Alternative Litter Management in Texas

Final Administrative Report[1]

Submitted to the
Texas State Soil & Water Conservation Commission
Temple, Texas

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Office of Pollution Prevention & Recycling
Texas Natural Resources Conservation Commission
Austin, Texas

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[1] This Report is the administrative portion of the final report prepared under the *Alternative Litter Management in Texas* Project. The Project was implemented under contract #99-7 between the Texas State Soil and Water Conservation Board and the Foundation for Organic Resources Management with funding from the U.S. Environmental Protection Agency's Nonpoint Source Program.

[2] The Foundation for Organic Resources Management is a private nonprofit organization [501(c)(3)].

[3] The Pineywoods Resource Conservation and Development Council is a private nonprofit organization [501(c)(3)].

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*Unless otherwise noted deliverables are included in the Interim Report submitted to the Texas State Soil and Water Conservation Board in December 2001.

Project Work Plan Summary Page Error! Bookmark not defined.

1. **Title of Project**: Alternative Litter/Manure Management in East Texas
2. **Project Goals/Objectives**: To identify and deploy alternative litter/manure management practices that will:
   2.1. Mitigate soil phosphorous accumulation and resulting potential for nonpoint source water contamination within the target watersheds,
   2.2. Assist with the development and implementation of *alternative* Best Management Practices for manure/litter utilization (applicable specifically to the project's target watersheds), and
   2.3. Ensure the continued economic viability of the region's poultry and livestock producers.
3. **Project Tasks**:
   ***3.1. Program Coordination*:** Coordinate and facilitate efforts amongst a broad set of stakeholders to identify, develop, and implement alternatives for managing poultry litter and livestock manure.
   ***3.2. Education & Technology Transfer*:** Increase stakeholders' awareness, understanding, and appreciation of phosphorous-related issues and litter/manure management alternatives. Identify and help poultry/livestock producers and industries embrace alternative management practices, including transport of excess litter/manure out of areas of concentrated loading, conversion of litter/manure into value-added products, and other "off-farm" management options.
   ***3.3. BMP Development and Implementation*:** Work with appropriate technical assistance agencies to establish new best management practices for alternative litter/manure management and assist poultry and livestock producers regarding implementation of these alternative BMPs.
   ***3.4. Supporting Information*:** Obtain and analyze litter/manure, soil, water, and logistical data in support of project objectives and activities
4. **Measures of Success**: Establishment of a regionally coordinated program for alternative litter management (including, in particular, off-farm management options for producers); participation in the program by at least 100 producers; 20% reduction in litter/manure-derived phosphorous NPS pollution within the target watersheds based on modeling results.
5. **Project Type**: Multiple Watersheds.
6. **Waterbody Type**: Rivers.
7. **Project Locations**: portions of the Cypress Creek Watershed (segment 0401~0403), Sabine River Watershed (segments 0505, 0508, 0513), Angelina/Neches River Watershed (segments 0606, 0610), a portion of the Navasota watershed (within Brazos County; segment 1202), and the Guadalupe watershed (within Gonzales County).
8. **NPS Management Program Reference**: State of Texas Agricultural/Silvicultural Nonpoint Source Management Program, approved November 1994.
9. **NPS Assessment Report Status**: Threatened
10. **Key Project Activities**: Technical Assistance; Education; Implementation
11. **NPS Management Program Elements**:
12. **Project Costs**: Federal ($550,641); Non-Federal match ($367,094); Total Project ($917,735)
13. **Project Management**: Foundation for Organic Resources Management

    Partners: Pineywoods Resource Conservation & Development Council; Stephen F. Austin University; Texas Natural Resources Conservation Commission

    Cooperating Entities: numerous Soil & Water Conservation Districts; Natural Resources Conservation Service; Texas A&M University; Texas Agricultural Extension Service; producers, landowners, industry representatives.
14. **Project Period**: January 1, 2000 to April 30, 2002

1. Work Plan

1. **Problem/Need Statement**: Animal agriculture is an important component of the rural landscape in east Texas, offering significant employment and income generation opportunities to farmers / landowners. However, in areas of concentrated animal agriculture there are increasing concerns that the large quantities of manure generated by these animal feeding operations may lead to nonpoint source pollution of the region's waters.[4] Traditional methods of on-farm land application of the poultry litter and/or livestock manure can sometimes lead to build-up of phosphorous in soils and excessive loading of nutrients in some basins/watersheds. There is increasing understanding and appreciation of the "mass balance" of phosphorous—that, due to on-farm accumulations, more phosphorous is entering these areas of concentrated production than is leaving. New strategies and management technologies are needed to reverse these trends, achieve a more acceptable balance of the "inflows and outflows" of phosphorous into these areas, and ensure the continued viability of the production farms without attendant nonpoint source impacts from excessive nutrients (in particular, from phosphorous).

   Efforts in the region [and in other areas of concentrated production in the U.S.] have begun to focus on moving "excess" nutrients—in the form of poultry litter or livestock manure—off of the production farms and elsewhere (nearby to the extent possible, outside of the basin or watershed if necessary), where the material can be beneficially used (typically for agronomic purposes). Such "export" activities can successfully address the mass balance issue and achieve acceptable nutrient management/loading goals. However, establishment and implementation of export activities can be challenging and complex, and must encompass numerous considerations, including, for example:

   Coordinating the supply of raw material (locating/organizing the litter/manure sources)

   Stimulating the demand elsewhere for the "manure-derived products" (in raw/processed form)

   Addressing the numerous logistical elements necessary to "bring together supply and demand" (e.g., clean-out, transportation, storage, processing, distribution, spreading)

   Addressing the policy and regulatory issues that can constrain or stimulate such activities

   To be successful, these nutrient export activities must also be implemented in ways that ensure the economic viability of the poultry/livestock producers. Moreover, because investments in these activities are also subject to "economies of scale" and can be greatly influenced by public sector programs, such activities need to be coordinated on a regional basis.

   This project will help the full spectrum of stakeholders—producers, landowners, agribusiness companies, and industry representatives; federal, state, and local agencies; education and research institutions; nonprofit organizations—develop and implement a regionally coordinated program for alternative nutrient (litter/manure) management practices, with an emphasis on off-farm/export activities. Implementation of such a program will help achieve water quality goals in the region while ensuring the continued economic vitality of the region's poultry, livestock, and agricultural enterprises.

[4] Recognizing that the region's waters may also be impacted by nonpoint source pollution of nutrients from other sources such as commercial fertilizer, waste water treatment plans, and other anthropogenic activities.

2. **General Project Description**: This proposed project will consist of the Foundation for Organic Resources Management (FORM) working cooperatively with partners and collaborators to coordinate and facilitate efforts to identify and embrace regionally coordinated alternative management programs. In addition, FORM and its partners—Stephen F. Austin University (SFA), Pineywoods Resource Conservation and Development Council (RC&D), and the Texas Natural Resources Conservation Commission/Office of Pollution Prevention and Recycling (TNRCC)—will help educate stakeholders regarding nutrient management issues and options and will transfer technologies for converting litter/manure into value-added products. The team will also assist with the development of Best Management Practices (BMPs) associated with alternative strategies, and will compile/develop technical information necessary for support of all project activities.

   The team will first assess the current situation in the areas of concentrated poultry and livestock production in the target watersheds to better understand the quantities of litter/manure being generated, the application lands being used or potentially available, and the existing or potential markets for the raw/processed material. The team will then work with all stakeholders to identify specific options for alternative nutrient management and to develop strategies for pursuit of the prioritized options. Numerous tactics will be employed to address logistical elements—for example, a "hotline" will be established to coordinate supplies of raw material and to enable coordination between sellers and buyers (and with those who will consummate the transactions, such as clean-out contractors, haulers, and spreaders). The hotline will be integrated with a project website to further disseminate key information (although code numbers will be used to ensure confidentiality where necessary). Interaction and coordination with collaborators/stakeholders will be an essential and on-going activity.

3. **Tasks and Sub-Objectives**

   TASK 1: Program Coordination

Costs:	Federal	$110,128	
	Non-Federal match	$73,419	
	Total	$183,547	Task is 20% of total

   Objective: To coordinate and facilitate efforts amongst a broad set of stakeholders to identify, develop, and implement alternatives for managing poultry litter and livestock manure. Stakeholders include: technical assistance agencies (e.g., SWCDs, NRCS, TSSWCB, TNRCC, TAEX); producers, landowners, and poultry/livestock companies and industry representatives; and other organizations (e.g., TAMU, appropriate river authorities, TIAER).

   Subtask 1.1: Meetings will be convened quarterly with project participants/stakeholders to discuss key issues, implementation strategies and activities, and results.

   Subtask 1.2: A "hotline" will be established to facilitate and coordinate off-farm litter/manure management activities between suppliers (producers), consumers (other farmers), and "middlemen" (clean-out contractors, haulers, brokers, spreaders, etc.).

   Subtask 1.3: Project staff will coordinate project activities with other, related efforts underway within the target watersheds (e.g., development of TMDLs, WRASs, CNMPs; USDA/EPA Unified AFO Strategy).

   Subtask 1.4: Project staff will seek to identify and secure additional resources to extend / compliment project efforts and activities.

Deliverables:

Quarterly progress reports including copies of agendas, attendance, and minutes

Status reports regarding hotline activities will be appended to quarterly progress reports

Copies of the executive summaries for any complimentary project proposals submitted/awarded will be appended to quarterly progress reports

Establishment of a litter/manure "hotline" (including raw and processed products)

TASK 2: Education & Technology Transfer

Costs:	Federal	$176,205	
	Non-Federal match	$117,470	
	Total	$293,675	Task is 32% of total

Objective: To increase stakeholders' awareness, understanding, and appreciation of nutrient-related issues and nutrient [litter/manure] management alternatives; identify and help poultry/livestock producers and industries embrace alternative management practices, including transport of excess litter/manure out of areas of excessive loading, conversion of litter/manure into value-added products, and other "off-farm" management options.

Subtask 2.1: At least 12 focus group meetings will be convened with subsets of project participants (with emphasis on producers/landowners and poultry/livestock company staff and industry representatives) to discuss:

key issues (e.g., understanding nutrient balances; understanding soil-phosphorous accumulation phenomena; impacts from NPS pollution from nutrients)

implementation strategies and activities (e.g., comprehensive management plans; on-farm storage options; phytase, alum, targeted crop uptake, and other phosphorous reduction techniques; clean-out & off-farm management options; new utilization options such as silvicultural applications, short-term vs. long-term strategies)

results (e.g., soil phosphorous reductions; economic benefits to producers)

Subtask 2.2: Project staff will identify, evaluate, and transfer information to applicable assistance agencies and industry participants regarding litter/manure value-added conversion technologies (e.g., composting, densification, energy). The information will be transferred through:

distribution of hard copy material

forwarding of links to appropriate internet sites

access to the project's own web site (with links to partners/collaborators as appropriate)

Subtask 2.3: Convene at least 3 meetings with clean-out contractors/haulers/spreaders operating in or near the target watersheds to help them better understand nutrient management issues and options.

Subtask 2.4: Communication of project activities/results to stakeholders and other interested parties through development and dissemination of a project brochure and participation (including exhibiting) at appropriate conferences and similar events in Texas and regional NPS events

Deliverables:

Reports of focus group meetings will be appended to quarterly progress reports

Copies of handout materials compiled/developed/disseminated will be appended to quarterly progress reports

Establishment of a project-specific web site (as a component of FORM's existing website – www.organix.org)

Reports of meetings with contractors will be appended to quarterly progress reports

Project brochure

TASK 3: BMP Development and Implementation

Costs:	Federal	$143,167	
	Non-Federal match	$95,444	
	Total	$238,611	Task is 26% of total

Objective: Work with appropriate technical assistance agencies to establish new best management practices for alternative litter/manure management and assist poultry and livestock producers regarding implementation of these alternative BMPs.

Subtask 3.1: At least 4 meetings will be convened with technical assistance agencies to assess the feasibility and/or facilitate the establishment of new BMPs specifically associated with alternative nutrient [litter/manure] management practices, including, for example:

use of a "phosphorous index" system for guiding land application activities

construction of on-farm storage facilities

export of excess nutrients (i.e., transport of the material off of the production farm with subsequent beneficial use elsewhere)

production and off-farm sales of certain forage crops with high-phosphorous uptake rates

conversion of litter/manure into value-added products (e.g., compost, pellets, energy)

Subtask 3.2: At least three meetings will be convened to help establish new cost-share programs at federal/state/local levels for support of alternative nutrient (litter/manure) management strategies (e.g., EQIP incentive payments for excess nutrient export or for use [elsewhere] of the manure-derived products).

Deliverables:

Discussion notes from the technical meetings will be appended to quarterly progress reports

Copies of BMPs established specifically for alternative management practices will be appended to quarterly progress reports

TASK 4: Supporting Information

Costs:	Federal	$121,141	
	Non-Federal match	$80,761	
	Total	$201,902	Task is 22% of total

Objective: Obtain and analyze litter/manure, soil, water, and logistical data in support of project objectives and activities.

Subtask 4.1: Litter/manure resources:

Compile and analyze information regarding the sources of litter/manure in the target watersheds; data will include type, quantity, location, characteristics, and availability. The information will be collected in close coordination with producers, companies, and industry representatives, and will be compiled and analyzed in such a way as to ensure the confidentiality of the information as may be requested.

Obtain and analyze sufficient samples of litter/manure produced within the target watersheds to develop a reasonable confidence level of the characteristics of the raw materials (e.g., moisture content, nutrient content, ash content, etc.).

Subtask 4.2: Land availability / soil nutrient levels:

Compile and analyze information regarding existing land application fields in target watersheds and associated soil nutrient levels, with particular emphasis on soil phosphorous levels. This information will enable stakeholders to better understand the need for alternative practices to avoid/reduce high soil nutrient levels.

Compile and analyze information regarding target land application fields within/near the target watersheds, taking into account acceptable soil nutrient levels. This information will enable stakeholders to identify off-farm utilization options for the litter/manure.

Subtask 4.3: Water quality impacts:

Obtain from project collaborators (e.g., local WQCDs, TSSWCB) data from water quality monitoring and analysis activities to assess possible correlation with project activities.

Through development and use of a spreadsheet model, determine soil phosphorous loading reductions (and associated NPS pollution reductions) based on varying levels of participation by producers in alternative management strategies developed through this project.

Subtask 4.4: Logistical information:

Through the development of the hotline, establish and maintain a database regarding: potential sources of raw litter/manure; potential clean-out contractors, haulers, and spreaders; potential value-added processors; potential consumers of the raw/processed material.

Deliverables:

Report regarding sources and characteristics of litter/manure produced within the watersheds

Report regarding soil nutrient levels within the target watersheds and target application lands within/near the target watersheds

Report of projected soil phosphorous loading reductions within the target watersheds

4. Activity Schedule: Project activities are set forth in the task-timeline in Attachment 1.

5. Estimated Costs: Below is a summary of the project budget set forth in Attachment 2 (details are available upon request).

	Amount	% of total
EPA portion	$550,641	60%
Non-federal match	$367,094	40%
Total	$917,735	

6. Coordination, Roles, and Responsibilities:

Foundation for Organic Resources Management: Responsible for overall project management and administration. FORM's President, Mr. Jim Wimberly, and FORM's Administrative Coordinator, Ms. Theresa Mangione, will be assigned to the project approximately 20% and 25% FTE, respectively. FORM will engage a full-time project

coordinator, to be based in Nacogdoches, to provide day-to-day project coordination and technical support.

FORM is a nonprofit, 501(c)(3) organization based in Fayetteville, Arkansas. A one page description of the organization is provided in Attachment 3. A list of relevant project experience is provided in Attachment 4. More information regarding FORM or its staff is available upon request (also, refer to the organization's website: www.organix.org).

Stephen F. Austin University: SFA, under the project management of Dr. Leon Young with the University's Agriculture Department, will assist with information compilation and analysis. Specifically, SFA will have primary responsibility for developing the database of information regarding litter/manure production and availability (subtask #4.1), land availability/soil nutrient levels (subtask 4.2), and water quality impacts (subtask 4.3). SFA will assist with other project activities including, in particular, quarterly meetings with project participants/stakeholders, focus group meetings, and discussions regarding alternative BMPs.

Pineywoods Resource Conservation and Development Council: Through the leadership of Ken Awtrey, senior resource conservationist with the USDA Natural Resources Conservation Service, the RC&D will assist with coordination and convening activities. The RC&D will also host the project office, located adjacent to the RC&D office in downtown Nacogdoches where Mr. Awtrey will provide on-going guidance and support to FORM's full-time project coordinator, and the RC&D's secretary will provide administrative/clerical support for project activities. Mr. Awtrey will also serve as a key liaison with NRCS and Conservation District staff, offices, and resources in the region and at the state office in Temple.

Texas Natural Resources Conservation Service/Office of Pollution Prevention and Recycling: TNRCC will provide technical assistance regarding litter/manure management conversion technologies, strategies, and policy/regulatory considerations. TNRCC will also assist with focus group meetings and other educational and technology transfer activities. Mr. Scott McCoy, Senior Program Specialist, will coordinate TNRCC's participation in this project.

Letters of support and intent to participate will be forwarded by each partner organization directly to the Texas State Soil and Water Conservation Board. In addition, letters of support from numerous project collaborators can be provided upon request.

7. Public Participation: Producers, landowners, and staff of poultry/livestock agribusiness companies will be major participants in this project. It is recognized that their participation is essential for successful project outcome and achievement of project objectives. All reasonable efforts will be made to facilitate their active participation.

This project will also be coordinated with efforts underway by other stakeholders/participants. For example, project staff will ensure coordination with the Angelina-Neches River Authority regarding the establishment of TMDLs for litter/manure-derived nutrients.

8. Measures of Success:

Establishment of a regionally coordinated program for alternative litter management (including, in particular, off-farm management options for producers)

Participation in the program by at least 100 poultry/livestock producers

20% reduction in litter/manure-derived phosphorous NPS loading within the target watersheds based on modeling results.

9. Project Leader:

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2. Program Coordination:

Objective: To coordinate and facilitate efforts amongst a broad set of stakeholders to identify, develop, and implement alternatives for managing poultry litter and livestock manure. Stakeholders include: technical assistance agencies (e.g. SWCDs, NRCS, TSSWCB, TNRCC, TAEX); producers, landowners, and poultry/livestock companies and industry representatives; and other organizations (e.g. TAMU, appropriate river authorities, TIAER).

2.1. Partner/Stakeholder Meetings: Meetings will be convened quarterly with project participants/stakeholders to discuss key issues, implementation strategies and activities, and results.

Activities: Quarterly stakeholder meetings have been convened as planned for this project. Meetings have focused on the tasks as defined in the project proposal. The initial meetings during the first three quarters of the project were used as planning sessions to develop detailed plans to implement all tasks for the project. These meetings included partners and stakeholders from TNRCC, Pineywoods RC&D Council, NRCS and Stephen F. Austin State University. Multiple representatives attended quarterly meetings from NRCS, conservation district staff, commercial timber companies, Stephen F. Austin State University, poultry integrators, poultry clean-out contractors, and landowners. The intent of these meetings has been to develop working relationships with all stakeholders impacted by this project. Through these relations we have become aware of the real and perceived issues regarding management of animal wastes and have, thereby, become better equipped to direct our efforts for developing alternative litter management practices.

The following is a summary of the meetings that were convened during the project:

- Jan 11, 2000: Planning meeting of project partners held in Nacogdoches; attendees included Wimberly/FORM; Awtrey/RC&D; McCoy/TNRCC; Young & Kevin Isom/SFA.
- June 5 – 6, 2000: Separate planning meetings in Nacogdoches with Leon Young – SFA, and Ken Awtrey/RC&D.
- Sep 27, 2000: Team meeting in Nacogdoches.
- March 7, 2001: Team meeting in Nacogdoches (Herron, Awtrey, Young); also, focused meeting on litter in forestlands markets.
- Apr 10, 2001: Wimberly met with Awtrey & Young.
- Jun 25, 2001: Wimberly met with McCoy.

- July 23, 2001: Herron met with Awtrey to coordinate project activities described herein.
- July 23, 2001: Herron met with Awtrey to discuss litter in timber economics and litter production in Lower Angelina watershed.

Deliverables:

- January 11, 2000: Agenda – Project Partners Meetings

2.2. Litter Hotline: A hotline will be established to facilitate and coordinate off-farm litter/manure management activities between suppliers (producers), consumers (other farmers), and "middlemen" (clean-out contractors, haulers, brokers, spreaders, etc.).

Activities: Efforts were initiated to identify litter clean-out contractors, haulers, and spreaders in E/NE TX in the early stages of the project. Pre-release activities included development of website, development and distribution of announcements (different versions for buyers and sellers) and identification & coordination with service providers (to get them pre-registered to the extent possible). The hotline was promoted aggressively, including direct mail-outs to potential buyers through county extension and conservation district offices (over 5,000 flyers) and to potential sellers (over 2,000 seller flyers were distributed to all poultry producers in Texas through the various integrators). A website was designed for buyers, sellers, and middlemen to register to obtain information on-line (www.litterhotline.com). A toll-free number was setup (1-866-269-7448) with 24-hour attendance by the Project Coordinator so interested parties could call in to register or get information. The hotline was officially released on September 28, 2000. As of the close of the project, signups included 66 buyers, 30 sellers, and 7 service providers. Several one-time buyers requested contact information for sellers and service providers. A follow-up survey was conducted with all parties registered on the hotline to determine the effectiveness of the service. Comments from this survey are included as an attachment to this summary.

