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Management Research Unit

1-6601-05 Southeast Watershed Research Laboratory

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Location

Tifton, Georgia

Title

Soil Resources in the Coastal Plain: Process Characterization, Management Impacts, and Assessment Tools

Investigators

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Total Scientific Staff Years

2.04

Planned Duration

60 months

Signatures

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1/19/01		

Laboratory Director	Date Approved
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Project Summary

Problems facing farmers of the Atlantic and Gulf Coastal Plain include water availability and use efficiency; runoff and sediment production; and soil and water quality impacts from intense agrichemical usage. We will conduct lab, plot, and field experiments and simulation modeling analyses that will improve our understanding of basic processes controlling rainfall-runoff relationships, agrichemical (phosphorus and pesticides) fate and transport, and event-based, phosphorus and pesticide contamination of Coastal Plain soils, as well as the potential for sediment and agrichemical transport to impact water quality in this region. Although phosphorus and pesticides are not typically investigated together, we are in a position to conduct many experiments that will characterize both simultaneously.

We will evaluate the impact of site-specific management practices on soil quality and agrichemical transport. We will provide tools via modeling for predicting, controlling, and mediating pollution by these chemicals. Results will provide fundamental relationships between tillage/cropping systems, soil and water management, and assessment of overall impacts on field-scale soil and water quality. Benefits of the research will include the development of science and technology in support of soil protection and conservation, and reduced-risk pest management practices and strategies applicable throughout the Coastal Plain region. Farmers will benefit from the adoption of BMP's, but this research is to develop the technology for their validation and selection; thus the benefits to farmers will be indirect initially. Although the immediate "users" of this research will be regulators and water quality managers, we will do the research on real farms to make sure the results are both realistic and relevant to real farm situations. We will work through partnership with university extension services, the NRCS, and local and regional stakeholder groups as well as commodity groups to select research locations, design objectives that are of interest to growers in the area, and to make our results available to those growers so that they can be prepared for potential alterations in policy or can take advantage of cost saving practice revisions.

Objectives

Objectives of this 5-yr project include both basic research and development of new technology to apply the research. They are 1) Define and quantitatively describe the processes controlling relationships between rainfall characteristics, infiltration, runoff, sediment yields, and event-based agrichemical losses from Coastal Plain soils; 2) Describe and define the factors and processes, including their spatial and temporal variability, affecting phosphorus and pesticide fate and transport in soil, runoff, foliage and sediments in Coastal Plain agricultural settings.; 3) Develop and evaluate a process-based phosphorus index (PI) to assess impacts of land management practices on soil quality and potential phosphorus loadings at the field edge; 4) Based in part on the research results in Objectives 1 and 2, develop a "pesticide runoff potential index" algorithm which estimates relative pollution characteristics, i.e., allows comparison of the environmental consequences of different pesticides used for the control of the same pest.

Research to address objectives will be conducted in the Coastal Plain region of the Southeastern U.S. This work will also support other research on animal wastes and water quality research done at field, farm and watershed scales by this Laboratory.

Need for Research

- Description of Problem to be Solved

The Coastal Plain physiographic province extends from Maryland to east Texas and comprises about 70% of the land area in the southeastern U.S. It has gently sloping to sloping uplands, and is dissected by slow, low-gradient streams with broad, poorly-drained flood plains. Soils in this region generally have sandy-loamy sand surfaces, distinct subsurface horizons, and low organic carbon content, fertility and agrichemical binding capacity. They are also generally intensively cropped under conventional tillage systems, tend to be drought-prone, and are susceptible to erosion. Subsurface horizons usually consist of argillic horizons (B_t) at about 1 m, and most (60-80%) have plinthite in the lower part of the B_t which restricts vertical water movement and initiates lateral subsurface flow. Soils are underlain by and forming in residuum from Neocene undifferentiated sediments.

The warm humid climate in the region (11°C mean winter temperature) contributes to a long growing season--crops are produced almost year round--and high pest pressures. Crops grown in the region such as cotton, peanuts, and a large variety of smaller-acreage crops such as vegetables and tree fruits require high rates of pesticide use. High-density animal production, especially poultry and swine, generates large volumes of nutrient-rich wastes that are land applied. These wastes have economic and agronomic benefits, however, soil assimilation capacities are limited. Phosphorus is of specific concern because of its potential for runoff into streams and negative water quality impacts.

Agrichemicals are often applied in the spring when rainfall is characterized by short-duration, high intensity convective thunderstorms and the soil is bare or canopy cover is slight, or in the fall when tropical storms occur. These conditions result in high rates of runoff that promotes sediment loss and transport of agrichemicals in soluble and sorbed phases. In any given year, the majority of runoff, sediment, and agrichemical losses occur as a result of a few extreme storms. Understanding the processes linking soil and climatic conditions to runoff, sediment, and agrichemical transport will support the development of management practices that limit their losses.

- Relevance to ARS National Program Action Plan

This research addresses all Components of the Soil Resource Management National Program: Soil Conservation & Restoration; Nutrient Management; Soil Water; Soil Biology; and Productive and Sustainable Soil Management Systems. Specific components, problem areas, and goals to be addressed by this CRIS project are outlined in appendix 1. The pollution indexing and spatial variability research also relates to components and goals in the Integrated Agricultural Systems, Animal Waste and By-Product, and Water Management/Quality National Programs. The Southeast Watershed Research Lab has additional major CRIS research projects in water quality at field and

watershed scale, and fertilizer and animal waste management. All the research described here will be nested within those larger scale studies and will thus provide basic process information valuable for validation of assumptions made in larger scale model representations of water resource impacts.

- Potential Benefits

This research will provide fundamental science in support of the development and implementation of Best Management Practices (BMP's) for this region. As agricultural nonpoint pollution regulation evolves away from national approaches to regional and site-specific approaches the tools and knowledge provided by this research will support the conservation programs that help Coastal Plain farmers make the transition to a more sustainable and economically viable agriculture. Results will help regional policy makers, environmental groups, federal and state regulators and individual farmers make informed decisions about agronomic, environmental, and economic benefits from soil and water conservation and management practices in the Coastal Plain. Benefits of the research will include development of more efficient and economical soil, water, and pest management practices/strategies that are applicable throughout the Coastal Plain. Knowledge and data on pesticide transport potential will have immediate application in the current EPA/USDA/USGS development of methodology for improving approaches for estimating human pesticide exposure via drinking water--a process that is likely to profoundly affect the pest management options available to farmers in this region.

- Anticipated Products

Products include (a) values and guidelines for erodibility and soil loss tolerance; (b) site-specific characterization of runoff, sediment delivery, and agrichemical fate and transport; (c) better understanding of the fate and transport of sediment-transported and foliar-applied agrichemicals, (d) risk assessment tools for management of agricultural soils and pest management; (e) a process-based phosphorus index for field-scale nutrient management and overall soil quality; (f) improved process-based fate and transport pesticide models; (g) a runoff potential index for pesticide pollution risk management, and (h) validations of economically and environmentally viable agricultural practices (BMPs) and systems for phosphate management..

- Customers of the research and their involvement:

Customers include federal, state and local action/regulatory agencies (EPA, NRCS, ERC), wildlife and fisheries agencies and scientists, regional and state water management and quality agencies, agricultural, environmental, and natural resource scientists, and ultimately farmers, landowners, and the agrochemical industry, Research will be developed with direct customer input and cooperation. We will conduct as much of the research as possible "on-farm" and to encourage action agency and state water quality and management agency participation. We will use our relationships with NRCS and EPA scientists, especially, to ensure that our research findings are used to optimize resource conservation programs for this region. We will also participate in local and regional stakeholder groups such as the Coffee County Conservation Tillage Alliance and

the Upper Suwannee River Watershed Initiative to insure that they contribute to our research objectives and can take advantage of our findings.

•—Congressional Mandates:

This research will support USDA mandates under the Clean Water Act (CWA), the Food Quality Protection Act (FQPA), and the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).

Scientific Background

Soil Properties Affecting Sediment and Agrichemical Losses from Soils. Soil properties (texture, organic matter, surface sealing/crusting, compaction, antecedent water, aggregation, etc.) influence processes controlling agrichemical fate and transport and sediment delivery. Soil texture and organic matter content affect infiltration rates; usually infiltration is lower and runoff is higher on finer-textured soils compared to coarser-textured soils. Time until runoff is also greater for sandy soils than clayey soils. Organic matter (OM) and its variability is important in pesticide adsorption and mobility (Wauchope, et al., 1992). Aggregation affects partitioning of rainfall into infiltration and runoff by influencing potential surface seal or crust formation. Aggregation influences effective depth of agrichemical entrainment and sediment transport. Antecedent soil water content and its variability has a significant effect on runoff and sediment and pesticide transport (Hance, 1976), but the effect has not been well defined. Generally, increased antecedent water contents are associated with low infiltration rates, reduced time until runoff, and high runoff, sediment, and agrichemical losses. However, antecedent water content has also been reported to decrease soil cohesion (Kemper et al., 1987), increase aggregate stability (Truman et al., 1990), decrease runoff and splash detachment, and increase soil shear strength and sediment size (Truman and Bradford, 1990).

Rainfall Characteristics. Rainfall duration, amount, intensity and kinetic energy, and timing with respect to soil management and agrichemical application influence soil erosion processes, infiltration and runoff rates, and agrichemical transport. In the development of the USLE, it was shown that a few large storms accounted for much of the erosion occurring on small plots (Wischmeier, 1962) and watersheds (Hjelmfelt et al., 1986). Edwards and Owens (1991) studied large storm effects on soil erosion from nine watersheds in Ohio. and found that for the more than 4000 rainfall events during the 28-year study period, the five biggest erosion-producing events on each watershed accounted for 66% of the total long-term erosion. On one watershed, a single storm caused more than 50% of the total long-term erosion. Agrichemicals follow the same pattern (Wauchope, 1978).

Increased rainfall intensity (or energy) decreases time until runoff and increases runoff rate. In addition, surface seal development and the depth of soil surface-runoff water interaction and pesticide extraction into runoff are likely increased. White et al. (1967)

reported that 1 hour after application atrazine losses in runoff following 0.5, 1.25, and 2.5 inch rainfalls was 4.3, 12, and 17%, respectively. Percent loss for the same size storms 96 hrs after atrazine application was 2, 5.5, and 7.3%, respectively. Ahuja et al. (1982) studied the effect of rainfall kinetic energy and storm size on soluble phosphorus (P) released to runoff in 100 by 30 by 7.5-cm soil boxes under simulated rainfall. They found that increased storm size linearly decreased average solution P concentration in runoff, and that average solution P concentration in runoff linearly decreased as rainfall kinetic energy decreased. The slope of these linear relationships increased with field slope steepness, indicating that the effect of topography on average runoff concentration was directly proportional to relative kinetic energy of raindrops. Similar results occur in the Southeast and processes controlling them need to be quantified.

