimation of biomass production and allocation.

Growth Allocation

The most important tissue in determining nutrient use by a stand of trees is the foliage. Fortunately, for many species, foliage biomass or leaf area is related to gross increment by fairly simple relationships. REMSS uses a simple ratio (growth efficiency) to determine leaf area and foliage biomass, and then calculates the foliage production required to achieve the target biomass in a given year. Biomass increment for other tissues is determined using a hybrid of functional balance and allometric equations. Currently, REMSS tracks five tissues: foliage, branches, bulk stemwood, coarse roots, and fine roots.
In addition to tracking growth, REMSS maintains an inventory of the standing biomass in each tissue type, and the litterfall or senescence of each tissue type. Whenever a harvest occurs, the tissues of the felled trees are partitioned into removals and litterfall based on the user's decisions about the degree of utilization of the aboveground portions of the tree, and the seasonality of harvest in relation to foliage dynamics.

Nutrition

To assess the nutrient requirement for a given level of growth, REMSS uses a straightforward conservation-of-mass approach. REMSS tracks production cost, maintenance or throughfall losses, and retranslocation from senescing foliage. In addition to nitrogen, phosphorus, potassium, calcium, and magnesium, REMSS also tracks carbon allocation and dynamics. Estimates of standing pools of each nutrient, uptake from the soil, retranslocation, litterfall losses, and harvest removals are each found on separate pages of the spreadsheet.

Management Outputs

REMSS automatically generates four figures, which are especially useful for management:

1. Uptake of each nutrient throughout the simulation;
2. Production of each tissue type through time;
3. Standing biomass by tissue type through time; and
4. Total harvest removals during the simulation period.

Because REMSS is in spreadsheet form, it is easy to create additional graphs of other variables of interest, or export the numbers to other applications for further analysis.

REMSS contains a worksheet to make transferring information to NuCSS (the Nutrient Cycling Spreadsheet) easy. This worksheet may be automatically copied into NuCSS through a macro that has been developed and is included with NuCSS. Using REMSS and NuCSS together, users can relate target levels of growth to fertilizer requirements, soil chemistry, and the dynamics of nutrients and carbon in the soil and forest floor.

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Sustainable Target

Forest managers estimate the sustainable target productivity for their specific land area using available growth and yield data, predictions from growth and yield models such as PTAEDA2, or estimates from experiments such as conducted by the North Carolina State Forest Nutrition Cooperative. Some generalized estimates of enhanced forest productivity for the loblolly pine region are given in a productivity map. Important issues for obtaining enhanced sustainable forest productivity are site preparation, competition control, fertilization during establishment and mid-rotation fertilization.

Sustainable target for loblolly pine plantations may also be estimated with the 3PG spreadsheet model. The 3PG model was developed by Landsberg and Waring (1977, Forest Ecol. Manage. 95:209-228) and has been calibrated for loblolly pine applications with data from The Southeast Tree Research and Education Site (SETRES) research.

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Site Diagnostics

***Diagnosis* Spreadsheet**

Foliar nutrient analysis of loblolly pine from a previous rotation or current plantation are used to identify possible soil fertility limitations for enhanced growth at a site using the Diagnosis spreadsheet. Samples of foliage from a site planned for intensive management are analyzed for needle nutrient concentration and total nutrient content (determined from concentration by knowing the mean needle weight). These site measurements are inputs to the Diagnosis spreadsheet for determination of nutrients in low supply and for evaluation of potential fertilizer requirements.

Spreadsheet documentation is available here in a Microsoft® WordTM file.

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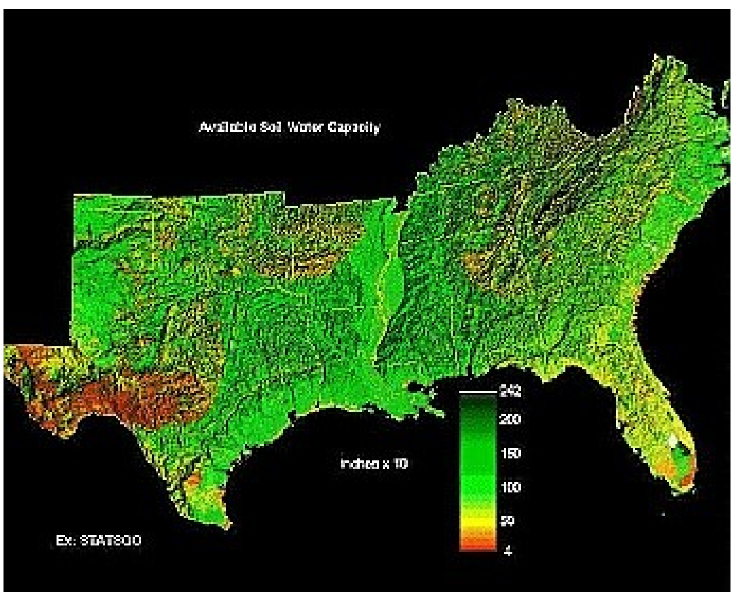
Site Characterization

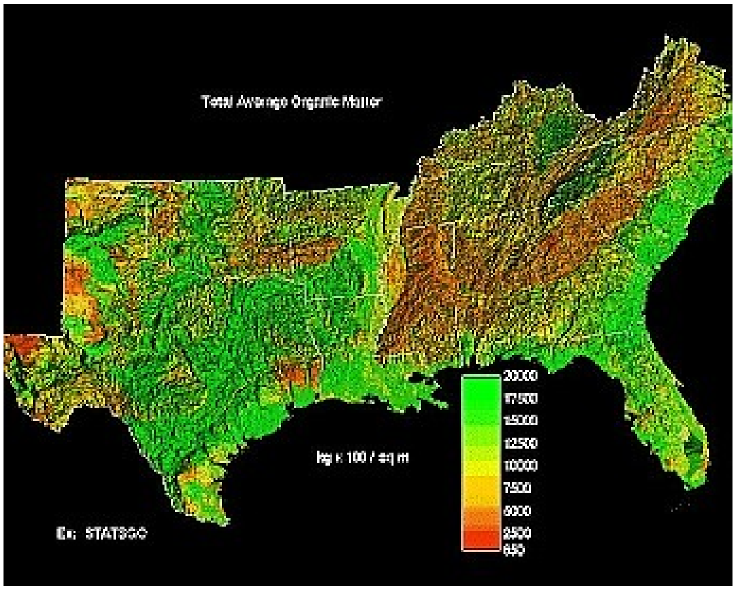
Data and maps for the Loblolly pine region can only provide general estimates of the soil, climate and landscape attributes needed in calculations in the soil nutrient supply spreadsheet NuCSS and can be used in the REMSS model for tree nutrient requirement. Some links to information that may be useful are provided in the links reference on this web site. At this point in time, site-specific data should be used unless good quality online data are available.

The following maps have been generated as a geographical overview of various datum that may be of interest in site characterization. Most maps have a 1 sq. km (247 acre) resolution.

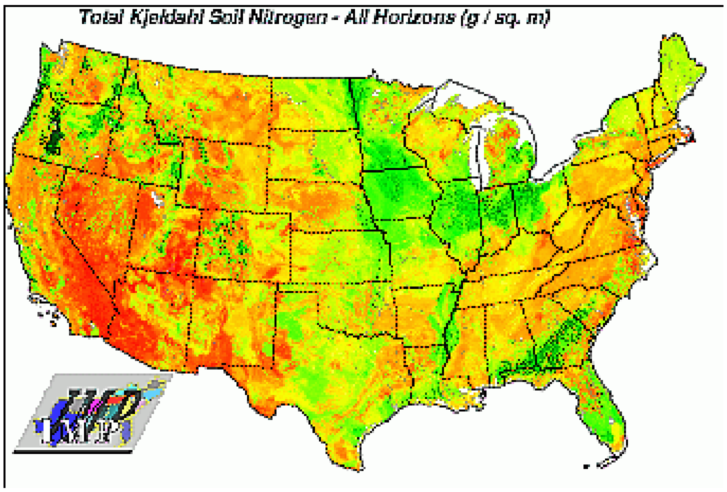
Click on any of the maps below in order to view the large scale map image.



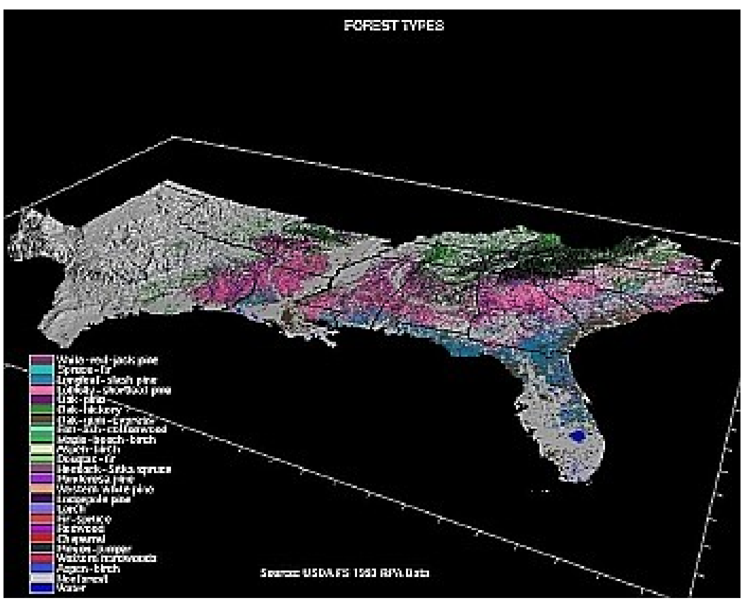
Available Soil Water Capacity, Planar View