Deliverables:

- Home Page from www.litterhotline.com
- Seller Flier
- Buyer Flier
- October 24, 2001: Survey Letter to Hotline Registrants
- Postcards with Survey Responses
- Database List of Hotline Registrants

2.3. Coordination with Other Projects: Project staff will coordinate project activities with other, related efforts underway within the target watersheds.

Activities:

- Feb 4, Mar. 29, 2000: Wimberly participated in meetings of Brazos/Navasota Integrated Resource Management Project (as a team member of that project, Wimberly provides guidance regarding litter/nutrient management issues and options).
- Jan ~ Mar 2000: Project partners participated in numerous meetings amongst TNRCC, TxDOT, and others to develop detailed plans for implementing the TNRCC-TxDOT compost market stimulation project. Wimberly has recommended to TNRCC and TSSWCB that FY01 funds be used to extend the project to composted litter in east/northeast Texas.
- June 6, 2000: A meeting regarding the "Using Litter on Forestlands" initiative was held in Nacogdoches, after a proposal by FORM and the Pineywoods RC&D to NRCS-TX (under the EQIP educational program) for demonstration of litter applications on forestlands in East Texas and an accompanying workshop for poultry producers and forest landowners was funded.
- Jul 26, 2000: Wimberly met with James Grimm, Texas Poultry Federation, and John Carey, TAMU, to plan the upcoming workshop series focused on litter management for Texas poultry producers. A proposal submitted by FORM, the Texas Poultry Federation and TAMU to NRCS-TX (under the EQIP educational program) for a series of workshops for growers & integrator staff regarding pending regulations for poultry waste management and alternatives for addressing said regulations was funded.
- Sep 26, 2000: Brazos/Navasota Water Quality Task Force meeting in Bryan.
- Sep 27, 2000: Meeting regarding the "Using Litter on Forestlands" initiative was held in Nacogdoches.
- Oct 12 & Dec 4~5, 2000: Planning meetings were held in Nacogdoches regarding the "Using Litter on Forestlands" initiative.
- Feb. 8, 2001: "Using Litter on Forestlands" workshop convened in Nacogdoches.
- Mar. 1, 2001: FORM staff hosted a tour of the sawdust/litter-fired furnace system currently being developed (under a DOE grant) for heating poultry houses; the unit is being tested at the University of Arkansas.

- Mar 28/29, 2001: Litter management workshops (in coordination with Texas Poultry Federation & TAMU) held in Bryan and Gonzales.
- Apr 10/11, 2001: Litter management workshops (in coordination with Texas Poultry Federation & TAMU) held in Nacogdoches.
- May 3, 2001: Litter management workshop (in coordination with Texas Poultry Federation & TAMU) held in Mt. Pleasant
- Jun 2001: Assessment of possible regional organics management (ROM) facility in Victoria included poultry litter/mortality from Gonzales area.
- Sep 2001: Report to Golden Crescent Regional Planning Commission (GCRPC) re Regional Composting Facility in/near Victoria. The report includes discussion of potential for using litter / poultry mortality as feedstocks.

2.4. Pursuit of Additional Resources: Project staff will seek and secure additional resources to extend/compliment project efforts and activities.

Activities:

- Mar 29, 2000: FORM helped the Pineywoods RD&D prepare and submit a proposal to NRCS-TX (under the EQIP educational program) for demonstration of litter applications on forestlands in East Texas and an accompanying workshop for poultry producers and forest landowners. The proposal was funded.
- Mar 31, 2000: FORM helped the Texas Poultry Federation and TAMU prepare and submit a proposal to NRCS-TX (under the EQIP educational program) for a series of workshops for growers & integrator staff re pending regulations re poultry waste mgt and alternatives for addressing said regulations. The proposal was funded.
- Apr 2000: FORM received a grant from the Tulsa Metropolitan Utility Authority to develop a "Litter Marketing Plan", which will provide additional insights for this project.
- Jun 2000: FORM received a grant from the U.S. Department of Energy to undertake a "Pre-Feasibility Assessment of Litter-to-Ethanol Technologies for Northwest Arkansas" which will have significant relevance to this project.
- Mar 2001: FORM submitted a proposal to the Golden Crescent COG in Victoria to assess the pre-feasibility of establishing a regional organics management complex that may include poultry litter/residuals as feedstocks.

- Mar 31, 2001: FORM submitted a proposal with the Pineywoods RC&D for 2002 EQIP funds to host a field day demonstrating poultry litter applications in commercial timber.

Deliverables:

- EQIP Proposal – March 2000: Litter in Forestlands
- EQIP Proposal – March 2001: Litter in Forestlands
- EQIP Proposal – March 2000: Poultry Grower Workshops

3. Education & Technology Transfer

Objective: To increase stakeholders' awareness, understanding, and appreciation of nutrient-related issues and nutrient (litter/manure) management alternatives; identify and help poultry/livestock producers and industries embrace alternative management practices, including transport of excess litter/manure out of areas of excessive loading, conversion of litter/manure into value-added products, and other "off-farm" management options.

3.1. Group Meetings: At least 12 focus group meetings will be convened with subsets of project participants (with emphasis on producers/landowners and poultry/livestock company staff and industry representatives) to discuss key issues, and implementation strategies and activities.

Activities:

The following is a summary of the meetings that were convened during the project:

- Feb 7, 2000: Dairy Manure Waste Mgt Workshop organized by TNRCC held in Stephenville. Wimberly spoke re alternatives & regional strategies.
- Mar 23, 2000: Poultry Waste Mgt Workshop organized by TNRCC held in Bryan. Wimberly spoke re alternatives & regional strategies.
- Apr 13, 2000: Poultry Manure Waste Mgt Workshop organized by TNRCC held in Gonzales. Wimberly spoke re alternatives & regional strategies.
- May 23, 2000: Poultry Waste Mgt Workshop organized by TNRCC held in Mt. Pleasant. Wimberly spoke re alternatives & regional strategies.
- Jul 26/27, 2000: Series of meetings in the Gonzales region with integrators and producers.
- Nov 30, 2000: Brazos/Navasota Task Force meeting in Bryan, which focused on residuals mgt; Wimberly helped develop agenda & spoke re off-farm litter mgt options. Contract growers and Sanderson Farms reps attended.
- Feb 8, 2001: Litter-forestlands workshop.
- Mar 28, 2001: Litter mgt workshop - Bryan.
- Mar 29, 2001: Litter mgt workshop – Gonzales.
- Apr 10/11, 2001: Litter mgt workshops - Nacogdoches.
- May 3, 2001: Litter mgt workshop – Mt. Pleasant.

Deliverables:

- June 6, 2000: Meeting Notes: Litter Applications on Forestlands in East Texas
- White Paper for Demo Project: "Using Poultry Litter on Forestlands in East Texas"
- September 27, 2000: Meeting Notes: Workshop Planning
- Tri-fold Registration Flier for Workshop for Fertilizing Forestlands with Poultry Litter

- February 8, 2001: Agenda - Workshop for Fertilizing Forestlands with Poultry Litter
- List of Participants from Workshop for Fertilizing Forestlands with Poultry Litter
- Speaker Evaluations from Workshop for Fertilizing Forestlands with Poultry Litter
- New Release for Workshop for Fertilizing Forestlands with Poultry Litter
- March 7, 2001: Meeting Notes - Further Discussions Re: Promoting Litter in Timber
- Registration Fliers for Poultry Grower Workshops
- List of Participants from Poultry Grower Workshops

3.2. Litter/Manure Value Added Technologies: Project staff will identify, evaluate, and transfer information to applicable assistance agencies and industry participants regarding litter/manure value-added conversion technologies.

Activities:

The following is a summary of the meetings that were convened during the project:

- Jan 25-Mar 30, 2000: Wimberly had seven meetings with poultry industry representatives to identify and evaluate technologies and deployment strategies.
- Jan – Mar, 2000: Numerous discussions with Ron Richardson and Morris Peltier of MagnaGro.
- Mar 29, 2000: Meeting with Ricky Lout, owner of DRL sawmill in St. Augustine, to discuss pelletizing.
- Apr – Jun, 2000: Development of the project website was initiated.
- May 2000: Discussions were initiated with Russell Smith, Exec Dir of the Tx Renewable Industries Assn, re litter-to-electricity and litter-to-ethanol in Tx.
- Sep 26, 2000: Technical discussions with NRCS-TX re phosphorus issues (e.g., litter mgt options, P index).
- Oct – Dec, 2001: Some additional links to litter management issues & options were added to the project website.
- Jan – Mar, 2001: FORM staff continued efforts to identify and evaluate technologies for converting litter into ethanol, thermal/electrical energy, and compost.
- Apr – Jun, 2001: Numerous discussions with team members and collaborators (e.g., David Moore, Fred Schweider, Robert Melvin, Mike Neal) re technical feasibility of composting of litter.
- Jul – Sep, 2001: FORM staff & consultants worked on preparation of a report regarding composting of litter (and other poultry residuals). Efforts included interviews with and site visits to numerous entities that are/have been involved in litter composting. Additional efforts were invested in evaluating other litter conversion technologies (e.g., combustion/ gasification, fermentation, pyrolysis).

Deliverables:

- February 17, 2000: Report of Litter/Manure Waste Management Workshop
- February 17, 2000: Agenda - Alternative Manure Management & Compost Market Mtg.
- March 23, 2000: Agenda - Alternative Manure Management & Compost Market Mtg.
- March 23, 2000: Report of Litter/Manure Waste Management Workshop
- January 1, 2000: Report of Technical Meeting with MagnaGro
- March 29, 2000: Report of Technical Meeting with Various Value-Added Companies
- Proposal: Pre-Feasibility Assessment of Litter to Ethanol in Northwest Arkansas

3.3. Meetings with Litter Haulers: Convene at least three meetings with clean-out contractors/ haulers/spreaders operating in or near the target watersheds to help them better understand nutrient management issues and options.

Activities:

See the following deliverables for notes from meetings.

Deliverables:

- February 16, 2000: Report of Meeting with Mike Neal
- February 21, 2000: Report of Meeting with Weldon Elliot
- February 23, 2000: Report of Meeting with Terry Oates
- March 29, 2000: Report of Meeting with Jeff Bailey
- June 19, 2001: Report of Follow-up Meeting with Terry Oates
- June 19, 2001: Report of Follow-up Meeting with Jeff Bailey
- July 24, 2001: Report of Follow-up Meeting with Elliot's Agri Services

3.4. Communication with External Audiences: Communication of project activities/results to stakeholders and other interested parties through development and dissemination of a project brochure and participation (including exhibiting) at appropriate conferences and similar events in Texas and regional NPS events.

Activities:

The following is a summary of the activities for this subtask:

- Jan 11, 2000: Project press release disseminated.
- Jan 26, 2000: Wimberly gave a presentation at the TNRCC Clean Rivers Program conference in Austin.
- Feb 3, 2000: Wimberly gave a briefing of project activities to EPA R6 staff.
- Mar 7, 2000: McCoy spoke at the BioCycle Southwest Conference regarding alternative litter/manure management and the TxDOT compost market stimulation project.
- Mar 27, 2000: TNRCC-TxDOT composted litter demonstration (San Antonio).

- May 2000: Project flyer was completed and disseminated.
- Apr 18, 2000: Wimberly gave a presentation at a litter/ manure management conference in Mississippi (and established important links re forestland).
- Aug 8, 2000: Wimberly gave a presentation at the EPA TriRegion conference regarding alternative strategies for manure/litter management.
- Mar 6, 2001: Sheri Herron gave a presentation to the Center Rotary Club re litter and forestlands.
- Jun 26, 2001: Herron met with Mike Neal, Mida-Bio, re litter composting.
- Jun 27, 2001: Herron met with Charles Horn, Clean Water Foundation, to discuss potential financial support for poultry farm assessments in Texas.
- Jul – Sep, 2001: FORM staff & consultants worked with numerous collaborators from the forest products and poultry industries re economic analysis of spreading litter on forestlands in East Texas.

Deliverables:

- January 11, 2000: Project Flier
- Project Press Release
- May 2000: Program - BioCycle Conference
- April 18, 2000: Agenda – Mississippi Water Resources Conference
- June, 2000: Agenda – Texas Council Meeting SWCS Program
- November 30, 2000: Mintues – Quality Water for the Brazos Community Task Force Mtg

4. BMP Development & Implementation

Objective: Work with appropriate technical assistance agencies to establish new best management practices for alternative litter/manure management and assist poultry and livestock producers regarding implementation of these alternative BMPs.

4.1. Meetings Regarding BMP Development: At least 4 meetings will be convened with technical assistance agencies to assess the feasibility and/or facilitate the establishment of new BMPs specifically associated with alternative nutrient (litter/manure) management practices.

Activities:

The following is a summary of the meetings that were convened during the project:

- Jan 18, 2000: Wimberly met with NRCS-TX staff to discuss project objectives and development of off-farm BMPs for managing excess litter/nutrients.
- Jan 21/Feb 4, 2000: Wimberly met with USDA-ARS and NRCS staff regarding development of the Phosphorus Index system specifically for litter applied to pasturelands.
- Feb 22, 2000: Wimberly & Awtrey convened a meeting in Nacogdoches focused on forestland applications for litter.
- Sep 26, 2000: Sheri Herron (soil scientist with FORM) met with NRCS-Tx to discuss off-farm litter mgt as a BMP.
- Dec 4, 2000: Sheri Herron met with Rick Leopold to discuss off-farm options as a component of WQMPs in Tx. Off-farm management options are specifically recognized in the CNMP guidance issued by NRCS in December 2000 (section 4.2.6 Other Utilization Practices).
- Mar 6, 2001: Herron met with George Martin (NRCS-Nacogdoches) re spreading litter on forestlands as a potential BMP.
- Sep 26, 2001: Herron discussed BMPs for using litter in timber with George Martin, Program Liaison for NRCS in Nacogdoches.

Deliverables:

- Report of Technical Meeting Re: Alternative Litter BMPs

4.2. Meetings Regarding Cost-Share Programs: At least three meetings will be convened to help establish new cost-share programs at federal/state/local levels for support of alternative nutrient (litter/manure) management strategies.

Activities:

The following is a summary of the meetings that were convened during the project:

- Jan – Mar, 2000: Numerous discussions re the transportation cost-share program to support TxDOT use of composted manure and expand the project to composted litter in east/northeast TX.
- Jan – Mar, 2000: FORM began evaluating:
  - Federal tax credit for converting litter into electricity (Dec 99);
  - Texas legislation (SB 7, '99) for renewable energy systems;
  - Federal ethanol support program.
- Jun 27, 2001: Herron met with Charles Horn, Clean Water Foundation, to discuss possible financial support for poultry farm assessments in Texas.

5. Supporting Information

Objective: Obtain and analyze litter/manure, soil, water, and logistical data in support of project objectives and activities.

5.1. Assess Litter/Manure Resources: Compile and analyze information regarding the sources of litter/manure in the target watersheds. Obtain and analyze sufficient samples of litter/manure produced within the target watersheds to develop a reasonable confidence level of the characteristics of the raw materials.

Activities: The '97 Agricultural Census was analyzed to determine poultry & livestock production (and corresponding manure & nutrient production) by county; loading rates were also analyzed. A list of poultry production facilities in Texas is being compiled from information provided by the Texas Poultry Federation and the individual poultry companies. To date, we have been unable to locate any source of production data within Texas that was more specific or accurate than the '97 Ag Census. Numbers were determined for poultry manure for each county in Texas, based on the '97 USDA Agricultural Census. The data set has some inaccuracies and did not pick up the new Sanderson Farms complex near Bryan. Nonetheless, this data set represents the best data currently available for poultry & livestock production. Information was obtained from Sanderson Farms staff regarding their contract producers and associated litter production. Herron and Moore worked with the Texas Department of Forestry to use aerial photos to locate poultry operations to estimate litter production in the Lower Angelina watershed. Herron used aerial photos from the National Landcover Dataset (circa 1992) to locate and size broiler farm operations in the Lake O'The Pines and Middle Guadalupe watersheds.

Dr. Leon Young at Stephen F. Austin State University performed litter sampling analysis on samples obtained from farms in east Texas. This data was compared to a sampling study completed by Texas A&M University.

Deliverables:

- Manure Production from USDA Agricultural Census
- Sanderson Farms Litter Production
- Lower Angelina Watershed Litter Production
- Lake O'The Pines Watershed Litter Production
- Middle Guadalupe Watershed Litter Production

5.2. Assess Land Availability & Soil Nutrient Levels: Compile and analyze information regarding existing land application fields in and near target watersheds and associated soil nutrient levels.

Activities: Landuse and availability information obtained from USDA Agricultural Census and LandSat imagery.

Deliverables**:

- Lower Angelina Watershed Landuse Data
- Lower Angelina Watershed Poultry Farms and Landuse Map
- Lower Angelina Watershed Poultry Farms and Pasture/Hayland Map
- Lower Angelina Watershed 20, 40, 60-mile Landuse Map
- Lake O'The Pines Watershed Landuse Data
- Lake O'The Pines Watershed Poultry Farms and Landuse Map
- Lake O'The Pines Watershed Poultry Farms and Pasture/Hayland Map
- Lake O'The Pines Watershed 20, 40, 60-mile Landuse Map
- Middle Guadalupe Watershed Landuse Data
- Middle Guadalupe Watershed Poultry Farms and Landuse Map
- Middle Guadalupe Watershed Poultry Farms and Pasture/Hayland Map
- Middle Guadalupe Watershed 20, 40, 60-mile Landuse Map
- Texas Map of Poultry Manure Production as Excreted
- US Map of Poultry Manure as Excreted
- Texas Maps of Phosphorous Loading Rates
- Texas Map of Rice Producing Regions versus Litter Producing Regions
- Texas Map of Minelands versus Litter Producing Regions

5.3. Assess Water Quality Impacts: Obtain from project collaborators data from water quality monitoring based on varying levels of participation by producers in alternative management strategies developed through this project. Through development and use of a spreadsheet model, determine soil phosphorus loading reductions based on varying levels of participation by producers in alternative management strategies developed through this project.

Activities: Herron compiled GIS maps to determine if there is an association between impaired waters and high concentrations of poultry operations in the Lower Angelina, Lake O'The Pines and Middle Guadalupe watersheds. The spreadsheet models were completed for the three watersheds and were used to evaluate off-farm options for poultry litter.

**Deliverables for Section 5.2 are included in the Final Technical Report submitted to Texas State Soil and Water Conservation Board with the Final Administrative Report.

Deliverables:

- Lower Angelina Watershed Poultry Litter Management Model & Model Assumptions
- Lake O'The Pines Watershed Poultry Litter Management Model & Model Assumptions
- Middle Guadalupe Watershed Poultry Litter Management Model & Model Assumptions

5.4. Compile & Evaluate Logistical Information: Through the development of the hotline, establish and maintain a database regarding: potential sources of raw litter/manure; potential clean-out contractors, haulers, and spreaders; potential value-added processors; potential consumers of the raw-processed material.

5.5. Activities:

- Develop litter hotline: A website was designed for buyers, sellers, and middlemen to register to obtain information on-line (www.litterhotline.com). A toll-free number was setup (1-866-269-7448) with 24-hour attendance by the Project Coordinator so interested parties could call in to register or get information. The hotline was officially released on September 28, 2000. See Subtask 1.2 for more information and deliverables.
- Establish and maintain a database regarding potential sources of raw litter/manure: As of Sept. 30, 2001, registrants to the hotline included 66 buyers, 30 sellers, and 7 service providers.
- Establish and maintain a database of potential clean-out contractors: As of September 30, 2001, seven service providers were registered with the hotline. See Subtask 2.3 for information regarding meetings with the service providers.
- Establish and maintain a database of potential value-added processors: See the following Subtask 2.2 deliverables for information regarding value-added processors.
    - Report of Litter/Manure Waste Management Workshop
    - Agenda - Alternative Manure Management & Compost Market Mtg.
    - Agenda - Alternative Manure Management & Compost Market Mtg.
    - Report of Litter/Manure Waste Management Workshop
    - Report of Technical Meeting with MagnaGro
    - Report of Technical Meeting with Various Value-Added Companies
    - Proposal: Pre-Feasibility Assessment of Litter to Ethanol in Northwest Arkansas

Foundation for Organic Resources Management

Cooperative Agreement No. 99-7 for CWA 319(h) FY 99 project
Alternative Litter Management in East Texas

Final Summary of Project Expenditures
30-Apr-02

		Reimbursable Expenditures		Non-Federal Match		
		Budget	Project Total	Budget	Project Total	Project Total: Reimbursable + Match
1.	Personnel					
	1.1 Sr. Project Director	62,800.00	50,852.17			50,852.17
	1.2 Project Coordinator	0.00	0.00			0.00
	1.3 Project Support Staff	31,000.00	18,789.45			18,789.45
	1.4 Consultants	82,273.00	71,082.95 *			71,082.95
	1.5 Collaborators			299,468.00	269,810.58	269,810.58
	Total Personnel	176,073.00	153,286.71	299,468.00	269,810.58	423,097.29
2.	Fringe Benefits	31,133.00	26,583.53	0.00	0.00	26,583.53
3.	Travel	52,139.00	32,553.66	0.00	0.00	32,553.66
4.	Equipment	6,100.00	6,095.48	0.00	0.00	6,095.48
5.	Supplies	0.00	0.00	0.00	0.00	0.00
6.	Contractual					
	6.1 Pineywoods RC&D	46,000.00	25,172.68	0.00	0.00	25,172.68
	6.2 SFA	42,000.00	6,563.91	67,626.00	27,922.58	34,486.49
	6.3 TNRCC	18,000.00	0.00	0.00	0.00	0.00
	Total Subagreements	106,000.00	31,736.59	67,626.00	27,922.58	59,659.17
7.	Construction	0.00	0.00	0.00	0.00	
8.	Other Direct Costs	76,231.00	58,610.95	0.00	0.00	58,610.95
9.	Total Direct Costs	447,676.00	308,866.92	367,094.00	297,733.16	606,600.08
10.	Indirect Costs	102,965.00	71,099.42	0.00	0.00	71,099.42
11.	Total Project Costs	550,641.00	379,966.34	367,094.00	297,733.16	677,699.50
12.	Match Percentage (based on total project expenses)			40.00%	43.93%	
			69.0%		81.1%	

* Includes credit of $12,562.14 for Grower Workshops

Alternative Litter Management in Texas

Final Technical Report[1]

Submitted to the
Texas State Soil & Water Conservation Commission
Temple, Texas

Prepared by
Jim Wimberly & Sheri Herron
Foundation for Organic Resources Management[2]
Fayetteville, Arkansas

in collaboration with the
Pineywoods Resource Conservation and Development Council[3]
Nacogdoches, Texas

the
Department of Agriculture – Stephen F. Austin State University
Nacogdoches, Texas

and the
Office of Pollution Prevention & Recycling
Texas Natural Resources Conservation Commission
Austin, Texas

April 2002

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[1] This Report is the technical portion of the final report prepared under the *Alternative Litter Management in Texas* Project. The Project was implemented under contract #99-7 between the Texas State Soil and Water Conservation Board and the Foundation for Organic Resources Management with funding from the U.S. Environmental Protection Agency's Nonpoint Source Program.