Tillage. Coastal Plain soils have traditionally been intensively cropped under conventional tillage systems, but conservation tillage systems have significant potential as a management tool for row crop production. Reported benefits of these systems include reduced erosion and runoff and enhanced infiltration and soil water holding capacity (Blevins et al., 1990; Seta et al., 1993; Edwards et al., 1993; Gaynor and Findlay, 1995; Potter et al., 1995). These benefits have been attributed to increased residue and OC at the soil surface with time (Edwards et al., 1992; Langdale et al., 1992) which dissipates rainfall energy, increases aggregate stability and soil resistance to raindrop impact, and decreases water dispersible clay (Blevins et al., 1990; McGregor et al., 1990; Castro et al., 1991). Alternatively, other reports have shown runoff differences from conventional- and conservation-till systems to either be negligible (Lindstrom et al., 1981; Laflen and Colvin, 1981) or that less runoff occurs from conventional-till systems than from conservation-till systems (Heard et al., 1988; Soileau et al., 1994), especially 1-3 years after reduced tillage establishment. These results suggest that soil and hydraulic properties of the near-surface soil altered by tillage change over time and space, and this rate of change is region or site dependent. This may in part, along with incorporation effects and changes in pest management needs, explain the concerns over possible greater agrichemical losses associated with reduced tillage systems (Soileau et al., 1994; Sharpley et al., 1994; Wauchope et al., 1985). *We need to elucidate the processes and rate of change in processes controlling soil quality and hydrology in conservation tillage systems in the Southeast.*

Indexing Phosphorus Fate, Transport, and Management. Damage to surface water quality due to sediments and nutrients is estimated at 2-7 billion dollars annually (Lovejoy et al., 1997). Phosphorus is the primary nutrient controlling eutrophication of inland surface waters and wetlands, and is transported in soluble and sediment-bound forms. A phosphorus index (PI) has been developed as a field scale assessment tool to screen various soils/land units and management practices for potential risk of P movement to water bodies (Lemunyon and Gilbert, 1992). PI was developed to better determine the contribution of individual fields and management practices to risks of P movement. Results of the PI are to be used to rank, in a relative way, different fields within a farm, and to identify field characteristics that affect P movement from field sites or those characteristics that could be altered to reduce P transport from agricultural fields. In its generic form, the PI uses only site characteristics: soil erosion, irrigation erosion, runoff class, soil test P, P fertilizer application rate and method, and organic P application rate and method.

Variability in P concentrations in runoff and attached to sediment occurs with experimental condition (rainfall and soil characteristics, lab vs. field, and management/tillage), between simulated and natural rainfall, from one rainfall event to another, and with soil levels (Sharpley et al., 1992; Daniel et al., 1994; Sharpley et al., 1994; Zhang and Miller, 1996; Gascho et al., 1998; Pote et al., 1996). Sediment-transported P can far exceed P transported by runoff (McDowell and McGregor, 1984). An improved understanding and estimation of P amounts and forms associated with solution and particulate phases and the "bioavailability" of P transported to the field edge under different scenarios is needed, especially for animal waste applications to row crop and pasture lands. This work will compliment work being done at Southeast Watershed Research Lab (SEWRL) in the Manure and Byproduct Utilization (NP 206) CRIS project (*Whole Farm Management of Animal Wastes and Other Agricultural Effluents*) and two CRIS projects currently being developed in the Water Quality and Management National Program (NP 201).

Modeling Pesticide Fate, Transport, and Management. Pesticides at or near the soil surface or on plant foliage are degraded or transformed by a wide array of physical, chemical, biological, and photochemical processes (Wauchope, et al., 1999). Models available for simulating pesticide transport in runoff and by leaching attempt to accurately represent the processes in the crop/soil system that control those losses (Leonard, 1990; Cohen, et al., 1995). All such models are currently weak in describing foliar and near-surface soil processes that profoundly affect pesticide fate. In the GLEAMS model (Leonard et al., 1987), Leonard and Wauchope (1980) defined a soil surface extraction ratio that approximated the effective mass ratio of interacting soil to water in runoff. The ratio was believed to be dependent on soil properties, rainfall intensity, and runoff rates, but insufficient data are available for evaluation. Leonard and Wauchope (1980) showed that runoff concentrations from several watersheds over a range of storm conditions were correlated with pesticide concentrations in the surface 1 cm ($R^2=0.93$). They concluded that a 1 cm surface zone could be used as a descriptor/predictor of pesticide amounts available for runoff, however, they made no inferences as to depth of soil actually affected by runoff, nor the spatial nature of this relationship. Sharpley et al. (1981) showed that the effective depth of interaction (EDI) between rainfall and solutes in the soil was related to soil aggregation and increased with soil slope, rainfall energy and intensity. The more aggregated/stable a soil is, the greater the EDI compared to a less aggregated/stable soil. Relating EDI to aggregation is essentially relating the change in surface roughness or rate of surface seal development to EDI. Erosion processes, aggregation, surface roughness, and surface seal development change during a rainstorm and from one rainfall event to another. Surface layer properties are influenced by tillage type and frequency, and water content throughout a landscape. Because of complex interactions between parameters influencing surface layer characteristics, a lack of understanding exists on how processes associated with rainfall partitioning influence pesticide fate, partitioning and transport occurring in the near surface (0-1 cm).

A pesticide is extracted by water flowing over the soil surface and by dispersion and mixing of soil by flowing water and raindrop impact. Effects of raindrop impact will be controlled by depth of runoff. At the interface between the soil and overland flow, some mass of soil is effective in supplying pesticide to the flow. This is generally described by an extraction coefficient, and varies with runoff conditions, pesticide solubility, adsorptivity, etc. Extraction coefficients are related to enrichment ratios, with both being dependent on

OC contents. Enrichment ratios are based upon the surface area of the sediment as compared to that of the matrix soil, and enables estimates of the mass of sediment-transported pesticide leaving an agricultural field. Enrichment ratios are a function of OC and aggregate/particle size distribution in the soil matrix and sediment. *Better information is needed on how and when organic and mineral fractions of soil move as sediments, their spatial and temporal distributions, how their distributions are related to transport capacity and/or infiltration, and their ability and capacity to carry pesticides.* Also, processes affecting the extraction coefficient and enrichment ratio need to be quantified, especially under different tillage systems where OC contents can vary drastically. Finally, relationships between pesticide transport via runoff (water and sediment) and pesticide K_d or K_{om} need to be defined across different rainfall, soil, pesticide, and management conditions.

The Coastal Plain has its own unique set of conditions controlling agrichemical nonpoint pollution. Most knowledge of agrichemical nonpoint pollution is based on monitoring and modeling of corn herbicides in the corn belt--e.g. the MSEA project (e.g., Clay, et al., 2000) and the USGS basin monitoring projects (e.g., Goolsby, et al., 1994). These herbicides are all applied pre-emergence to the soil surface. In the Coastal Plain many of the same herbicides are used, but also a wide variety of insecticides and fungicides are heavily used which are applied to the foliage as well as the soil. *Processes affecting the potential for nonpoint pollution of foliar-applied agrichemicals are much less understood, and this knowledge is critical for managing agrichemical pollution in the Coastal Plain.*

Pollution potential indices for Pesticides. Some twenty research groups around the world (e.g., Levitan (1997), Bockstaller, et al., (1997), and Van der Werf and Zimmer, (1998) are attempting to develop *pesticide environmental risk indexes*, in which specific uses of pesticides in specific situations are assigned a numerical score for probable environmental impact and human health impacts. These indexes are being proposed for use in regulatory risk management as early-tier estimates of risk. Although there are many steps between the concept and a useful product, this activity has the potential to integrate the information on environmental behavior of pesticides in a way to make good use of the enormous amounts of empirical data (a lot of which has come from ARS) that has been obtained over the last three decades.

These environmental risk indexes include weighted, scaled numerical scores for many factors involved in pesticide impacts on humans and ecosystems such as volatility, toxicity to indicator organisms, occupational exposure, etc. Perhaps the best known is the simple Groundwater Ubiquity Score or "GUS" developed by Gustafson (1989). This index combines laboratory measurements of a pesticides' persistence and mobility in a simple formula, whose value provides a fairly good prediction of the likelihood of the pesticide being widely found in groundwater (providing the compound is being widely used). No similar index for surface water pollution potential has been developed, but field work by ourselves and others is beginning to delineate the likely important variables.

Among these are the behavior of pesticide application deposits on the "target sites" (field soil surface and near-surface soil, plant foliage), which are the initial sites of application deposits. The behavior of pesticides in/on these surfaces is inadequately understood, yet these are the sites which supply all subsequent concentrations in the environment.

Conventional measurements of pesticide persistence, typically done by soil sampling, do not account for important loss and nontarget exposure pathways from these surfaces. The Root Zone Water Quality Model (RZWQM)(Wauchope et al., 2000), an ARS model that includes a detailed pesticide dissipation/transport model, is currently in the evaluation stage. This model has the potential to provide much improved predictions of pesticide environmental residues on the environmental surfaces controlling runoff. This integrated information is fundamental for the development of an index for pesticide runoff potential.

Approach and Research Procedures

Objective 1: Define and quantitatively describe processes controlling relationships between rainfall characteristics, infiltration, runoff, sediment yields, and event-based agrichemical losses from Coastal Plain soils

- Experimental Design

Hypothesis: While both surface and subsurface features and processes are important for rainfall partitioning into infiltration and runoff, there are under-investigated process that occur at or near the soil surface that control rainfall partitioning into infiltration and runoff, sediment delivery and agrichemical fate and transport from Coastal Plain soils.

Investigating these processes requires experimentation across a range of scales from controlled laboratory conditions to field scale. Results will be specific to these benchmark soils yet process principles developed will apply to any region.

Erodibility Experiments. Lab erosion pans (Ahuja, et al., 1982; Truman and Bradford, 1993; 1994; Truman et al., 1998; 2000) and field plots will be used to develop erosion databases for soil loss tolerance recommendations, erodibility (K_e) determinations, infiltration/runoff quantification, sediment size distributions (including carbon losses), colloidal facilitated transport on benchmark soils, and the effects of all the above on runoff phosphorus losses. This methodology is well established but data for many important regional soils are missing.

Rainfall simulation experiments. The scale of these experiments allows the effects of selected soil, rainfall, agrichemical, and management characteristics to be isolated and evaluated under well-defined experimental conditions. An oscillating-nozzle rainfall simulator will be used. The simulator uses nozzles that produce drops with a median drop size of about 2.3 mm. The rainfall simulator nozzles will be placed 3.05 m above each plot. Simulated rainfall will be applied with constant and variable rainfall intensities. Variable rainfall intensities will mimic natural rainstorms that occur most often in the Coastal Plain as characterized from 35-50 years of natural rainfall data. Soil samples will be collected before, during, and after each simulated rainfall event. Well water will be used for all simulations in the field (deionized water will be used for all lab simulations), with samples of well water being analyzed for pH, EC and the target analytes. Runoff and sediment yields will be measured continuously at 5-min intervals during each simulated rainfall event. Agrichemicals (P and pesticides) will be collected at 5-min intervals depending on runoff volumes. Runoff and sediment will be quantified gravimetrically, and infiltration calculated by difference (rainfall-runoff). Residue associated with tillage treatments will be quantified throughout the growing season and at the time of each simulated rainfall event. Plots (1-6 m² – 0.8 ha) will be strategically located in drainage basins throughout the Coastal Plain region. Benchmark soils will be identified by ARS, University, and/or NRCS personnel, and will be chosen in part by percentage of land area under cultivation. Each soil evaluated will be in a relatively dry, seedbed (freshly-tilled) condition. Areas surrounding each plot will remain undisturbed (same surface conditions as the soil surface inside the plot) so that the adjacent border area can be used to sample soil at selected times before and during each rainfall simulation. Before each simulation, soil samples (0-1 and 1-15 cm) will be taken in border areas to determine P amounts and antecedent water content. Soil samples (0-1 cm) will be taken at selected times during the

rainfall simulation to determine P amounts. P analysis in runoff will include total P, bioavailable P, and dissolved/soluble reactive P. P analysis in soil will include distilled water extracts in addition to standard extraction procedures used the Georgia soil test lab. Similar procedures will be used for all lab rainfall simulations and pesticide experiments in Objective 2.

In these experiments emphasis will be on describing soil properties and processes in the 0-1 cm layer, including their spatial and temporal variability, and how they influence rainfall partitioning into infiltration and runoff, sediment production and agrichemical fate and transport. Soil properties to be measured for this layer include OC, aggregate stability, water content, mineralogy, temperature, and water dispersible clay. Data will be used to evaluate management effects on soil processes, and subsequently, soil and water quality.