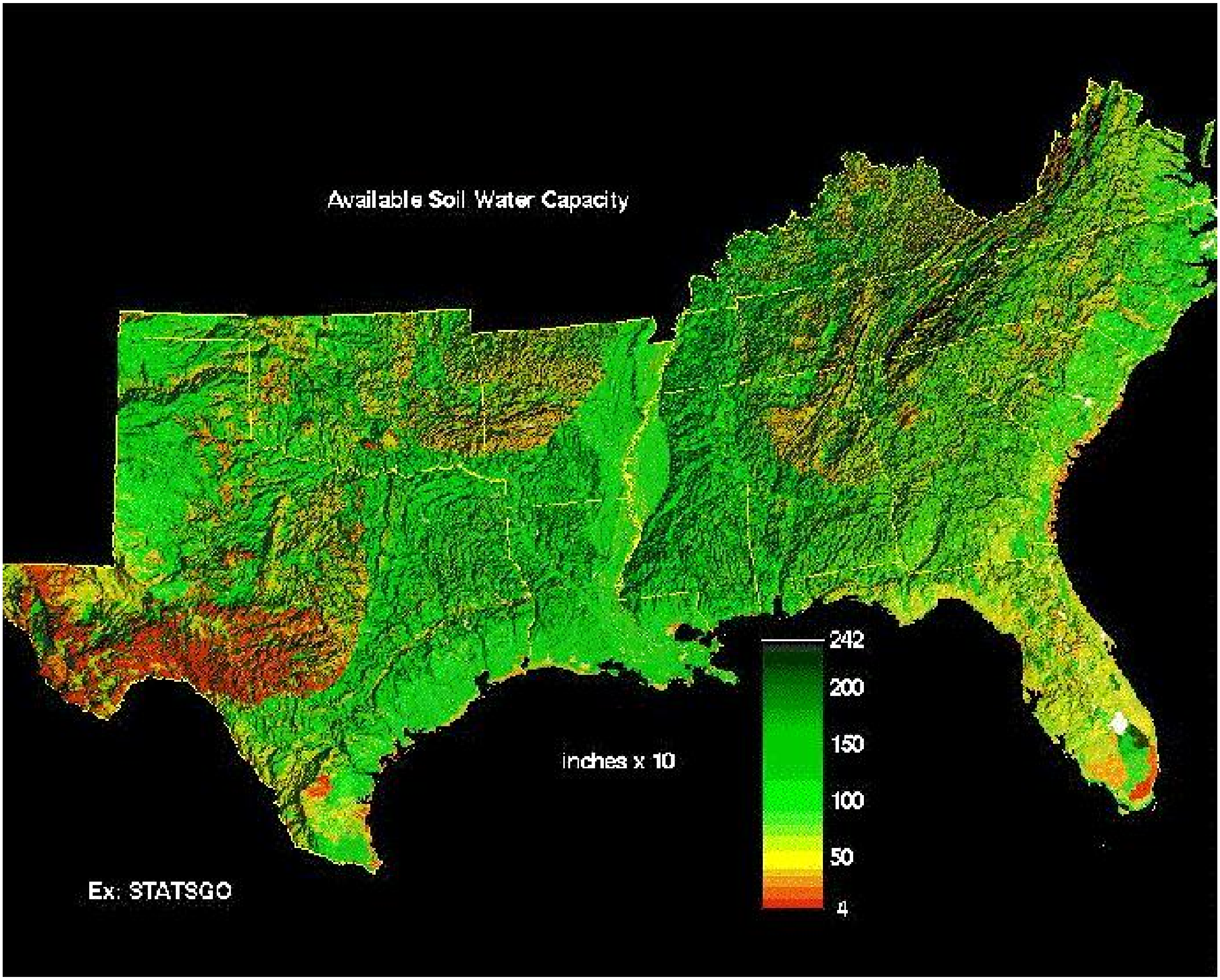
Total average organic matter

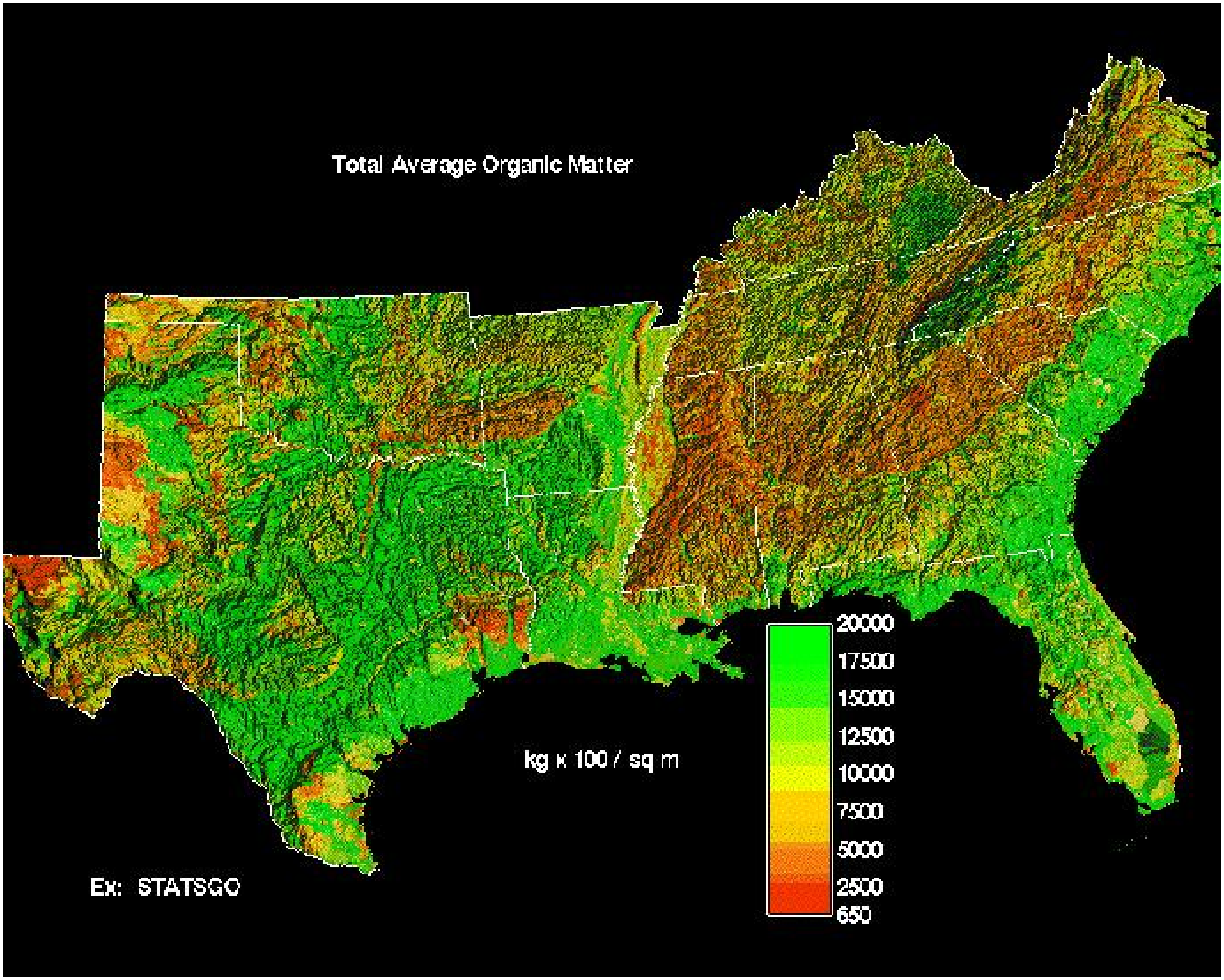


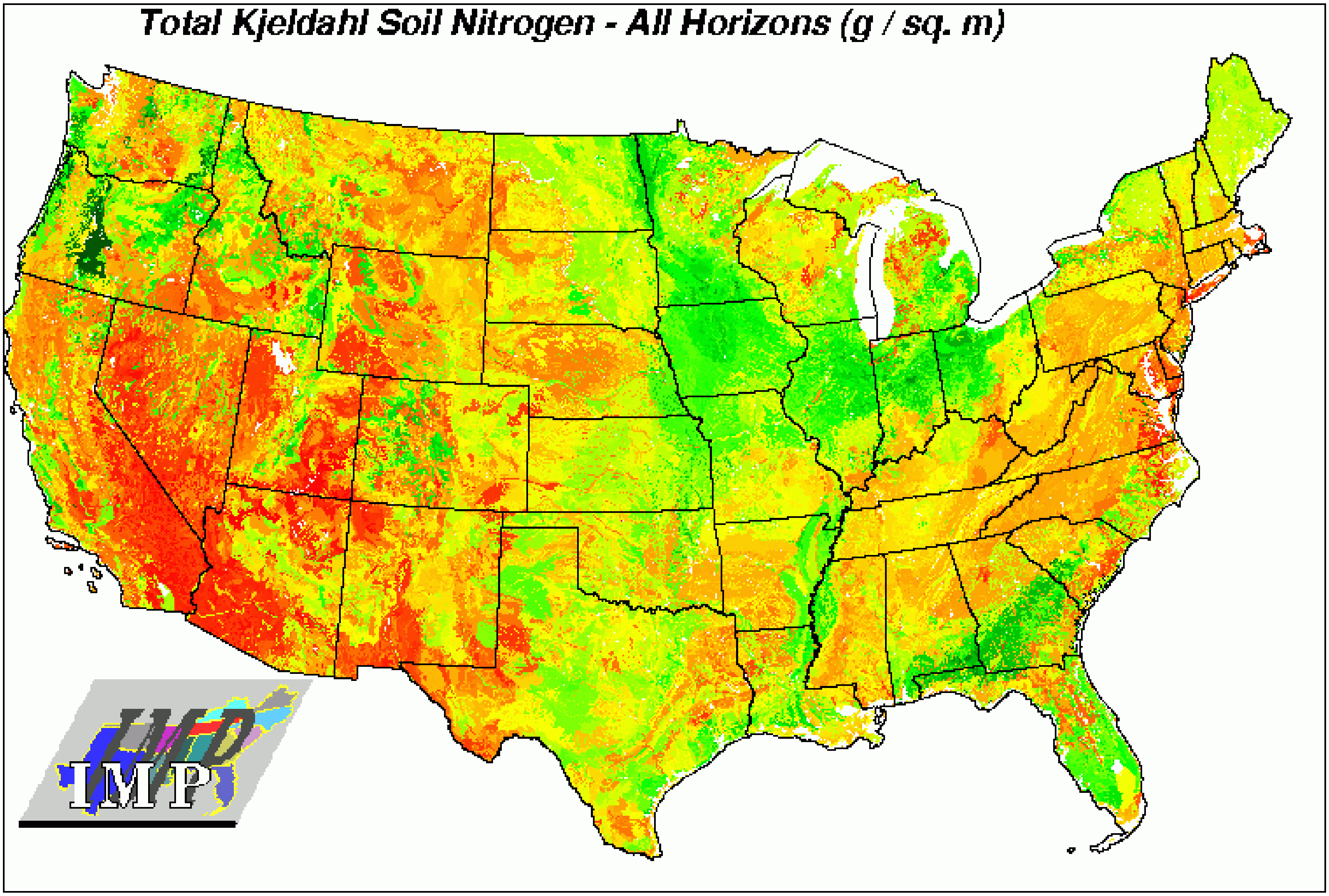
Total Kjeldahl Soil Nitrogen

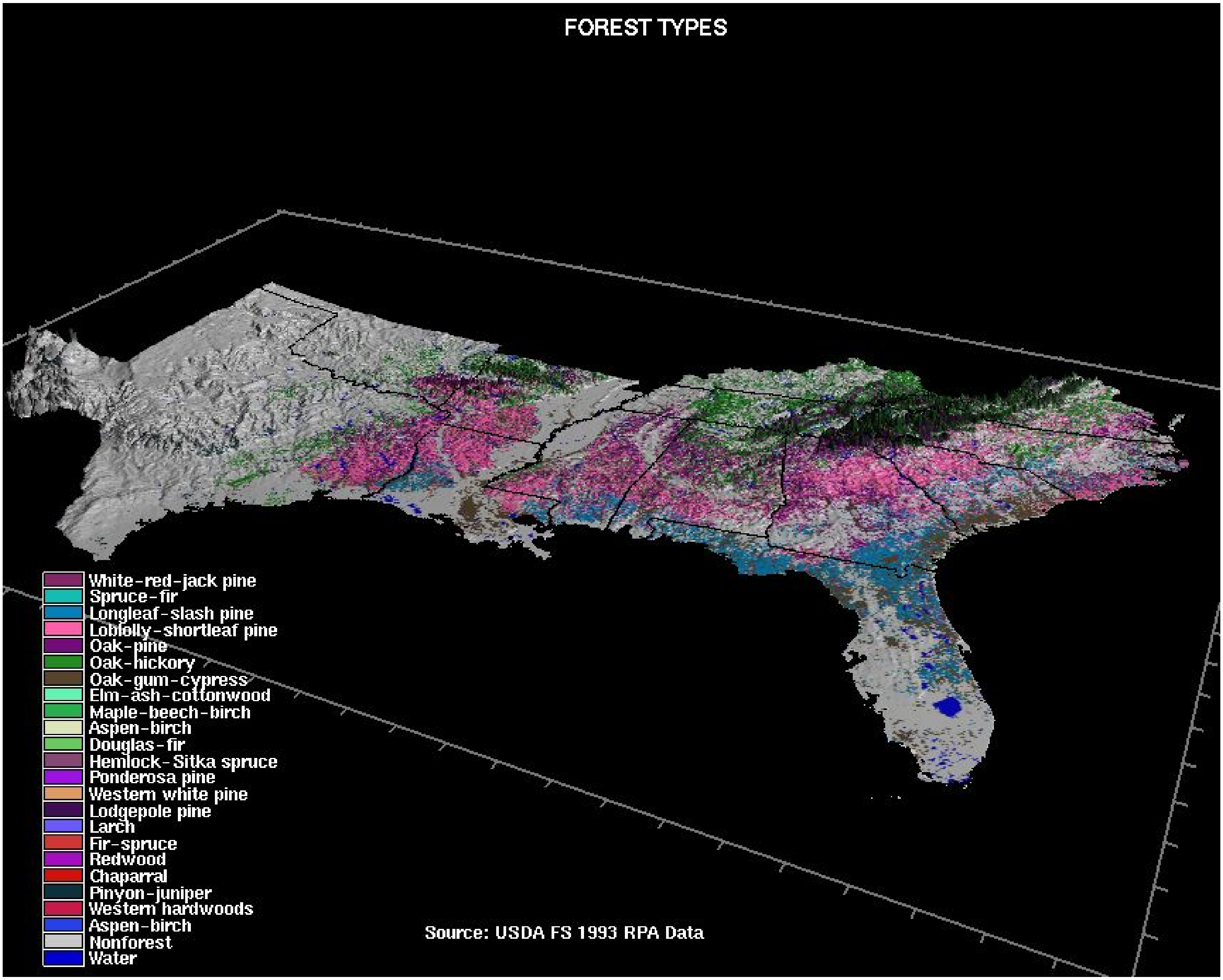


Forest types


Available Soil Water Capacity
inches x 10
242
200
150
100
50
4
Ex: STATSGO


Total Average Organic Matter
kg x 100 / sq m
20000
17500
15000
12500
10000
7500
5000
2500
650
Ex: STATSGO


Total Kjeldahl Soil Nitrogen - All Horizons (g / sq. m)
IMP


FOREST TYPES
White-red-jack pine
Spruce-fir
Longleaf-slash pine
Loblolly-shortleaf pine
Oak-pine
Oak-hickory
Oak-gum-cypress
Elm-ash-cottonwood
Maple-beech-birch
Aspen-birch
Douglas-fir
Hemlock-Sitka spruce
Ponderosa pine
Western white pine
Lodgepole pine
Larch
Fir-spruce
Redwood
Chaparral
Pinyon-juniper
Western hardwoods
Aspen-birch
Nonforest
Water
Source: USDA FS 1993 RPA Data

Links to Information on Soils

The following links are provided to web sites or data sources that may be useful to forest managers using the spreadsheet tools described herein. Identification of any web site here does not constitute an endorsement of the site or its sponsors, but is simply provided as a possible source of information. In addition, the list does not purport to represent a complete or exhaustive review of all relevant sites. Links are provided for soil testing facilities in each state. These facilities are primarily focused on testing of agricultural soils, but they may be able to provide useful information for managers without other soil testing resources.

General:

STATSGO Browser: http://www.nstl.gov/research/onepage/onepagst.html
Natural Resources Conservation Service soils webpage: http://soils.usda.gov/
National SSURGO Database: http://www.ftw.nrcs.usda.gov/ssur_data.html
National Soil Information System: http://nasis.nrcs.usda.gov
Soils and Landscapes in the Southern Region:
http://soilphysics.okstate.edu/S257/book/soils/index.html#Peninsular%20Florida
Alternative Soil Testing Laboratories-Agronomy Resource List:
http://attra.ncat.org/attra-pub/soil-lab.html

Alabama:

Natural Resources Conservation Service Alabama State Office:
http://soils.usda.gov/contact/state_offices/directories/al.html
Alabama soils map: http://alabamamaps.ua.edu/alabama/physical/
The Private Forest Management Team: http://www.pfmt.org/
Alabama Spatial Data Sets: http://www.fws.gov/data/statdata/aldata.html

Soil Testing
Auburn University Soil Testing Laboratory
118 Funchess Hall, Auburn University, AL 36849
(334) 844-3958
http://www.ag.auburn.edu/dept/ay/soiltest.htm

Arkansas:

Natural Resources Conservation Service Arkansas State Office:
http://soils.usda.gov/contact/state_offices/directories/ar.html
Arkansas Soils Digitization: http://soils.uark.edu/currentprojects.htm
Statewide Land Use/Land Cover of Arkansas: http://www.cast.uark.edu/cast/research/lulc/
Arkansas Soils Map: http://quake.ualr.edu/armitig-plan/pdfs/Attach_17.pdf
Arkansas Spatial Data Sets: http://www.fws.gov/data/statdata/ardata.html

Soil Testing
Soil Testing and Research Laboratory
University of Arkansas
P.O. Drawer 767, Marianna, AR 72360
(870) 295-2851 http://www.uark.edu/depts/soiltest

Florida:

Natural Resources Conservation Service Florida State Office:
http://soils.usda.gov/contact/state_offices/directories/fl.html
NRCS Florida Soils Information: http://www.mo15.nrcs.usda.gov/states/fl.html
Florida Forestry Information: http://www.sfrc.ufl.edu/Extension/ffws/soils.htm
Natural Soil Landscape Positions: http://www.sfwmd.gov/org/pld/proj/wetcons/nslp/nslp_home.html
Forest Soils of Florida: http://www.sfrc.ufl.edu/Extension/pubtxt/frc33.htm
Florida Spatial Data Sets: http://www.fws.gov/data/statdata/fldata.html

Soil Testing
Soil Testing Laboratory
University of Florida IFAS
Wallace Bldg. No. 631,
P.O. Box 110740, Gainesville, FL 32611
(352) 392-1950, ext. 221
http://edis.ifas.ufl.edu/SS312

Georgia:

NRCS Georgia State Office: http://soils.usda.gov/contact/state_offices/directories/ga.html
State of Environment Georgia - Soils:
http://www.grida.no/enrin/htmls/georgia/soegeor/english/soils/soils.htm
Organic Matter in Georgia Soils: http://www.ces.uga.edu/pubcd/B1196.htm
Georgia's Virtual Forest: http://www.gaforests.com/
USGS State Soils: http://csat.gatech.edu/statewide/layers/statsgo.html
Georgia Spatial Data Sets: http://www.fws.gov/data/statdata/gadata.html