[2] The Foundation for Organic Resources Management (F.O.R.M.) is a private nonprofit organization [501(c)(3)].

[3] The Pineywoods Resource Conservation and Development Council is a private nonprofit organization [501(c)(3)].

1. Executive Summary

The poultry industry is an important component of the State's economy, employing over 12,000 people statewide and contributing over $1.3 billion annually. There are twelve broiler/turkey production complexes in four major areas of production in Texas, which ranks 5th in poultry production in the United States.

But there are increasing concerns regarding potential water quality impacts from surplus litter—and, in particular, the phosphorus contained in the litter—within areas of concentrated poultry production, including the four areas in Texas. Such concerns are being manifested through increased regulatory pressures at both federal and state levels and, in recent instances, through litigation filed against the poultry industry in other states. Therefore, it is essential to identify and evaluate—and, ultimately, pursue—alternative management strategies that address such environmental concerns while also helping ensure the economic viability of the poultry industry. The need to pursue surplus litter export options will become increasingly apparent in Texas as new comprehensive nutrient management plans are prepared that determine how much litter for the farm is question can no longer be land applied on the production farm (due primarily to restrictions on soil-phosphorus levels) and is therefore deemed to be surplus.

The most effective way to address such concerns is to move the surplus litter off of the farm and out of the area of concentrated poultry production. The material can be removed from production farms and subsequently exported in either raw form for direct use as a soil amendment or in processed form. Such export will enable the phosphorus to be beneficially used for agronomic purposes in crop production systems outside the area of concentrated production where phosphorus application rates are balanced with agronomic requirements and there is much less potential for run-off or accumulation.

Export options for raw litter entail expansion of existing markets (e.g., forage croplands) and development of new markets. Existing markets primarily include forage and pasture lands; possible new markets include forestlands, rice lands, and mine lands. An in-depth analysis of applying litter to forestlands in east Texas concluded that such export strategies are feasible and attractive from an economic perspective, provided that sufficient market commitments can be secured in advance of investments in specialist litter spreading equipment. A Litter Hotline was also established and operated, which has facilitated communications among poultry producers (i.e., litter suppliers), potential customers, and service providers (i.e., clean-out, transport, and/or spreading services) and expanded the export of litter in raw from, primarily from the Nacogdoches region.

Processed litter options should be considered when such options open up new markets for litter-derived products, are more economically attractive, or when markets for raw litter are insufficient relative to the quantities of litter that need to be exported. Processed or "value-added" options include compost, pellets, energy (thermal, electrical, liquid fuels), and other litter-derived products. While some of these conversion options could, in theory, be pursued at the farm level, in reality none of the conversion technologies are practical (or available) for farm-scale applications.

Large-scale, off-farm, centralized litter processing options have numerous attributes such as economies of scale, ability to utilize professional processing and marketing expertise, and opportunities to serve numerous poultry producers within a region. Litter can be composted (although additional carbon is usually required) or co-composted with other organic materials and new markets are being developed in Texas for compost products (for roadside erosion control and agricultural applications). Several composting companies in Texas still use some litter in their composting operations and one company focuses exclusively on turkey litter feedstocks.

Litter pelletizing is also a commercially proven technology, although the process is expensive and the overall economics are challenging—the products' prices in most markets are not sufficient to cover production and marketing expenses, and most facilities established in the past fifteen years in the U.S. have failed or are struggling. Nonetheless, a new 88,000 ton per year state-of-the-art pelletizing facility began operation in Delmarva in 2001; the company intends to market the products to grain producers in the Midwest (thereby exporting some of the surplus litter-derived phosphorus produced in the Delmarva region).

Litter can also be converted into several energy products: thermal energy, electricity, and biogas. A litter-to-electricity facility represents the most promising conversion technology:

- The technology is already proven, and at commercial scale—this essentially eliminates any technological risk for the enterprise. Four large-scale litter-to-energy processing facilities are already in operation (in the U.K.).
- Markets for the primary product —electricity—are omnipresent., and can be sold for premium prices as "green power." Note that, unlike all other litter-derived products, electricity is the only product for which large-volume, long-term product purchase agreements are obtainable.
- All of the phosphorus and most of the other nutrients in the litter survive the conversion process as ash. The nutrient-rich ash co-product has significant market value as a fertilizer ingredient and is readily transportable to distant agricultural markets out of the region' (thereby addressing surplus phosphorus concerns).

However, under current economic conditions, none of the surplus litter management options described herein (including litter-to-electricity) are considered economically viable. Therefore, deployment of any such option would require supplemental financial support (from the public and/or private sectors). Moreover, without such supplemental support it is unlikely that any private entrepreneur will establish a large-scale surplus litter management program in Texas.

One strategy for proceeding with deployment of a large-scale surplus litter management program under current conditions is to establish a third-party nonprofit organization that would serve as the deployment vehicle for a regional initiative. There are numerous potential benefits associated with such a strategy:

- A nonprofit organization is an attractive mechanism for securing additional financial support to ensure enterprise viability (from both the public and the private sectors).
- Given the transparent nature of a nonprofit organization, use of this structure should optimize potential support and "buy-in" from various stakeholders and interested parties.
- The nonprofit provides opportunities for tax-free bond financing of the conversion facility.
- The Litter Bank will purchase litter from participating growers, thereby transferring ownership, responsibility, and liability associated with the litter from the grower to the enterprise.
- Growers who sell 100% of their litter to the Litter Bank should not need to obtain [or comply with] a comprehensive nutrient management plan, since no litter would be used on-farm.

As the poultry industry in Texas comes under increasing scrutiny regarding environmental concerns and potential regulatory constraints vis-à-vis traditional on-farm litter management practices, the industry should consider deployment of a large-scale litter-to-electricity facility through establishment an operation of a regional litter bank. It is also recommended that the following actions be undertaken as follow-up to this Project:

- Coordinate industry and technical assistance agency efforts to identify and evaluate surplus litter management options through establishment of a task force.
- Continue operation of the Litter Hotline.
- Demonstrate raw litter applications on forestlands, rice lands, and forage lands.
- Convene a statewide symposium focused on alternative litter management.
- Pursue a variety of related outreach and educational efforts.

2. Impact of this Project on Water Quality

The overall thrust of this Project has been to identify and evaluate management options (including technologies and strategies) that can address water quality concerns associated with poultry litter (with primary focus on the phosphorus *in* the litter). To address such concerns effectively, the surplus phosphorus will have to *not* be applied to farmlands that are already phosphorus-limited. In some areas of concentrated poultry production in Texas (e.g., the Nacogdoches region), this would also entail export of the surplus phosphorus—in whatever form is desired (e.g., within raw litter or within some processed litter product). That is why this Project has focused on identifying and evaluating technologies and strategies that can effectively export surplus litter (in raw and/or processed form) and the phosphorus contained therein.

Efforts under this Project have laid the groundwork for large-scale surplus litter export initiatives in Texas. For example, a regionally coordinated 300,000 ton-per-year litter-to-energy project established in the Nacogdoches area would enable the export of approximately 18,000,000 pounds of phosphate per year.

In addition, Project efforts have facilitated and enhanced existing raw litter export activities through the establishment of the Litter Hotline, which facilitated communications between poultry producers (litter suppliers), distant consumers, and service providers (i.e., clean-out, transport, and spreading services). Since the Hotline served as a match-making function and was not a litter brokerage or wholesaling mechanism, neither the Hotline nor the Project partners were party to any of the litter transactions that occurred. Thus, no specific data was available regarding the amount of litter that was exported as a result of Hotline-based transactions.

It should also be noted that export of surplus litter will not result in immediate, measurable impacts on water quality within a target watershed. Even the water quality benefits of exporting *all* of the litter from a watershed will not become apparent (or measurable) for some years, because of the residual phosphorus that has accumulated in the soils in application fields during the past forty years. Depending on the extent of phosphorus accumulation, erosion control practices, and other conservation measures implemented on such lands, some phosphorus will likely continue to move from those lands into surface waters for years to come—particularly on lands that are highly erodable, do not employ buffer strips, or are poorly managed. Thus, while specific efforts that may result from this Project—deployment of a regional surplus litter export program—will be essential for minimizing future soil-phosphorus accumulation and loading within target watersheds, such efforts must be accompanied by on-going conservation practices and on-farm management techniques that will minimize movement of phosphorus that has already accumulated in soils on agricultural lands with areas of concentrated poultry production in Texas.

Table of Contents

3. List of Figures

4. Acknowledgements

- Ken Awtrey, Pineywoods Resource & Conservation Development Council
- Leon Young, Stephen F. Austin State University
- Scott McCoy, Texas Natural Resources Conservation Commission
- James Grimm, Texas Poultry Federation
- John Carey, Texas A&M University Poultry Science Department
- Saqib Muktar, Texas A&M University Agricultural Engineering Department
- Rick Leopold, USDA Natural Resource Conservation Service - Texas
- George Martin, USDA Texas Natural Resources Conservation Service - Texas
- Ken Farrish, Stephen F. Austin State University Forestry Department
- Vernon Rowe, RowEnvironmental
- Jerry Pearce, De-Go-La Resource & Conservation Development Council
- David Moore, composting specialist
- Robert Van Waasbergen, Applied Environmental Data Services
- Darwin Foster, Texas A&M University Department of Forest Science
- Jim Tillman, SUPERTRAK, Inc.
- Mike Bird, Bird Forestry Services
- David Dickens, Georgia State University
- Mike and David Neal, Mida-Bio Ltd.
- George TenBerge
- Weldon Elliot, Elliots Agri-Service Inc.
- Allan Chandler, Son-Way Agri. Products
- Wes Cook, Cooks Poultry Service
- Jeff Bailey, Bailey Bark Materials
- Terry Oates, Oates Farm Inc.
- Nicole Lynch, Foundation for Organic Resources Management

5. Introduction

5.1. About this Project

The Alternative Litter Management Project was undertaken during December 1999 ~ April 2002. Project activities focused on identification, evaluation, and deployment of alternative litter management practices that could mitigate soil phosphorus accumulation and associated water quality concerns while also ensuring the economic viability of the State's poultry industry. The project involved the Foundation for Organic Resources Management (FORM) working cooperatively with partners and collaborators to coordinate and facilitate efforts to identify and embrace regionally coordinated alternative management programs.

FORM and its partners—Stephen F. Austin University (SFA), Pineywoods Resource Conservation and Development Council (RC&D), and the Texas Natural Resources Conservation Commission/Office of Pollution Prevention and Recycling (TNRCC)—helped educate stakeholders regarding nutrient management issues and options and transferred technologies for converting litter/manure into value-added products.

The team assessed the current situation in the areas of concentrated poultry and livestock production in the target watersheds to better understand the quantities of litter/manure being generated, the application lands being used or potentially available, and the existing or potential markets for the raw/processed material. They worked with stakeholders to identify specific options for alternative nutrient management and developed strategies for pursuit of the prioritized options.

Numerous tactics were employed to address logistical elements—for example, a "hotline" was established to coordinate supplies of raw material and to enable coordination between sellers and buyers (and with those who will consummate the transactions, such as clean-out contractors, haulers, and spreaders). The hotline was integrated with a project website to further disseminate key information. Interaction and coordination with collaborators/stakeholders was an essential and on-going activity.

5.2. Overview of the poultry industry in Texas

Industry size & economic benefits:

- Texas is the 5th largest poultry production state in the U.S, producing over 579 millions birds and 4.7 million eggs annually.
- The poultry industry in Texas contributes over $1.3 billion each year to the state's economy.
- The poultry industry in Texas directly employs over 12,000 people statewide.

Primary production of broilers and turkeys include the following areas/complexes:

- **Northeast Texas**

- Pilgrim's Pride, based in Pittsburg

➢ **East Texas**

- Pilgrim's Pride, based in Nacogdoches
- Tyson Foods, based in Center
- Tyson Foods, based in Carthage
- Tyson Foods, based in Nacogdoches

➢ **Central Texas**

- Sanderson Farms, based in Bryan
- Plantation Foods (Cargill), based in Waco

➢ **Southern Texas**

- Tyson Foods, based in Seguin
- Holmes Foods, based in Gonzales
- Maxim Production Co., based in Bowling
- Buddy's Natural, based in Gonzales
- Plantation Foods (part of the Waco complex)

5.3. Traditional litter management practices

Relative to manure generated from other animal production systems, poultry litter has several unique characteristics:

➢ Litter is a mixture of bedding (e.g., biomass such as pine shavings or rice hulls) and bird excreta, with a moisture content typically ranging from 20% ~ 35% (wet basis).

➢ The nutrient content of litter is relatively high; in Texas, nitrogen (N) typically ranges from 2.11% ~ 5.02%, phosphorus (P) typically ranges from 1.06% ~ 2.74%, potassium (K) typically ranges from 1.42% ~ 3.70%, and calcium (Ca) typically ranges from 1.18% ~ 3.99%.[4]

➢ Litter is readily "collectible" and transportable.

➢ Litter is most commonly used as a soil amendment/fertilizer for agricultural crop production, typically applied to forage crops and pasturelands on or near the production farm. Clumps of litter[5] are usually removed between flocks and subsequently land applied; the frequency of total house clean-out and full litter removal varies. In East Texas, total clean-out commonly occurs once a year (i.e., for broilers, after 5~6 flocks of birds have been grown on a layer of

[4] Doctorian, D.S. and G.W. Evers, *Utililzing Broiler Litter as a Protein and Mineral Supplement for Beef Cows.*
[5] These clumps of litter are akin to dirt clods and are referred to as "cake."

bedding). However, in the Gonzales area, total clean-out is much less frequent, with some farms in the region exceeding ten years.

5.4. Why are alternatives needed?

- **Environmental concerns:** High application rates of litter can increase the potential for nonpoint source runoff of the nutrients during rain events and subsequent degradation of water quality. The potential for nonpoint source water quality impairment also increases as soil phosphorus levels increase.

  This is the situation facing many poultry growers in Texas who have traditionally applied litter based on its nitrogen content and the nitrogen requirements of the target crops. In such situations, the amount of phosphorus exceeds crop requirements, resulting in accumulation of phosphorus in the soils of the application fields.[6]

  Applications of litter year after year on the same fields have, in fact, led to widespread accumulation of phosphorus in many areas of concentrated poultry production. While the accumulated phosphorus does not constitute an agronomic problem (the plants take what they need and leave the rest), it can, as noted above, increase the potential for nonpoint source pollution.

  In response to concerns regarding potential nonpoint source impacts associated with increased soil-phosphorus levels, the Texas Natural Resources Conservation Commission has established limits on soil-phosphorus levels[7], Texas A&M University's Cooperative Extension Service has developed recommendations for phosphorus application rates based on crop uptake requirements,[8] and the Natural Resources Conservation Service has developed and is currently deploying revised nutrient management recommendations that are designed to minimize or eliminate accumulation of phosphorus in soils.[9]

Understanding the Phosphorus Accumulation Phenomenon:

Traditionally, animal manures have been applied to forage and crop lands at rates that will supply the crops' nitrogen needs. However, application rates based on nitrogen will usually supply phosphorus in excess of most plant needs. With continued applications, phosphorus can build up in the soil beyond what the soil can naturally adsorb. This phenomenon is acerbated when applying litter to pasturelands, since over 90% of the P taken up by the forage crops is returned to the same field via cattle manure.

The phosphorus holding capacity of a soil varies primarily with soil texture (e.g., sandy soils have a lower phosphorus adsorption capacity than clayey soils). Research has shown that phosphorus concentrations in runoff increase as phosphorus concentrations in soil increase.

[6] http://www.litterhotline.com/manurephosphorus.pdf

[7] 200 parts per million (http://www.tnrcc.state.tx.us/admin/topdoc/rg/374.pdf)

[8] 65 parts per million (L-5043 *Animal Waste Management*, Texas Cooperative Extension Publication)

[9] Ref: Conservation Practice 590 http://www.tx.nrcs.usda.gov/eng/TexasStandards/Final/590tx.pdf

- **Liability concerns:** Litigation has recently been filed in several states by downstream water consumers claiming that their source waters have been degraded by nonpoint source contamination of manure/litter-derived phosphorus.[10] Adoption of alternative management strategies for surplus manure/litter can help reduce or even eliminate such potential liability – for both growers and integrators in Texas.
- **Economic viability of the poultry industry:** Inadequate response (or even the perception of inadequate response) of the poultry industry to environmental concerns associated with traditional litter management practices could lead to adverse economic impacts on the poultry industry and perhaps even jeopardize the viability of the industry.
- **Resource conservation:** Accumulation of unused phosphorus in soils means that the mineral – a finite geologic resource – is not available for use elsewhere. Instead, phosphorus resources contained in litter should be captured and re-used to the extent possible. "The supply of phosphate rock is forecast to decline in the United States as existing mines in Florida are mined out and unfavorable economics discourage new mine development."[11]

5.5. What are the options?

In theory, there are two categories for litter management options: **on-farm** and **off-farm**. In reality, there are no viable on-farm options for managing surplus litter because:

- The only technically viable option available – composting – is capital/- and labor-intensive and not suitable for farm-scale applications (composting operations, like most other conversion processes, are subject to economies of scale and therefore more economically attractive at larger scales such as regional facilities serving numerous farms).
- Other technical options targeted for farm-scale use are still being developed and not commercially viable. For example, several efforts are underway to develop a litter-fired furnace system for heating poultry houses, although none of those initiatives are close to commercial feasibility.

Any on-farm system for managing surplus litter must include a method for capturing and exporting from the farm the surplus phosphorus contained in the surplus litter (which is why the litter is considered to be surplus). This entails a significant extra component to any potential on-farm surplus litter management approach.

Regarding the export of surplus litter (phosphorus) off of the farm and/or from the area of concentrated poultry production, there are two basic options in terms of the *form* of material that is to be exported: **raw** vs. **processed**.

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[10] For example, the City of Tulsa filed suit in December 2001 against six poultry companies in Arkansas regarding degradation of water quality in Lake Eucha, a primary source of water for the city. http://biz.yahoo.com/prnews/011210/dam031_1.html

[11] http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/stat/

- **Raw litter** is widely recognized as an excellent soil amendment; therefore, it is conceivable to expand or create export markets for raw litter as discussed in Section 5 of this report. However, as also discussed in Section 5, the economics of raw litter export are generally not attractive, so other options are needed (***or*** additional economic support is required to enable raw litter export to occur in those situations where the economics are not favorable).
- **Processed litter:** Various processes (e.g., composting, densification, combustion / gasification) can be used to convert litter into value-added products (at larger, centralized [off-farm] conversion facilities). As discussed in Section 6, there are a number of benefits associated with each of the litter processing options (e.g., stabilized nutrients, pathogen/odor reduction or elimination, new markets for litter-derived products), as well as drawbacks (i.e., varying degrees of technical and/or economic risk).

5.6. Why export surplus litter?

Rather than expect each poultry producer to identify and pursue export options for his/her farm, it is more efficient and effective to coordinate the export of surplus litter from numerous farms within an area or region of concentrated poultry production. As discussed in Section 7, there are numerous strategies for pursuing alternative litter management from a regional perspective and numerous factors to be considered when deploying an alternative litter management program.

5.7. Key criteria for an alternative litter management program

Export of litter in processed form constitutes a product manufacturing, sales, and marketing effort. Export strategies must satisfy the following criteria to be successful:

- be technically feasible;
- be logistically feasible;
- be economically viable;
- be environmentally, socially and politically acceptable; and
- reflect economic concerns of watershed residents *and* water quality concerns by all watershed stakeholders.