Field-Scale Studies. To impact farm decisions, we must transfer process-based information obtained from small scales and under relatively controlled conditions, and apply it to larger (farm) scales. Thus, plot work will be embedded in larger field/farm scale research (in conjunction with current and developing NP201 and 206 projects) so that scaling issues can be more easily addressed. Selected locations where field-scale work will be done (all in conjunction with water-quality research under 201 CRIS projects of this Unit) include:

Gibbs Farm. This site is located at a University of Georgia research farm near Tifton, GA. Fields plots established are on a Tifton-Carnegie soil association, with the Tifton loamy sand having 2-5% slope and the Carnegie sandy loam having a 2-8% slope. The A_p horizon has relatively low OC, and the BC subsurface horizon has a relatively low permeability that restricts percolation and induces lateral subsurface flow (LSF). The site is divided into seven subplots. Six subplots, each about 0.20 ha., have flumes and water samplers. On the down-slope side of each plot, 5-cm PVC tubes have been installed to monitor soil water with depth. A 15 cm tile drain has been installed to intercept LSF originating from the three conventional till plots and for the three strip till plots. These plots have been established to compare conventional and strip tillage treatments in cotton-peanut rotations (2 yrs cotton, 1 yr peanut). Poultry litter (2 t A^{-1}) will be used as the primary nutrient source with commercial fertilizer supplied on an as-need basis. We will evaluate nutrient fate and transport from animal waste and commercial fertilizer applications, and field dissipation rates of selected pesticides, which have been detected in surface water monitoring programs (USGS, 2000).

Station Z. Station Z is a 0.34-ha field plot located in Tifton, GA, and consists of a Cowarts loamy sand (Typic Kanhapludult). This loamy sand commonly occurs on 0-8% slopes, and is derived from Miocene sediments. It has about 5% clay in the A_p horizon (30-45 cm thick), with clay content generally increasing with depth to about 45% in lower parts of the B_t horizon. Vertical water movement is restricted at the B_t /BC interface resulting in LSF (avg. K_{sat} values for B_t horizons are $2.5 \times 10^{-2} \text{ mm s}^{-1}$, while avg. K_{sat} values for BC horizons are $5 \times 10^{-4} \text{ mm s}^{-1}$). While under conventional till, OC content is about 1% in the surface horizon. Station Z has been under strip till practices for two years. Station Z is instrumented for sampling and measurement of rainfall and surface and subsurface flow. Rainfall is measured with a digital rain gauge located adjacent to the plot, and is part of

the overall rain gauge network of the Little River Watershed. Rainfall volumes and drop size distributions are also measured on a 1-min basis with a distrometer also located adjacent to the plot. Surface runoff leaving the plot is directed through a 0.30-m type H flume equipped with a water level recorder. Lateral subsurface flow (LSF) moves down-gradient across the B_i/BC interface and is intercepted by tile drain located about 1 m below the soil surface. LSF is directed through V-notch weirs each equipped with a water level recorder.

- Contingencies

Research includes work in-progress (plot studies) and work in the planning and implementation stage. Contingent on additional funding similar (plot and field) studies will be conducted within the Suwannee River Basin and the Satilla River Basin (e.g., Coffee Co.).

Integrated field/farm nutrient management systems (contingent, proposed addition to CRIS). Agronomic nutrient management is typically implemented by the farmer at the field level, but water resource conservation decisions must be made at the farm and larger scale (e.g., effluent discharge permitting, odor ordinances, waste transport costs, etc.). Our goal is to improve on-farm management practices so that water quality impacts of sediments, nutrients and pathogens can be mitigated with minimal cost to the producer. This can be accomplished by developing and implementing BMPs and understanding the spatial and temporal variability associated with key processes, parameters, or factors controlling contaminant movement. We will initially target fields and farms in the Upper Suwannee River Basin, and will identify and work with farmers who manage land in strategic locations within this river basin. Each field within the farm will be characterized and evaluated in terms of soils, nearest sensitive water body, existing management and water quality, potential BMPs, and geographic location. For nutrients, a comparison will be made of the agronomic and environmental costs and benefits of using animal waste as an alternate nutrient sources. A “carrying-capacity” approach to nutrient management based on farm size/area, land type and use, soil type and landscape position, crop diversity and crop nutrient requirements, and distance to nearest sensitive water body will be implemented at the field and farm scale. Management of all nutrients normally applied by cooperating farmers will be considered in this research. Where appropriate, regression analysis will be used to develop relationships. We will determine the effects of BMPs on soil properties and their potential to alter nutrient transport. Farm-scale management plans will be developed based on experimental and/or modeling results. They will be founded on process-based data obtained in plot studies, and will emphasize reduction in runoff and sediment loadings, P-based application rates of inorganic and organic fertilizers, and the build up of OC through cover crops and reduced tillage systems. Ultimately, we want to provide information on how a “model” farm can sustain itself by becoming environmentally and economically viable by conserving soil and water resources, and contributing to water quality improvement. Development of soil-BMP-water quality associations database describing process-level responses should facilitate the development of soil indicator suites that are easily measured and transferable to other parts of the Coastal Plain. This project will be completed concurrently with watershed-scale projects developed under the 201 national program.

Coffee Co. (contingent, proposed addition to CRIS) Plot (1 m² – 6 m²) and field studies will be conducted on at least four soils to examine how changes in soil properties among tillage systems, especially those in the near surface layer (0-1 cm) affect rainfall partitioning, sediment characteristics and transport, agrichemical fate and transport (N, P, and pesticides). Of particular interest is the use of poultry litter to land, which potentially impacts on-site soil quality and off-site water quality. Soil properties including but not limited to OC, aggregate stability, bulk density, soil strength, saturated hydraulic conductivity, soil water content and retention, water dispersible clay, and clay mineralogies will be determined. Sites will be selected by tillage/cropping systems, fertilizer source(s), and how long reduced tillage has been imposed. At a minimum, we will select sites that have been in reduced tillage for at least three years and those that use poultry litter and commercial fertilizer as crop nutrient sources. All reduced tillage results will be compared to conventional till results. Emphasis will be on OC content increases associated with reduced tillage and use of poultry litter. Along with sites that have been in reduced tillage for at least 3 years, we will also evaluate tillage system conversion (conventional to reduced tillage) with time. Simulated rainfall (as previously described) will be initially used to quantify rainfall partitioning into infiltration and runoff and sediment delivery. Soil properties will be determined in the 0-1, 1-6, 6-12, 12-18, and 18-24 cm depth increments. Soil samples (bulk and/or cores) will be taken immediately adjacent to runoff plots. Additional research will focus on the applicability and usefulness of para-tilling, with emphasis on its impacts on hydrology (leaching, percolation, high water tables, and lateral subsurface flow) and associated agrichemical movement.

- Collaborations

Within ARS – D. Wayne Reeves (Auburn, AL). Dr. Reeves is experienced in evaluating tillage effects on agronomics and changes in soil properties. Dr. Reeves will be instrumental in selecting and providing sites to conduct experiments. He will work collaboratively throughout the duration of this project so that processes associated with agronomics-tillage-soil/water/agrichemical management interactions can be accurately represented.

External to ARS – Glen Harris (Univ. of GA, Tifton); M. Cabrera (UGA, Athens, GA); Joey Shaw (Auburn Univ., Auburn). Dr. Harris is an extension specialist in soil fertility and tillage issues. He will help identify farmers or customers where on-farm research will be conducted. Dr. Harris is also part of the team developing the Georgia Phosphorus Index (PI), which will be based in part on experimental work described above and will help design nutrient and crop management strategies. Dr. Cabrera is also interested in phosphorus fate and transport in Georgia. He and Dr. Truman are on the committee to develop and evaluate the PI for Georgia. His involvement will be instrumental in developing and comparing PIs from Georgia and Florida. Dr. Shaw is a pedologist who is interesting in mineralogical aspects of colloidal facilitated transport of agrichemicals. He will work to better describe sediments in terms of their physical and chemical characteristics and transport potential.

- Resources

Plot and field site resources at SEWRL include rain gauges, flumes, automated ISCO samplers, distrometers, and moisture access tubes. A rainfall simulator is also available that is capable of operating in a lab or field setting. SEWRL has a state-of-the-art pesticide lab and a fully functional nutrient lab. Instrumentation in these labs include: Lachat flow analyzers, Carlo/Erba C/N analyzer, gas and high pressure liquid chromatographs, Technicon autoanalyzer, and liquid chromatograph mass spectrometer. SEWRL also has a fully operational soil physics and hydraulics lab.

Objective 2: Define and describe the factors and processes, including their spatial and temporal variability, controlling phosphorus and pesticide fate and transport in soil, runoff, foliage and sediments in Southeastern Coastal Plain agricultural settings.

- Experimental Design

Hypothesis: The climate, crops, pesticide use patterns, and soils of the Coastal Plain are unique. Thus, the fate and behavior of agrichemicals in the Coastal Plain cannot be adequately described by process research and modeling developed in other agricultural settings. We hypothesize that data developed in other settings is likely in many cases to overestimate the extent of the problem in the Coastal Plain. This knowledge gap can be closed by an interactive combination of laboratory, field and modeling studies on selected agrichemical/crop/soil combinations, which represent the region.

Dissipation of pesticides in coastal plain crops, with an emphasis on foliar-applied pesticides.

We will determine deposition, foliar interception, foliar-soil transfer, degradation and dissipation processes, and rainfall-runoff potential for chlorothalonil fungicide use in peanuts, tribufos defoliant use in cotton, diazinon insecticide use in vegetables, and metolachlor herbicide use in corn. Simultaneously we will evaluate phosphate transport in these systems. These four crop/chemical combinations are selected to provide a wide range of use patterns, application procedure, deposition target, active ingredient chemistry, and interactions with soil properties. Diazinon and metolachlor are two of the most commonly detected pesticides in surface waters of the region (USGS, 2000). USEPA (2000) recently concluded that risk reduction procedures were required to reduce potential ecological impacts of tribufos in aquatic ecosystems in the Southeast. Chlorothalonil is used at high rates and its degradates have been shown to be environmentally stable (Potter and Wauchope, 2000).

With the exception of metolachlor, which we will use as an environmental benchmark chemical, these compounds have received little environmental fate analysis. We have completed initial work on chlorothalonil (Potter and Wauchope, 2000; Wauchope and Potter, 2000), metolachlor (Johnson et al., 2000) and tribufos (Potter et al, 2000).

Chemicals will be applied to crops in research plots in cooperation with scientists at the Coastal Plain Experiment Station. Application schedules, Irrigation, and all other management practices will be applied as in the usual practice. Rainfall simulation will be used at the "microplot" scale (Burgoa and Wauchope, 1995) to determine "worst case"

scenarios. Foliage, soil and runoff water will be sampled and analyzed for the active ingredients and selected metabolites (Potter et al, 2000). Spatial variability of residues and of processes and soil properties affecting the fate and mobility of active ingredients will be determined (Isaaks and Srivastava, 1989).

Rainfall simulation: runoff and leaching of pesticides

Rainfall simulation plot studies will be conducted to evaluate phosphorus and pesticide fate and transport under severe weather conditions. Field sites, including those described above at the Gibbs Farm and Station Z, will be used. Emphasis will be placed on sites where different soil conditions (texture, landscape position, OC, tillage, etc.) exist and scale studies can be conducted so that nests of data with different spatial characteristics can be obtained. A key to the success of this research will be farmer participation.

Rainfall simulation studies will evaluate foliar fate and washoff of the pesticides effect of timing of first rainstorm after application, and canopy cover effects on the mass of the active ingredient entrained in runoff. Emphasis will be placed on quantifying processes associated with field dissipation rates and reducing runoff risk early in the growing season when canopy is minimal. Key questions to be addressed include the rate at which the active ingredients are transferred from the canopy to soil, and how the chemicals behave after they contact the soil surface. The research will emphasize the importance of the zone of soil (top 1 cm) at the near surface and delineate processes that allow description of enrichment ratios and sediment-water partitioning.