Soil Testing
Soil, Plant and Water Analysis Laboratory
University of Georgia, College of Agricultural and Environmental Sciences
2400 College Station Rd., Athens, GA 30602
(706) 542-5350
http://aesl.ces.uga.edu/

Kentucky:

NRCS Kentucky State Office: http://soils.usda.gov/contact/state_offices/directories/ky.html
Kentucky Division of Conservation GIS and Soil Survey: http://www.conservation.ky.gov/soil_survey.htm
Kentucky Spatial Data Sets: http://www.fws.gov/data/statdata/kydata.html

Soil Testing
University of Kentucky Soil Testing Laboratory
103 Regulatory Service Bldg., Lexington, KY 40546
(859) 257-2785
http://soils.rs.uky.edu

Louisiana:

NRCS Louisiana State Office: http://soils.usda.gov/contact/state_offices/directories/la.html
USGS Digital Soil Map of Louisiana: http://sdms.nwrc.gov/pub/la/lasoil.html
New General Soils Map of Louisiana: http://sdms.nwrc.gov/data/metadata/lagsm.html
The National Cooperative Soil Survey of Louisiana Parishes:
http://www.agronomy.lsu.edu/AN2001pdf/hudnall3.pdf
The Louisiana Environment: http://www.tulane.edu/~bfleury/envirobio/forest.html
Louisiana Spatial Data Sets: http://www.fws.gov/data/statdata/ladata.html

Soil Testing
Louisiana State University Soil Testing and Plant Analysis Lab
126 Madison B. Sturgis Hall, Baton Rouge, LA 70803
(225) 578-1261
http://www.lsuagcenter.com/stpal/index.asp

Mississippi:

NRCS Mississippi State Office: http://soils.usda.gov/contact/state_offices/directories/ms.html
NRCS Mississippi Soils Information: http://www.mo15.nrcs.usda.gov/states/ms.html
Mississippi NRRA Soils: http://www.nps.gov/gis/metadata/miss/misssolp.html
Mississippi State Forest and Wildlife Research Center: http://www.cfr.msstate.edu/fwrc/forestry/pine.htm
Mississippi Spatial Data Sets: http://www.fws.gov/data/statdata/msdata.html

Soil Testing
Soil Testing Laboratory
Mississippi State University Cooperative Extension Service
Box 9610,
Mississippi State, MS 39762
(662) 325-3313
http://www.msucares.com

North Carolina:

NRCS North Carolina State Office: http://soils.usda.gov/contact/state_offices/directories/nc.html
North Carolina Land and Biological Resources: http://cgia.cgia.state.nc.us/ncgdc/s5lbr.html
North Carolina Cooperative Extension Service Forest Soils and Site Index:
http://www.ces.ncsu.edu/nreos/forest/woodland/won-07.html
North Carolina Spatial Data Sets: http://www.fws.gov/data/statdata/ncdata.html

Soil Testing
North Carolina Dept. of Agriculture and Consumer Services
Agronomic Division - Soil Testing Section
4300 Reedy Creek Road, Raleigh, NC 27607
(919) 733-2655
http://www.ncagr.com/agronomi/

South Carolina:

NRCS South Carolina State Office: http://soils.usda.gov/contact/state_offices/directories/sc.html
South Carolina Spatial Data Sets: http://www.fws.gov/data/statdata/scdata.html

Soil Testing
Agricultural Service Laboratory,
Clemson University Cooperative Extension Service
171 Old Cherry Road, Clemson, SC 29634
(864) 656-2068
http://www.clemson.edu/agsrvlb

Tennessee:

NRCS Tennessee State Office: http://soils.usda.gov/contact/state_offices/directories/tn.html
NRCS Tennessee Soils Information: http://www.mo15.nrcs.usda.gov/states/tn.html
Tennessee Spatial Data Server Soils: http://63.148.169.50/soils24k.html
Tennessee Spatial Data Sets: http://www.fws.gov/data/statdata/tndata.html

Soil Testing
University of Tennessee Soil Test Lab
5201 Marchant Drive, Nashville, TN 37211
(615) 832-4936
http://bioengr.ag.utk.edu/SoilTestLab

Virginia:

NRCS Virginia State Office: http://soils.usda.gov/contact/state_offices/directories/va.html
Virginia Earth Science Resource Page: http://www.geol.vt.edu/vesr/vesrsoils.html
VPI Forest Soils Program: http://soils.fw.vt.edu/main.html
Virginia Department of Forestry: http://www.vdof.org/
Virginia Spatial Data Sets: http://www.fws.gov/data/statdata/vadata.html

Soil Testing
Virginia Tech Soil Testing Lab
145 Smyth Hall (0465), Blacksburg, VA 24061
(540) 231-6893
http://www.ext.vt.edu

West Virginia:

NRCS West Virginia State Office: http://soils.usda.gov/contact/state_offices/directories/wv.html
West Virginia GIS Data Clearinghouse: http://wvgis.wvu.edu/data/data.php
http://fargo.nserl.purdue.edu/rusle2_dataweb/NRCS_Soils_Data_Files.htm
Wesv Virginia Spatial Data Sets: http://www.fws.gov/data/statdata/wvdata.html

Soil Testing
Soil Testing Laboratory
Ag. Sciences Building, West Virginia University
Morgantown, WV 26506
(304) 293-6256
http://www.caf.wvu.edu/~forage/3201.htm

Links to General Information on Loblolly Pine

Loblolly Pine Habitat - Soils and Topography:
http://www.forestworld.com/public/silvics/conifers/pinus/taeda/taeda_b3.html

Tree Crops for Marginal Farmland Loblolly Pine:
http://www.ext.vt.edu/pubs/forestry/446-604/446-604.html
Local Soils Information Needed to Define the Root Zone in Process Models on the Gulf Coastal Plain:
http://www.srs.fs.usda.gov/pubs/viewpub.jsp?index=5001
North Carolina Department of Environment and Natural Resources Forest Soils and Site Index:
http://www.dfr.state.nc.us/starting/starting_soilsandsiteindex.htm
Loblolly Pine Management: http://www.uaex.edu/Other_Areas/publications/HTML/FSA-5008.asp
Loblolly Pine Growth and Yield Research Cooperative, Virginia Tech: http://www.fw.vt.edu/g&y_coop/

Links to Related Nutrient Studies:

Determining Nutrient Requirements for Intensively Managed Loblolly Pine Stands Using The Ssand (Soil Supply And Nutrient Demand) Model:
http://www.srs.fs.usda.gov/bssrc/bssrc2002/Adegbedi%2C%20H++.pdf
North Carolina State Forest Nutrition Cooperative:
http://www2.ncsu.edu/unity/lockers/project/ncsfnchpg/
Water And Nutrient Effects on Loblolly Pine Production and Stand Development on a Sandhill Site:
http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs048/article/gtr_srs048-allen01.pdf
A Model for Soil Nutrient Uptake and Harvest Removals in Loblolly Pine:
http://www.unh.edu/natural-resources/resnot14.pdf
Sampling Loblolly, Longleaf, and Slash Pine Foliage for Nutrient Analyses:
http://www.bugwood.org/fertilization/foliage.html
Fertilizing Pine Plantations - A County Agents' Guide for Making Fertilization Recommendations:
http://www.bugwood.org/fertilization/csoillab.html
Fertilizing Pine Plantations - A County Agents's Guide for making Fertilization Recommendations: http://www.bugwood.org/acrobat/98009.pdf
Forest Fertilization - Some Guidelines for Determining Potentially Suitable Sites/Stands:
http://www.forestry.state.al.us/publication/forest_management/forest_fertilization.htm

Project Publications:

Ducey, M. and H. L. Allen. 2001. Nutrient Supply and Fertilization Efficiency in Midrotation Loblolly Pine Plantations: A Modeling Analysis. Forest Science 47(1):96–102.

Johnson, D. W., W. Cheng, and I. C. Burke. 2000. Biotic and Abiotic Retention in a Variety of Forest Soils. Soil Sci. Am. J. 64:1503–1514.

Johnson, D. W., T. Sogn, and S. Kvindesland. 2000. The Nutrient Cycling Model: Lessons Learned. Forest Ecology and Management 138:91–106.

Johnson, D. W., R. B. Susfalk, H. L. Gholz, and P. J. Hanson. 2000. Simulated Effects of Temperature and Precipitation Change in Several Forest Ecosystems. J. Hydrology 235:183–204.

Luxmoore, R. J., W. W. Hargrove, M. L. Tharp, W. M. Post, M. W. Berry, K. S. Minser, W. P. Cropper Jr., D. W. Johnson, B. Zeide, R. L. Amateis, H. E. Burkhart, V. C. Baldwin Jr., and K. D. Peterson. 2002. Addressing Multi-Use Issues in Sustainable Forest management with Signal- Transfer Modeling. Forest Ecology and Management 165: 295–304.

Luxmoore, R. J., M. L. Tharp, and R. A. Efroymson. 1999. Comparison of Simulated Forest Responses to Biosolids Applications. J. Eviron. Qual. 28:1996–2007.

Verburg, P. S. J., and D. W. Johnson. 2000. NUCSS: A Nutrient Cycling Spreadsheet Model to Support Forest Management. Desert Research Institute, Reno, Nevada, 14 pp.

Verburg, P. S. J., and D. W. Johnson. 2001. A Spreadsheet-Based Biogeochemical Model to Simulate Nutrient Cycling Processes in Forest Ecosystems. Ecological Modeling 141:185–200.

Verburg, P. S. J., D. W. Johnson, and R. Harrison. 2001. Long-term Nutrient Cycling Patterns in Douglas-fir and Red Alder Stands: A Simulation Study. Forest Ecology and Management 145:203–217.

Downloads

This page includes links to downloadable spreadsheet management tools and documents. Downloads are generally provided in two formats, a compressed .zip format and the native documet format. The compressed .zip document is provided for individuals who may not be able to download a non-compressed document due to firewall limitations or to reduce download times. Click on the links below to download the files. You may use the right mouse button to select a file download destination on your personal computer.

Although it is possible to run spreadsheet models from within a browser window, we recommend downloading the spreadsheet models and executing them directly from your spreadsheet application. This will minimize any problems that you may have in running any embedded spreadsheet macros.

REMSS Spreadsheet

The Nutrition Requirement Spreadsheet (REMSS) models the above- and belowground biomass construction, nutrient content, and nutrient use associated with prescribed levels of stand growth.

REMSS Spreadsheet (.xls format) 730KB (.zip format) 200 KB

REMSS and NuCSS combined download, (.zip format) 643 KB

NuCSS Spreadsheet

The Nutrient Cycling Spreadsheet (NuCSS) is a hybrid of simple empirical regressions and complicated stand or watershed simulation models to assist in determining site fertilization requirements. The model includes an input macro to import data from REMSS (for baseline nutrient requirement values) and forms for growth parameters, litterfall, decomposition constants, nutrient concentrations (vegetation, litter and soil), soil physical properties, and other data. Please also note that macros may have been disabled within your spreadsheet application. If you are unable to view the screens as shown in the NuCSS process on this web site, you will need to enable macros in your spreadsheet application.

NuCSS Spreadsheet (.xls format) 1.10 MB (.zip format) 445 KB

REMSS and NuCSS combined download (.zip format) 643 KB

NuCSS and REMSS Spreadsheet documentation (.doc format) 667 KB (.zip format) 552 KB

Diagnosis Spreadsheet

Foliar nutrient analysis of loblolly pine from a previous rotation or current plantation are used to identify possible soil fertility limitations for enhanced growth at a site using the Diagnosis spreadsheet.

Diagnosis Spreadsheet (.xls format) 1 MB (.zip format) 261 KB

Diagnosis Documentation (.doc format) 94 KB (.zip format) 33 KB

3PG Spreadsheet

Target productivity can also be estimated with the 3PG model developed by Waring and Landsberg (1977, Forest Ecol. Manage. 95:209-228).

3PG Spreadsheet (.xls format) 113 KB (.zip format) 39 KB

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Nutrient Management for Enhanced Productivity of Loblolly Pine Stands

Agenda2020 Program contribution in support of forest products industry

Warnings and Disclaimers

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Appendix B

PROGRAMMING CODE LINKING REMSS AND NuCSS

Contents

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Introduction

The following technical report contains information on the programming code and forms that have been developed to both link the Nutrient Requirement Spreadsheet or REMSS (remss.xls) and the Nutrient Cycling Spreadsheet or NuCSS (nucss.311.xls). The code listed in the sections below can be accessed through the design mode of Visual Basic for Applications and has been embedded into the NuCSS spreadsheet. No linking code is embedded in the REMSS spreadsheet. This document is meant to provide the programmer with a hard copy of the code with some guidance provided on how to manage changes that may be required in the future due to worksheet modifications or linking to alternate versions of the models.

This document does not serve as a technical reference to the models that have been developed in the NuCSS and REMSS spreadsheets. Additional technical information on the models may be accessed on the web at http://loblolly.esd.ornl.gov/. A users guide and the associated spreadsheets with the embedded code may also be downloaded from this web site.

The document is structured to reflect the relationship between visual object components and the associated code. These components include the worksheet object and input forms.

Overview

The current version of the NuCSS spreadsheet was developed with a basic input workbook. A user was required to manually transfer information from the REMSS spreadsheet to the NuCSS spreadsheet. The macro listed below was designed to simplify data entry and to allow for automated transfer of input parameters from the REMSS spreadsheet into the corresponding locations on the NuCSS spreadsheet.

The data transfer and data entry forms may be opened at any time by selecting the “View Entry Forms” button on the Input worksheet, the code that calls the entry forms once the button is clicked can be seen in the section entitled “Sheet2”.

Additionally, when the NuCSS spreadsheet is first opened, a macro is called to automatically select the Input worksheet and to run the entry forms. This function is listed in the “ThisWorkbook” section below.