6. Assessment of Manure/Litter Production and Loading Rates

6.1. Poultry manure/litter production

- **Poultry manure production** in Texas (by county) is shown in Figure 1; the corresponding tabular data are provided in Table 1. To put this into perspective, poultry manure production in the Continental United States is shown in Figure 2. The figures were derived by FORM, based on the data in the 1997 USDA Agricultural Census.[12]
- **Litter production** can be estimated using the following methods. However, because actual production varies significantly from region to region and complex to complex,[13] neither method is universally applicable.
  - **NRCS figures**: Manure and litter production data are set forth in Tables 4-14 and 4-15, Chapter 4, of the Natural Resources Conservation Service's *Animal Waste Management Field Handbook* (http://www.ftw.nrcs.usda.gov/awmfh.html).
  - "**Rule of Thumb**": In many areas of the country, litter production at broiler facilities is estimated at two pounds per bird. Thus, a 20,000-bird capacity production house would generate 280,000 pounds of litter per year (140 tons) at seven flocks per year.

A physical description of typical broiler litter is provided in Appendix A, along with typical results from compositional/proximate analyses that are considered representative. [14]

Litter production estimates were used to determine the approximate "loading rate" of nutrients to litter application sites which, in Texas, are generally pasture and hayland fields. These production estimates and USDA landuse information were used to determine if there is sufficient land base within a production region to utilize the nutrients produced. Figure 3 represents the phosphorus loading rate from poultry litter to all farmland within the poultry production counties. Figure 4 represents the phosphorus loading rate from all animal manures to all farmland within the animal production counties. It is important to note that the figures represent the assumption that the manure is equally distributed on 100% of the farmland. In actual practice the manure is distributed at best on 50% of the farmland, producing much higher concentrations of nutrients within the soils in the large production regions. Areas of high P loading, then, are where nutrient management alternatives should be developed.

[12] National Agricultural Statistics Service, U.S. Department of Agriculture; http://www.nass.usda.gov/census/

[13] Examples of factors affecting the amount and nature of litter generated within a typical broiler house in a year include: type and amount of bedding used; number of flocks of birds grown on the bedding; extent of cake removal between flocks; in-house environmental parameters (e.g., ambient moisture levels), which are, in turn, determined by different management practices, and bio-security concerns. In East Texas it is common to do a total clean-out each year, whereas many of the houses in Southern Texas go for many years before total clean-out.

[14] Moore, et.al. 1995. Final Report Southeastern Poultry and Egg Association.

Figure 1: Poultry Manure Production in Texas

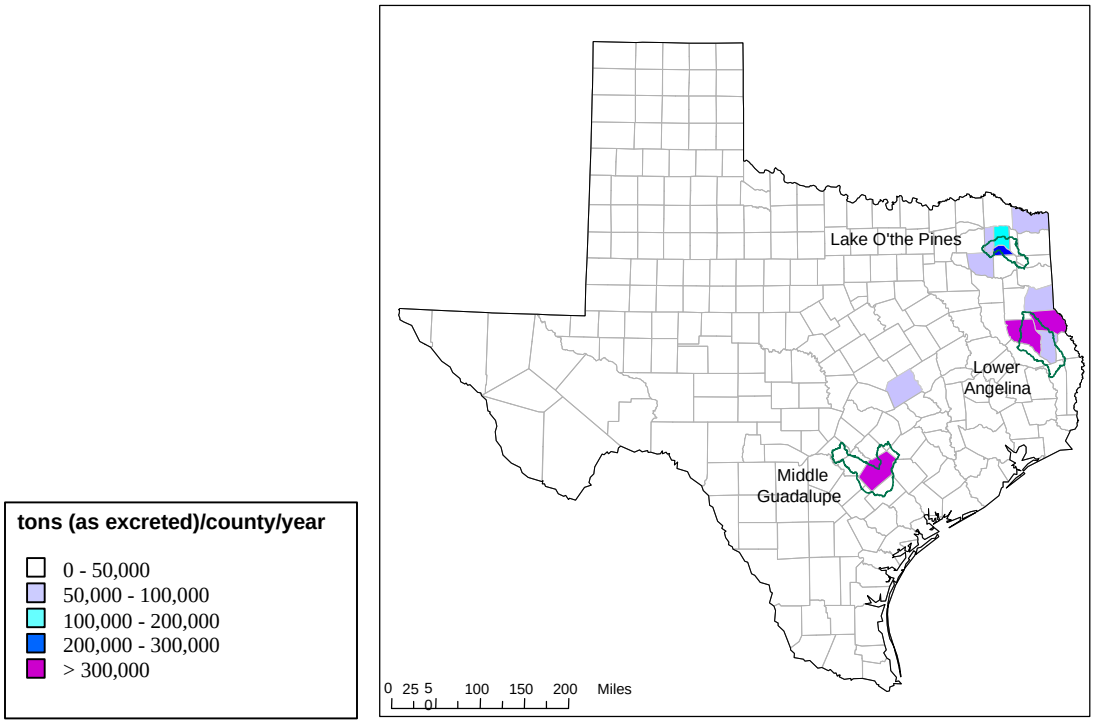


Figure 2: Poultry Manure Production in the United States

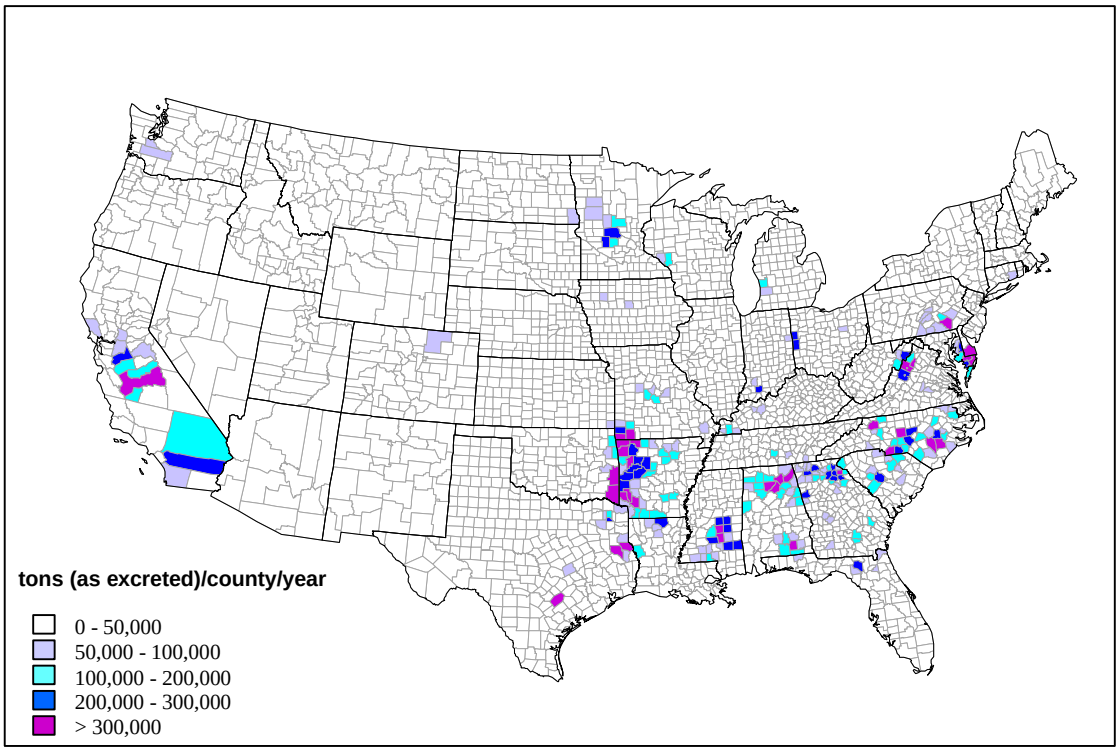
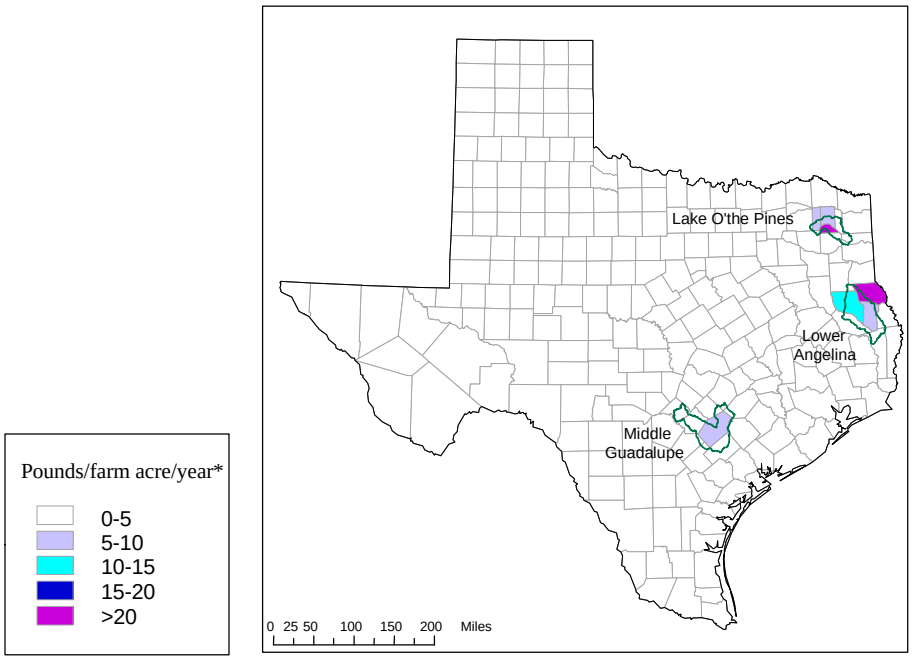


Table 1. Texas Poultry Manure Production as Excreted (tons/county/year)

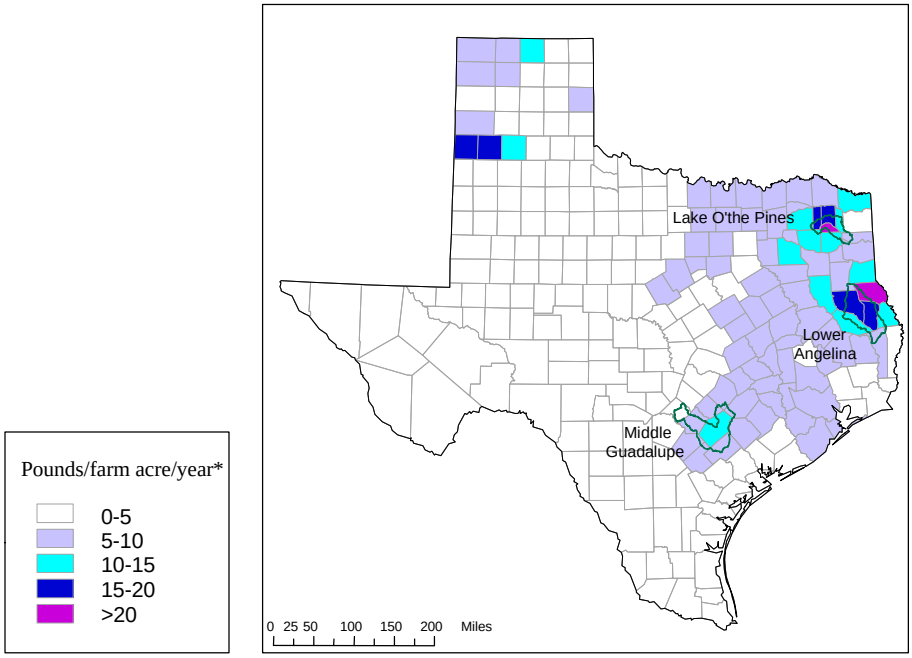
ANDERSON	12	DONLEY	1	KAUFMAN	16	REAL	0
ANDREWS	1	DUVAL	1	KENDALL	47	RED	3,534
ANGELINA	26,190	EASTLAND	13	KENEDY	0	REEVES	0
ARANSAS	0	ECTOR	2	KENT	0	REFUGIO	0
ARCHER	0	EDWARDS	0	KERR	10	ROBERTS	0
ARMSTRONG	1	ELLIS	13	KIMBLE	1	ROBERTSON	0
ATASCOSA	20	EL	8	KING	0	ROCKWALL	1
AUSTIN	26	ERATH	18	KINNEY	0	RUNNELS	24
BAILEY	0	FALLS	1	KLEBERG	7	RUSK	23,659
BANDERA	10	FANNIN	7	KNOX	0	SABINE	10,501
BASTROP	15	FAYETTE	7,438	LAMAR	12	SAN	60,005
BAYLOR	4	FISHER	0	LAMB	1	SAN	6
BEE	3	FLOYD	1	LAMPASAS	15	SAN	2
BELL	20	FOARD	0	LA	0	SAN	0
BEXAR	54	FORT	15	LAVACA	17,646	SCHLEICHER	0
BLANCO	5,856	FRANKLIN	73,827	LEE	22	SCURRY	1
BORDEN	0	FREESTONE	23	LEON	12,501	SHACKELFORD	0
BOSQUE	5	FRIO	0	LIBERTY	22	SHELBY	384,265
BOWIE	62,173	GAINES	1	LIMESTONE	3	SHERMAN	0
BRAZORIA	26	GALVESTON	26	LIPSCOMB	0	SMITH	13
BRAZOS	0	GARZA	0	LIVE	6	SOMERVELL	0
BREWSTER	0	GILLESPIE	17,019	LLANO	1	STARR	14
BRISCOE	0	GLASSCOCK	0	LOVING	0	STEPHENS	0
BROOKS	1	GOLIAD	1	LUBBOCK	0	STERLING	0
BROWN	7,091	GONZALES	388,218	LYNN	0	STONEWALL	0
BURLESON	13	GRAY	1	MCCULLOCH	3	SUTTON	0
BURNET	26	GRAYSON	18	MCLENNAN	51	SWISHER	1
CALDWELL	23,955	GREGG	1	MCMULLEN	0	TARRANT	18
CALHOUN	1	GRIMES	27	MADISON	2	TAYLOR	14
CALLAHAN	2	GUADALUPE	29	MARION	1	TERRELL	0
CAMERON	9	HALE	0	MARTIN	0	TERRY	0
CAMP	218,595	HALL	0	MASON	1	THROCKMORTON	0
CARSON	1	HAMILTON	10	MATAGORDA	5	TITUS	93,523
CASS	36,927	HANSFORD	0	MAVERICK	1	TOM	9
CASTRO	0	HARDEMAN	0	MEDINA	11	TRAVIS	32
CHAMBERS	1	HARDIN	7	MENARD	0	TRINITY	219
CHEROKEE	26,184	HARRIS	56	MIDLAND	4	TYLER	4
CHILDRESS	0	HARRISON	4	MILAM	48,427	UPSHUR	30,974
CLAY	1	HARTLEY	0	MILLS	1	UPTON	0
COCHRAN	0	HASKELL	0	MITCHELL	0	UVALDE	3
COKE	0	HAYS	39	MONTAGUE	6	VAL	1
COLEMAN	1	HEMPHILL	0	MONTGOMERY	43	VAN	18
COLLIN	8	HENDERSON	12	MOORE	0	VICTORIA	11
COLLINGSWORTH	1	HIDALGO	12	MORRIS	24,836	WALKER	0
COLORADO	660	HILL	7	MOTLEY	0	WALLER	74
COMAL	27	HOCKLEY	1	NACOGDOCHES	356,853	WARD	0
COMANCHE	4	HOOD	5	NAVARRO	60	WASHINGTON	15
CONCHO	0	HOPKINS	20,996	NEWTON	7	WEBB	1
COOKE	22	HOUSTON	6	NOLAN	0	WHARTON	1
CORYELL	6	HOWARD	0	NUECES	1	WHEELER	2
COTTLE	0	HUDSPETH	0	OCHILTREE	1	WICHITA	3
CRANE	0	HUNT	26	OLDHAM	0	WILBARGER	7
CROCKETT	0	HUTCHINSON	0	ORANGE	8	WILLACY	0
CROSBY	1	IRION	0	PALO	4	WILLIAMSON	22
CULBERSON	0	JACK	3	PANOLA	79,175	WILSON	33
DALLAM	0	JACKSON	7	PARKER	38	WINKLER	1
DALLAS	5	JASPER	11	PARMER	0	WISE	27
DAWSON	0	JEFF	0	PECOS	1	WOOD	64,825
DEAF	2	JEFFERSON	16	POLK	13	YOAKUM	0
DELTA	1	JIM	0	POTTER	1	YOUNG	1
DENTON	12	JIM	1	PRESIDIO	0	ZAPATA	0
DE	1	JOHNSON	48	RAINS	4	ZAVALA	0
DICKENS	0	JONES	4	RANDALL	2		
DIMMIT	0	KARNES	0	REAGAN	0		

Figure 3: Phosphorus Loading Rates for Poultry Manure in Texas at 100%



*Note: This assumes that all of the manure is evenly applied to 100% of the farmland acreage in each county where the manure is generated.

Figure 4: Phosphorus Loading Rates for All Manure in Texas at 100% (poultry, beef, dairy, swine, equine)



*Note: This assumes that all of the manure is evenly applied to 100% of the farmland acreage in each county where the manure is generated.

6.2. Production and application rates in the Project Watersheds

Broiler litter production in the Lower Angelina Watershed (LAW) is estimated at 148,000+ tons annually; in the Lake O' The Pines Watershed (LOPW) it is estimated at 64,000+ tons annually; in the Middle Guadalupe Watershed (MGW) it is estimated at 97,000+ tons annually.[15] Current application rates in these watersheds are approximately two tons per acre per year on pasture and hayland.[16] These application rates are considered to be unsustainable due to the resulting buildup of phosphorous in the soil and the potential for water quality impairment from runoff.

According to F.O.R.M.'s calculations, sufficient acreage is available in the watersheds for sustainable land application of raw litter if the majority of the pasture/hayland acreage is hayed and the forage is fed outside the watershed, and if land application is extended to crops and/or commercial timber.

[15] Broiler operations were located and sized using the Texas Forest Service aerial photography. Production is estimated from average volume of litter cleaned out annually as reported by service contractors.
[16] Average application rates according to service contractors and Soil & Water Conservation District personnel.

7. Raw Litter Management

7.1. Overview

Export of litter in raw form should be considered and evaluated before investments are made in processing options. Potential advantages of a raw litter export program include:

- lower capital costs – the cost of clean-out, transport, and spreading equipment is likely to be less than the costs associated with litter processing facilities (which also must include the costs of clean-out and transport [to the facility], as well as the processing components; and, in the case of compost or pellet products, costs may also include equipment costs for land application of the material).
- New – and, possibly, relatively close markets – As discussed below, new markets such as forestlands may be available for raw litter application that are close to the production farms.
- Full agronomic benefits from the material – Most of the litter processing options entail some loss of potential agronomic benefits (e.g., nitrogen, carbon, beneficial microbes), whereas use of raw litter can realize the full spectrum of agronomic benefits.
- Potential use of existing clean-out, transport, and spreading service providers (although these providers could also be involved in the aggregation activities associated with centralized litter processing facilities).

The following topics need to be addressed when implementing a raw litter export program.

- **Markets**: Often the sizes of the target markets for raw litter are insufficient compared to the quantities of surplus litter produced. Often the target markets are too distant or not realistically accessible. Perhaps most importantly, it is difficult if not impossible to obtain long-term purchase contracts for the material.
- **Logistics**:
  - **Storage** of raw litter can be problematic, particularly since litter must be kept dry and cannot be stacked more than about five feet deep without fear of spontaneous combustion.[17] And there are both advantages and drawbacks associated with on-farm storage vs. bulk storage. For example, on-farm stacking sheds provide greater flexibility vis-à-vis clean-out activities, where bulk storage in or near the target markets facilitate spreading activities (i.e., such storage is more responsive to the heavily seasonal demand for litter).
  - **Transportation** of litter requires enclosed or covered transport equipment (e.g., enclosed trailers with walking floors, or end-dump trailers with tarps). Also, the heavily seasonal demand for litter (most commonly in the early spring) means that the transport infrastructure is needed primarily for a short period of time (e.g., two months) but almost idle for the balance of the year.

[17] http://www.aces.edu/department/extcomm/publications/anr/anr-915/anr-915.html

- **Spreading** of the litter can be problematic. While litter spreaders (both self-propelled and tractor-drawn units) and litter spreading services are generally available in poultry production areas, such equipment and services are essentially non-existent in most target markets for raw litter. Strategies used in the past to address such spreading constraints include:
  - A litter export service provider (commonly referred to as "clean-out contractor") can pull a trailer spreader behind the transport truck when transporting litter to a target market. Although this strategy has been used for extraordinary situations, it is unrealistic to use this method in most instances.
  - A litter spreader(s) can be placed in a target market area by a service provider, although sufficient quantities of anticipated litter sales are required to justify the investment and risk.
  - A litter spreader(s) can be purchased by one or more raw litter consumers in the target market area, although sufficient quantities of anticipated litter purchases are required to justify the investment.
  - A litter spreader(s) can be obtained from grant funds (e.g., through the EPA's nonpoint source program) and given to the local conservation district office in a target market for rental to service providers and/or litter buyers. This approach was successfully used to significantly expand demand and purchase of raw litter in the Eastern Arkansas row crop region in the early nineties.[18]

Texas Poultry Litter Hotline Clean-Out, Hauling, and Spreading Contractors

County	Town	Name	Telephone	Other Phone
Hopkins	Sulphur Springs	George TenBerge	903-885-0854	903-885-6561
Houston	Crockett	Oates Farm Inc.-Terry Oates	936-546-5805	936-544-6835
McLennan	Waco	Mida-Bio Ltd. (Mike and David Neal)	254-709-6584	254-709-3794
Nacogdoches	Nacogdoches	Jeff Bailey (Bailey Bark Materials)	800-209-8017	936-552-6606
Robertson	Franklin	Cooks Poultry Service - Wes Cook	979-828-4830	
Sabine	Pineland	Elliots Agri-Service Inc.	800-323-4417	409-584-2155
Shelby	Center	Allan Chandler dba Son-Way Agri. Products	936-598-2258	936-591-9043

- **Economics:** The prices offered by most markets for raw litter are commonly lower than the true economic value of the material – market prices tend to reflect only the economic value of the agronomic benefits from the nitrogen in the litter and do not reflect the agronomic and associated economic value of other constituents/benefits such as phosphorus, potassium, calcium, trace minerals, and organic matter. This generally means that the overall economics of

[18] The litter spreaders were purchased and deployed as part of a litter export program initiated by Winrock International with funds from the US Department of Agriculture.

a raw litter enterprise are not attractive, with potential revenues often not even sufficient to offset transportation expenses (without regard to acquisition costs, clean-out costs, storage costs, and/or spreading costs, overhead, and profit).