In each of the studies, rainfall simulations will be conducted at different times during the growing season, thus providing seasonal loss data for all contaminants, erodibility data, and data on crop canopy effects on runoff, sediment, and agrichemical losses. Rainfall simulations will be as similar as possible throughout all studies described. Physical characteristics and carbon contents of the top 1-cm of soil under different environmental conditions will be determined before, during, and after all simulated rainfall events, and during the growing season for field and farm scale studies. This data will provide a foundation for improved enrichment and entrainment relationships for OC, mineral soil particles, and selected agrichemicals, which will significantly improve our predictions of agrichemical fate and transport and their associated risk assessment.

Laboratory studies of soil pesticide degradation processes

A series of laboratory incubation studies are also planned which help parameterize pesticide degradation models. These studies will focus on the active ingredients and degradates.

Our work with chlorothalonil in peanut production provides a model for the work (Potter and Wauchope, 2000). In this work, degradation and accumulation and decay of degradation products following sequential application of the chemical to peanuts through and entire growing season was studied. Application schedules and timing followed normal agronomic practice.

The RZWQM model: testing, validation, improvement

We will use the RZWQM model, with its detailed pesticide fate module (Wauchope, et al., 1999) to both integrate and extrapolate data from the field experiments, and to help prioritize the knowledge gaps to be addressed. Particular gaps in knowledge that are

universally missing for pesticides include (a) the relationship between soil bioavailability, standard estimators of microbial activity, and pesticide degradation and (b) the importance of processes in the top cm of soil and at the soil surface. Although it is well recognized that this 1-cm soil-air interface is critically important for phosphorus and pesticide fate, this will be the first field study to specifically target this compartment. We expect the RZWQM pesticide module to be both validated and improved in this process. An important gap currently is that the RZWQM does not have an erosion component, and sediment transport and its associated agrichemical transport (particularly important for phosphorus) cannot be evaluated using this model. We have an objective under NP201 to develop an erosion component for RZWQM.

- **Contingencies**

Chlorothalonil and tribufos work is in the implementation stage, with no contingencies foreseen. Metolachlor and diazinon plans contingent on identification of and coordination with field cooperators.

Contingent (unfunded) study: System Feedback Interactions Between Pesticide Management, Pesticide Biotransformation, Soil Fertility, Microbial Activity, and Biomass Production in Peanuts.

Independent lines of research suggest that there may be interactions between the direct and indirect effects of application of the fungicide chlorothalonil, to peanut cropping systems. Although chlorothalonil is readily degraded by a wide variety of soil bacteria (Katayama et al., 1997), this degradation results in the production of daughter products (particularly 4-hydroxy-2,5,6-trichloroisophthalonitrile (TPN-OH)) which not only inhibit further chlorothalonil degradation, but also suppress soil respiration (Motonaga et al., 1998). Sub-hypothesis #1 suggests that the inhibition of respiration will also inhibit the activity of soil bacteria that decompose soil organic matter...and thus, of animal waste amendments. Research by Bell et al. in 1989 indicates that peanuts grown without Vesicular-Arbuscular Mycorrhizae (VAM) exhibit a minimum growth threshold (60 kg P/ha) below which plants grow poorly. Independent research by Habte et al. (1992) showed a direct inhibition of VAM activity in peanut roots caused by chlorothalonil. Sub-hypothesis #2 suggests that long-term chlorothalonil use will create systems in which all P available to the plant must be provided by inorganic sources. Sub-hypothesis #3 suggests that the combined reduction in organic-P mineralization and increased inorganic-P demand will result in a requirement for a more intensively-managed system and will render uneconomical the practice of animal waste amendments to peanut cropping systems. This system may also result in special-case conditions for the application of the PI to peanut production systems.

Preliminary exploratory surveys will be conducted to examine the microbial communities, associated soil respiration rates, organic matter decomposition rates, VAM colonization levels and P uptake thresholds in peanuts grow with and without chlorothalonil in otherwise similar soils and management scenarios. In addition, although no citations

have been found demonstrating direct inhibition of *Bradyrhizobium* spp. by TPN-OH, we will conduct exploratory examinations to determine whether the broad-scale inhibition of other bacteria by TPN-OH also extends to *Bradyrhizobium* spp., and thus to nitrogen nutrition in peanuts and nitrogen cycling in soil.

- **Collaborations**

Within ARS – Cathleen Hapeman, ARS-ECL, Beltsville, will be working with us on the application of RZWQM to vegetable crops.

External to ARS – Albert Culbreath (UGA, Tifton, GA); G. Harris (UGA, Tifton, GA); J. Shaw (Auburn Univ., Auburn, AL); G. King (UME, Orono, ME). Dr. C. Bednarz (UGA, Tifton, GA); Dr. Gary King, University of Maine, has expressed interest in microbial community associations and their role in trace gas emissions, carbon sequestration and host plant signaling. Drs. Harris and Shaw involvement has been previously described. Dr. Culbreath is Research Plant Pathologist specializing in the peanut diseases. Dr. Bednarz is a research Plant Physiologist specializing in cotton production. We are also communicating with Professor Arata Katayama, Nagoya University, Japan, on a possible collaboration to characterize microbiological degradation pathways for chlorothalonil.

- **Resources**

Facilities and equipment at SEWRL include field and lab equipment. Plot and field site resources include rain gauges, flumes, automated ISCO samplers, distrometers, and moisture access tubes. A rainfall simulator is also available that is capable of operating in a lab or field setting. SEWRL has a state-of-the-art pesticide lab and a fully functional nutrient lab. Instrumentation in these labs include: Lachat flow analyzers, Carlo/Erba C/N analyzer, gas and high performance liquids chromatographs, Technicon autoanalyzer, and liquid chromatograph mass spectrometer. SEWRL also has a fully operational soil physics and hydraulics lab. SEWRL currently has excellent modeling capabilities and personnel (RZWQM) with a long history of model develop, testing, and application (CREAMS, GLEAMS, REMM).

Objective 3: Develop and evaluate a process-based phosphorus index (PI) to assess impacts of land management practices on soil quality and potential phosphorus loadings at the field edge. This one is OK as is, I think

As part of the Georgia and Florida PI teams, we will develop the PI for GA, with emphasis on PI applicability in the Coastal Plain region of GA. This will involve developing the internal workings of the Index and testing the PI under different scenarios throughout GA. Experimental work described above (objective 1) has been planned in part with the PI needs considered. For example, process-based experimental data algorithms and weighting factors contained in the PI. Relationships between a) soil test P and runoff P, b) P in the 0-1 cm layer vs. runoff P (soluble and sediment-transported), c) sediment characteristics and sediment-transported P, and d) P application and rainfall timing and runoff P will be incorporated into the PI to make it more scientifically defensible.

Once developed, tested, and implemented, we will work closely with other team members and NRCS field personnel to continuously monitor its performance. Experimental research will be designed and conducted on an as-need basis to determine spatial and temporal attributes of processes that are statistically represented by individual weighing factors in the PI. Emphasis will be placed on its application in instrumented watersheds throughout GA to see how well this field scale tool can help identify and correct P problems within the watershed. The PI will then be used as a first-tier screen to focus additional research efforts and resources to those fields with the most P problems, and to aid in remediation strategies. It will also be used to help design, determine, and predict impacts of BMPs imposed to bring "problem" fields to sustainable conditions.

- **Contingencies**

The PI work has been ongoing and has been mainly funded with grant funds awarded to the universities of Florida and Georgia.

- **Collaborations**

Within ARS - D. Franklin (Watkinsville, GA)

External to ARS – W. Harris (UF, Gainesville, FL); D. Radcliffe, M. Cabrera (UGA, Athens, GA).

All cooperators mentioned above are part of PI teams either in Georgia or Florida.

- **Resources**

Resources needed to complete this part of this project are detailed under objectives 1 & 2.

Objective 4: Based in part on the research results in Objectives 1 and 2, develop a "pesticide runoff potential index" algorithm which estimates relative pollution characteristics, i.e., allows comparison of the environmental consequences of different pesticides used for the control of the same pest. This one is OK as is, I think

- **Experimental Design**

Hypothesis: A pesticide runoff potential index can be developed from soil process-based research which can be used to help producers, water quality managers, and environmental stakeholders to make on-farm management decisions with reduced potential risk to surface water resources.

The RZWQM and GLEAMS models will be used to help integrate lab and field data collected under objectives 1 & 2. Some deficiencies in these models will be addressed experimentally and theoretically under other programs of this laboratory. For example,

The RZWQM model does not have an erosion component, nor does it account for effects of microbial communities on persistence times. The RZWQM pesticide property database will be updated to include new compounds, and fields will be added which will allow it to be applied in a more regionally specific manner. This will also be closely coordinated with the EPA-OPP pesticide properties database currently in preparation by that agency. We will use the above-mentioned models, the pesticide property database, and pesticide runoff data from this and other projects to develop a probabilistic runoff potential index for pesticides. Field work proposed in Objective #2 will close some significant knowledge gaps for foliar and soils surface processes.

We will attempt to use basic pesticide active ingredient physical and chemical properties, including but not limited to (a) aqueous solubility (b) vapor pressure (c) soil OM sorptivity (d) soil flask persistence measurements (e) acid/base potential (f) formulation characteristics (e.g., Davis, et al, 1996). These universal properties will be used to predict pesticide "availability" for runoff as a function of time and application target (foliage, soil surface, soil subsurface). This availability for runoff should be site-independent (except that we will likely need to build in a temperature dependence). This availability function will then be combined with a probability distribution function for rainfall runoff events, using long-term weather data and soil hydrologic data combinations for specific sites. We will use Coastal Plain regional data because we will want to validate our predictions with the extensive and growing pesticide runoff data from our lab.

The weather probability distribution function approach was pioneered by Mills and Leonard 14 years ago (Mills and Leonard, 1986) but has never been followed up because at the time the theory/data needed to build the "availability" function was not available. We believe much of the information needed is now available, and some major gaps will be filled by work proposed in Objectives 1 and 2. For example, we are currently pursuing the deficiencies in foliar-pesticide understanding with field and modeling studies. Some of the scenarios being studied will be crucial for the small-farm, small-acreage-crops that are such an important part of Coastal Plain agriculture. It will also provide fundamental information on the relative pollution potential of these chemicals that should be useful in any region.

- **Contingencies**

This pesticide pollution indexing research has been envisioned as part of an integrated whole-farm systems management practice tool that assesses economic and environmental impact at farm and watershed scales. The proposed research has been detailed in a project entitled "Southern Coastal Plain Small Farm Survival Project" which is currently unfunded.

Collaborations

Within ARS - L. Ahuja and K. Rojas (Ft. Collins, CO); T. Webster, C Johnson, and J. Lewis (Tifton, GA); Marshall Lamb (Dawson, GA), Cathleen Hapeman (Beltsville, MD)

- External to ARS – J. Merenda and R. Parker (EPA-OOP); J. Bagdon, S. Plotkin (NRCS); L. Levitan (Cornell); M. Ahearn (USDA-ERS).

Facilities and equipment at SEWRL have been discussed above. SEWRL has a state-of-the-art pesticide lab and a fully functional nutrient lab. SEWRL also has excellent modeling capabilities, and a full-time, highly trained computer programmer and data manager.

Milestones and Expected Outcomes

Selected Milestones are given below. We will not limit ourselves to these, and emphasis or priorities may change based on research findings.

Milestone 1 (24 months) – Database and journal publications describing sediment delivery from and erodibilities (and their variability) of Coastal Plain soils.

Milestone 2 (24 months) – Field day demonstration, one page fact sheets, and journal publications quantifying reduced tillage effects on runoff and sediment delivery from Coastal Plain soils. [Key customer: Georgia Conservation Tillage Alliance].