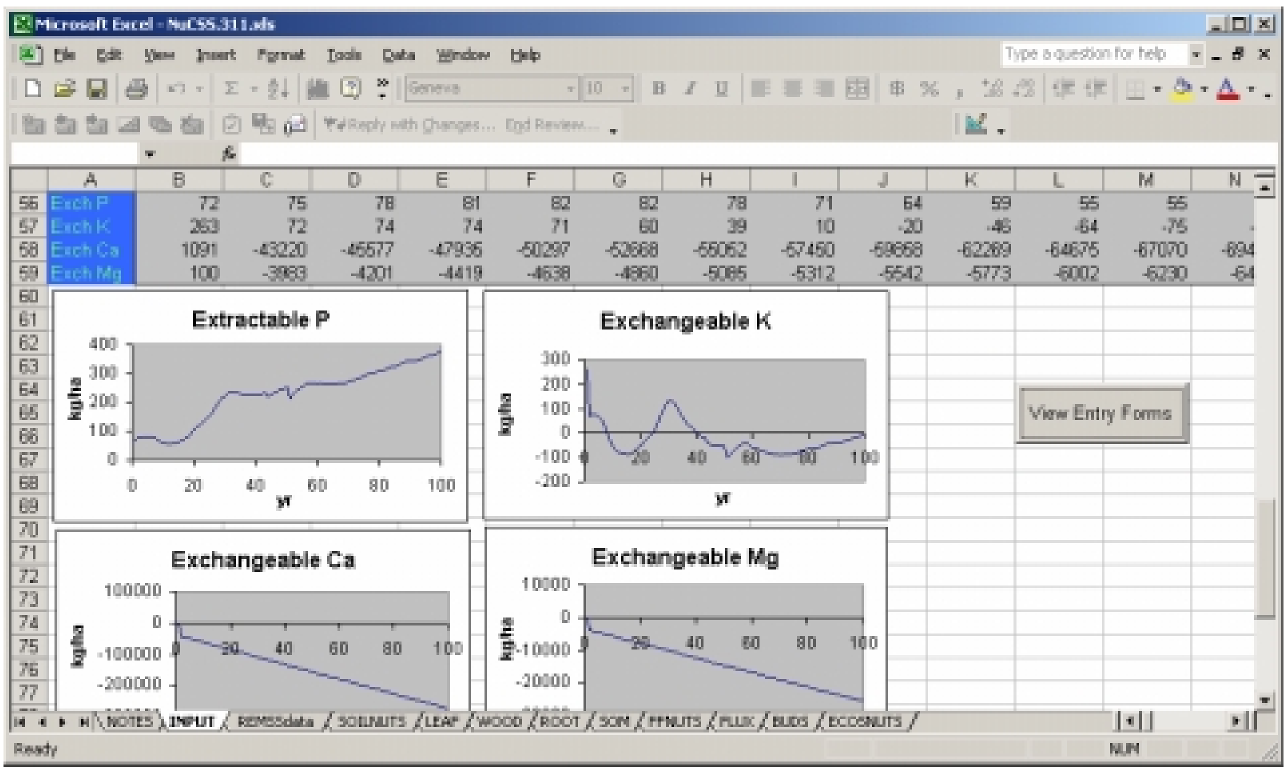
All forms and their associated code are listed in the sections below that begin with “frm”. Basic labels that accept input can be seen on the raw forms in the figures. Structural linking between the forms is maintained in a drop down menu on each form to allow the user to switch between forms.

The Module code, “Module1 and Module2” contains a listing of the code that is run when the “Import REMSS Tables” button is selected from any form. “Module1” contains the code that selects and transfers the ranges from the REMSS spreadsheet to the NuCSS spreadsheet, and

"Module2" contains the code that searches for the REMSS spreadsheet, and prompts the user to locate the spreadsheet if the REMSS spreadsheet is not available in the same directory as the NuCSS spreadsheet.

The following sections as stated before reference the functional units that link code to objects. Sections will begin with an image representing the base object, followed by a code overview, and finally ending with the actual associated VBA code. With the exception of the Modules sections at the end of this document, which may be accessed from any form, the sections follow the program hierarchy.

Sheet2



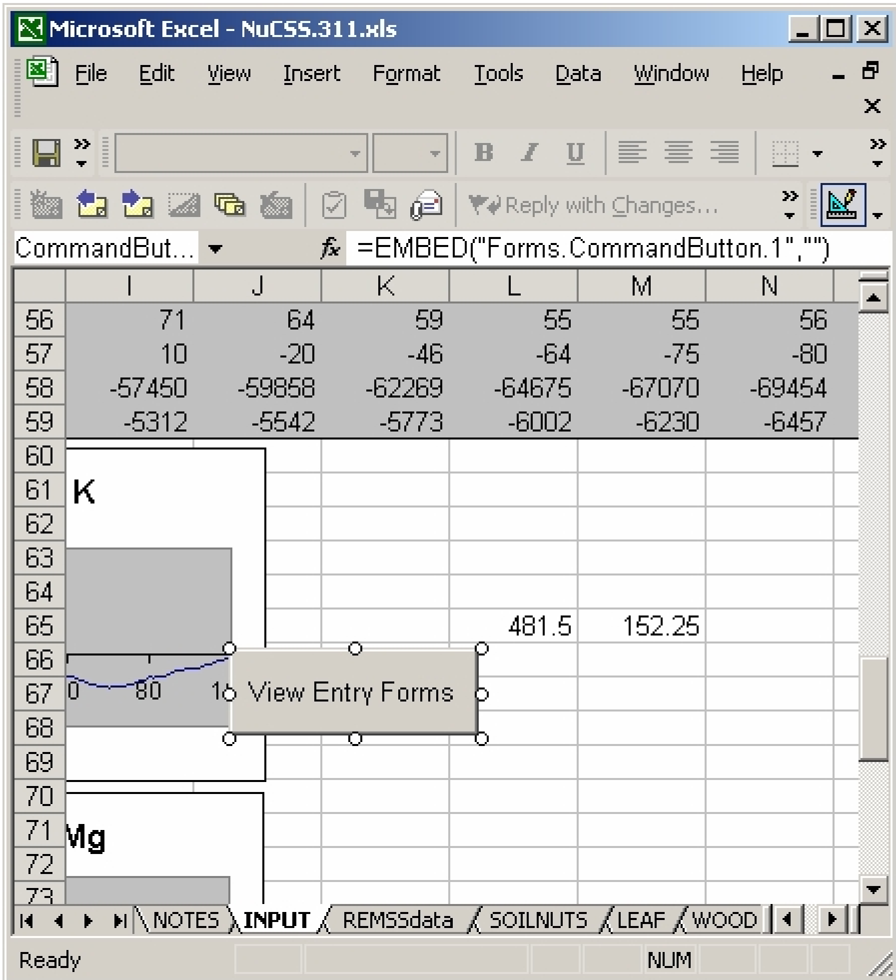
Code Overview

```
Sheet2 is the entry point into the macro and consists of the object
CommandButton1 which is named "View Entry Forms". The code associated with
the click of this mouse button shows the first form.
```

Code

```
Private Sub CommandButton1_Click()
    frmAtmosDep.Show
End Sub
```

ThisWorkbook



Code Overview

The image above reflects the spreadsheet in design mode and has been provided for illustrative purposes. The CommandButton1 has been moved from the original position to reveal two hidden cells that lie behind the button. These cells serve as static global variables that are associated with the application and store the values for the relative positions of the entry forms from the last time that the function was called. Each form contains the following function that would need to reflect any change in location of the corresponding cells or button on the input sheet:

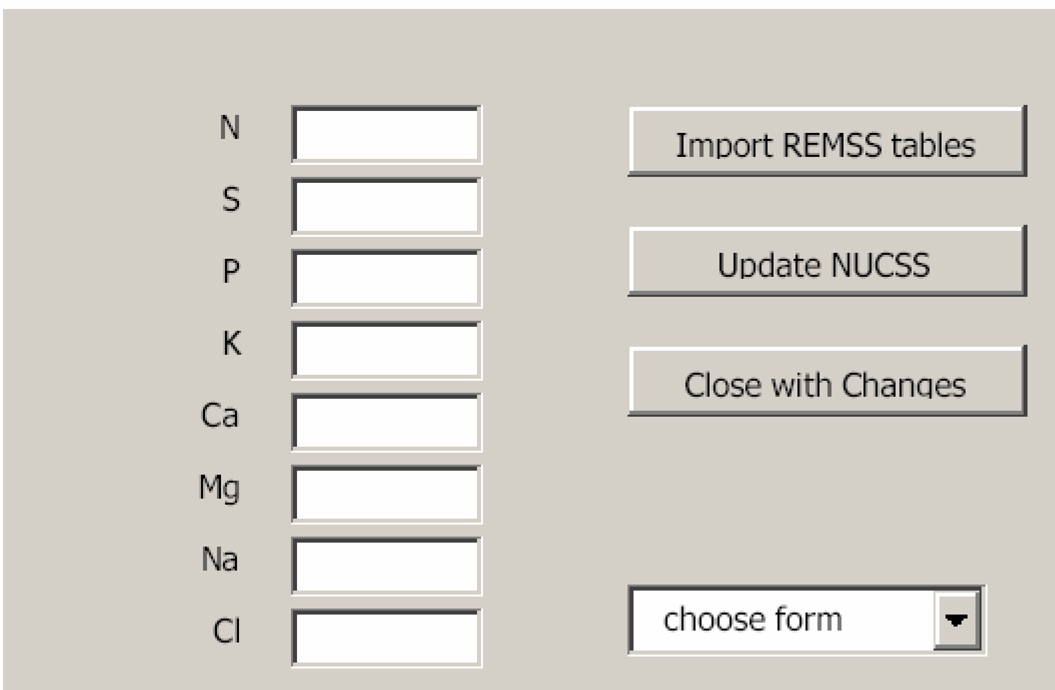
```
Private Sub UserForm_Activate()
      . . .
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
      . . .
```

When the spreadsheet is first opened, the following code section associated with the workbook object “thisWorkbook” is called. The primary function of this code is to open the “Input” worksheet, the worksheet contianing user input and resulting output graphs. The worksheet then scrolls to a location on the page that corresponds closely with the entry button, and opens the first user entry form. This occurs whenever the Spreadsheet is opened.

Code

```
Private Sub Workbook_Open()
    Sheets("Input").Select
    ActiveWindow.ScrollRow = 56
    Range("K61").Select
    frmAtmosDep.Show
End Sub
```

frmAtmosDep



Base Form Code Overview

This code overview section will serve as primary guidance for the functioning of all basic form functions, any additional form specific functions or unique features will be described for each corresponding form. This section should serve as guidance for all general features associated with all forms.

All forms contain a series of TextBox controls for data entry. All forms contain the following code that identifies whether the user has changed a value with an associated TextBox and sets the value binMod to true if a change has been made. This value is used to identify whether the spreadsheet needs to be updated with a form value. The corresponding subroutine is listed below:

```
Private Sub TextBox1_Change()
    binMod = True
End Sub
```

The next subroutine populates the dropdown box, which allows the user to switch between forms for data entry:

Private Sub UserForm_Activate()

On activation, the *LoadData* subroutine is called which populates the text boxes with the corresponding values from the input spreadsheet.
The next subroutine calls the associated form from the drop down list if the user selects a new entry form. If the binMod value = True, the user is prompted on whether the current form data is to be updated to the spreadsheet. Optional code has been embedded to allow for automatic updates of user specified data, view the code comments to modify the behavior of the code:

Sub ComboBox1_Change()

Each Form also contains the following three command buttons that are associated with the _Click() event:

CommandButton1, labeled as “Update NuCSS”;
CommandButton2, labeled as “Close with Changes”; and
CommandButton3 labeled as “Import REMSS tables”.

Code associated with CommandButton4 is not used, but is included as a placeholder for future functionality. Code associated with this button will close the form and not incorporate any changes, subroutines would have to be added and assigned to a button named CommandButton4.

CommandButton1, labeled as “Update NuCSS” calls the updateData subroutine which populates the spreadsheet with user values and leaves the data entry forms open.

CommandButton2, labeled as “Close with Changes” calls the updateData subroutine which populates the spreadsheet with user values and closes the data entry forms with the Unload function.

CommandButton3 labeled as “Import REMSS tables” calls the Modules listed at the end of the code documentation containing references to cells that are to be imported and updated in the REMSS input worksheet.

Code Overview

In addition to the base code overview above, the frmAtmosDep form has the following characteristics:

The data ranges addressed in the LoadData and UpdateData functions correspond with the worksheet cells labeled “atmosdep” on the input worksheet in NuCSS. A corresponding number of TextBox objects has been provided on the form for data entry.