7.2. Land Availability and Options

Litter has traditionally been applied in raw form on pasturelands and haylands on or near the poultry production farms. This will remain a sustainable option within the poultry producing regions in Texas only if current application rates are reduced. Other potential markets in or near areas of concentrated poultry production in Texas include commercial timber, croplands, land reclamation and bio-remediation; these markets should be developed to increase the options for raw litter use. Each of these potential markets for raw litter is discussed in the following sections.

7.3. Using Litter on pasture and hayland

The values in Table 2 below are estimates of production and available hayland and pastureland acreages within the project watersheds. It is important to note that the litter application rates in this table are based on phosphorus and assume a target of zero phosphorus buildup in the soil. The phosphorus (P) balance application rate for grazed pastures is based on a removal rate of 3.4 lb per acre by a calf grown to 500 lb (grown cattle recycle close to 100% of phosphorus consumed).[19] The P balance application rates for hay are based on estimated consumption by these crops. (See Figures 5, 6 and 7 for locations of poultry farms and pastureland/hayland acreages within the project watersheds).

Table 2. Litter Production and Potential Litter Use on Pasture/Haylands[20]

Watershed	Broiler Litter Production (tons/year)	Pasture/Hayland Acres	Potential Litter Use (tons)*	
			Grazed only	Hayed only
Lower Angelina	148,734	175,313	26,889	145,510
Lake o' the Pines	64,805	203,352	18,302	168,782
Middle Guadalupe	97,857	335,164	30,165	278,186

*Based on P Balance Application Rates of .09 tons/acre for grazed land and .83 tons/acre for hayed land.

[19] Ball, D.M., C.S. Hoveland, and G.D. Lacefield. 1996. Southern Forages. 264 pp. Potash and Phosphate Institute and Foundation for Agronomic Research. Norcross, GA.

[20] Phosphorus content of litter was estimated from Texas A&M Doctorian, D.S. and G.W. Evers, *Utilizing Broiler Litter as a Protein and Mineral Supplement for Beef Cows.* Land use acreages were estimated using 1997 USDA Agricultural Census data.

Figure 8 shows the locations of pasture and hayland versus poultry production for the entire state. There is adequate pasture and hayland acreage surrounding the concentrated poultry production regions to sustain land application of a portion of the raw litter produced as long as litter application rates are reduced. Applications of litter on hayland should be made at agronomic rates.[21]

[21] Visit the following links for information on raw litter management and application:

http://muextension.missouri.edu/xplor/envqual/wq0223.htm http://tammi.tamu.edu/pdf pubs/animalwaste.pdf http://tammi.tamu.edu/CTR.htm http://tammi.tamu.edu/pdf pubs/manurestorage.pdf)

Figure 5 - Lower Angelina Watershed Poultry Farms and Pasture/Hayland Acreages

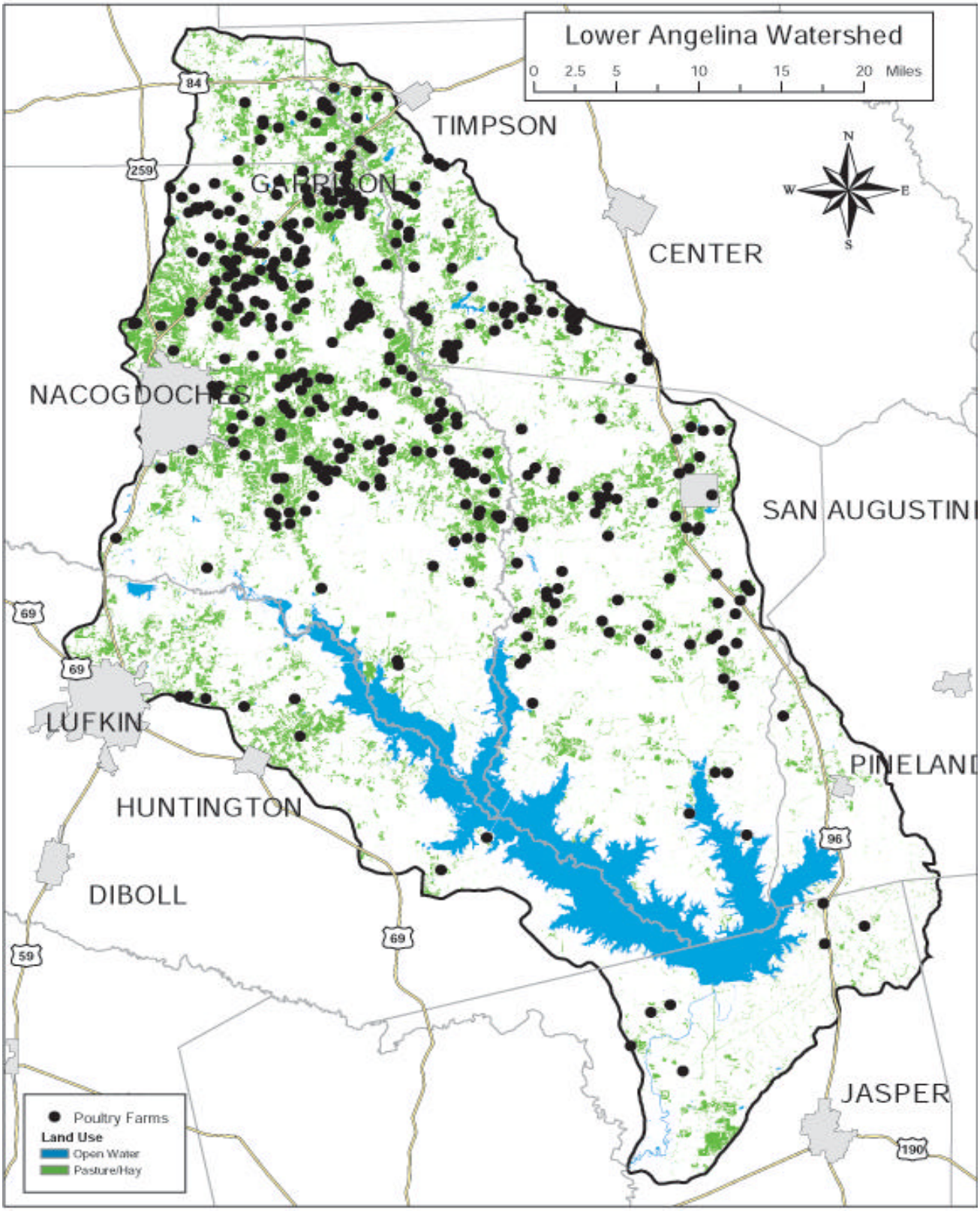


Figure 6 - Lake O' The Pines Watershed Poultry Farms and Pasture/Hayland Acreages

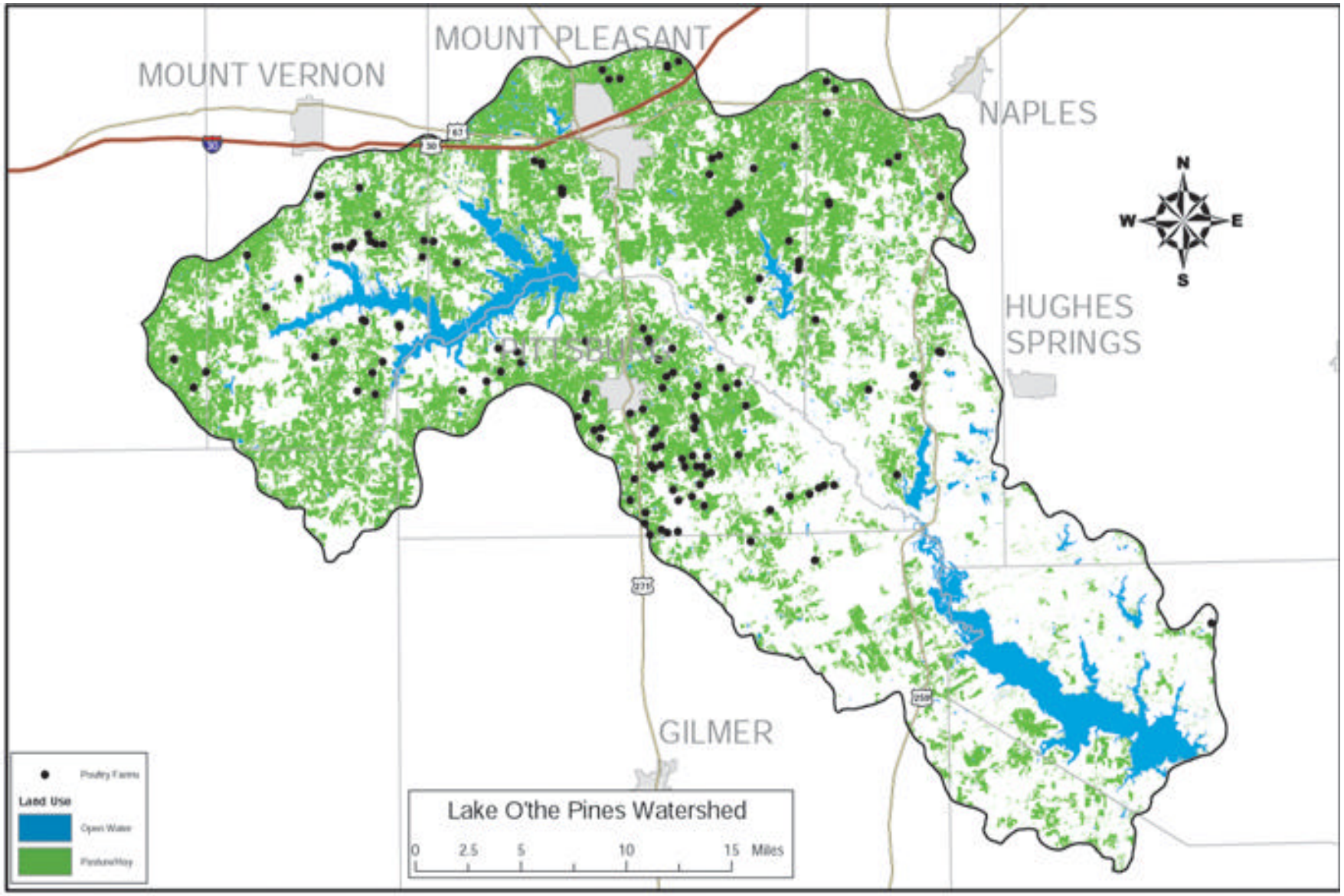


Figure 7 - Middle Guadalupe Watershed Poultry Farms and Pasture/Hayland Acreages

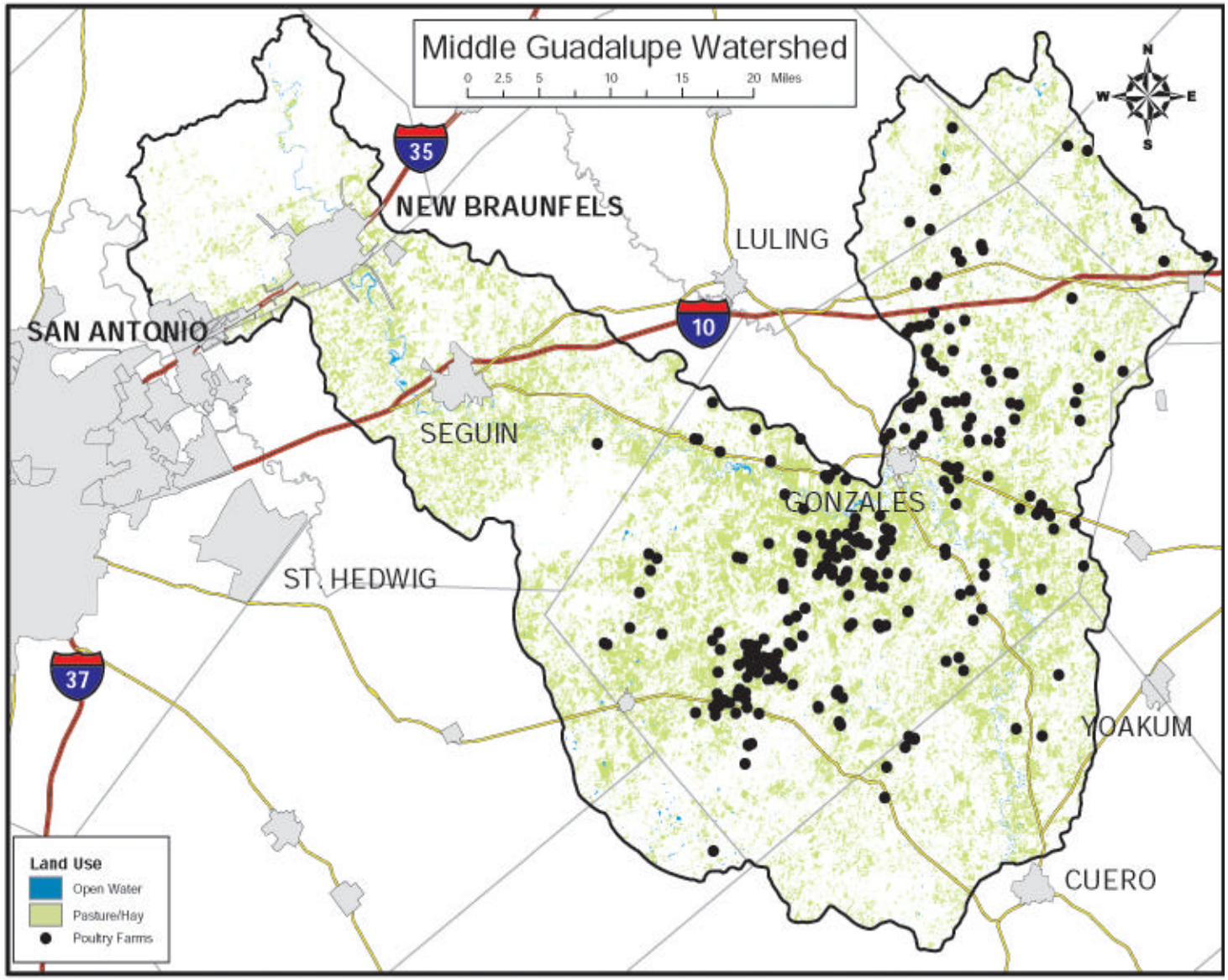
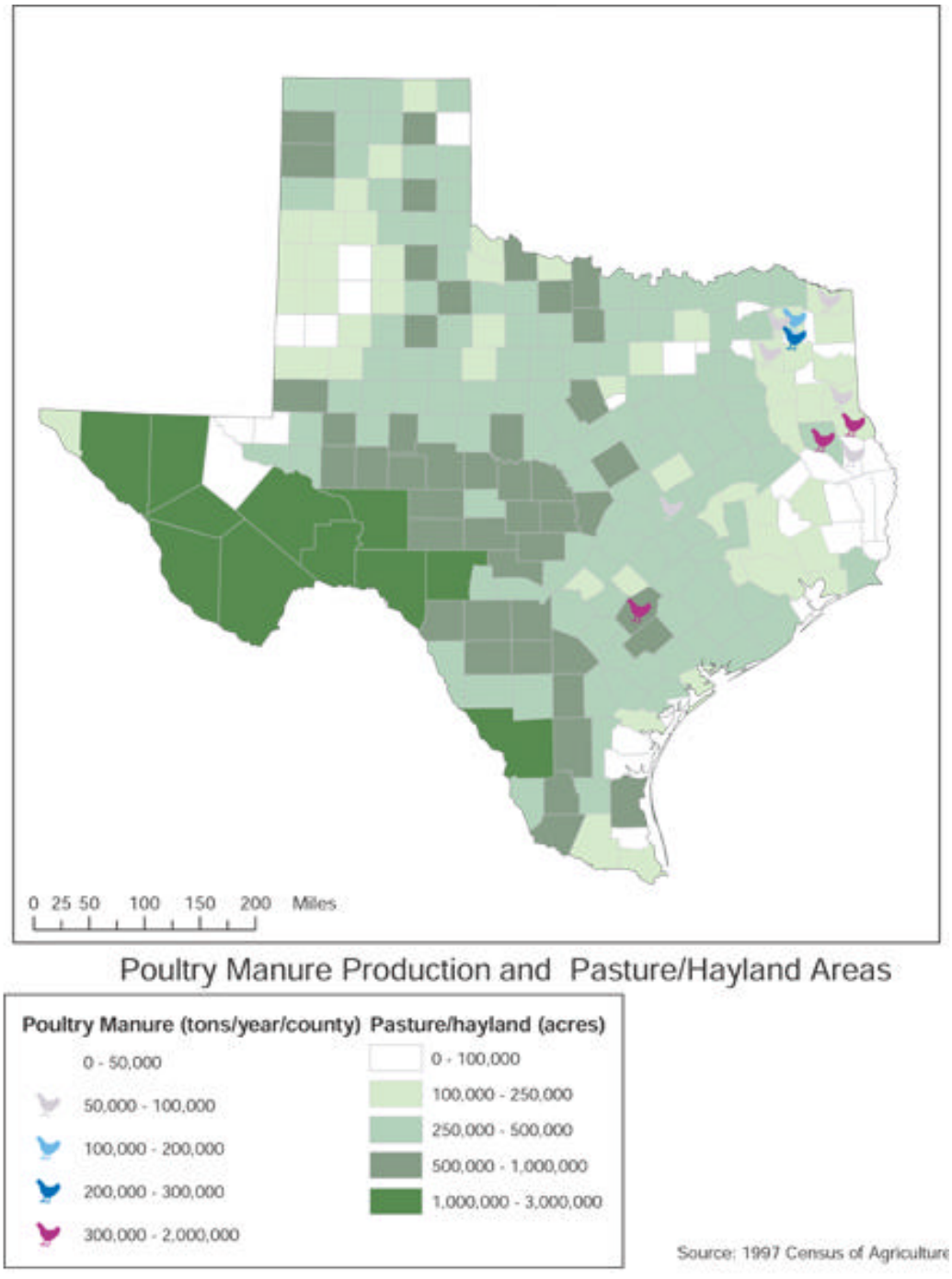


Figure 8 - Locations of Texas Poultry Production and Pastureland/Hayland Areas



7.4. Using litter on forestlands

The forestry industry – the other major rural economic force in East Texas besides poultry & livestock production – has increasingly embraced intensive timber production practices, including fertilization of many of the forestlands in the region. There are approximately 11 million acres of commercial timberland in east Texas.[22] These forestlands represent attractive potential markets for surplus litter produced in the region because:

- these fertilized forestlands could readily benefit from the nutrients, trace minerals, and organic matter contained in poultry litter (including, in particular, the relatively high levels of phosphorus in poultry litter that can become problematic vis-à-vis traditional application fields)
- these forestlands are *local* relative to the poultry production facilities (see Figures 9, 10 and 11)

Although there is significant timber acreage in and around the three project watersheds, the most likely location for litter application is in the commercial timber production region surrounding the Lower Angelina. Table 3 provides a summary of timber production and potential litter use in the project watersheds.

Table 3. Timber Production and Potential Litter Use in Project Watersheds[23]

Watershed	Broiler Litter Production (tons/year)	Timber Acres	Potential Litter Use (tons)*
Lower Angelina	148,734	267,434	34,766
Lake o' the Pines	64,805	32,159	4,141
Middle Guadalupe	97,857	144,338	18,764

*Based on an application rate of .13 tons/acre/year.

While such proposed activities raise obvious questions regarding agronomic, logistical, and economic aspects of applying litter to forestlands, the potential benefits of such activities warrant serious consideration. In fact, interest in evaluating/developing such markets for surplus litter has increased substantially in recent years in other areas of concentrated poultry production in the U.S., including other ecosystems similar to those of East Texas.

[22] http://www.texasforestry.org/texforests.htm
[23] Land use acreages were estimated using 1997 USDA Agricultural Census data.

An in-depth economic analysis of spreading poultry litter (as a fertilizer) on timberlands concluded that such an option could be economically viable if sufficient markets exist. More specifically, investment in the equipment and labor required for spreading litter on accessible timber acreage could show reasonable investment performance with a market size of 12,000 acres of timberland (per spreading unit). However, until there is high confidence that such markets exist, such an investment would likely exceed the risk tolerance levels of most entrepreneurs. Thus, to deploy such a surplus litter management option, timberland markets need to be secured (e.g., through up-front and long-term fertilization contracts) and/or strategies embraced for reducing the financial risk of the investment (e.g., through loan guarantees underwritten by a state or federal agency).