Milestone 3 (12-24 months) – Complete Phosphorus Index (PI) development for Florida and Georgia.

Milestone 4 (36 months) – Journal publications detailing parameters and processes associated with sediments and their characteristics, and sediment-transported agrichemicals.

Milestone 5 (36-48 months) – Model and Pollution Index development and testing. Incorporate algorithms into GLEAMS, PRZM, RZWQM, and REMM describing characteristics of sediments and entrainment and enrichment of mineral and organic particulates, and their ability/potential to transport agrichemicals.

Milestone 6 (36-48 months) - communication and development of regionalized version of USEPA WARP model by collaboration with USEPA-OPP.

Milestone ~~6-7~~ (48 months) – Journal publication detailing PI's applicability as an assessment tool of P status to Coastal Plain soils.

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- Wauchope, R.D. 1978. The pesticide content of surface water draining from agricultural fields--a review. *J. Environ. Qual.* 7:459-472.
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- Wauchope, R.D., McDowell, L.L. and Hagen, L.J. Environmental effects of limited tillage. Chapt. 17, pp. 266-281 In A. F. Wiese (ed.), *Weed Control in Limited Tillage Systems*, Weed Sci. Soc. Amer. Monograph, 279pp. 1985.
- Wauchope, R.D., Nash, R. G., Ahuja, L.R., Rojas, K.W., Willis, G.H., McDowell, L.L., Moorman, T.B. and Ma, Q.-L. 1999. Pesticide Processes. Chapt. 7, pp 163-244 In L. R. Ahuja, J. D. Hanson, M. J. Shaffer and K. Rojas (Eds.), *Root Zone Water Quality Model: Modeling Management Effects on Water quality and Production*. Water Resources Publications, LLC, Englewood CO 300pp.
- Wauchope and Potter RZWQM of chlorothalonil in peanuts
- White, A.W., A.P. Barnett, B.C. Wright, and J.H. Holladay. 1967. Atrazine losses from fallow land caused by runoff and erosion. *Environ. Sci. Tech.* 1:740-744.
- Wildung, R.E., R.L. Schmidt, and A.R. Gahler. 1974. The phosphorus status of eutrophic lake sediments as related to changes in limnological conditions - total, inorganic and organic phosphorus. *J. Environ. Qual.* 3:133-138.
- Wischmeier, W.H. 1962. Storms and soil conservation. *J. Soil and Water Cons.* 17:55-62.
- Zhang, X.C., and W.P. Miller. 1996. Physical and chemical crusting processes affecting runoff and erosion in furrows. *Soil Sci. Soc. Am. J.* 60:860-865.

Past Accomplishments of R. Don Wauchope, Lead Scientist

Education:

1971 North Carolina State University, Physical Chemistry, PhD

Experience:

1971-1972	Post-Doc, Oregon State Univ., Corvallis, OR
1971-1984	Research Chemist, USDA-ARS, Southern Weed Science Lab., Stoneville, MS
1983-1988	Research Chemist, USDA-ARS, Southeast Watershed Research Lab., Tifton, GA
1987-1999	Research Chemist, USDA-ARS, Nematodes, Weeds, and Crop Unit, Tifton, GA
1999-Present	Research Chemist, USDA-ARS, Southeast Watershed Research Lab., Tifton, GA

Accomplishments:

Pesticides in runoff. We have demonstrated the utility of small-plot simulated rainfall experiments to provide worst-case pesticide runoff measurements as a function of formulation and antecedent environmental conditions.

The RZWQM model pesticide module. The ARS RZWQM model has been re-released this year. The components, pesticide process theory and pesticide parameters database, used by the model came from this research. The model contains the most complete description of pesticide fate and dissipation in the environment available, and has been shown to represent “real” scenarios. It has the potential to be the next generation model for dealing with complex pesticide and nutrient processes and transport in the environment.

The ARS Pesticide Properties Database. The book “Pesticide Properties in the Environment” by Hornsby, Wauchope, and Herner is an important product of recently completed research, and is used globally with its first printing selling out. The book gives a complete set of property values for all major pesticides in existence at the time, and allows modelers/risk assessors to make a wide range of “first-tier” risk calculations. Data provided within it has been made the default data set for the PRZM, GLEAMS, and RZWQM models. The database has been placed on NRCS’s web site.

Most significant Publications in last 10 years [R. Don Wauchope]:

- R.D. WAUCHOPE, R.G. WILLIAMS, and L.R. MARTI. 1990. Runoff of sulfometuron-methyl and cyanazine from small plots: Effects of formation and grass cover. *J. Environ. Qual.* 19:119-125.
- R.D. WAUCHOPE, J.R. YOUNG, R.B. CHALFANT, L.R. MARTI, and H.R. SUMNER. 1991. Deposition, mobility, and persistence of sprinkler-irrigation-applied chlorpyrifos on corn foliage and in soil. *Pesticide Sci.* 32:235-243.
- R.D. WAUCHOPE, T.M. BUTLER, A.G. HORNSBY, P.W.M. AUGUSTIJN-BECKERS, and J.P. BURT. 1992. The SCS/ARS/CES pesticide properties database for environmental decision-making. *Rev. Environ. Cont. Toxicol.* 123:1-164.
- R.D. WAUCHOPE. 1992. Environmental risk assessment of pesticides: Improving simulation model credibility. *Weed Technol.* 6:753-759.
- A. G. HORNSBY, R.D. WAUCHOPE, and A.E. HERNER. 1995. Pesticide properties in the environment. New York: Springer-Verlag New York, Inc., 1995. ISBN 0-387-9453-6: disk ISBN 3-540-94353-6.
- A.W. JOHNSON, R.D. WAUCHOPE, and H.R. SUMNER. 1996. Effect of simulated rainfall in efficacy and leaching of two formulations of fenamiphos. *J. Nematology.* 28:374-388.
- R. F. DAVIS, R.D. WAUCHOPE, A.W. JOHNSON, B. BURGOA, and A.B. PEPPERMAN. 1996. Release of fenamiphos, atrazine, and alachlor into flowing water from granules and spray deposits of conventional and controlled-release formulations. *J. Agr. Food Chem.* 44:2900-2907.
- R. D. WAUCHOPE, H.R. SUMNER, and C.C. DOWLER. 1997. A measurement of the total mass of spray and irrigation mixtures intercepted by corn and cotton seedlings. *Weed Technol.* 11:466-472.
- R.D. WAUCHOPE, R.G. NASH, L.R. AHUJA, K.W. ROJAS, G.H. WILLIS, L.L. MCDOWELL, T.B. MOORMAN, and Q.L. MA. Pesticide Processes. Ch. 6, In Ahuja, L.R., J.D. Hanson, and M.J. Shaffer (eds). 1999. Root Zone Water Quality Model: Modeling Management Effects on Water Quality and Production. Water Resources Publications, LLC, Englewood, CO. (In Press).
- R. D. WAUCHOPE R. D., SUMNER, H. R., TRUMAN, C. C., JOHNSON, A. W., DOWLER, C. C., HOOK, J. E, GASCHO, G. J., DAVIS, J. G. AND CHANDLER, L. C. 1999. Runoff from a cornfield as affected by tillage and corn canopy: a large-scale simulated-rainfall hydrologic data set for model-testing . *Water Resources Res.* 35:2882-2885 (1999).

Past Accomplishments of Clinton C. Truman

Education:

1990 Purdue University, Soil Physics, PhD

Experience:

1990—1991	Post-Doc, USDA-ARS, Southeast Watershed Research Lab., Tifton, GA
1991-Present	Soil Scientist, USDA-ARS, Southeast Watershed Research Lab., Tifton, GA

Accomplishments:

Ground-penetrating Radar. Developed and adapted ground-penetrating radar as an efficient, cost-effective tool for nondestructively describing spatial variability of selected subsurface soil features.

Erosion Processes. Identified and characterized parameters affecting erosion processes controlling sediment delivery, thus improving current simulation model technologies. Provide C-factors for peanuts grown in the Coastal Plain soil province.

Pesticide Fate and Transport. Described and quantified effects of intrinsic soil, pesticide, and rainfall characteristics on pesticide fate and transport, thus improving the understanding of how pesticides are transported to and by surface and subsurface flow.

Phosphorus Transport. Continuous application of commercial fertilizer and/or poultry litter can cause build up of P (STP) in the 0-1 cm and 0-15 cm soil layer within 2-5 yrs. Soluble P (SP) and sediment-transported P (SedP) losses tend to be greater from poultry litter applications than from commercial fertilizer applications. During the growing season, SP losses were greatest 1 day after fertilization, while percent of total P transported from Coastal Plain fields as SedP increased during the growing season. Majority of P lost during any given year is in the SedP form. Variation in annual P losses can be explained by the occurrence of major storms near the day of fertilization.

Event-based Models. Developed and altered event-based models for improved risk assessment technologies and ag-management decision aids, thus extending the ability to simulate agrichemical contamination of sensitive water bodies. Used 50-yr GLEAMS simulations to show that SP and SedP losses from poultry litter applications were 0.2-0.4 and 25-29%, respectively. Created Gumbel extreme-value (probability) plots for poultry litter applications to determine "recurrence intervals" for the average time within which a value/loss of specific magnitude will be equaled or exceeded.

Most significant Publications in last 10 years [Clinton C. Truman]:

- TRUMAN, C.C., and J.M. BRADFORD. 1990. Effect of antecedent soil moisture on splash detachment under simulated rainfall. *Soil Sci.* 150:787-798.
- TRUMAN, C.C., and R.A. LEONARD. 1991. Effects of pesticide, soil, and rainfall characteristics on potential pesticide loss by percolation – A GLEAMS simulation. *Trans. ASAE.* 34:2461-2468.
- TRUMAN, C.C., L.E. ASMUSSEN, and H.D. ALLISON. 1991. Ground-penetrating radar: A tool for mapping reservoirs and lakes. *J. Soil and Water Cons.* 46:370-373.
- LEONARD, R.A., C.C. TRUMAN, W.G. KNISEL, and F.M. DAVIS. 1992. Pesticide runoff simulations: Long-term annual means vs. event extremes? *Weed Technology.* 6:725-730.
- TRUMAN, C.C., and J.M. BRADFORD. 1993. Relationships between rainfall intensity and the interrill soil loss-slope steepness ratio as affected by antecedent water content. *Soil Sci.* 156:405-413.
- TRUMAN, C.C., G.J. GASCHO, J.G. DAVIS-CARTER, and R.D. WAUCHOPE. 1993. Seasonal phosphorus losses in runoff from a Coastal Plain soil. *J. Prod. Agric.* 6:507-513.
- TRUMAN, C.C., and J.M. BRADFORD. 1994. Laboratory determination of interrill soil erodibility. *Soil Sci. Soc. Am. J.* 59:519-526.
- SUMNER, H.R., R.D. WAUCHOPE, C.C. TRUMAN, and C.C. DOWLER. 1996. A rainfall simulator for mesoplot runoff studies. *Trans. ASAE.* 39:125-130.
- SHAW, J.N., L.T. WEST, C.C. TRUMAN, and D.E. RADCLIFFE. 1997. Morphologic and hydraulic properties of soils with water restrictive horizons in the Georgia Coastal Plain. *Soil Sci.* 162:875-885.
- TRUMAN, C.C., R.A. LEONARD, and F.M. DAVIS. 1998. GLEAMS-TC: A two-compartment model for simulating temperature and soil water content effects on pesticide losses. *Soil Sci.* 163(5):362-373.
- TRUMAN, C.C., R.A. LEONARD, and A.W. JOHNSON. 1998. Fenamiphos transport, transformation, and degradation in a highly weathered soil. *Trans. ASAE.* 41(3):663-671.
- TRUMAN, C.C., P. STEINBERGER, R.A. LEONARD, and A. KLIK. 1998. Laboratory determination of water and pesticide partitioning. *Soil Sci.* 163:556-569.
- GASCHO, G.J., R.D. WAUCHOPE, J.G. DAVIS, C.C. TRUMAN, C.C. DOWLER, J.E. HOOK, H.R. SUMNER, and A.W. JOHNSON. 1998. Runoff of nitrate-N, soluble-N,

and bio available-P following simulated extreme rainfall conditions. *Soil Sci. Soc. Am. J.* 62:1711-1718.