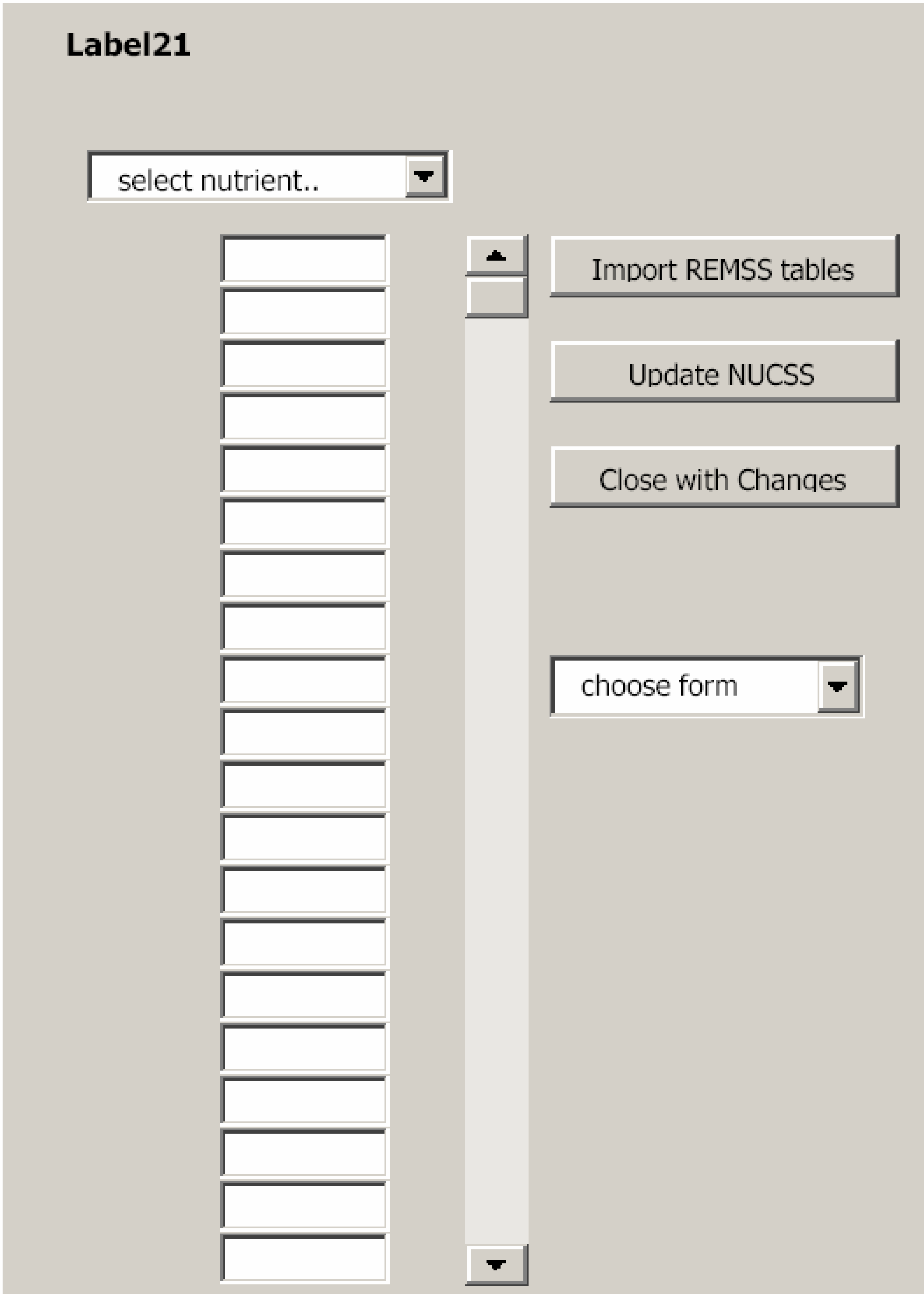
Code

```
Option Explicit
Dim binMod As Boolean


Private Sub TextBox1_Change()
    binMod = True
End Sub


Private Sub TextBox2_Change()
    binMod = True
End Sub


Private Sub TextBox3_Change()
    binMod = True
End Sub


Private Sub TextBox4_Change()
    binMod = True
End Sub


Private Sub TextBox5_Change()
    binMod = True
End Sub


Private Sub TextBox6_Change()
    binMod = True
End Sub


Private Sub TextBox7_Change()
    binMod = True
End Sub


Private Sub TextBox8_Change()
    binMod = True
End Sub
```

```
Private Sub UserForm_Activate()
    binMod = False
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
    LoadData
    ComboBox1.AddItem ("Fertilizer %")
    ComboBox1.AddItem ("Atmospheric Dep")
    ComboBox1.AddItem ("Soil Physical Prop")
    ComboBox1.AddItem ("Soil Chemical Prop")
    ComboBox1.AddItem ("% Weathering")
    ComboBox1.AddItem ("Organic Matter")
    ComboBox1.AddItem ("Fertilization")
End Sub


Sub ComboBox1_Change()
    If binMod = True Then
        'to have this code go from a prompt to autosave, comment out the
next if - end if block
        If MsgBox("Would you like to first save changes?", vbYesNo) =
vbYes Then
            Updatedata
        End If
    End If
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
    If ComboBox1.Value = "Fertilizer %" Then
        frmPercentFert.Show
    ElseIf ComboBox1.Value = "Atmospheric Dep" Then
        frmAtmosDep.Show
    ElseIf ComboBox1.Value = "Soil Physical Prop" Then
        frmSoilProp.Show
    ElseIf ComboBox1.Value = "% Weathering" Then
        frmWeathering.Show
    ElseIf ComboBox1.Value = "Soil Chemical Prop" Then
        frmSoilChemProp.Show
     ElseIf ComboBox1.Value = "Organic Matter" Then
        frmOrganic.Show
    ElseIf ComboBox1.Value = "Fertilization" Then
        frmFertilization.Show
   End If
End Sub


Private Sub CommandButton1_Click()
    Updatedata
End Sub


Private Sub CommandButton2_Click()
    Updatedata
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub
```

```
Private Sub CommandButton3_Click()
    Update_REMSS
End Sub


Private Sub CommandButton4_Click()
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub



Private Sub Updatedata()
    With Me
        Range("atmosdep").Cells(1, 1) = FormatNumber(.TextBox1, 3)
        Range("atmosdep").Cells(2, 1) = FormatNumber(.TextBox2, 3)
        Range("atmosdep").Cells(3, 1) = FormatNumber(.TextBox3, 3)
        Range("atmosdep").Cells(4, 1) = FormatNumber(.TextBox4, 3)
        Range("atmosdep").Cells(5, 1) = FormatNumber(.TextBox5, 3)
        Range("atmosdep").Cells(6, 1) = FormatNumber(.TextBox6, 3)
        Range("atmosdep").Cells(7, 1) = FormatNumber(.TextBox7, 3)
        Range("atmosdep").Cells(8, 1) = FormatNumber(.TextBox8, 3)
    End With
End Sub


Private Sub LoadData()
    With Me
        .TextBox1 = Range("atmosdep").Cells(1, 1)
        .TextBox2 = Range("atmosdep").Cells(2, 1)
        .TextBox3 = Range("atmosdep").Cells(3, 1)
        .TextBox4 = Range("atmosdep").Cells(4, 1)
        .TextBox5 = Range("atmosdep").Cells(5, 1)
        .TextBox6 = Range("atmosdep").Cells(6, 1)
        .TextBox7 = Range("atmosdep").Cells(7, 1)
        .TextBox8 = Range("atmosdep").Cells(8, 1)
    End With
    binMod = False
End Sub
```

frmFertilization



Code Overview

In addition to the base form code overview section, the frmFertilization form has the following characteristics:

The data ranges addressed in the LoadData and UpdateData functions correspond with the worksheet cells labeled "Fertilization" on the input worksheet in NuCSS. Ranges are addressed by row corresponding to fertilization type (intNut) and column referencing year (intRange). A scroll bar has been added to the form to allow for easier management of the potential years of fertilization:

```
intRange = iRowNumber * 20
ScrollBar1.Value = iRowNumber
ScrollBar1.Min = 0
ScrollBar1.Max = 4
```

The following functions update the corresponding annual data range and labels:

```
ChangeLabels
LoadData
HeaderChange
```

A drop down menu is also added to switch between the five different fertilization types, locations referenced by integer values 1-5 and stored in the intNut variable:

```
Sub LoadDD()
        ComboBox5.AddItem "N - Nitrogen"
        ComboBox5.AddItem "P - Phosphorus"
        ComboBox5.AddItem "K - Potassium"
        ComboBox5.AddItem "Ca - Calcium"
        ComboBox5.AddItem "Mg - Magnesium"
End Sub
```

A corresponding number of TextBox objects have been provided on the form for data entry.

Code

```
Option Explicit
Dim binMod As Boolean
Dim iRowNumber As Integer
Dim intNut As Integer
Dim intRange As Integer
Dim intScroll As Integer


Private Sub TextBox1_Change()
    binMod = True
End Sub
```

```
Private Sub TextBox2_Change()
    binMod = True
End Sub

Private Sub TextBox3_Change()
    binMod = True
End Sub

Private Sub TextBox4_Change()
    binMod = True
End Sub

Private Sub TextBox5_Change()
    binMod = True
End Sub

Private Sub TextBox6_Change()
    binMod = True
End Sub

Private Sub TextBox7_Change()
    binMod = True
End Sub

Private Sub TextBox8_Change()
    binMod = True
End Sub

Private Sub TextBox9_Change()
    binMod = True
End Sub

Private Sub TextBox10_Change()
    binMod = True
End Sub

Private Sub TextBox11_Change()
    binMod = True
End Sub

Private Sub TextBox12_Change()
    binMod = True
End Sub
```

```
Private Sub TextBox13_Change()
    binMod = True
End Sub


Private Sub TextBox14_Change()
    binMod = True
End Sub


Private Sub TextBox15_Change()
    binMod = True
End Sub


Private Sub TextBox16_Change()
    binMod = True
End Sub


Private Sub TextBox17_Change()
    binMod = True
End Sub


Private Sub TextBox18_Change()
    binMod = True
End Sub


Private Sub TextBox19_Change()
    binMod = True
End Sub


Private Sub TextBox20_Change()
    binMod = True
End Sub


Private Sub UserForm_Activate()
    binMod = False
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
    iRowNumber = 0
    intNut = 1
    intRange = iRowNumber * 20
    ScrollBar1.Value = iRowNumber
    ScrollBar1.Min = 0
    ScrollBar1.Max = 4
    LoadDD
    LoadData
    ChangeLabels
    HeaderChange
```

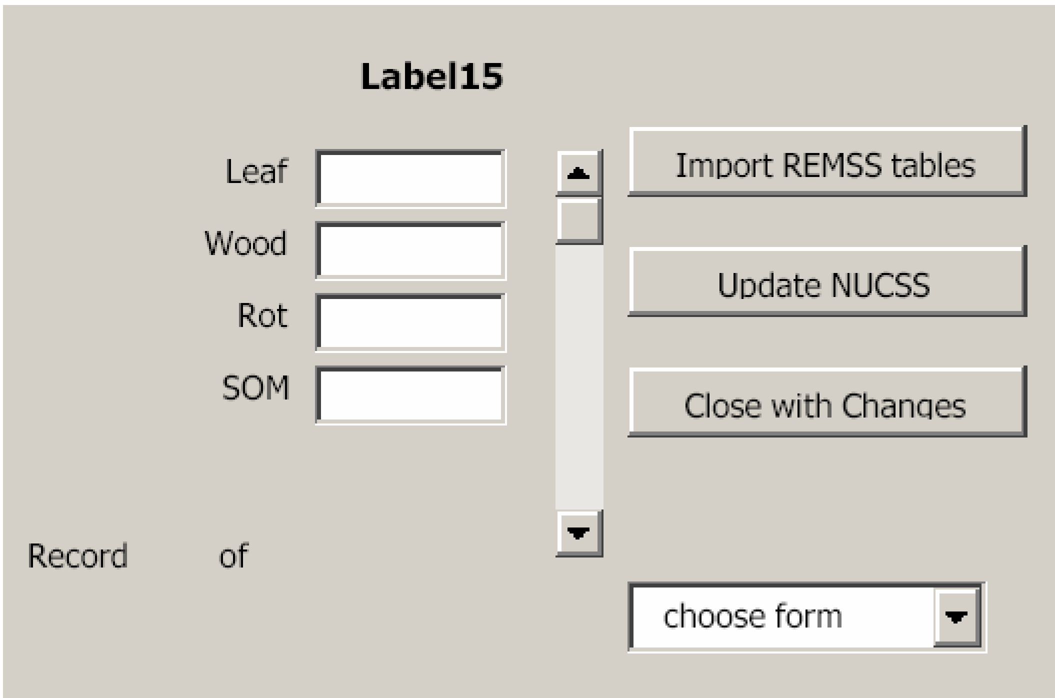
```
    ComboBox1.AddItem ("Fertilizer %")
    ComboBox1.AddItem ("Atmospheric Dep")
    ComboBox1.AddItem ("Soil Physical Prop")
    ComboBox1.AddItem ("Soil Chemical Prop")
    ComboBox1.AddItem ("% Weathering")
    ComboBox1.AddItem ("Organic Matter")
    ComboBox1.AddItem ("Fertilization")
End Sub


Sub ComboBox1_Change()
    Autosave
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
    If ComboBox1.Value = "Fertilizer %" Then
        frmPercentFert.Show
    ElseIf ComboBox1.Value = "Atmospheric Dep" Then
        frmAtmosDep.Show
    ElseIf ComboBox1.Value = "Soil Physical Prop" Then
        frmSoilProp.Show
    ElseIf ComboBox1.Value = "% Weathering" Then
        frmWeathering.Show
    ElseIf ComboBox1.Value = "Soil Chemical Prop" Then
        frmSoilChemProp.Show
    ElseIf ComboBox1.Value = "Organic Matter" Then
        frmOrganic.Show
    ElseIf ComboBox1.Value = "Fertilization" Then
        frmFertilization.Show
    End If

End Sub


Private Sub CommandButton1_Click()
    Updatedata
End Sub


Sub ComboBox5_change()
    Autosave
    If ComboBox5.Value = "N - Nitrogen" Then
        intNut = 1
    ElseIf ComboBox5.Value = "P - Phosphorus" Then
        intNut = 2
    ElseIf ComboBox5.Value = "K - Potassium" Then
        intNut = 3
    ElseIf ComboBox5.Value = "Ca - Calcium" Then
        intNut = 4
    ElseIf ComboBox5.Value = "Mg - Magnesium" Then

        intNut = 5
    End If
    HeaderChange
    LoadData
End Sub
```

```
Private Sub CommandButton2_Click()
    Updatedata
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub CommandButton3_Click()
    Update_REMSS
End Sub


Private Sub CommandButton4_Click()
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub Updatedata()
    With Me
        Range("Fertilization").Cells(intNut, intRange + 1) =
Trim(.TextBox1)
        Range("Fertilization").Cells(intNut, intRange + 2) =
Trim(.TextBox2)
        Range("Fertilization").Cells(intNut, intRange + 3) =
Trim(.TextBox3)
        Range("Fertilization").Cells(intNut, intRange + 4) =
Trim(.TextBox4)
        Range("Fertilization").Cells(intNut, intRange + 5) =
Trim(.TextBox5)
        Range("Fertilization").Cells(intNut, intRange + 6) =
Trim(.TextBox6)
        Range("Fertilization").Cells(intNut, intRange + 7) =
Trim(.TextBox7)
        Range("Fertilization").Cells(intNut, intRange + 8) =
Trim(.TextBox8)
        Range("Fertilization").Cells(intNut, intRange + 9) =
Trim(.TextBox9)
        Range("Fertilization").Cells(intNut, intRange + 10) =
Trim(.TextBox10)
        Range("Fertilization").Cells(intNut, intRange + 11) =
Trim(.TextBox11)
        Range("Fertilization").Cells(intNut, intRange + 13) =
Trim(.TextBox12)
        Range("Fertilization").Cells(intNut, intRange + 13) =
Trim(.TextBox13)
        Range("Fertilization").Cells(intNut, intRange + 14) =
Trim(.TextBox14)
        Range("Fertilization").Cells(intNut, intRange + 15) =
Trim(.TextBox15)
```

```
        Range("Fertilization").Cells(intNut, intRange + 16) =
Trim(.TextBox16)


        Range("Fertilization").Cells(intNut, intRange + 17) =
      Trim(.TextBox17)
        Range("Fertilization").Cells(intNut, intRange + 18) =
Trim(.TextBox18)
        Range("Fertilization").Cells(intNut, intRange + 19) =
Trim(.TextBox19)
        Range("Fertilization").Cells(intNut, intRange + 20) =
Trim(.TextBox20)
    End With
End Sub


Private Sub LoadData()
    With Me
        .TextBox1 = Range("Fertilization").Cells(intNut, intRange + 1)
        .TextBox2 = Range("Fertilization").Cells(intNut, intRange + 2)
        .TextBox3 = Range("Fertilization").Cells(intNut, intRange + 3)
        .TextBox4 = Range("Fertilization").Cells(intNut, intRange + 4)
        .TextBox5 = Range("Fertilization").Cells(intNut, intRange + 5)
        .TextBox6 = Range("Fertilization").Cells(intNut, intRange + 6)
        .TextBox7 = Range("Fertilization").Cells(intNut, intRange + 7)
        .TextBox8 = Range("Fertilization").Cells(intNut, intRange + 8)
        .TextBox9 = Range("Fertilization").Cells(intNut, intRange + 9)
        .TextBox10 = Range("Fertilization").Cells(intNut, intRange + 10)
        .TextBox11 = Range("Fertilization").Cells(intNut, intRange + 11)
        .TextBox12 = Range("Fertilization").Cells(intNut, intRange + 12)
        .TextBox13 = Range("Fertilization").Cells(intNut, intRange + 13)
        .TextBox14 = Range("Fertilization").Cells(intNut, intRange + 14)
        .TextBox15 = Range("Fertilization").Cells(intNut, intRange + 15)
        .TextBox16 = Range("Fertilization").Cells(intNut, intRange + 16)
        .TextBox17 = Range("Fertilization").Cells(intNut, intRange + 17)
        .TextBox18 = Range("Fertilization").Cells(intNut, intRange + 18)
        .TextBox19 = Range("Fertilization").Cells(intNut, intRange + 19)
        .TextBox20 = Range("Fertilization").Cells(intNut, intRange + 20)
    End With
binMod = False
End Sub


Private Sub ScrollBar1_Change()
    Autosave
    iRowNumber = ScrollBar1.Value
    intRange = (iRowNumber * 20)
    ChangeLabels
    LoadData
    HeaderChange
    TextBox1.SetFocus
End Sub


Private Sub ChangeLabels()
    intScroll = ScrollBar1.Value
```

```
    Label1.Caption = "Year " & intScroll * 20 + 1
    Label2.Caption = "Year " & intScroll * 20 + 2
    Label3.Caption = "Year " & intScroll * 20 + 3
    Label4.Caption = "Year " & intScroll * 20 + 4
    Label5.Caption = "Year " & intScroll * 20 + 5
    Label6.Caption = "Year " & intScroll * 20 + 6
    Label7.Caption = "Year " & intScroll * 20 + 7
    Label8.Caption = "Year " & intScroll * 20 + 8
    Label9.Caption = "Year " & intScroll * 20 + 9
    Label10.Caption = "Year " & intScroll * 20 + 10
    Label11.Caption = "Year " & intScroll * 20 + 11
    Label12.Caption = "Year " & intScroll * 20 + 12
    Label13.Caption = "Year " & intScroll * 20 + 13
    Label14.Caption = "Year " & intScroll * 20 + 14
    Label15.Caption = "Year " & intScroll * 20 + 15
    Label16.Caption = "Year " & intScroll * 20 + 16
    Label17.Caption = "Year " & intScroll * 20 + 17
    Label18.Caption = "Year " & intScroll * 20 + 18
    Label19.Caption = "Year " & intScroll * 20 + 19
    Label20.Caption = "Year " & intScroll * 20 + 20
End Sub


Sub LoadDD()
        ComboBox5.AddItem "N - Nitrogen"
        ComboBox5.AddItem "P - Phosphorus"
        ComboBox5.AddItem "K - Potassium"
        ComboBox5.AddItem "Ca - Calcium"
        ComboBox5.AddItem "Mg - Magnesium"
End Sub


Sub HeaderChange()
        Label21.Caption = Range("Fertilization").Cells(intNut, 0) & _
    " - Years " & (intRange + 1) & " to " & (intRange + 20)
End Sub


Sub Autosave()
    If binMod = True Then
        'to have this code go from a prompt to autosave, comment out the
next if - end if block

        If MsgBox("Would you like to first save changes?", vbYesNo) =
vbYes Then
            Updatedata
        End If
    End If
 End Sub
```