Marketing strategies should be directed not only at the industrial companies but, more importantly, at the private non-industrial forest landowners, who own approximately 7.3 million acres of commercial timber in east Texas. According to Dickens, et al, "The private non-industrial forest landowner (NIPF) sector has become increasingly interested in using commercial and other fertilizer materials such as poultry litter to fertilize stands."[24]

[24] http://www.organix.org/Projects/Texas/poultryapp5.pdf

Figure 9 – Lower Angelina Watershed Poultry Farms and Landuse

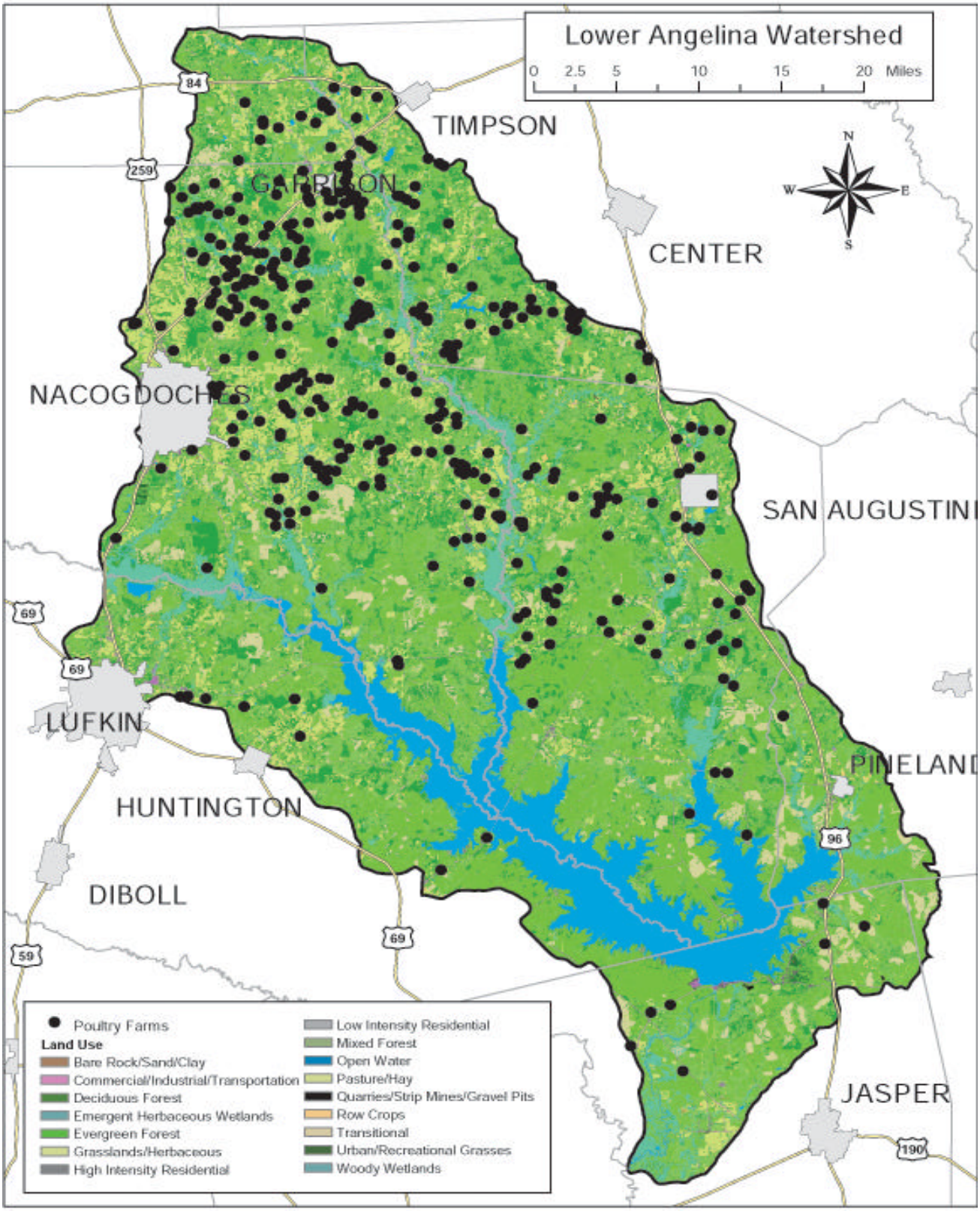


Figure 10 – Lake O' The Pines Watershed Poultry Farms and Landuse

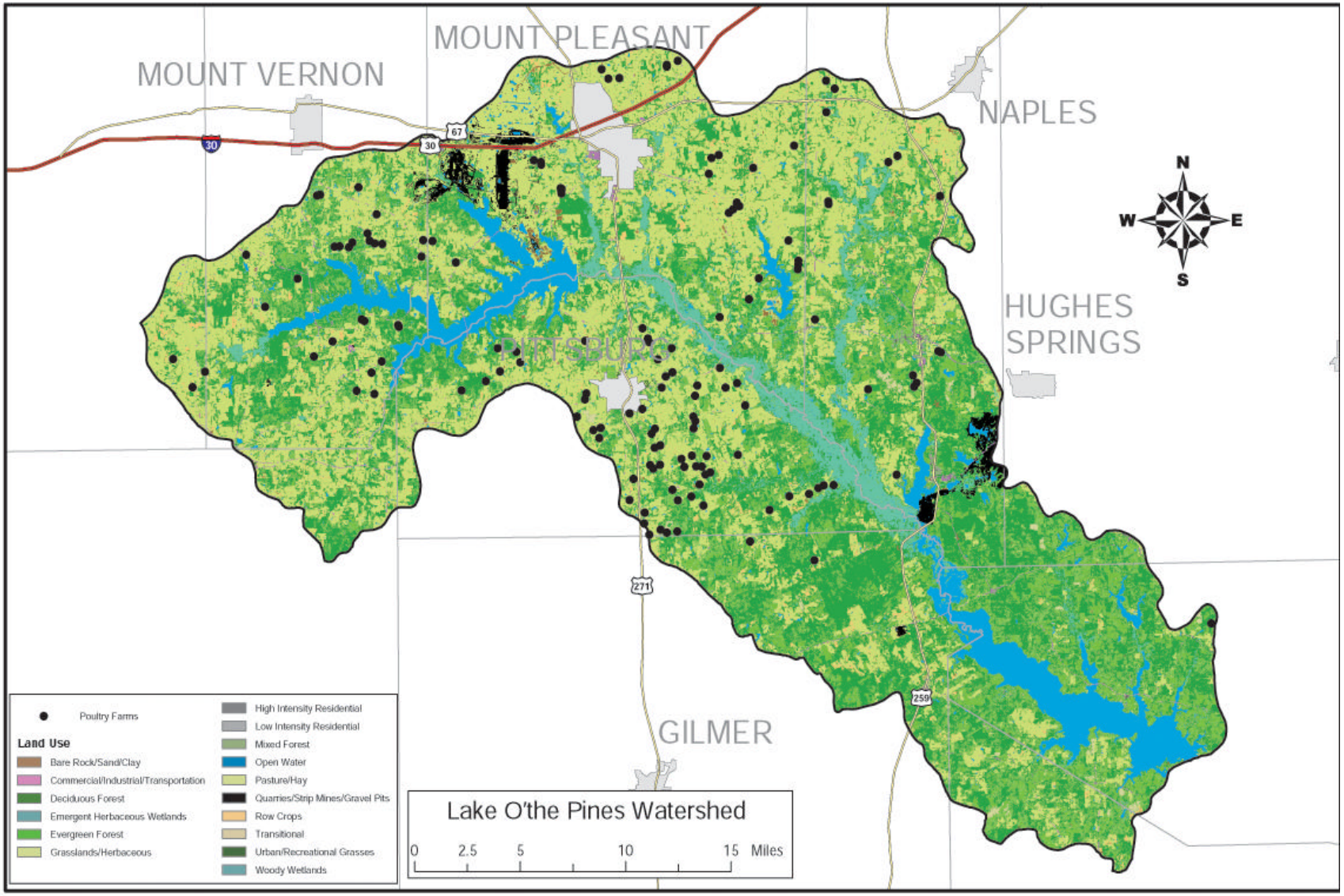
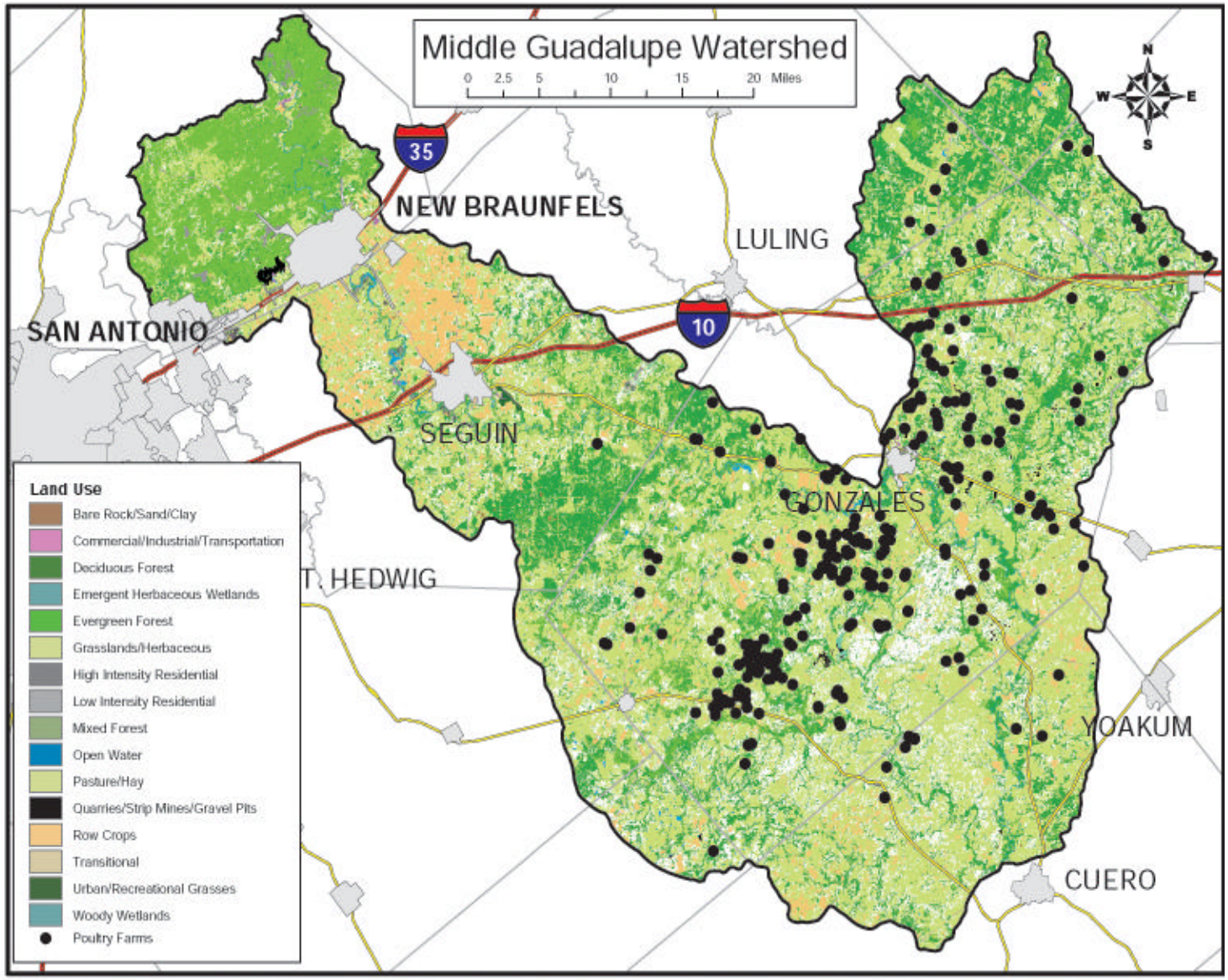


Figure 11 – Middle Guadalupe Watershed Poultry Farms and Landuse



7.5. Using litter on ricelands in Southeast Texas

With an economic impact of near $1 billion annually—fifth among the state's largest cash crops—rice is a major commodity for Texas. The state boasts one of the world's largest rice milling, processing, drying, storing, and shipping industries, which processes rice from Texas, Louisiana, Mississippi, and Arkansas.[25] Approximately 216,000 acres of rice were harvested in Texas in 2001.[26] Poultry litter can be an excellent fertilizer source for rice in southeast Texas due to the proximity of the farms to the rice production areas (see Figure 12).

7.6. Land Reclamation

Poultry litter can be used as a source of carbon and nutrients to expedite revegetation in soils that have been disturbed through practices such as surface mining and construction. Manipulated soils on mining and construction sites are generally low in pH, organic matter, and nutrients. Litter is naturally high in pH, organic matter, macronutrients and micronutrients, making it a valuable amendment for rapid reclamation of disturbed soils. Several mining operations are located near the major poultry producing regions in east Texas (see Figure 13); this proximity and the associated low transportation costs could make litter an attractive soil amendment option.

Bioremediation:

Bioremediation is the process by which living organisms act to degrade or transform hazardous organic contaminants into benign forms. Poultry litter has been successfully used as a source for microorganisms, carbon, and nutrients to enhance the biodegradation of petroleum and other chemical compounds in contaminated soil.

For more information regarding bioremediation, refer to:

http://www.nal.usda.gov/ttic/tektran/data/000007/27/0000072729.html
http://www.ces.ncsu.edu/depts/agcomm/writing/apwmc18.htm

[25] http://agsummit.tamu.edu/Publications/9702/ricepub.htm
[26] http://www.nass.usda.gov/tx/tcrprpt.htm

Figure 12 – Texas Poultry Production and Rice Production Areas

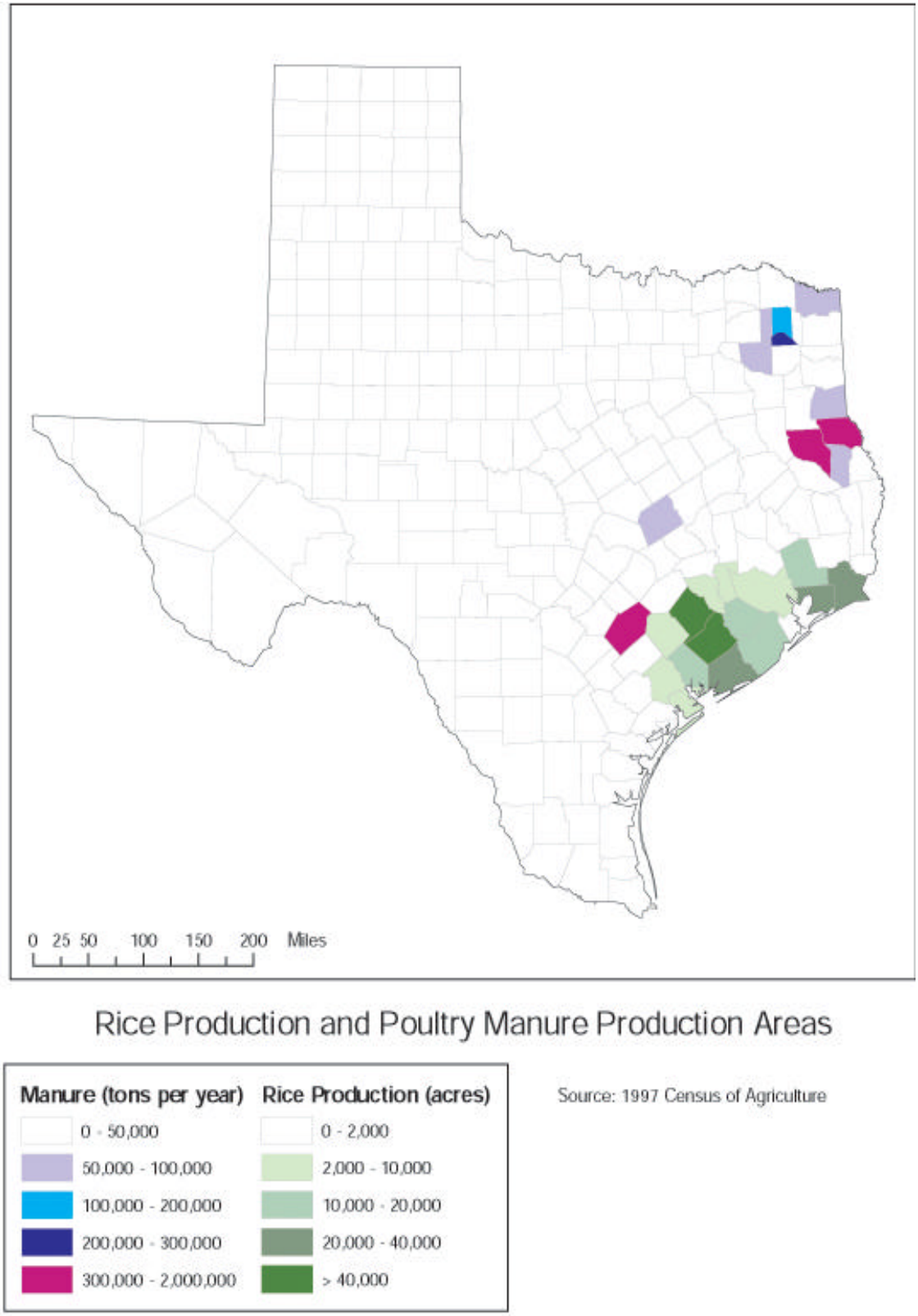
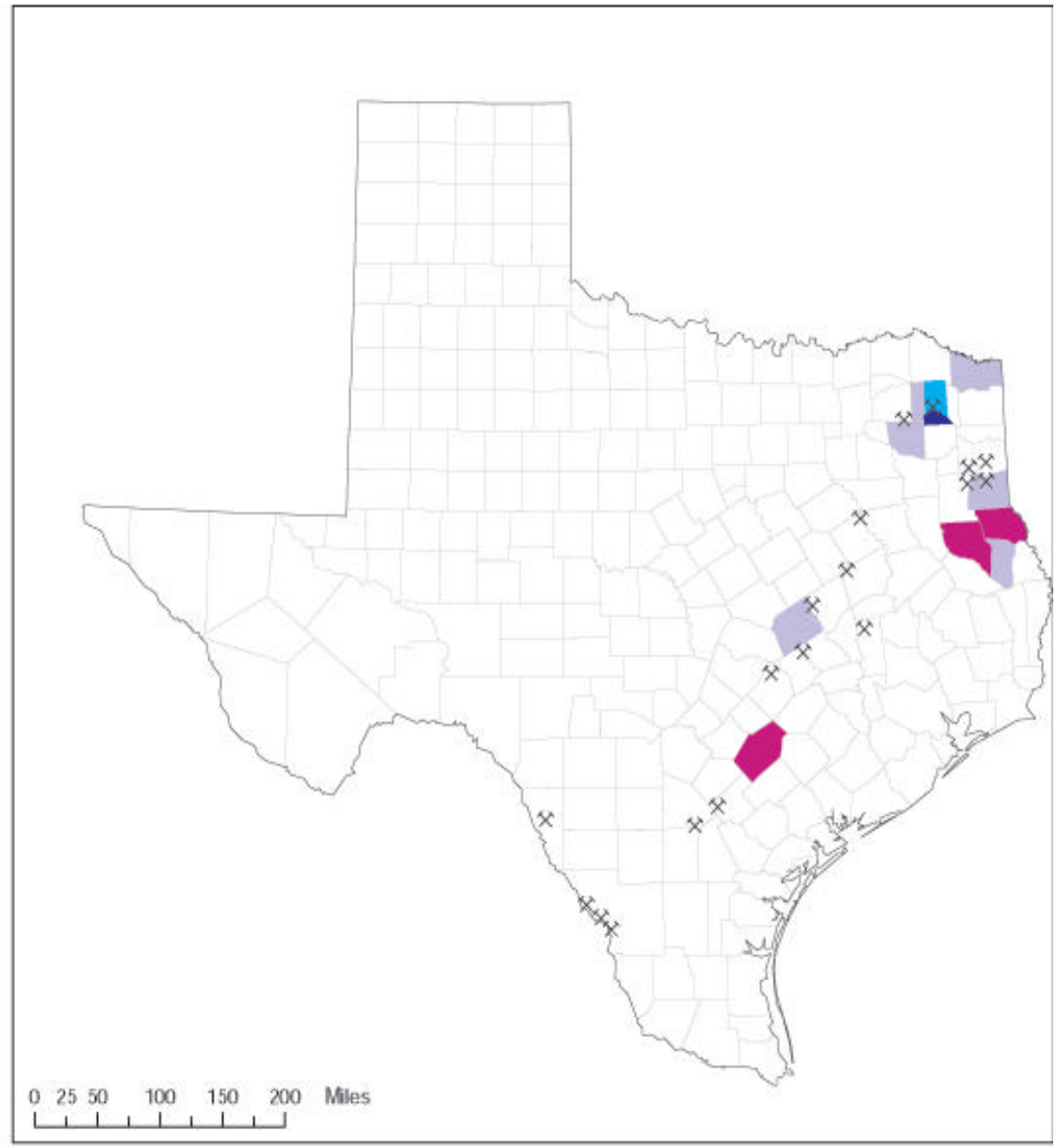


Figure 13 – Texas Poultry Production and Surface Minelands



7.7. Land Availability for Raw Litter Use Outside Project Watersheds

Litter application sites outside the watershed: Table 4 provides an estimate of the available acreages for land application of raw litter within 20, 40, and 60 miles of the project watershed boundaries. According to the service contractors for these areas, hauling charges are fixed for distances up to 50 miles; beyond 50 miles, additional mileage charges may be added. Sufficient acreage is available within 60 miles of the boundaries of the watersheds for land application of all litter produced within the watersheds (see Figures 14, 15, and 16 that visually depict the land use for the 20, 40, and 60-mile zones beyond the watershed boundaries).