- RAHMAN, A.G., R.D. WAUCHOPE, C.C. TRUMAN, C.C. DOWLER. 1999. Runoff and leaching of atrazine and alachlor on a sandy soil as affected by chemigation. *J. Env. Sci. & Hlth.* B34:381-396.
- WAUCHOPE, R.D., H.R. SUMNER, C.C. TRUMAN, A.W. JOHNSON, C.C. DOWLER, J.E. HOOK, G.J. GASCHO, J.G. DAVIS, and L.D. CHANDLER. 1999. Runoff from a corn field as effected by tillage and corn canopy: A large scale simulated-rainfall hydrologic data set for model testing. *Water Resources Research.* 35:2881-2885.
- TRUMAN, C.C., and R.G. WILLIAMS. 2000. Peanut cropping practices effects on event and seasonal runoff and soil losses. *J. Soil and Water Conservation.* (ACCEPTED).
- TRUMAN, C.C., R.D. WAUCHOPE, H.R. SUMNER, J.G. DAVIS, and G.J. GASCHO. 2000. Slope-length and crop growth effects on runoff and sediment delivery. *J. Soil and Water Conservation.* (ACCEPTED).
- POTTER, T.L., L. MARTI, S. BELFLOWER, and C.C. TRUMAN. 2000. Multi-residue analysis of cotton defoliant, herbicide and insecticide residues in water by solid-phase extraction and GC-NPD, GC-MS and HPLC-diode array detection. *J. Agric. Food Chem.* (ACCEPTED).
- SHAW, J.N., L.T. WEST, D.D. BOSCH, C.C. TRUMAN, and D.S. LEIGH. 2000. Parent material uniformity and soil distribution and genesis in a Kandiudult association. *Soil Sci. Soc. Am. J.* (ACCEPTED).
- SHAW, J.N., D.D. BOSCH, L.T. WEST, C.C. TRUMAN, and D.E. RADCLIFFE. 2000. Evidence of lateral flow in SE (USA) upper Coastal Plain kandiudults with loamy to sandy argillic horizons. *Geoderma.* (ACCEPTED).

Past Accomplishments of Thomas L. Potter

Education:

1991 University of Massachusetts, Environmental Chemistry, PhD

Experience:

1979-1984	Senior Chemist, Maine Dept. of Environ. Protection, Augusta, MA
1984-1998	Research Chemist, Univ. of Mass., Amherst, MA.
1998-Present	Research Chemist, USDA-ARS, Southeast Watershed Research Lab., Tifton, GA

Accomplishments:

Developed trace residue analysis methods for pesticides and other contaminants in environmental matrices

Implemented environmental fate studies of anthropogenic pollutants including pesticides, petroleum, trace metals, and chemicals which have been implicated as environmental estrogens

Evaluated human and ecological risks of environmental releases of toxic chemicals.

Developed and published rapid test procedures for herbicide and petroleum residues in soil and water. Provided a complete mass spectral characterization of the environmental degradation products of alachlor. Showed that there are numerous environmental stable products of this compound that leach to groundwater.

Investigated the degradation of alkyl-phenol ethoxylate surfactants in estuarine waters and identified products that formed and their rate of formation and decay. Showed that the principal environmental breakdown products were carboxylates rather than alkylphenols. Work led to re-evaluation of the risks of use of alkylphenol ethoxylate surfactants. Prior work had indicated significant risk since it was believed that alkylphenols, which behave as estrogen mimics, were common breakdown products.

Founder and organizer of the Total Petroleum Hydrocarbon Criteria Workshop that developed techniques for risk based corrective action of complex mixtures of chemicals in soil. Procedures are now used nationally and internationally.

Most significant Publications in last 10 years [Thomas L. Potter]:

- POTTER, T.P., K. SIMMONS, J. SANCHEZ-OLVERA, E. CALABRESE, AND P. KOSTECKI. 1999. Static die-away of a nonylphenol ethoxylate surfactant in estuarine water. *Environ. Sci. Tech.* 33:113-118.
- SALAMA, A.A., M. MOHAMED, B. DUVAL, T.L. POTTER, AND R. LEVIN. 1998. PCB concentration in raw and cooked North Atlantic Bluefish (*Pomatomus saltatrix*) filets. *J. Agric. Food Chem.* 46:1359-1362.
- YANG, R., T.L. POTTER, O.F. CURTIS, AND K. SHETTY. 1997. Tissue-culture based selection of high rosmarinic acid producing clones of rosemary (*Rosmarinus officinalis* L.) using *Psuedomonas* Strain F. *Food Biotechnology.* 11:73-88.
- CALABRESE. E.J., L.A. BALDWIN, T.L. POTTER, AND P.T. KOSTECKI. 1997. A toxicologically-based weight-of-evidence methodology for the relative ranking of chemicals for endocrine disrupting potential. *Reg. Tox. Pharm.* 26:36-40.
- BRAMLAGE, W., T.L. POTTER, AND J. ZU. 1996. Detection of diphenylamine on surfaces of non-treated apples (*Malus domestica* Borkh). *J. Agric. Food Chem.* 44:1348-1351.
- POTTER, T.L. 1996. Essential oil composition of cilantro. *J. Agric. Food Chem.* 44:1824-1826.
- SHETTY, K., T.C. CARPENTER, D. KWOK, and T.L. POTTER. 1996. Selection of high phenolics-containing clones of thyme (*Thymus vulgaris* L.) using *Psuedomonas* spp. *J. Agric. Food Chem.* 44:3408-3413.
- SHETTY, K., T.C. CARPENTER, O. CURTIS, AND T.L. POTTER. 1996. Reduction of hyperhydricity in tissue cultures of oregano (*Origanum vulgare*) by extracellular polysaccharide isolated from a *Psuedomonas* spp. *Plant Sci.* 120:175-183.
- ESNARD, J., T.L. POTTER, and B.M. ZUCKEMAN. 1995. *Streptomyces costaricus* sp. nov, isolated from nematode-suppressive soil. *Intl. J. Sys. Bact.* 45:775-779.
- YIN, C.M., B.X. ZOU, M.F. JIANG, L.W. QIN, T.L. POTTER, and G.G. STOFFOLANO. 1995. Identification of juvenile hormone III Bisepoxide (JHB3), juvenile hormone III and methyl farnesoate secreted by the corpus allatum of *Phormia regina* (Meigen) in vitro and function of JHB3 either applied alone or as part of a juvenoid blend. *J. Insect. Physiol.* 41:473-479.
- POTTER, T.L., and T.L. CARPENTER. 1995. Occurrence of alachlor environmental degradation products in ground water. *Environ. Sci. Tech.* 29:1557-1563.
- POTTER, T.L. 1995. Floral volatiles of *Elaeagnus umbellata* Thunb. *J. Essen. Oil. Res.* 7:347-354.

Past Accomplishments of Timothy C. Strickland, RL

Education:

1985 Univ. of Georgia, Microbiology, PhD

Experience:

1985- 1987	Post-Doc, Dept. of Forest Science, Oregon State Univ., Corvallis, OR
1987-1992	Project Scientist, USEPA, Environmental Research Lab., Corvallis, OR
1992-1997	Program Director, USDA-NRI Competitive Grants Program, CSREES, Washington, DC
1994-2000	Special Assistant for Science and Technology to the Under Secretary for Research, Education, and Economics (USDA), Washington, DC
1998-2000	National Program Leader (Water Quality), USDA-CSREES, Washington, DC
2000-Present	Research Leader, USDA-ARS, Southeast Watershed Research Lab., Tifton, GA

Accomplishments:

Developed laboratory procedures to determine the importance of biological processes in mitigating the potential negative impacts of acidic sulfate deposition in the U.S. The basic premise of this research was that soil inorganic chemical processes do not constitute the sum total of buffering capacity in soils exposed to sulfate from atmospheric deposition. It was postulated that microbial communities were responsible for the ultimate buffering potential in forest soils. Radioisotopic procedures were used to determine that active microbiological process work in concert with soil chemical adsorption to result in a large soil organic-S pool. This pool is very dynamic and fluctuates seasonally in response to temperature, moisture, and type of soil OM.

Developed methodologies to evaluate the relative importance of soil physical structure in the incorporation of added nitrogen into active and passive pools of soil OM. Central theory relating to the ageing of soil OC attributed the decomposition recalcitrance of "old" soil OC solely to complex poly-aromatic chemical structures associated with humic and fulvic acids. This research culminated in the finding that newly introduced nitrogen is rapidly incorporated into "recalcitrant" OM. Subsequent mineralization studies indicated that at least some of this material was "physically protected" from decomposition by its relationship to inorganic soil particles within micro-aggregates (<250 micrometers in diameter). This protected nitrogen is labile when micro-aggregates are disrupted.

Lead a team effort that developed a procedure to establish critical loads for atmospheric deposition of sulfur and nitrogen to sensitive ecosystems in the northeastern United States. The development process assumes that individual spatial/temporal associations of ecosystems can be identified that will respond to excess acidic sulfur and nitrogen in a similar fashion. It is further assumed that a process linking predictive process models with representative members of ecosystem populations can be used to bound ranges of

expected regional sensitivities. This project was successful in demonstrating that policy-relevant information can be presented in a scientifically-defensible manner and that ecosystem specific regulations can reasonably be established using the current state of scientific knowledge.

Collaborated on two federal inter-Departmental teams that defined the research and development priorities for the Clinton Administration: 1) the NSTC/CENR Ecosystem Working Group developed an integrated set of ecosystem R&D priorities and objectives that reflect to common goals of multiple subcommittees within the CENR; and 2) the NSTC/CENR Monitoring Team developed a strategy to construct a national framework for integration and coordination of environmental monitoring and related research through collaboration and building upon existing networks and programs.

Most significant Publications in last 10 years [Timothy C. Strickland]:

- STRICKLAND, T.C., P. SOLLINS, N. RUDD, and D.S. SCHIMEL. 1992. Rapid stabilization and mobilization of ¹⁵N in forest and range soils. *Soil Biol. Biochem.* 24:849-855.
- STRICKLAND, T.C., G. R. HOLDREN, P.L. RINGOLD, D. BERNARD, K. SMYTHE, and W. FALLON. 1993. A national critical loads framework for atmospheric deposition effects assessment: I. Method summary. *Environ. Management.* 17:329-334.
- HUNSAKER, C.T., R. GRAHAM, P.L. RINGOLD, G. R. HOLDREN, and T.C. STRICKLAND. 1993. A national critical loads framework for atmospheric deposition effects assessment: II. Defining regulatory endpoints, indicators, and functional subregions. *Environ. Management.* 17:335-341.
- HICKS, B.B., R. McMILLEN, R.S. TURNER, G. R. HOLDREN, and T.C. STRICKLAND. 1993. A national critical loads framework for atmospheric deposition effects assessment: III. Deposition characterization. *Environ. Management.* 17:343-353.
- HOLDREN, G.R., D. MARMOREK, C.T. HUNSAKER, D. BERNARD, C.T. DRISCOLL, R.S. TURNER, and T.C. STRICKLAND. 1993. A national critical loads framework for atmospheric deposition effects assessment: IV. Model selection, application, and critical loads mapping. *Environ. Management.* 17:355-363.
- HOLDREN, G.R., T.C. STRICKLAND, P.W. SHAFFER, P.F. RYAN, P.L. RINGOLD, and R.S. TURNER. 1993. Sensitivity of critical load estimates for surface waters to model selection and regionalization schemes. *J. Environ. Qual.* 22:279-289.
- ROSENBAUM, B.J., T.C. STRICKLAND, and M.K. McDOWELL. 1994. Critical levels of ozone, sulfur dioxide, and nitrogen dioxide for crops, forests, and natural vegetation in the United States. *Water, Air, and Soil Pollution.* 74:307-319.
- MULTIPLE AUTHORS. 1995. Building a Scientific Basis to Ensure the Vitality and Productivity of U.S. Ecosystems. National Science and Technology Council Special Report. White House Publications Archives.
<http://www.cop.noaa.gov/pubs/ewgfn2.txt>
- MULTIPLE AUTHORS. 1997. Integrating the Nation's Environmental Monitoring & Research Networks & Programs – A Proposed Framework. National Science and Technology Council Special Report. White House Publications Archives.
<http://www.epa.gov/cludygxb/Pubs/framework.wp5>
- WIGINGTON, P.J., M.R. CHURCH, T.C. STRICKLAND, K.N. ESHLEMAN, J.VAN SICKLE. 1998. Autumn chemistry of Oregon coast range streams. *J. American Water Resources Association.* 34:1035-1049.