frmOrganic



Code Overview

In addition to the base form code overview section, the frmOrganic form has the following characteristics:

The data ranges addressed in the LoadData and UpdateData functions correspond with the worksheet cells labeled "OrganicMatter" on the input worksheet in NuCSS. Ranges are addressed by row corresponding to various organic matter parameters (iRowNumber). Labels are extracted from the first row, and logic is added to prevent text box entry fields when parameters are not to be entered into the spreadsheet.

```
.Label15.Caption = Range("OrganicMatter").Cells(iRowNumber, 1)
.TextBox1 = Range("OrganicMatter").Cells(iRowNumber, 5)
.TextBox2 = Range("OrganicMatter").Cells(iRowNumber, 6)
.TextBox3 = Range("OrganicMatter").Cells(iRowNumber, 7)
.TextBox4 = Range("OrganicMatter").Cells(iRowNumber, 8)
If (iRowNumber = 1 Or iRowNumber = 2) Then
    .TextBox4.Enabled = False
ElseIf iRowNumber = 7 Then
    .TextBox4.Visible = False
Else
    .TextBox4.Visible = True
    .TextBox4.Enabled = True
End If
```

A scroll bar has been added to the form to allow for easier management of the potential layers of organic matter:

```
iRowNumber = 1
ScrollBar1.Value = iRowNumber
ScrollBar1.Min = iRowNumber
ScrollBar1.Max = Range("OrganicMatter").Rows.Count
```

A corresponding number of TextBox objects have been provided on the form for data entry.

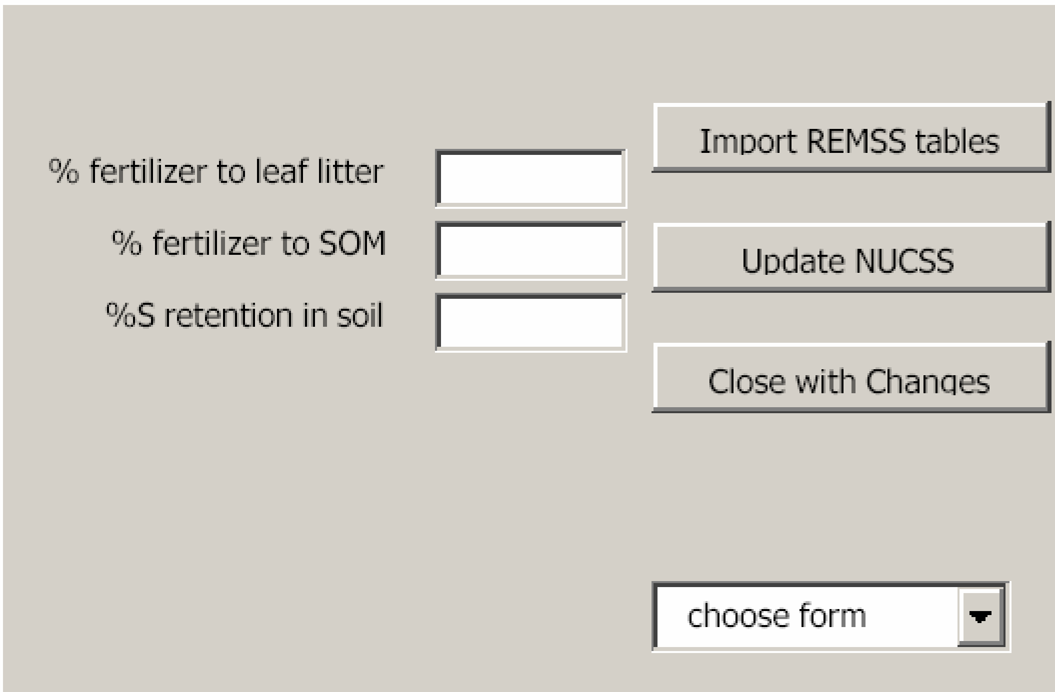
Code

```
Option Explicit
Dim binMod As Boolean
Dim iRowNumber As Integer


Private Sub TextBox1_Change()
    binMod = True
End Sub


Private Sub TextBox2_Change()
    binMod = True
End Sub


Private Sub TextBox3_Change()
    binMod = True
End Sub


Private Sub TextBox4_Change()
    binMod = True
End Sub


Private Sub UserForm_Activate()
    binMod = False
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
    Me.TextBox4.Visible = True
    iRowNumber = 1
    ScrollBar1.Value = iRowNumber
    ScrollBar1.Min = iRowNumber
    ScrollBar1.Max = Range("OrganicMatter").Rows.Count
    LoadData
    ComboBox1.AddItem ("Fertilizer %")
    ComboBox1.AddItem ("Atmospheric Dep")
    ComboBox1.AddItem ("Soil Physical Prop")
    ComboBox1.AddItem ("Soil Chemical Prop")
```

```
    ComboBox1.AddItem ("% Weathering")
    ComboBox1.AddItem ("Organic Matter")
    ComboBox1.AddItem ("Fertilization")
End Sub


Sub ComboBox1_Change()
    Autosave
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
    If ComboBox1.Value = "Fertilizer %" Then
        frmPercentFert.Show
    ElseIf ComboBox1.Value = "Atmospheric Dep" Then
        frmAtmosDep.Show
    ElseIf ComboBox1.Value = "Soil Physical Prop" Then
        frmSoilProp.Show
    ElseIf ComboBox1.Value = "% Weathering" Then
        frmWeathering.Show
    ElseIf ComboBox1.Value = "Soil Chemical Prop" Then
        frmSoilChemProp.Show
    ElseIf ComboBox1.Value = "Organic Matter" Then
        frmOrganic.Show
    ElseIf ComboBox1.Value = "Fertilization" Then
        frmFertilization.Show
   End If
End Sub


Private Sub CommandButton1_Click()
    Updatedata
End Sub


Private Sub CommandButton2_Click()
    Updatedata
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub CommandButton3_Click()
    Update_REMSS
End Sub


Private Sub CommandButton4_Click()
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub Updatedata()
    With Me
```

```
        Range("OrganicMatter").Cells(iRowNumber, 5) =
FormatNumber(.TextBox1, 3)
        Range("OrganicMatter").Cells(iRowNumber, 6) =
FormatNumber(.TextBox2, 3)
        Range("OrganicMatter").Cells(iRowNumber, 7) =
FormatNumber(.TextBox3, 3)
    If Not (iRowNumber = 1 Or iRowNumber = 2 Or iRowNumber = 7) Then
        Range("OrganicMatter").Cells(iRowNumber, 8) =
FormatNumber(.TextBox4, 3)
    End If
    End With
End Sub


Private Sub LoadData()
    With Me
        .Label15.Caption = Range("OrganicMatter").Cells(iRowNumber, 1)
        .TextBox1 = Range("OrganicMatter").Cells(iRowNumber, 5)
        .TextBox2 = Range("OrganicMatter").Cells(iRowNumber, 6)
        .TextBox3 = Range("OrganicMatter").Cells(iRowNumber, 7)
        .TextBox4 = Range("OrganicMatter").Cells(iRowNumber, 8)
        If (iRowNumber = 1 Or iRowNumber = 2) Then
            .TextBox4.Enabled = False
        ElseIf iRowNumber = 7 Then
            .TextBox4.Visible = False
        Else
            .TextBox4.Visible = True
            .TextBox4.Enabled = True
        End If
    End With
binMod = False
End Sub


Private Sub ScrollBar1_Change()
    Autosave
    '\ Clicking on the scroll bar changes its value - from the minumum to
    '\ the maximum.  This value is used to select a new row from range
    iRowNumber = ScrollBar1.Value
    LoadData
    TextBox1.SetFocus
    Label12.Caption = iRowNumber
    Label14.Caption = Range("OrganicMatter").Rows.Count
End Sub


Sub Autosave()
    If binMod = True Then
        'to have this code go from a prompt to autosave, comment out the
next if - end if block
        If MsgBox("Would you like to first save changes?", vbYesNo) =
vbYes Then
            Updatedata
        End If
    End If
End Sub
```

frmPercentFert



Code Overview

The form frmPercentFert contains many of the default code characteristics listed in the discussion in the Base Form Code Overview section. The ranges addressed by this form are in the “percentfert” range on the spreadsheet. A corresponding number of textbox objects have been created on the form.

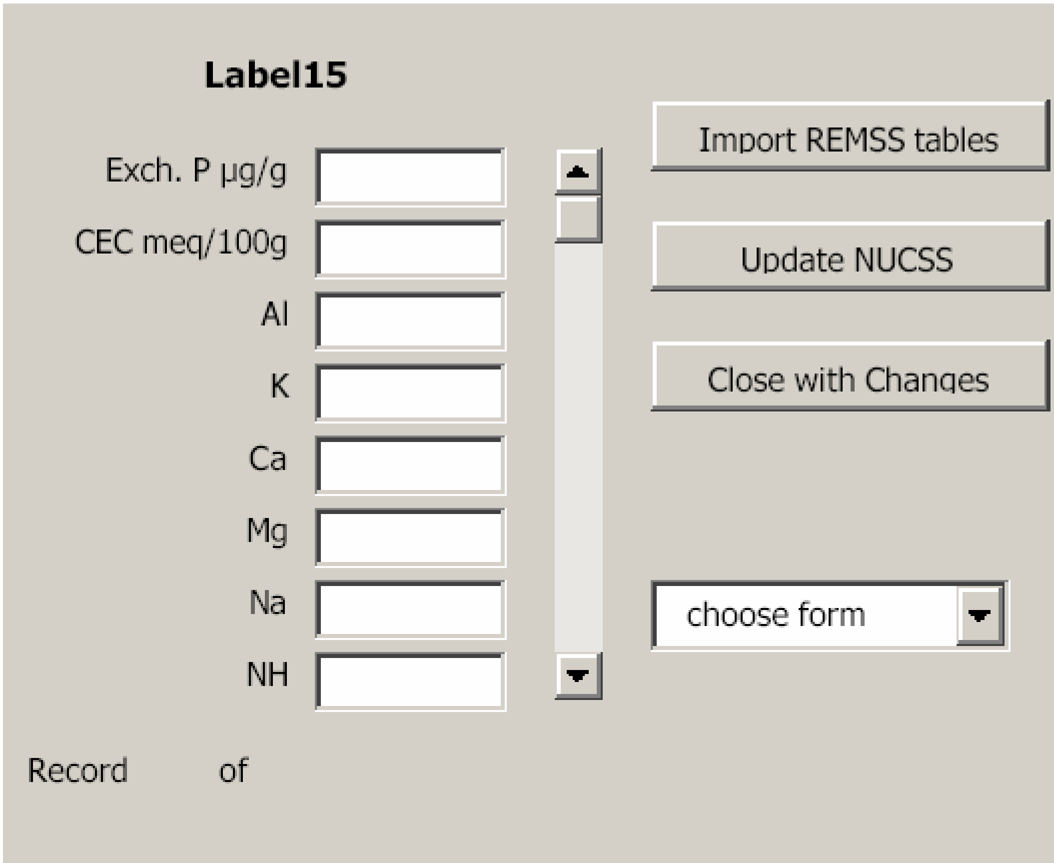
Code

```
Option Explicit
Dim binMod As Boolean


Private Sub TextBox1_Change()
    binMod = True
End Sub


Private Sub TextBox2_Change()
    binMod = True
End Sub
```

```
Private Sub TextBox3_Change()
    binMod = True
End Sub


Private Sub UserForm_Activate()
binMod = False
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
    LoadData
    ComboBox1.AddItem ("Fertilizer %")
    ComboBox1.AddItem ("Atmospheric Dep")
    ComboBox1.AddItem ("Soil Physical Prop")
    ComboBox1.AddItem ("Soil Chemical Prop")
    ComboBox1.AddItem ("% Weathering")
    ComboBox1.AddItem ("Organic Matter")
    ComboBox1.AddItem ("Fertilization")
End Sub


Sub ComboBox1_Change()
    If binMod = True Then
        'to have this code go from a prompt to autosave, comment out the
next if - end if block
        If MsgBox("Would you like to first save changes?", vbYesNo) =
vbYes Then
            Updatedata
        End If
    End If
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
    If ComboBox1.Value = "Fertilizer %" Then
        frmPercentFert.Show
    ElseIf ComboBox1.Value = "Atmospheric Dep" Then
        frmAtmosDep.Show
    ElseIf ComboBox1.Value = "Soil Physical Prop" Then
        frmSoilProp.Show
    ElseIf ComboBox1.Value = "% Weathering" Then
        frmWeathering.Show
    ElseIf ComboBox1.Value = "Soil Chemical Prop" Then
        frmSoilChemProp.Show
    ElseIf ComboBox1.Value = "Organic Matter" Then
        frmOrganic.Show
    ElseIf ComboBox1.Value = "Fertilization" Then
        frmFertilization.Show
   End If
End Sub


Private Sub CommandButton1_Click()
    Updatedata
End Sub
```

```
Private Sub CommandButton2_Click()
    Updatedata
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub CommandButton3_Click()
    Update_REMSS
End Sub


Private Sub CommandButton4_Click()
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub Updatedata()
    With Me
        Range("percentfert").Cells(1, 1) = FormatNumber(.TextBox1, 3)
        Range("percentfert").Cells(2, 1) = FormatNumber(.TextBox2, 3)
        Range("percentfert").Cells(3, 1) = FormatNumber(.TextBox3, 3)
    End With
End Sub


Private Sub LoadData()
    With Me
        .TextBox1 = Range("percentfert").Cells(1, 1)
        .TextBox2 = Range("percentfert").Cells(2, 1)
        .TextBox3 = Range("percentfert").Cells(3, 1)
    End With
    binMod = False
End Sub
```