Table 4. Available Acreages for Land Application of Raw Litter within 20, 40 and 60 miles of Project Watersheds[27]

	Pasture/Hayland Acreage			Crop Acreage			Evergreen Forest Acreage		
Watershed	0 - 20 mile zone	20 - 40 mile zone	40 - 60 mile zone	0 - 20 mile zone	20 - 40 mile zone	40 - 60 mile zone	0 - 20 mile zone	20 - 40 mile zone	40 - 60 mile zone
Lower Angelina	637134	1,027,537	1,693,379	33,878	97,675	738,291	830,951	1,356,958	1,214,555
Lake o' the Pines	945165	1,522,848	2,053,913	66,478	325,473	585,052	164,687	224,918	428,235
Middle Guadalupe	800522	943,423	1,362,979	293,854	465,871	896,044	665,307	856,486	1,089,992

[27] Land use obtained from 1997 USDA Agricultural Census.

Figure 14 – Lower Angelina Watershed 20, 40, and 60 Mile Landuse Zones

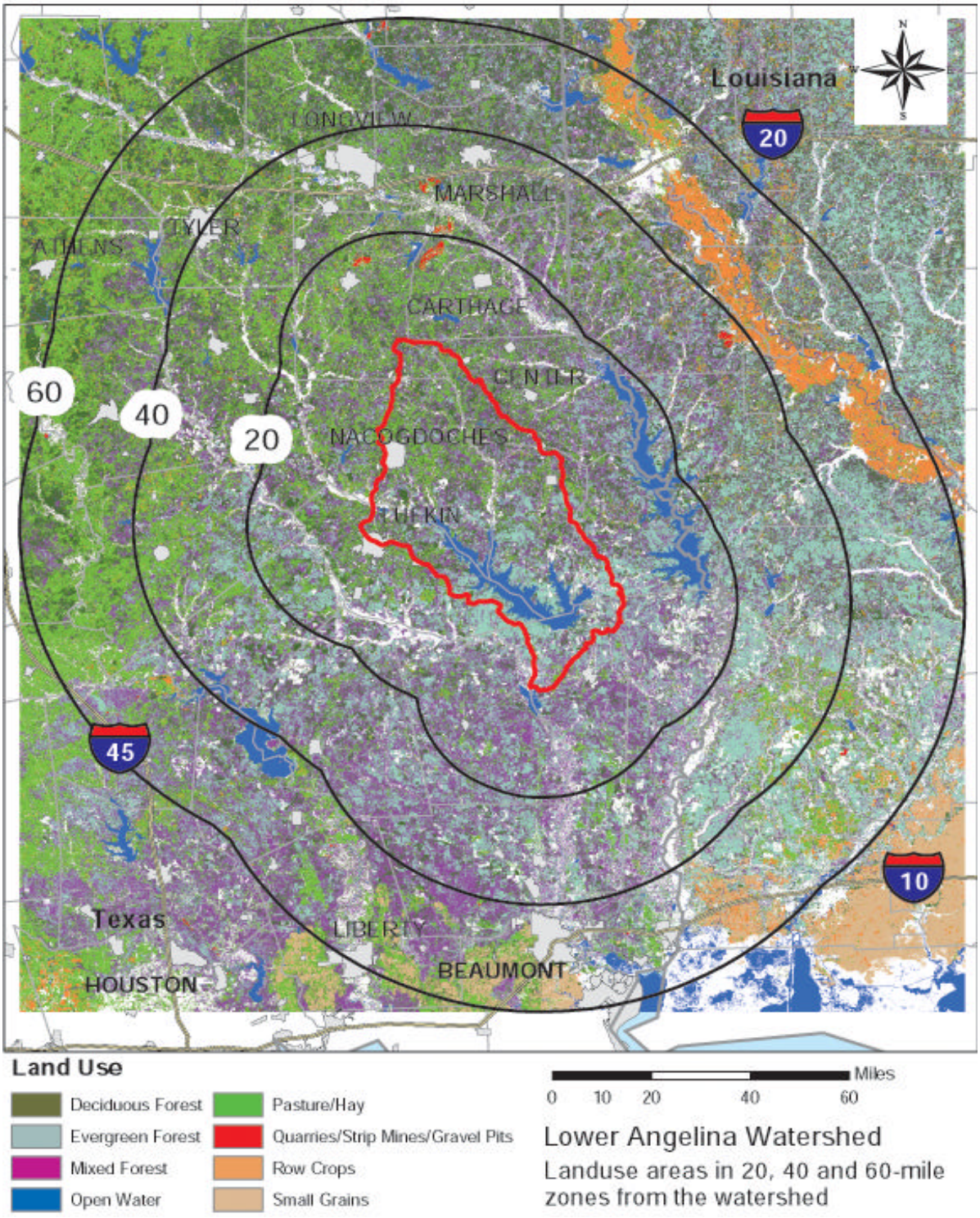


Figure 15 – Lake O' The Pines Watershed 20, 40, and 60 Mile Landuse Zones

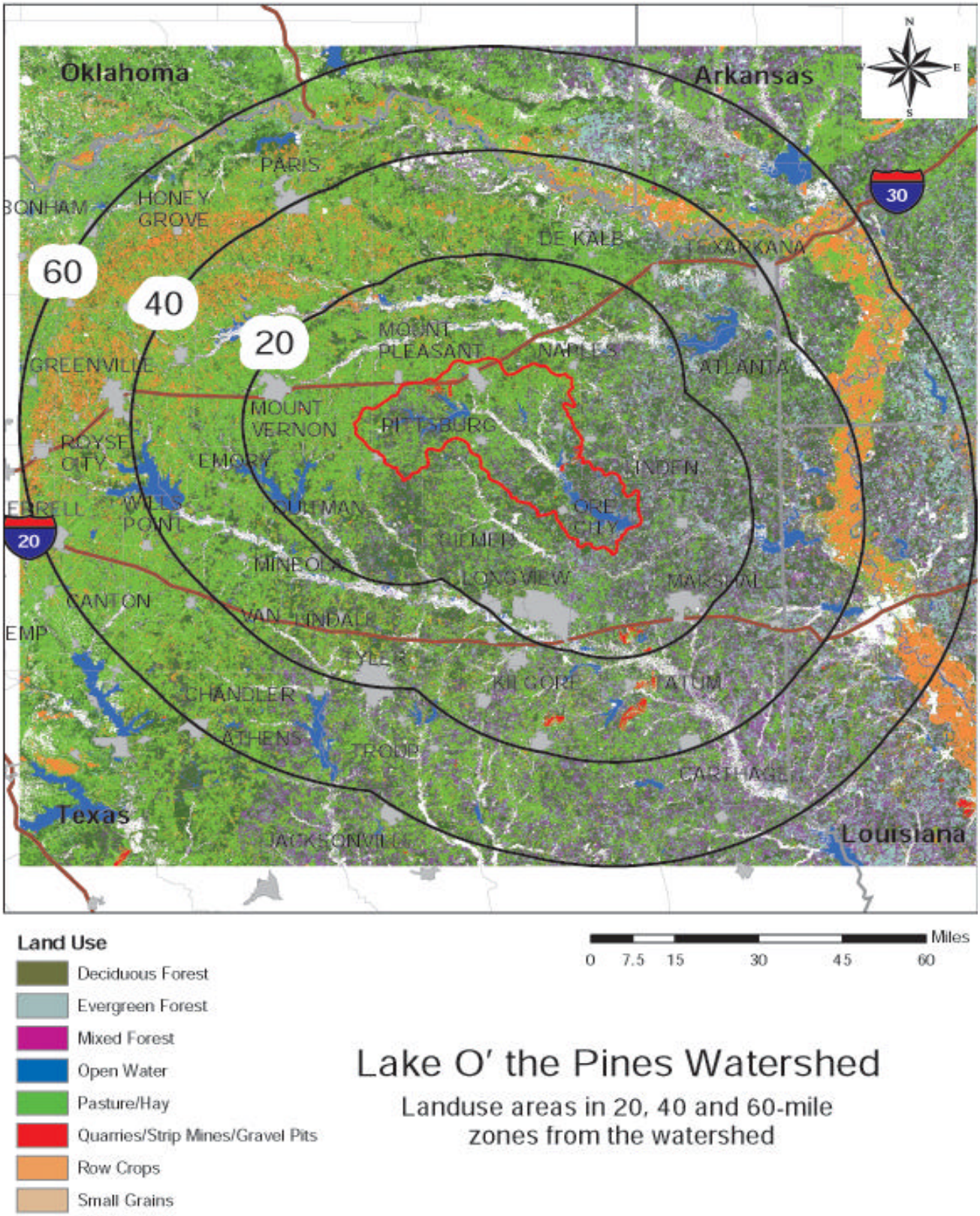
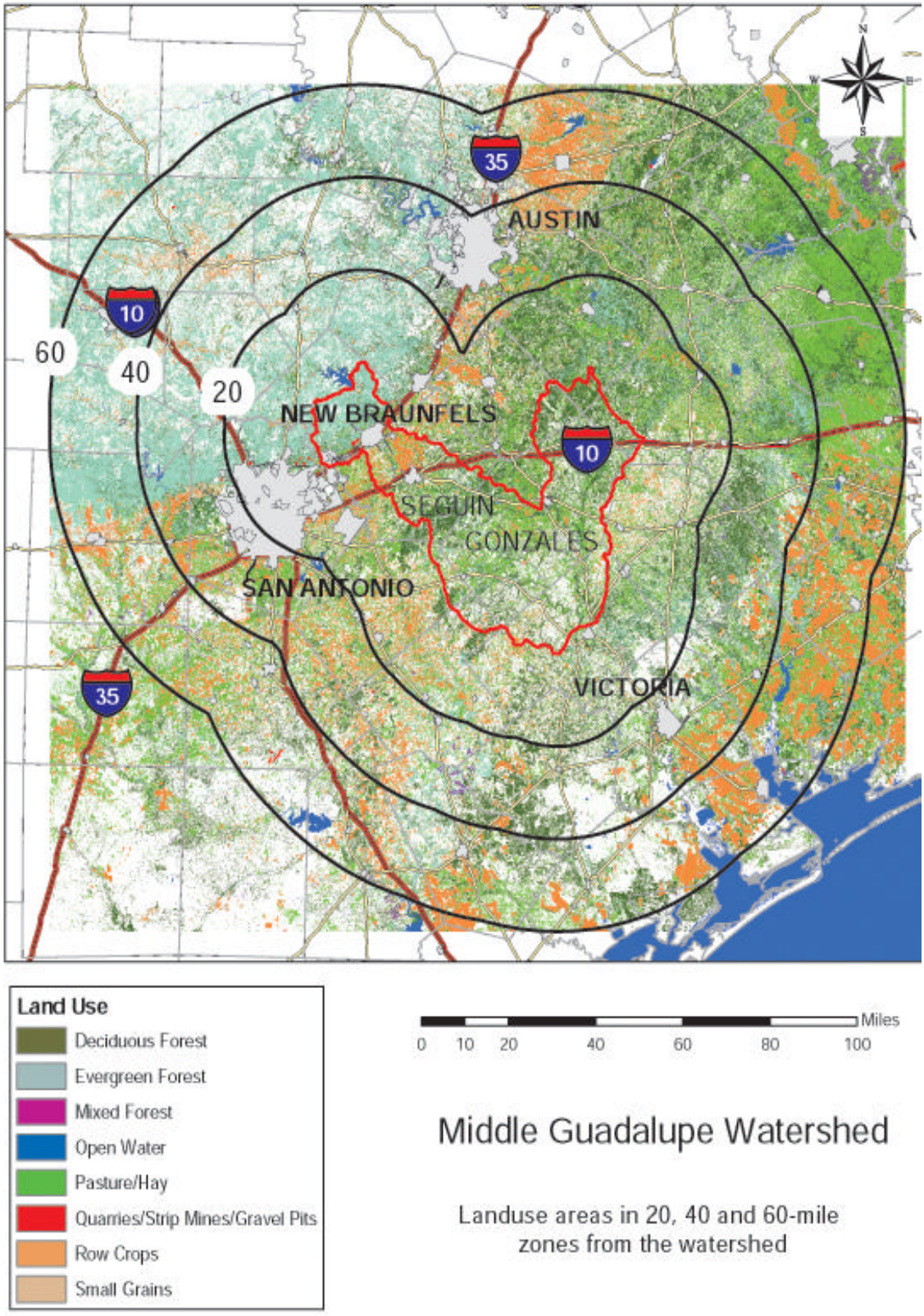


Figure 16 – Middle Guadalupe Watershed 20, 40, and 60 Mile Landuse Zones



Litter-Phosphorus perspectives from SFA

This essay is based on about 30 years experience as a soil fertility specialist, 12 years experience studying the application of broiler litter on East Texas soils and it subsequent effects on surface water quality, and finally, 6 years of experience as a contract broiler grower in the East Texas region.

Soil test summaries show, without a doubt, that the level of soil test phosphorus (P) is increasing in areas where there is a concentration of broiler production. These summaries show that in counties where broiler production is high, about 50% of the soils tested have P levels high enough so that no additional P fertilizer is needed for optimum crop yield. Thus additional application of P on these already high P soils is not good use of the broiler litter resource. Continued loading of these soils with P from litter will result in soils with sufficiently high levels of soil P that surface runoff water will contain excessive levels of P and can contribute to eutrophication. The scientific evidence relating levels of soil P to levels of P in runoff water is strong. Unfortunately, determination of levels of soil P, above the agronomically critical level, that will actually cause
eutrophication of surface waters has not been well defined. This has resulted in the use of arbitrary numbers that are not based on scientific experimentation.

Looking at the integrated broiler industry in East Texas, one is immediately impressed with the large amounts of P brought into the region as feedstuffs, corn and soybean meal, and as P feed additives like dicalcium phosphate. It is not surprising that P is becoming a problem. Anecdotal reports of soils with soil test P levels ranging from several hundred parts per million (ppm) to over 2000 ppm are common. Most broiler growers tend to spread broiler litter as close to their broiler houses as possible. They are usually in a hurry to get ready for the next flock of birds and hauling the litter farther from the broiler houses takes time and costs money.

Development of nutrient management plans on a voluntary basis by broiler growers are seen by the industry as a way to forestall the imposition of more stringent regulation. The rates of litter prescribed by these nutrient management plans will quickly put many growers in a situation that will require them to remove most litter from their farm or else be in situation where they cannot operate under their voluntary plan. Although some broiler growers effectively move litter to their neighbors land, other growers have difficulty disposing of their litter. Development of more markets for litter are needed and it is hoped that significant quantities of litter can be moved out of the immediate production region.

Failure to move significant quantities of litter out of the region or to develop alternative uses for litter within the region will result in more and more soils developing high P levels and hastening the imposition of strict regulations. These regulations will likely have a negative effect on the whole broiler industry.

Prepared by J. Leon Young, Professor, Department of Agriculture, Stephen F. Austin State University, Nacogdoches, Texas.

8. Converting Litter into Value-added Products

8.1. Overview

Relative to export of litter in raw form, there are several significant advantages to producing and exporting value-added products derived from litter:

- Expansion of potential markets for the litter-derived products
- Improved economics regarding transport of value-added products to export markets
- Other environmental/economic benefits associated with the value-added products
- Rural economic development through establishment of litter processing facilities

Value-added processing and export options are increasingly being recognized as the most effective strategy for addressing litter management concerns in areas of concentrated production.

8.2. Technical options & considerations

There is a wide range of technologies—at least, in theory—that can convert litter into value-added products. Conversion technologies can be categorized into:

- biological (e.g., aerobic composting, anaerobic digestion, fermentation)
- thermo-chemical (e.g., combustion, gasification)
- densification (e.g., pelletizing, cubing, extrusion)
- other (e.g., chemical treatment, dewatering & particle size reduction)

As discussed in this section, some of these technologies have already been demonstrated and proven commercially, some have been shown to not be technically and/or economically viable with litter feedstocks, and some are still in research/development stages (i.e., they have not yet been deployed commercially).

Litter-derived products can be categorized into:

- soil amendment/fertilizers (e.g., compost, pellets)
- energy (e.g., thermal, electrical, liquid fuels)
- other (chemicals, building materials)Some of the conversion technologies generate multiple products (e.g., combustion leads to both electrical, thermal, and fertilizer products).

8.3. Financial considerations

In selecting a technology for processing litter, it is essential that the conversion process be focused on the markets for its products. Like other manufacturing and sales enterprises, success will ultimately be determined by the extent to which the enterprise is market driven. Other economic/financial considerations include economies of scale, access to capital, and options for public sector financial support.

It is important to note that, under current economic conditions, none of the value-added litter processing options are considered economically viable. More specifically, the potential revenues from sale of litter-derived products are not sufficient to cover all of the costs of selling the products (i.e., the costs of aggregating and processing the litter and making it available to the target market). Thus, deployment of any processed litter export program will require one or both of the following changes to occur:

- **Recovery of new operating expenses associated with surplus litter management, which is not possible under the current structure of the poultry industry.** More specifically, the poultry growers—those who currently own the litter and have responsibility for surplus litter management—have no access to markets for poultry products and therefore have no ability to pass on to consumers of poultry products any additional [net] costs associated with management of surplus litter. One option being discussed nationwide to address this economic barrier is for those who are able to pass on and recover such costs—the integrators—to take ownership and responsibility for the litter. However, another option, and one widely considered more acceptable within the industry, entails the establishment of a formal mechanism in which the entire poultry industry agrees to recover additional revenues through increased product pricing that would be used to offset the additional operating expenses associated with litter management (e.g., something akin to a market order or check-off program already in use by other agricultural industries in the U.S.). Regardless of which course of action occurs, it is likely that it will take many years for such changes to occur. Therefore, interim strategies are needed to address economic shortfalls associated with surplus litter management.
- **Supplemental economic support for litter export activities**. Such support could come from the public and/or the private sector, although it is widely recognized that little, if any, financial investments can be made by independent contract poultry growers (who typically have limited financial resources and ability to invest). Interim deployment strategies will likely entail public-private partnerships, with some of the expenses associated with surplus litter processing/export borne by public agencies (e.g., through incentive payments under the NRCS' Environmental Quality Incentives Program) and some by the poultry companies.

Unless and until current economic conditions change, it is unrealistic to expect that private entrepreneurs will invest in large-scale litter processing and export enterprises because of: a) perceived technical risks (as discussed with each of the technologies noted below) and/or b) real fi-

nancial risks (e.g., soft product markets, inability to obtain long-term product sales contracts, unattractive overall economics for the enterprise).

When evaluating a potential litter conversion technology and associated export program, the following factors are considered to have primary impact on the economic viability of the potential investment and therefore should be carefully evaluated:

- Has the technology been demonstrated and proven at a commercial scale? If so, is actual operational data available that can enhance confidence levels (and reduce potential risk) in the estimated costs of a new enterprise using the same or similar technology?
- Can product purchase commitments be obtained? Long-term contracts for purchase of litter-derived products can fundamentally enhance the ability of the enterprise to attract investors and secure financing.
- Regardless of the type of technology utilized, any large-scale conversion enterprise will also entail aggregation of the litter. A viable aggregation strategy and contracts with litter suppliers are also needed to ensure investor confidence and minimize financial risk.

8.4. Other considerations

Key elements of a litter processing and value-added product sales enterprise include:

- Access to and aggregation of litter feedstocks (e.g., securing commitments by producers and integrators, scheduling and coordination of clean-out, storage, and delivery activities)
- Infrastructural and logistical considerations (e.g., transport systems for feedstocks and litter-derived products, product storage and distribution, facility siting and permitting)
- Regulatory and policy considerations (e.g., current/forthcoming regulations regarding litter management, public sector incentives and disincentives, political support for value-added options)
- Deployment strategies (e.g., coordination at the watershed and regional levels, ownership and management options such as a nonprofit litter bank or a producer cooperative)—refer to Section 8

9. Litter Composting Options & Opportunities

9.1. Technical considerations

- **Co-composting options:** A unique benefit of composting is that it offers significant co-processing opportunities. A composting operation using primarily litter feedstocks could also utilize and effectively co-compost a variety of other organic waste products (e.g., poultry mortality, poultry processing residuals, cannery residuals, municipal organic wastes). Some of the other organic waste materials have negative values, meaning that the composting enterprise would be paid to take the materials, which would contribute toward the economic feasibility of the enterprise.
- **High-nitrogen challenges:** The ratio of carbon (C) to nitrogen in broiler litter is low (relative to other organic composting feedstocks), i.e., the amount of nitrogen (N) in the material is relatively high. The target C:N ratio of feedstocks for effective composting is generally considered to be 20:1 ~ 30:1, whereas the C:N ratio of litter typically ranges from 6:1 ~ 12:1. The low C:N ratio of litter is problematic from a composting perspective…the high nitrogen levels mean that the material must be managed "aggressively" to avoid anaerobic conditions or other undesirable results. Alternately, additional high-carbon material (e.g., wood chips) can be mixed in with the litter prior to composting, although this approach entails significant effort, potential cost, and risk (i.e., if the high-carbon bulking agent is not thoroughly mixed, then problems will likely occur during the composting process and there could be inconsistent quality in the compost products). Note that turkey litter has a higher C:N ratio in those instances where the litter is removed from the houses after a single flock of birds. In such instances, it may be feasible to compost the turkey litter directly, i.e., without additional carbon-rich material.
- **Quality control considerations:** One of the greatest problems plaguing many composting operations has been quality control – sufficient control must be invested [by a knowledgeable composting person] during the compost process to ensure consistent and high quality of the ensuing compost product[s]. Such quality is essential for penetrating premium quality [and premium price] markets and attracting repeat customers.