Past Accomplishments of Robert K. Hubbard

Education:

1979 Michigan State University, Soil Science, PhD

1975 Michigan State University, Soil Science, MS

1971 University of Illinois, Agriculture, BS

Experience:

1999 GS-14, Soil Scientist, USDA-ARS, Southeast Watershed Research Laboratory (SEWRL), Tifton, GA.

1990-1999 GM-13, Soil Scientist, USDA-ARS, SEWRL, Tifton, GA

1984-1990 GS-12, Soil Scientist, USDA-ARS, SEWRL, Tifton, GA

1980-1984 GS-11, Soil Scientist, USDA-ARS, SEWRL, Tifton, GA

1979-1980 Asst. Prof., Environ. Science, Wm. Paterson College of NJ, Wayne, NJ.

Accomplishments:

Discovered that recommended Coastal Plain fertilizer rates including application of animal wastes resulted in nitrate concentrations that exceeded public health standards for drinking water. First to show that nitrate leaching in the Coastal Plain under recommended N rates is negatively impacting shallow groundwater quality and that rates and quantities of nitrate leached depend on N application rate, method of application, and time of year.

Characterized properties of Coastal Plain soils and determined their effects on solute transport. Determined that the physical and chemical properties of Coastal Plain soils are dominated by the relative proportions of sand and clay, and that on the sandier soils percolation rather than surface runoff is the major loss pathway for solutes. Discovered that some phosphorus will leach through sandy Coastal Plain soils, but not through clayey ones.

Discovered that nitrate will leach through plinthite and Hawthorn Formation materials to contaminate groundwater as deep as 4 m in the Tifton Upland physiographic region. Senior authored the book chapter entitled "Nitrates in groundwater in the southeastern United States".

Investigated spatial and temporal patterns of solute transport through a riparian forest and discovered that agrichemicals applied upslope of a riparian area may take several seasons to completely leave the upslope area and move through the riparian forest. Conceived, developed, and tested an overland flow- grass-riparian forest buffer system for utilizing nutrients contained with animal lagoon wastewater. The system combines inexpensive application of wastewater via overland flow with nutrient uptake and filtering by grasses, forest and/or planted wetland vegetation.

Prepared an invited book chapter on dairy cattle manure management. It provides an overview of management and utilization of dairy cattle manure and emphasizes strategies for utilizing the nutrients in the waste without negatively impacting the environment.

Most significant Publications in last 10 years [Hubbard RK]:

- ENTRY J.A., HUBBARD R.K., THIES J.E. and FUHRMAN J. 2000. Influence of vegetation in riparian filterstrips on coliform bacteria: I. Movement and survival in surface flow and groundwater. Accepted by J. Environ. Qual.
- ENTRY J.A., HUBBARD R.K., THIES J.E. and FUHRMAN J. 2000. The influence of vegetation in riparian filterstrips on coliform bacteria: II. Survival in soils. Accepted by J. Environ. Qual.
- BOSCH D.D., HUBBARD R.K., LEONARD R.A. and HICKS D.W. 1999. Subsurface flow patterns identified through tracer studies in a sandy loam profile. TRANS of ASAE 42(2):337-349.
- HUBBARD R.K. RUTER J.M., NEWTON G.L. and DAVIS J.G. 1999. Nutrient uptake and growth response of six wetland/riparian plant species receiving swine lagoon effluent. TRANS of ASAE 42(5):1331-1341.
- HUBBARD R.K., NEWTON G.L., DAVIS J.G., LOWRANCE R., VELLIDIS G. and DOVE R. 1998. Nitrogen assimilation by riparian buffer systems receiving swine lagoon wastewater. TRANS of ASAE 41(5):1295-1304.
- LOWRANCE R., ALTIER L.S., WILLIAMS R.G., INAMDAR S.P., SHERIDAN, J.M., BOSCH, D.D., HUBBARD R.K. and THOMAS D.L. 1998. REMM: The Riparian Ecosystem Management Model. J. Soil Wat. Conserv.
- HUBBARD R.K. and LOWRANCE R.R. 1997. Assessment of forest management effects on nitrate removal by riparian buffer systems. TRANS of ASAE 40(2):383
- LOWRANCE R.R., VELLIDIS G. and HUBBARD R. 1995. Denitrification in a restored riparian forest wetland. J. Environ. Qual. 24:808-8.
- HUBBARD R.K. and LOWRANCE R.R. 1994. Riparian forest buffer system research at the Coastal Plain Experiment Station, Tifton, GA. Water, Air, and Soil Pollution 77:409-432.
- HUBBARD R.K. and SHERIDAN J.M. 1994. Retention of solutes by clayey coastal plain soils. J. Soil Wat. Conserv. 49:356-362.
- VELLIDIS G.R., LOWRANCE R., SMITH M.C. and HUBBARD R.K. 1992. Methods to assess the water quality impact of a restored riparian wetland. J. Soil Wat. Conserv. 48:223-230.
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Past Accomplishments of David D. Bosch

Education:

1990 University of Arizona, Hydrology, PhD

Experience:

1990 – Present Research Hydrologist, USDA-ARS, Southeast Watershed Research Lab., Tifton, GA

Accomplishments:

AGNPS model. Co-developer of the AGNPS water quality model used by public service agencies as a tool for prioritizing watersheds according to non-point source pollution level.

Shallow groundwater characterization. Established the first and most accurate characterizations of the interaction between shallow groundwater and low-gradient streams of the Southeastern U.S.

REMM model. Co-developer of the Riparian Ecosystem Management Model (REMM) for assessing the impact of riparian zone management on stream and groundwater quality.

Rainfall Variability. Developed methods for quantifying the seasonal and spatial variability of rainstorms in the Southeastern Coastal Plain region of the U.S.

Most significant Publications in last 10 years [David D. Bosch]:

- BOSCH, D.D. 1991. Error associated with point observations of matric potential in heterogeneous soil profiles. *Trans. Am. Soc. Agr. Eng.* 34:2427-2436.
- BOSCH, D.D., R.K. HUBBARD, L.T. WEST, and R.R. LOWRANCE. 1994. Subsurface flow patterns in a riparian buffer system. *Trans. Am. Soc. Agr. Eng.* 37:1783-1790.
- BOSCH, D.D., J.M. SHERIDAN, and R.R. LOWRANCE. 1996. Hydraulic gradients and flow rates of a shallow coastal plain aquifer in a forested riparian buffer. *Trans. Am. Soc. Agr. Eng.* 39:865-871.
- BOSCH, D.D., and F.M. DAVIS. 1997. Methods for calculating flow from observed or simulated hydraulic head data. *Advances in Engineering Software.* 28:267-272.
- LOWRANCE, R.R., G. VELLIDIS, R.D. WAUCHOPE, P. GAY, and D.D. BOSCH. 1997. Herbicide transport in a managed riparian forest buffer system. *Trans. Am. Soc. Agr. Eng.* 40:1047-1057.
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- BOSCH, D.D., R.K. HUBBARD, R.A. LEONARD, and D.W. HICKS. 1999. Tracer studies of subsurface flow patterns in a sandy loam profile. *Trans. Am. Soc. Agr. Eng.* 42:337-349.
- BOSCH, D.D., J.M. SHERIDAN, AND F.M. DAVIS. 1999. Rainfall characteristics and spatial correlation for the Georgia Coastal Plain. *Trans. Am. Soc. Agr. Eng.* 42:1637-1644.
- INAMDAR, S.P., J.M. SHERIDAN, D.D. BOSCH, R.G. WILLIAMS, R.R. LOWRANCE, L.S. ALTIER, AND D.L. THOMAS. 1999. Riparian ecosystem management model (REMM): I. Hydrology Evaluation. *Trans. Am. Soc. Agr. Eng.* 42:1679-1689.
- LOWRANCE, R.R., L.S. ALTIER, R.G. WILLIAMS, S.P. INAMDAR, J.M. SHERIDAN, D.D. BOSCH, R.K. HUBBARD, and D.L. THOMAS. 1999. REMM: The riparian ecosystem management model. *J. Soil and Water Cons.* 55:27-24.

Past Accomplishments of R. Richard Lowrance

Education:

1981 University of Georgia, Ecology, PhD

Experience:

1982- 1983 Post-Doc, Institute of Ecology, Univ. of Georgia, Athens, GA
1983-Present Ecologist, USDA-ARS, Southeast Watershed Research Lab.,
Tifton, GA

Accomplishments:

Dr. Lowrance led a series of studies of denitrification, N cycling, and carbon dynamics in important crop production systems of the southeastern Coastal Plain. Denitrification led to high losses of N from a year-round forage production system using liquid manure as the only form of fertilizer. Denitrification accounted for the excess N in manure application. In an irrigated multiple-crop vegetable production system, found that denitrification was limited by C availability and was not important in limiting $\text{NO}_3\text{-N}$ movement to groundwater. Only 28% of the N fertilizer was removed in crop harvest and nitrogen was not being accumulated in soil OC. Large amounts of $\text{NO}_3\text{-N}$ were available for leaching.

Dr. Lowrance showed that total N (nitrate + ammonium + organic N) loss from a typical Coastal Plain agricultural field in subsurface flow was about three times the total in denitrification and surface runoff combined. This was the first literature report where these three N transport mechanisms were measured concurrently. Results have been used by USDA-NRCS to develop guidelines for N application from liquid manure systems in Georgia and Florida to account for losses by denitrification. Results have also been used by fertilizer and food processing industries concerned with N retention and processing in agricultural soils (e.g. Biogro Systems, Annapolis, MD; potato processing industries). Results showed that reduction of N loss from Coastal Plain fields using inorganic N fertilizer will be most effective when efforts are focused on reducing leaching losses, rather than reducing surface runoff or increasing denitrification.