frmSoilChemProp



Code Overview

In addition to the base form code overview section, the frmSoilChemProp form has the following characteristics:

The data ranges addressed in the LoadData and UpdateData functions correspond with the worksheet cells labeled “IntSoilProp” on the input worksheet in NuCSS. Ranges are addressed by row corresponding to various soil horizons (iRowNumber).

```
.Label15.Caption = Range("IntSoilProp").Cells(iRowNumber, 1)
.TextBox1 = Range("IntSoilProp").Cells(iRowNumber, 2)
.TextBox2 = Range("IntSoilProp").Cells(iRowNumber, 3)
    . . .
.TextBox8 = Range("IntSoilProp").Cells(iRowNumber, 9)
```

A scroll bar has been added to the form to allow for easier management of the potential layers of organic matter:

```
    ScrollBar1.Value = iRowNumber
    ScrollBar1.Min = iRowNumber
    ScrollBar1.Max = Range("IntSoilProp").Rows.Count
```

A corresponding number of TextBox objects have been provided on the form for data entry.

Code

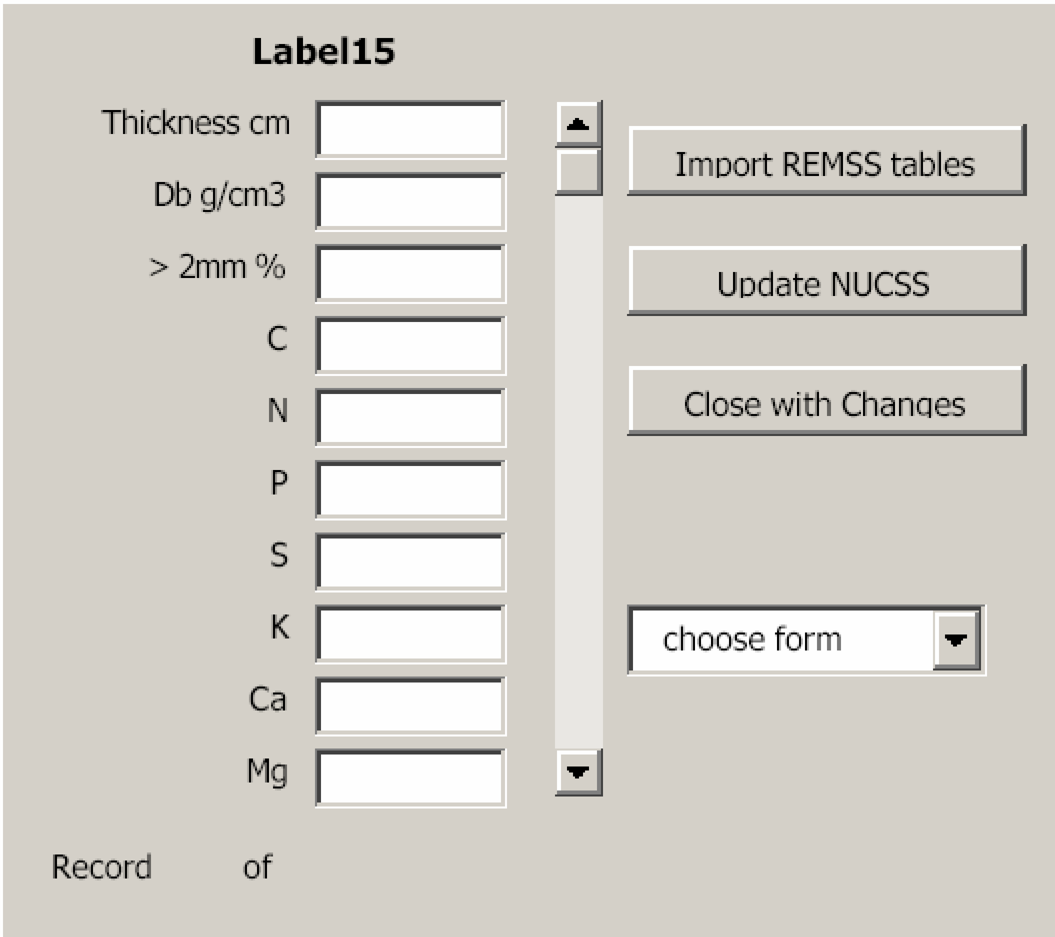
```
Option Explicit

Dim iRowNumber As Integer
Dim binMod As Boolean


Private Sub TextBox1_Change()
    binMod = True
End Sub


Private Sub TextBox2_Change()
    binMod = True
End Sub


Private Sub TextBox3_Change()
    binMod = True
End Sub


Private Sub TextBox4_Change()
    binMod = True
End Sub


Private Sub TextBox5_Change()
    binMod = True
End Sub


Private Sub TextBox6_Change()
    binMod = True
End Sub


Private Sub TextBox7_Change()
    binMod = True
End Sub


Private Sub TextBox8_Change()
    binMod = True
End Sub
```

```
Private Sub UserForm_Activate()
binMod = False
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
    iRowNumber = 1
    ScrollBar1.Value = iRowNumber
    ScrollBar1.Min = iRowNumber
    ScrollBar1.Max = Range("IntSoilProp").Rows.Count
    LoadData
    ComboBox1.AddItem ("Fertilizer %")
    ComboBox1.AddItem ("Atmospheric Dep")
    ComboBox1.AddItem ("Soil Physical Prop")
    ComboBox1.AddItem ("Soil Chemical Prop")
    ComboBox1.AddItem ("% Weathering")
    ComboBox1.AddItem ("Organic Matter")
    ComboBox1.AddItem ("Fertilization")
End Sub


Sub ComboBox1_Change()
    Autosave
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
    If ComboBox1.Value = "Fertilizer %" Then
        frmPercentFert.Show
    ElseIf ComboBox1.Value = "Atmospheric Dep" Then
        frmAtmosDep.Show
    ElseIf ComboBox1.Value = "Soil Physical Prop" Then
        frmSoilProp.Show
    ElseIf ComboBox1.Value = "% Weathering" Then
        frmWeathering.Show
    ElseIf ComboBox1.Value = "Soil Chemical Prop" Then
        frmSoilChemProp.Show
    ElseIf ComboBox1.Value = "Organic Matter" Then
        frmOrganic.Show
    ElseIf ComboBox1.Value = "Fertilization" Then
        frmFertilization.Show
   End If
End Sub


Private Sub CommandButton1_Click()
    Updatedata
End Sub


Private Sub CommandButton2_Click()
    Updatedata
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub CommandButton3_Click()
```

```
    Update_REMSS
End Sub


Private Sub CommandButton4_Click()
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub Updatedata()
    With Me
        Range("IntSoilProp").Cells(iRowNumber, 2) =
FormatNumber(.TextBox1, 3)
        Range("IntSoilProp").Cells(iRowNumber, 3) =
FormatNumber(.TextBox2, 3)
        Range("IntSoilProp").Cells(iRowNumber, 4) =
FormatNumber(.TextBox3, 3)
        Range("IntSoilProp").Cells(iRowNumber, 5) =
FormatNumber(.TextBox4, 3)
        Range("IntSoilProp").Cells(iRowNumber, 6) =
FormatNumber(.TextBox5, 3)
        Range("IntSoilProp").Cells(iRowNumber, 7) =
FormatNumber(.TextBox6, 3)
        Range("IntSoilProp").Cells(iRowNumber, 8) =
FormatNumber(.TextBox7, 3)
        Range("IntSoilProp").Cells(iRowNumber, 9) =
FormatNumber(.TextBox8, 3)
    End With
End Sub


Private Sub LoadData()
    With Me
        .Label15.Caption = Range("IntSoilProp").Cells(iRowNumber, 1)
        .TextBox1 = Range("IntSoilProp").Cells(iRowNumber, 2)
        .TextBox2 = Range("IntSoilProp").Cells(iRowNumber, 3)
        .TextBox3 = Range("IntSoilProp").Cells(iRowNumber, 4)
        .TextBox4 = Range("IntSoilProp").Cells(iRowNumber, 5)
        .TextBox5 = Range("IntSoilProp").Cells(iRowNumber, 6)
        .TextBox6 = Range("IntSoilProp").Cells(iRowNumber, 7)
        .TextBox7 = Range("IntSoilProp").Cells(iRowNumber, 8)
        .TextBox8 = Range("IntSoilProp").Cells(iRowNumber, 9)
    End With
binMod = False
End Sub



Private Sub ScrollBar1_Change()
    Autosave
    '\ Clicking on the scroll bar changes its value - from the minumum to
    '\ the maximum.  This value is used to select a new row from range
    iRowNumber = ScrollBar1.Value
    LoadData
```

```
    TextBox1.SetFocus
    Label12.Caption = iRowNumber
    Label14.Caption = Range("IntSoilProp").Rows.Count
End Sub


Sub Autosave()
    If binMod = True Then
        'to have this code go from a prompt to autosave, comment out the
next if - end if block


        If MsgBox("Would you like to first save changes?", vbYesNo) =
vbYes Then
            Updatedata
        End If
    End If
End Sub
```

frmSoilProp



Code Overview

In addition to the base form code overview section, the frmSoilChemProp form has the following characteristics:

The data ranges addressed in the LoadData and UpdateData functions correspond with the worksheet cells labeled "soilProp" on the input worksheet in NuCSS. Ranges are addressed by row corresponding to various soil horizons (iRowNumber). Logic is added to prevent text box entry fields when parameters are not to be entered into the spreadsheet as with certain organic horizon properties.

```
Private Sub Updatedata()
    With Me
    If Not (iRowNumber = 1 Or iRowNumber = 2) Then
```

```
        Range("soilprop").Cells(iRowNumber, 2) = FormatNumber(.TextBox1,
3)
        Range("soilprop").Cells(iRowNumber, 3) = FormatNumber(.TextBox2,
3)
        Range("soilprop").Cells(iRowNumber, 4) = FormatNumber(.TextBox3,
3)
        Range("soilprop").Cells(iRowNumber, 5) = FormatNumber(.TextBox4,
3)
    End If
        Range("soilprop").Cells(iRowNumber, 6) = FormatNumber(.TextBox5,
3)
        Range("soilprop").Cells(iRowNumber, 7) = FormatNumber(.TextBox6,
3)
        Range("soilprop").Cells(iRowNumber, 8) = FormatNumber(.TextBox7,
3)
        Range("soilprop").Cells(iRowNumber, 9) = FormatNumber(.TextBox8,
3)
        Range("soilprop").Cells(iRowNumber, 10) = FormatNumber(.TextBox9,
3)
        Range("soilprop").Cells(iRowNumber, 11) = FormatNumber(.TextBox10,
3)
    End With
End Sub
```

A scroll bar has been added to the form to allow for easier management of the potential layers of organic matter:

```
    iRowNumber = 1
    ScrollBar1.Value = iRowNumber
    ScrollBar1.Min = iRowNumber
    ScrollBar1.Max = Range("soilprop").Rows.Count
```

A corresponding number of TextBox objects have been provided on the form for data entry.