Most significant Publications in last 10 years [R. Richard Lowrance]:

- LOWRANCE, R. 1990. Research approaches for ecological sustainability. *J. Soil and Water Cons.* 45:51-54.
- AMBUS, P. and R. LOWRANCE. 1991. A comparison of denitrification in two riparian soils. *Soil Sci. Soc. Am. J.* 55:994-997.
- OBENHUBER, D.C. and R. LOWRANCE. 1991. Reduction of nitrate in aquifer microcosms by carbon additions. *J. Environ. Qual.* 20:255-258.
- LOWRANCE, R. 1992. Groundwater nitrate and denitrification in a coastal plain riparian forest. *J. Environ. Qual.* 21:401-405.
- LOWRANCE, R. 1992. Nitrogen outputs from a field-size agricultural watershed. *J. Environ. Qual.* 21:602-607.
- LOWRANCE, R. 1992. Sustainable agriculture research at the watershed scale. *J. Sustainable Agriculture* 2:105-111.
- VELLIDIS, G., R. LOWRANCE, M.C. SMITH, and R.K. HUBBARD. 1993. Methods to assess the water quality impact of a restored riparian wetland. *J. Soil and Water Cons.* 48:223-230.
- VELLIDIS, G., R. LOWRANCE, and M.C. SMITH. 1994. Quantitative approach for measuring N and P concentration changes in surface runoff of a restored riparian forest wetland. *Wetlands* 14:73-81.
- LOWRANCE, R., G. VELLIDIS, and R.K. HUBBARD. 1995. Denitrification in a restored riparian forest wetland. *J. Environ. Qual.* 24:808-815.
- LOWRANCE, R. and G. VELLIDIS. 1995. A conceptual model for assessing ecological risk to water quality function of bottomland hardwood forests. *Environmental Management* 19:239-258.
- LOWRANCE, R., L.S. ALTIER, J.D. NEWBOLD, R.R. SCHNABEL, P.M. GROFFMAN, J.M. DENVER, D.L. CORRELL, J.W. GILLIAM, J.L. ROBINSON, R.B. BRINSFIELD, K.W. STAVER, W. LUCAS, and A.H. TODD. Water quality functions of riparian forest buffers in the Chesapeake Bay Watershed. *Environmental Management* 21:687-712.
- LOWRANCE, R., G. VELLIDIS, R.D. WAUCHOPE, P. GAY, and D.D. BOSCH. Herbicide transport in a managed riparian forest buffer system. *Trans. Am. Soc. Agr. Eng.* 40:1047-1057.

- INAMDAR, S.P., J.M. SHERIDAN, R.G. WILLIAMS, D.D. BOSCH, R.R. LOWRANCE, L.S. ALTIER, and D.L. THOMAS. 1999. Riparian Ecosystem Management Model (REMM): I. Testing of the Hydrologic Component for a Coastal Plain Riparian System. *Trans. Am. Soc. Agr. Eng.* 42:1679-1689.
- INAMDAR, S.P. , R.R. LOWRANCE, L.S. ALTIER, R.G. WILLIAMS, and R.K. HUBBARD. 1999. Riparian Ecosystem Management Model (REMM): II. Testing of the Water Quality and Nutrient Cycling Component for a Coastal Plain Riparian System. *Trans. Am. Soc. Agr. Eng.* 42:1691-1707.
- LOWRANCE, R., J.C. JOHNSON, Jr, G.L. NEWTON, and R.G. WILLIAMS. 1998. Denitrification from soils of a year-round forage production system fertilized with liquid dairy manure. *J. Environ. Qual.* 27:1504-1511.
- LOWRANCE, R. L.S. ALTIER, R.G. WILLIAMS, S.P. INAMDAR, D.D. BOSCH, R.K.HUBBARD, and D.L. THOMAS. 2000. The Riparian Ecosystem Management Model. *J. Soil and Water Cons.* 55: 27-36.
- LOWRANCE, R. R.K. HUBBARD, and R.G. WILLIAMS. 2000. Effects of a managed three-zone riparian buffer system on shallow groundwater quality in the southeastern coastal plain. *J. Soil and Water Cons.* 55: 212-220.

Appendix 1: SOIL RESOURCE MANAGEMENT (NP 202)

Component 1: Soil Conservation and Restoration

- Problem Area 1: Erosion: Wind, Rainfall, Irrigation, & Tillage
- Problem Area 2: Compaction
- Problem Area 3: Remediation & Restoration

Component 2: Nutrient Management

- Problem Area 1: Management of Nutrients for Sustainable Production Systems
- Problem Area 2: Basic Research in Soil-Plant Interactions, Nutrient Fate, & Transformations
- Problem Area 3: Soil Management Effects Controlling On-site Retention of Nutrients at Farm, Watershed, & Basin Scales
- Problem Area 4: Management Effects on Carbon-related Processes & Soil Response

Component 3: Soil Water

- Problem Area 1: Infiltration & Retention
- Problem Area 2: Soil Water Availability
- Problem Area 3: Excess Soil Water & Impaired Soil Aeration
- Problem Area 4: Soil Water-related Properties: Measurement & Applications

Component 4: Soil Biology

- Problem Area 1: Soil Ecology
- Problem Area 2: Rhizosphere & Spermosphere
- Problem Area 3: Interactions Between Soil Management & Soil Biota
- Problem Area 4: Management of Diseases, Pests, & Weeds
- Problem Area 5: Soil Processes Affecting Transformation of Pesticides & Other Xenobiotics

Component 5: Productive & Sustainable Soil Management Systems

- Problem Area 1: Developing Sustainable Soil Management Systems
- Problem Area 2: Identifying Critical Soil Information for Site-Specific Management
- Problem Area 3: Assessing & Interpreting the Effects of Soil Management on Soil Quality

The following are Components, Problem Areas, and Goals being addressed by researchers at Southeast Watershed Research Laboratory.

Component 1: Soil Conservation and Restoration

<u>Problem Area 1:</u>	Erosion: Rainfall
Goal 1 (1-1-1):	Develop new, effective, and economical erosion control technologies (how plant residues modify erosion exposure). Tifton Scientist(s): Truman, Potter.
Goal 2 (1-1-2):	Better understand soil erodibility (assess long-term soil erosion risks by rainfall). Tifton Scientist(s): Truman.
Goal 3 (1-1-3):	Develop new methods for assessing tolerable erosion losses (T-factor concept). Tifton Scientist(s): Truman.
Goal 5 (1-1-5):	Establish more complete erosion databases Tifton Scientist(s): Truman.
Goal 7 (1-1-7):	Management impact on erosion (evaluate and predict, also includes K and C factors). Tifton Scientist(s): Truman.
Goal 8 (1-1-8):	National leadership to ensure scientifically defensible erosion technologies. Tifton Scientist(s): Truman.

Component 1: Soil Conservation and Restoration (cont.)

<u>Problem Area 3:</u>	Remediation & Restoration
Goal 1 (1-3-1):	Improve knowledge of soil degradation and contamination processes and sources (better understanding of potential risks from fertilizer contaminations). Tifton Scientist(s): Potter, Truman.
Goal 2 (1-3-2):	Improve knowledge of long-term fate and potential effects of soil contaminants (human exposure). Tifton Scientist(s): Potter, Truman, Wauchope.
Goal 3 (1-3-3):	Identify soil properties that increase or decrease risk potential from specific element contamination. Tifton Scientist(s): Truman, Potter.

- Goal 4 (1-3-4): Develop improved, cost-effective methods for remediation of contaminated soils.
Tifton Scientist(s): Potter, Truman, Wauchope.
- Goal 5 (1-3-5): Develop cost-effective methods to restore degraded soils to productive state.
Tifton Scientist(s): Potter, Truman, Wauchope

Component 2: Nutrient Management

- Problem Area 1: Management of Nutrients for Sustainable Production Systems
- Goal 1 (2-1-1): Improve understanding of management effects and their interactions on nutrient availability from organic and inorganic nutrient sources.
Tifton Scientist(s): Truman, Potter, Lowrance.
- Goal 3 (2-1-3): Develop economically and environmentally sound nutrient management practices.
Tifton Scientist(s): Truman, Potter, Lowrance.
- Problem Area 2: Basic Research in Soil-Plant Interactions, Nutrient Fate, and Transformations
- Goal 4 (2-2-4): Quantify effects of fertilizer and organic by products on transformations and fate of nutrients.
Tifton Scientist(s): Truman, Potter, and Lowrance.
- Problem Area 3: Soil Management Effects Controlling On-site Retention of Nutrients at Farm, Watershed, and Basin Scales
- Goal 1 (2-3-1): Develop practices to minimize loss of nutrients to water.
Tifton Scientist(s): Truman, Potter, Bosch, Lowrance.
- Goal 2 (2-3-2): Develop site-specific nutrient management based on soil properties and hydrology.
Tifton Scientist(s): Truman, Potter, Bosch.
- Goal 3 (2-3-3): Develop nutrient management tools for action agencies.
Tifton Scientist(s): Truman.
- Problem Area 4: Management Effects on Carbon-related Processes and Soil Response

- Goal 1 (2-4-1): Develop practices that maintain or increase OC in soil.
Tifton Scientist(s): Truman, Potter, Wauchope.
- Goal 2 (2-4-2): Determine extent and relative importance of inorganic and organic C storage in soil.
Tifton Scientist(s): Potter, Truman, Wauchope.
- Goal 3 (2-4-3): Develop practices that allow OC accumulation and supply sufficient N, P, and S.
Tifton Scientist(s): Truman, Potter, Lowrance, Wauchope.

Component 3: Soil Water

Problem Area 1: Infiltration and Retention

- Goal 1 (3-1-1): Understand soil properties to improve water infiltration.
Tifton Scientist(s): Truman, Bosch.
- Goal 2 (3-1-2): Understand soil properties to optimize crop water use.
Tifton Scientist(s): Truman, Bosch.

Problem Area 2: Soil Water Availability

- Goal 1 (3-2-1): Identify crops, practices, and technologies to overcome water stress.
Tifton Scientist(s): Truman, Bosch.
- Goal 2 (3-2-2): Develop management practices to improve soil water availability.
Tifton Scientist(s): Truman, Bosch.
- Goal 3 (3-2-3): Determine the contribution of redistributed water to the available soil water pool.
Tifton Scientist(s): Truman, Bosch.

Problem Area 4: Soil Water-related Properties: Measurements and Applications

- Goal 1 (3-4-1): Develop new instruments and concepts to assess soil water processes and storage.
Tifton Scientist(s): Bosch, Truman.
- Goal 2 (3-4-2): Develop new theories and concepts for improved transport predictive capability.
Tifton Scientist(s): Bosch, Truman

- Goal 3 (3-4-3): Understand soil properties and develop new soil management strategies that account for effects of dissolved or suspended water contaminants.
Tifton Scientist(s): Truman, Bosch, Potter, Lowrance

Component 4: Soil Biology

- Problem Area 5: Soil Processes Affecting Transformation of Pesticides and Other Xenobiotics
- Goal 1 (4-5-1): Develop techniques to minimize the environmental impact of agrichemicals and other xenobiotics.
Tifton Scientist(s): Potter, Truman, Wauchope, Strickland.
- Goal 3 (4-5-3): Develop improved methods and decision-making tools for soils that require remediation to improved soil productivity, human health, and prevent environmental degradation.
Tifton Scientist(s): Potter, Truman, Wauchope.

Component 5: Productive and Sustainable Soil Management Systems

- Problem Area 1: Developing Sustainable Soil Management Systems
- Goal 1 (5-1-1): Develop productive, profitable, and sustainable soil management systems.
Tifton Scientist(s): Truman, Potter, Wauchope, Bosch, Lowrance, Strickland.
- Goal 2 (5-1-2): Develop tools to enable land managers to understand the effects of various management practices.
Tifton Scientist(s): Truman, Potter, Wauchope, Bosch, Lowrance, Strickland.
- Goal 3 (5-1-3): Compare organic and conventional farming systems for sustainability and environmental impact.
Tifton Scientist(s): Truman, Potter, Wauchope, Bosch, Lowrance.
- Problem Area 2: Identifying Critical Soil Information for Site-specific Management
- Goal 2 (5-2-2): Develop approaches to evaluate benefits of site-specific soil management.
Tifton Scientist(s): Truman, Potter, Wauchope, Bosch, Lowrance, Strickland.

Problem Area 3: Using Soil Quality to Assess Sustainable Land Management

Goal 3 (5-3-3): Quantify impacts of various land management practices on indicators of soil quality (@ field, landscape, farm, watershed, regional, and ecosystem scales).
Tifton Scientist(s): Truman, Potter, Wauchope, Bosch, Lowrance, Strickland.