Code

```
Option Explicit
Dim binMod As Boolean
Dim iRowNumber As Integer


Private Sub TextBox1_Change()
    binMod = True
End Sub


Private Sub TextBox2_Change()
    binMod = True
End Sub


Private Sub TextBox3_Change()
    binMod = True
End Sub
```

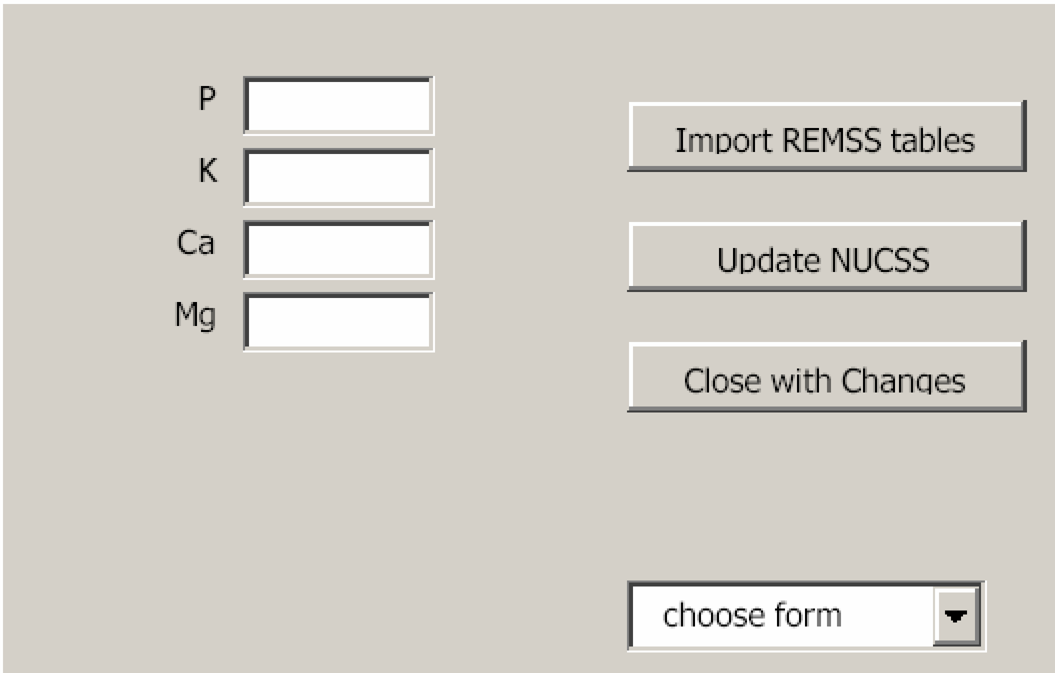
```
Private Sub TextBox4_Change()
    binMod = True
End Sub


Private Sub TextBox5_Change()
    binMod = True
End Sub


Private Sub TextBox6_Change()
    binMod = True
End Sub


Private Sub TextBox7_Change()
    binMod = True
End Sub


Private Sub TextBox8_Change()
    binMod = True
End Sub


Private Sub TextBox9_Change()
    binMod = True
End Sub


Private Sub TextBox10_Change()
    binMod = True
End Sub


Private Sub UserForm_Activate()
    binMod = False
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
    iRowNumber = 1
    ScrollBar1.Value = iRowNumber
    ScrollBar1.Min = iRowNumber
    ScrollBar1.Max = Range("soilprop").Rows.Count
    With Me
            .TextBox1.Visible = True
            .TextBox2.Visible = True
            .TextBox3.Visible = True
            .TextBox4.Visible = True
    End With
    LoadData
    ComboBox1.AddItem ("Fertilizer %")
    ComboBox1.AddItem ("Atmospheric Dep")
    ComboBox1.AddItem ("Soil Physical Prop")
    ComboBox1.AddItem ("Soil Chemical Prop")
```

```
    ComboBox1.AddItem ("% Weathering")
    ComboBox1.AddItem ("Organic Matter")
    ComboBox1.AddItem ("Fertilization")
End Sub


Sub ComboBox1_Change()
    Autosave
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
    If ComboBox1.Value = "Fertilizer %" Then
        frmPercentFert.Show
    ElseIf ComboBox1.Value = "Atmospheric Dep" Then
        frmAtmosDep.Show
    ElseIf ComboBox1.Value = "Soil Physical Prop" Then
        frmSoilProp.Show
    ElseIf ComboBox1.Value = "% Weathering" Then
        frmWeathering.Show
    ElseIf ComboBox1.Value = "Soil Chemical Prop" Then
        frmSoilChemProp.Show
    ElseIf ComboBox1.Value = "Organic Matter" Then
        frmOrganic.Show
    ElseIf ComboBox1.Value = "Fertilization" Then
        frmFertilization.Show
   End If
End Sub


Private Sub CommandButton1_Click()
    Updatedata
End Sub


Private Sub CommandButton2_Click()
    Updatedata
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub CommandButton3_Click()
    Update_REMSS
End Sub


Private Sub CommandButton4_Click()
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub Updatedata()
    With Me
```

```
    If Not (iRowNumber = 1 Or iRowNumber = 2) Then
        Range("soilprop").Cells(iRowNumber, 2) = FormatNumber(.TextBox1,
3)
        Range("soilprop").Cells(iRowNumber, 3) = FormatNumber(.TextBox2,
3)
        Range("soilprop").Cells(iRowNumber, 4) = FormatNumber(.TextBox3,
3)
        Range("soilprop").Cells(iRowNumber, 5) = FormatNumber(.TextBox4,
3)
    End If
        Range("soilprop").Cells(iRowNumber, 6) = FormatNumber(.TextBox5,
3)
        Range("soilprop").Cells(iRowNumber, 7) = FormatNumber(.TextBox6,
3)
        Range("soilprop").Cells(iRowNumber, 8) = FormatNumber(.TextBox7,
3)
        Range("soilprop").Cells(iRowNumber, 9) = FormatNumber(.TextBox8,
3)
        Range("soilprop").Cells(iRowNumber, 10) = FormatNumber(.TextBox9,
3)
        Range("soilprop").Cells(iRowNumber, 11) = FormatNumber(.TextBox10,
3)
    End With
End Sub


Private Sub LoadData()
    With Me
        .Label15.Caption = Range("soilprop").Cells(iRowNumber, 1)
        .TextBox1 = Range("soilprop").Cells(iRowNumber, 2)
        .TextBox2 = Range("soilprop").Cells(iRowNumber, 3)
        .TextBox3 = Range("soilprop").Cells(iRowNumber, 4)
        .TextBox4 = Range("soilprop").Cells(iRowNumber, 5)
        .TextBox5 = Range("soilprop").Cells(iRowNumber, 6)
        .TextBox6 = Range("soilprop").Cells(iRowNumber, 7)
        .TextBox7 = Range("soilprop").Cells(iRowNumber, 8)
        .TextBox8 = Range("soilprop").Cells(iRowNumber, 9)
        .TextBox9 = Range("soilprop").Cells(iRowNumber, 10)
        .TextBox10 = Range("soilprop").Cells(iRowNumber, 11)
        If (iRowNumber = 1 Or iRowNumber = 2) Then
            .TextBox1.Visible = False
            .TextBox2.Visible = False
            .TextBox3.Visible = False
            .TextBox4.Visible = False
        Else
            .TextBox1.Visible = True
            .TextBox2.Visible = True
            .TextBox3.Visible = True
            .TextBox4.Visible = True
        End If
    End With
binMod = False
End Sub


Private Sub ScrollBar1_Change()
```

```
    Autosave
    '\ Clicking on the scroll bar changes its value - from the minimum to
    '\ the maximum.  This value is used to select a new row from range
    iRowNumber = ScrollBar1.Value
    LoadData
    If (iRowNumber = 1 Or iRowNumber = 2) Then
        TextBox5.SetFocus
    Else
        TextBox1.SetFocus
    End If
    Label12.Caption = iRowNumber
    Label14.Caption = Range("soilprop").Rows.Count
End Sub


Sub Autosave()
    If binMod = True Then
        'to have this code go from a prompt to autosave, comment out the
next if - end if block
        If MsgBox("Would you like to first save changes?", vbYesNo) =
vbYes Then
            Updatedata
        End If
    End If
End Sub
```

frmWeathering



Code Overview

The form frmWeathering contains many of the default code characteristics listed in the discussion in the Base Form Code Overview section. The ranges addressed by this form are in the "weather" range on the spreadsheet. A corresponding number of textbox objects have been created on the form.

Code

```
Option Explicit
Dim binMod As Boolean


Private Sub TextBox1_Change()
    binMod = True
End Sub


Private Sub TextBox2_Change()
    binMod = True
End Sub
```

```
Private Sub TextBox3_Change()
    binMod = True
End Sub


Private Sub TextBox4_Change()
    binMod = True
End Sub


Private Sub UserForm_Activate()
    binMod = False
    Me.Left = Range("L65").Value
    Me.Top = Range("M65").Value
    LoadData
    ComboBox1.AddItem ("Fertilizer %")
    ComboBox1.AddItem ("Atmospheric Dep")
    ComboBox1.AddItem ("Soil Physical Prop")
    ComboBox1.AddItem ("Soil Chemical Prop")
    ComboBox1.AddItem ("% Weathering")
    ComboBox1.AddItem ("Organic Matter")
    ComboBox1.AddItem ("Fertilization")
End Sub


Sub ComboBox1_Change()
    If binMod = True Then
        'to have this code go from a prompt to autosave, comment out the
next if - end if block
        If MsgBox("Would you like to first save changes?", vbYesNo) =
vbYes Then
            Updatedata
        End If
    End If
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
    If ComboBox1.Value = "Fertilizer %" Then
        frmPercentFert.Show
    ElseIf ComboBox1.Value = "Atmospheric Dep" Then
        frmAtmosDep.Show
    ElseIf ComboBox1.Value = "Soil Physical Prop" Then
        frmSoilProp.Show
    ElseIf ComboBox1.Value = "% Weathering" Then
        frmWeathering.Show
    ElseIf ComboBox1.Value = "Soil Chemical Prop" Then
        frmSoilChemProp.Show
    ElseIf ComboBox1.Value = "Organic Matter" Then
        frmOrganic.Show
    ElseIf ComboBox1.Value = "Fertilization" Then
        frmFertilization.Show
   End If
End Sub
```

```
Private Sub CommandButton1_Click()
    Updatedata
End Sub

Private Sub CommandButton2_Click()
    Updatedata
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub CommandButton3_Click()
    Update_REMSS
End Sub


Private Sub CommandButton4_Click()
    Range("L65").Value = Me.Left
    Range("M65").Value = Me.Top
    Unload Me
End Sub


Private Sub Updatedata()
    With Me
        Range("weather").Cells(1, 1) = FormatNumber(.TextBox1, 3)
        Range("weather").Cells(1, 3) = FormatNumber(.TextBox2, 3)
        Range("weather").Cells(1, 5) = FormatNumber(.TextBox3, 3)
        Range("weather").Cells(1, 7) = FormatNumber(.TextBox4, 3)
    End With
End Sub


Private Sub LoadData()
    With Me
        .TextBox1 = Range("weather").Cells(1, 1)
        .TextBox2 = Range("weather").Cells(1, 3)
        .TextBox3 = Range("weather").Cells(1, 5)
        .TextBox4 = Range("weather").Cells(1, 7)
    End With
    binMod = False
End Sub
```

Module1

Code Overview

The Module 1 code provides the interface between the NuCSS and REMSS spreadsheets, Module 2 provides the logic for locating and opening the remss.xls spreadsheet file. The primary functionality identified in this module following the sample procedure listed below:

Activate the remss spreadsheet

```
    Windows("remss.xls").Activate
```

Select the NuCSSdata worksheet

```
    Sheets("NuCSSdata").Select
```

Select the corresponding range to be transferred and copy to clipboard

```
    Range("B5:AY9").Select
    Selection.Copy
```

Activate the NuCSS spreadsheet and select the REMSSData worksheet, the spreadsheet name can be changed here

```
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
```

Select and paste the clipboard content to the NuCSS spreadsheet, paste values only.

```
    Range("B5:AY9").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
```

Following code copies first 50 years to second 100 year range on ReMSS spreadsheet

```
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ5:CW9").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
```

Code

```
Option Explicit


Sub Macro2()
```

```
'Nitrogen - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B5:AY9").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B5:AY9").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ5:CW9").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Phosphorus - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B11:AY15").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B11:AY15").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ11:CW15").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Potassium - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B17:AY21").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B17:AY21").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ17:CW21").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Calcium - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
```

```
    Range("B23:AY27").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B23:AY27").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ23:CW27").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Magnesium - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B29:AY33").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B29:AY33").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ29:CW33").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Standing Biomass - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B36:AY40").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B36:AY40").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ36:CW40").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Detritus inputs
'Foliage - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B44:AY45").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
```

```
    Range("B44:AY45").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ44:CW45").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Aboveground Woody - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B47:AY48").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B51:AY52").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ51:CW52").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'Below ground - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B50:AY51").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B58:AY59").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
    'Range("AZ58:CW59").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False

'uptake from soil - Copy from NuCSS to REMSS
    Windows("remss.xls").Activate
    Sheets("NuCSSdata").Select
    Range("B54:AY59").Select
    Selection.Copy
    Windows("NuCSS.311.xls").Activate
    Sheets("REMSSdata").Select
    Range("B66:AY71").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
    'Below code pastes values for years 1-50 over years 51-100
```

```
    'Range("AZ66:CW71").Select
   ' Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
        False, Transpose:=False
End Sub
```

Module2

Code Overview

Module2 contains the code to locate and open the remss.xls file so that the NuCSS spreadsheet can be updated, code below is commented to show flow.

If the name of the remss.xls or NuCSS.311.xls spreadsheets change, the corresponding references can be changed in the code below to reference the new spreadsheet names.

Code

```
Option Explicit

Dim direct As String


Sub Update_REMSS()

'this sub searches the system to determine if REMSS is already open
'If REMSS is already open, it goes immediately to the update
'routine (updateREMSS).  Otherwise it calls the search Routine (findREMSS)
Dim WB As Excel.Workbook
Dim ExcelApp As Excel.Application
Dim binOpen

Set ExcelApp = GetObject(, "Excel.Application")
binOpen = False     'defaults to REMSS not being open

For Each WB In ExcelApp.Workbooks
    If LCase(WB.Name) = "remss.xls" Then    'REMSS is already open
        Windows("remss.xls").Activate
        binOpen = True
        UpdateREMSS ' (True)
    End If
Next WB
If binOpen = False Then     'REMSS has yet to be opened
    findREMSS
End If
End Sub
```

```
Sub findREMSS()
direct = ActiveWorkbook.Path 'CurDir()
'''Search for files in Directory
Dim fs As FileSearch
Set fs = Application.FileSearch
Dim fileToOpen As String
With fs
    .LookIn = direct
    .FileType = msoFileTypeExcelWorkbooks
    .Filename = "remss.xls"
    If .Execute > 0 Then
    'MsgBox "is true"
        Workbooks.Open Filename:=direct & "\\remss.xls"
        UpdateREMSS '(False)
    Else

        ChDir direct
        fileToOpen = Application.GetOpenFilename("Excel Files (*.xls),
*.xls")
        If Not fileToOpen = False Then
            Workbooks.Open Filename:=fileToOpen
        End If
        UpdateREMSS '(False)
    End If
End With
End Sub


Sub UpdateREMSS() '(binKeepOpen)    'if keepopen is true, Remss.xls stays
open
Dim awName
awName = LCase(ActiveWorkbook.Name)
    If awName = "remss.xls" Then
        Macro2
        'The below code will close REMSS if it was closed when sub began
        'If binKeepOpen = False Then
        '    ActiveWorkbook.Close
        'End If
    Else
        MsgBox "update does not happen.  Will only update to remss.xls"
    End If
Windows("NuCSS.311.xls").Activate
Sheets("input").Select
End Sub
```

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