9.2. Economic considerations

Composting is a well-known technology.[28] Composting expertise is widely available, capital requirements are small (relative to other value-added processing options), and there is a wide

[28] For more information contact: United States Composting Council compostingcouncil.org, BioCycle Magazine www.jgpress.com/, Journal of Compost Science & Utilization www.jgpress.com/

range of product markets in Texas, such as landscaping companies, vegetable crop producers, construction site renovators, etc.

- **Market focus:** Increasingly, compost markets have established product quality specifications that, in turn, have led to increased quality control requirements during processing. For example, specific requirements have been established by the Texas Department of Transportation for compost used for roadside erosion control.[29] Because of the need to focus on product markets [and product quality] and because of economies-of-scale considerations, it is important for litter composting enterprises to engage professional compost production and marketing expertise and experience (and, preferably, at a centralized facility rather than at the farm level).
- **Front-end vs. back-end revenues:** Historically, most composting enterprises in the U.S. have focused on municipal- or commercial-derived feedstocks, because composting facilities are typically *paid* to receive the material (i.e., "tipping fees" or "front-end revenues"). This means that, economically, such enterprises are less reliant on product sales ("back-end revenues"). But that is clearly not the case with litter feedstocks, as litter composters generally have to *pay* to obtain the raw material (and are considered fortunate if they can obtain the litter for zero cost). Thus, litter composting operations must focus exclusively on revenues from product sales (which underscores the need to focus on product quality as discussed above).
- **Market value vs. product cost:** Market prices for bulk compost varies from about $10 per ton to over $50 per ton, depending on the particular market and the quality of the compost product (niche markets for bagged compost can be even higher, although there are additional production costs associated with the bagging process). Agricultural markets generally value the compost based on its macro-nutrient content, i.e., the markets do not assign an economic value to the "non-NPK" benefits of compost (e.g., the soil's increased water holding capacity due to enhanced organic matter content, or potential disease suppression due to the beneficial microbes in the compost). Additional economic research regarding the non-NPK benefits of compost (both agronomic and, in turn, economic) are needed. Accordingly, composting enterprises generally cannot rely solely on market sales to achieve economic goals (i.e., they must also rely on tipping fees). Notable examples include the feedlot manure composting enterprises located in west Texas, whose compost products are sold to cotton and other farmers in bulk; years of experience and large volumes of feedstocks have enabled the composters to achieve economies-of-scale and keep product prices within reach of mainstream agricultural consumers.

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[29] http://www.dot.state.tx.us/insdtdot/orgchart/des/landscape/compost/topsoil.htm

9.3. Logistical & other considerations

As noted above, most (but not all) composting specialists believe that large-scale litter composting will require the addition of other carbon material (e.g., woody residues), which would increase the complexity (and probably the cost) of a litter composting operation. It is also likely that litter composting will require more intensive processing management and expertise to avoid anaerobic conditions and ensure quality control. A large, covered product storage facility would probably also be required to maintain the quality of the composted litter for the long periods of time after processing but before delivery to markets (due to the heavy seasonal demand for compost products vs. the need to obtain litter and process the material on a year-round basis).

9.4. Litter composting experiences

No large-scale commercial composting experience using 100% broiler litter feedstocks have been identified in the U.S., presumably because sales of *composted* litter have not been able to compete economically with *raw* litter sales. However, there are some commercial composting enterprises that use [or have used] *some* litter (which is mixed with other feedstocks and co-composted). There are also some composting enterprises that compost turkey litter because of its higher C:N ratio. Examples of some specific litter composting experience in Texas include:

- **Vital Earth Resources**: Vital Earth, located in Gladewater, has been producing numerous compost products from a variety of feedstocks (including litter) since 1983. The materials are composted (and co-composted) in a large, in-vessel rotary "digester". Products are sold in bulk and packaged form. www.vitalearth.com
- **Mida-Bio, Ltd:** Located near Waco, the company manages most of the litter generated at turkey production facilities associated with Cargill's Plantation Foods complex in the central Texas region. The company began composting some of the turkey litter in 2000 and is currently developing markets for it's "Dr. Gobbler's Soil Rx" label. www.buycentraltexas.com/webpage.cfm?ID=14797
- **Elliot's Agri-Service:** Established in the fifties, this company was the first poultry litter clean-out service in Texas. Located in Pineland, the company has had limited experience with litter composting. The enterprise was sold to Living Earth Technology in 1999 and is not currently engaged in any litter composting activities.
- **BW Organics, Inc:** Based in Sulfur Springs, the company has been developing farm-scale rotary (in-vessel) composting systems for almost ten years. Their units have been tested with a variety of feedstocks, including poultry litter (and mortality). www.neto.com/bworgani/top.htm

9.5. Potential opportunities

Opportunities for additional poultry litter composting in Texas include:

- **TxDOT:** The agency's use of compost for roadside erosion control began several years ago and, to date, has been focused primarily in the central Texas region. However, plans are underway by TxDOT to expand compost procurement and use in other areas, including, in particular, east Texas, where a primary potential feedstock is broiler litter. For additional information regarding TxDOT's compost program, contact:

  - Barrie Cogburn, Landscape Architect
    Texas Department of Transportation
    125 E. 11th Street, Austin, TX 78701-2483
    512-416-3098; bcogburn@mailgw.dot.state.tx.us

  - Scott McCoy, Composting Specialist
    Texas Natural Resources Conservation Commission
    Office of Pollution Prevention & Recycling
    P.O. Box 13087, Austin, TX 78711-3087
    512-239-6774; smccoy@tnrcc.state.tx.us

- **Golden Crescent regional composting facility:** Efforts are underway to establish a regional composting facility in Victoria that will co-compost a variety of organic feedstocks. Victoria is about 65 miles from Gonzales, so it may be possible for surplus litter (and/or mortality) produced in the Gonzales area to be processed at the new regional facility when it is established. However, the economics will be challenging…the composting facility anticipates obtaining tipping fees for the feedstocks it receives (e.g., municipal brush/biosolids); this would not likely be the case for broiler and/or turkey litter produced in the Gonzales region (and the cost of transporting the material to the site near Victoria will increase the economic challenges).

- **Agriculture:** Several projects underway in the Cross Timbers region (Erath & Comanche counties) are helping dairy farmers develop surplus manure/phosphorus management programs. The primary focus has been compost production and marketing. Initial marketing efforts have focused on the emerging TxDOT markets, although forthcoming efforts are intended to focus on agricultural markets. The extent to which agricultural markets for compost products are developed/expanded in central Texas will likely benefit efforts to penetrate agricultural markets in other areas of the state (including those in or near poultry production areas).

- **Other:** For additional information regarding compost production and/or marketing in Texas and nationwide, contact:

- **Composting Advisory Council of the Texas Recycling Coalition**
  P.O. Box 2359
  Austin Texas
  USA 78768
  Tel: 512 469-6079
  Fax: 512 467-4759
  Contact: Jim Sherwin

- **United States Composting Council**
  200 Parkway Drive South Suite 310
  Hauppauge, NY 11788
  Phone: 631-864-2567
  Fax: 631-864-3796
  Email: admin@compostingcouncil.org

- **BioCycle Magazine**
  The JG Press, Inc.
  419 State Avenue
  Emmaus, PA. 18049
  Phone: 610-967-4135
  E-mail biocycle@jgpress.com

10. Litter Pelletizing Options & Opportunities

10.1. Technical considerations

Litter pelletizing is also a well-known technology, and the resulting products are considered desirable by a variety of potential consumers. The process of pelletizing poultry litter typically involves the following steps:

1. ***Grinding*** the litter to reduce particle size (and achieve uniformity).
2. ***Heating*** the litter to reduce moisture content to about 10% (wet basis); this step also reduces and/or eliminates pathogens.
3. ***Densifying*** the material into pellets; pelletizing equipment used for poultry litter are typically heavier duty than those used to make feed pellets from grains. Litter requires more energy to pelletize and is more abrasive, which reduces the service life for the ring dies in the pelletizer. Pellets produced for agronomic markets typically range from 1/8" ~ 3/8" diameter. Refer to www.cpmroskamp.com/productresults.asp?ID=PelletMills for a description of modern pellet mills.
4. ***Cooling*** the product before storage, packaging, and or transport to market.
5. Some pellet manufacturers include an additional process (e.g., chemical treatment) to reduce odor (some odor reduction occurs as a result of the initial heat treatment).

Attributes of pelletized litter:

- **Homogeniety:** Compared to raw litter, pellets are more consistent and uniform in composition.
- **Ease of handling:** Pellets are dry, consistent, and flow readily (in contrast to wet litter, which can bridge up), so are easier to handle than raw litter (standard materials handling equipment such as screw augers, bucket elevators, and fertilizer spreaders can be used).
- **Storage benefits:** Pelletized litter is easier to store than raw litter due to its ease of handling into and out of storage (e.g., silos) and its low moisture content (unlike raw litter, there is little concern regarding potential spontaneous combustion in deep stacks).
- **Variety of markets:** Most pellets are sold as soil amendment products (either in bulk to agricultural consumers or packaged for horticultural, residential, or other markets). It is also possible to fortify the pellet products during the production process to enhance the product's value for certain target markets. Litter can be co-pelletized with other feed material (e.g., corn, alfalfa) to make blended cattle feed (such products are typically ¾" diameter and referred to as "range cubes"). Pelletized litter can also be used as a fuel in pellet-fired energy systems.

- **Pathogens and odor:** Most pellets are pathogen free; however, most pellets retain much of the raw litter's odor, which limits potential product marketing (e.g., pellets with high odor levels are unsuitable for residential markets).
- **Bulk density and nutrient density:** The pelletizing process *does not* substantially increase either the bulk density or the nutrient density of litter (unless the product is fortified).

10.2. Economic considerations

- **Logistical costs:** Material transport, storage, and spreading costs are reduced (vis-à-vis raw litter) due to the physical attributes (ease of handling) of pellets.
- **Processing costs:** The pelletizing process, including the pre-treatment, densification, and post-pelletizing steps noted above, is expensive—typically $65~$100 or more per ton of pellets produced (one particularly expensive aspect is the reduced service life of the ring dies in the pelletizing unit – refer to www.jacobscorp.com/pellet_mill.htm#J4-Dies). Like other processing options, economies-of-scale are very important…the larger the pelletizing facility, the lower the manufacturing cost per ton.
- **Market value vs. product cost:** The economic value of the macro-nutrients within litter pellets is commonly calculated to be about $40 ~ $50 (based on the retail value of the displaced nitrogen, phosphorus, and potassium from conventional sources). However, as with compost, there is considerable variation in the perceived value of the non-NPK agronomic [and associated economic] value of litter pellets, with essentially none of the non-NPK benefits reflected in the markets' valuations.

Product prices in most bulk pellet markets [for agricultural applications] are in the range of $140 ~ $200 per ton, as these are widely considered the minimum amount that must be recovered to offset total costs (including processing, transportation, marketing/spreading, overhead, and profit). While there are some consumers willing to pay such costs for pelletized litter, most consumers apparently do not consider the product to be worth this amount.

10.3. Litter pelletizing experiences

Because of high costs of making and selling pellets vs. soft product demand, litter pelletizing has been an "uphill battle." Numerous litter pelletizing facilities have been established in the U.S. within the past fifteen years, but few are still in business (and most of those appear to be struggling).

Three specific examples of pelletizing operations currently underway include:

- **Perdue-AgriRecycle:** A joint venture between Perdue Farms and AgriRecycle was recently established to provide a large-scale export option for some of the surplus litter generated in

the "Delmarva" region.[30] The facility, which opened in 2001, is designed to pelletize up to 88,000 tons of litter per year.[31] The company's marketing plan is to [transport and] sell products to agricultural consumers in the Midwest. The facility incorporates numerous odor and dust control systems and is widely regarded as "state-of-the-art" in litter pelletizing. For more information contact: www.agrirecycle.com or www.perdue.com/corporate/pellet_plant_schematic.pdf.

- **Harmony Products:** The company specializes in blending of various organic materials into premium organic fertilizer and soil amendment products. The company's first operation that uses primarily litter feedstocks is located in Harrisonburg, Virginia (adjacent to a Cargill poultry processing facility) and began operations in 2001. Products are manufactured in granular and pelletized forms. See www.harmonyproducts.com.
- **Oates Farm and Feed:** Located in Crockett, the company blends some litter with other feed ingredients to make ¾" diameter range cubes (up to 20% litter). The company has been listed as a service provider on the Texas Litter Hotline, although litter transport and use is only a small portion of its business (and demand for range cubes containing some litter is seasonal).

10.4. Potential opportunities

It is considered unlikely that a litter pelletizing operation will be established for surplus litter management in any of the areas of concentrated poultry production in Texas because: a) the economics of litter pelletizing are not favorable (i.e., substantial supplemental financial support is required to achieve breakeven financial performance); and b) the risks associated with product marketing are high (the existence of large-volume markets for pelletized litter products is questionable, and it is unlikely that any long-term product purchase commitments can be secured).

[30] Delmarva is the strip of land on the Eastern Shore of the Chesapeake Bay that is contains lands within three states (Delaware, Maryland, and Virginia).
[31] AgriRecycle is based in Springfield, Missouri; the company's original [and still operational] litter pelletizing facility is located in Purdy, MO.

11. Litter-to-Energy Options & Opportunities

11.1. Litter-to-Energy Options & Opportunities

Litter-to-energy conversion systems can be considered—at least in theory—at either the farm level or at a larger, centralized level. While the remaining portion of this section pertains to large-scale (off-farm) systems, the following comments apply to **on-farm litter-to-energy**:

- The concept of an on-farm system is attractive, in that such a system could convert litter into thermal and/or electrical energy for use on the farm, thereby avoiding transport of surplus litter off of the farm and displacing at least some (if not all) of the energy used on the farm.
- The energy content of broiler litter (as produced in east Texas) is about 4,600 Btu per pound (@ 25% moisture content, wet basis). Assuming that a typical broiler farm produces about 125 tons of litter per year, there is sufficient energy contained within the litter to provide more than 100% of the thermal (space heating) and electrical energy consumed by a typical broiler house located in east Texas—refer to the estimates and calculations in Appendix B. (In theory, surplus electricity could be sold to neighbors or into the grid, providing another source of revenue.) Another perspective is that only about 60% of the litter produced on a broiler farm would be required to generate 100% of the thermal and electrical energy demand for the broiler farm.
- All of the phosphorus, potash, calcium, and trace minerals in the litter would survive a combustion/gasification process and end up in the ash. Broiler litter ash is a dry, homogenous, pathogen-free, odor-free, phosphorus-rich (about 20%) material that can be readily transported (and exported) and blended with other inorganic fertilizer ingredients and therefore has significant market value (estimated at about $50 per ton in bulk, aggregated). Thus, use of an on-farm energy system would also entail collection and subsequent export of the ash "co-product" as a means of addressing phosphorus concerns while also generating a new revenue for the farmer.
- As described above, an on-farm litter-to-energy system could have three "energy" co-products: heat, electricity, and ash, and could be an effective way to address surplus phosphorus concerns.
- Despite the attractiveness of an on-farm litter-to-energy system, no such systems are currently available. Numerous attempts have been made to develop such a system although, to date, none have been successful. Nonetheless, given the numerous potential benefits and attractiveness, some efforts are still underway to develop an on-farm litter-to-energy system, including, in particular:
  - **Wood-Mizer** (WM): This company, which developed the portable sawmill over twenty years ago, is working with a subsidiary, External Power LLC (EP), to develop small bio-energy systems for thermal and cogeneration applications. With support from the U.S. Department of Energy's Commercialization Ventures Program, WM and EP are working

on a project (administered by FORM) to develop several biomass-fired furnaces specifically for poultry farm applications. The first two units will use sawdust as fuel; one is designed for space heating; the other will provide both thermal and electrical output. After the sawdust-fired units become commercially available (anticipated to occur in 2003) the companies intend to develop similar farm-scale units using litter as fuel. It is not known if or when the litter-fired furnaces will be commercially available. For more information contact: www.wood-mizer.com/domino/html/woodmizer/woodmizer.nsf

- **Community Power Corporation** (CPC): This company has also been developing small bioenergy cogeneration systems—their first commercial products were installed in the Philippines in 2001. Also in 2001 CPC and FORM received a grant from the U.S. Department of Energy to develop modified versions of CPC's small gasifier for poultry farm cogeneration applications using litter fuel. The company's business plan calls for units to be commercially available in 2004. For more information contact: www.gocpc.com/.
- **Pellet-fired heating system**: During the period 1997~2000, FORM engaged Pyro Industries[32] (with funding support from DOE) to assist with the design and development of a pellet-fired furnace system specifically for poultry house space heating. A full-scale furnace system was successfully tested using both wood- and litter-derived pellets. It is anticipated that, with several additional technical refinements, the unit will be technically viable, although economic feasibility will likely not occur until: a) the price of propane rises to [and stays above] well over $1.00 per gallon; or b) a new pelletizing technology is developed.[33]

11.2. Off-farm (large-scale, centralized) litter-to-energy systems

A large-scale, centralized litter-to-energy system could provide a surplus litter management option for many poultry growers within a given production region. There are numerous potential benefits associated with such an off-farm approach; in particular, such an approach is well proven…there are four large-scale litter-to-energy facilities, ranging from 100,000 ~ 400,000 tons per year, that have been in operation from 1 ~ 10 years. Electrical output of the systems can be approximated at 10 megawatts (MW) per 100,000 tons [per year] of litter.

The four facilities are all located in the United Kingdom, where fifty percent of all of the poultry litter produced in the country is converted into energy (three are in England; the fourth is in Scotland). The combined twenty-four years of successful operating experience of these facilities

[32] Pyro Industries is the largest manufacturer of pellet-fired heating systems for residential applications and was a primary force in the establishment of the wood pellet fuel industry in North America. However, the company withdrew from the CVP project after it was purchased by Lennox Industries in 2000 (all rights to the pellet-fired furnace system for poultry house heating applications were conveyed to FORM).

[33] In particular, what is needed is a pelletizing system that can: a) be portable, i.e., could pelletize the material at the poultry farm; and b) densify the material at relatively high moisture content (i.e., at 25% moisture content, instead of 10% which is the requirement for existing pelletizing equipment; the ability to pelletize higher moisture content material would reduce both capital and operating costs and enhance the potential portability of the technology).

clearly demonstrates the technical viability of converting poultry litter into electricity. Moreover, as noted above, phosphorus and other minerals contained in the litter survive the conversion process and are captured and exported (in ash form) as co-products.

11.3. Technical considerations

- **Products*:*** One or more of the following energy products can be derived from litter:
  - Thermal (e.g., process steam or hot air, either from a combustion, gasification, or anaerobic digestion process)
  - Electrical (an indirect product created by through a steam-driven turbine-generator, although research and development efforts are underway to develop solid fuel-fired turbines that use the direct products of combustion or gasification, thereby eliminating the steam cycle).
  - Fertilizer (often described as an energy product, since fertilizer manufacturing is an energy-intensive process)
  - Liquid fuels (e.g., methanol, ethanol, biodiesel)
- **Energy conversion technologies:**
  - Combustion / gasification: As discussed below, combustion of litter into thermal and electrical energy is well-known and commercially proven (although there is increasing interest in gasification systems).
  - Anaerobic digestion*:* Essentially all biodegradable materials are degradable (digestible) in an anaerobic environment and can produce biogas (which consists of 35%~70% methane), although the technology is usable only with aqueous or slurried feedstocks (e.g., scraped or flushed manure). Thus, anaerobic digestion of litter would entail adding water to the relatively dry material to convert it into slurry form. The efficiency of the subsequent anaerobic digestion process of the litter would be impeded by the nature of the litter feedstocks (the high-cellulose content bedding material [e.g., sawdust] is much more difficult to degrade than the volatile solids contained in the manure). Finally, significant additional processing [primarily moisture removal) of the effluent from the digester would be required in order to export the material. Alternately, flocculation or other processes could be employed to extract the phosphorus from the effluent, thereby enabling export of the nutrient. Each of the steps noted above entails a process, none of which have yet been proven commercially with litter feedstocks. Thus, digestion of poultry litter—particularly as a means of phosphorus management—is not considered feasible by most anaerobic digestion specialists.
  - Fermentation and other processes: Numerous efforts have been invested in the past twenty years to develop cellulose-to-ethanol (CTE) technologies that can convert various biomass materials (e.g., waste paper, sawdust, sludge) into ethanol and/or high-value

chemicals (e.g., acetic acid, lactic acid). Some of the technologies employ thermo-chemical conversion of the biomass feedstocks (to transform the solid material into gaseous form) before subsequent conversion [via fermentation] of the gasified cellulose and hemicellulose into ethanol/high-value chemicals, although most utilize acid or enzymatic hydrolysis pre-treatments prior to fermentation. A recent assessment of CTE technologies using litter feedstocks by FORM concluded that the technologies have not yet been commercialized (i.e., CTE technologies are still in research and development phases) and that litter is a poor feedstock for CTE processes (relative to other potential biomass feedstocks); a copy of the report is available at: www.organix.org.

- A research project underway at Western Virginia University (with support from DOE) is evaluating the technical feasibility of converting litter into biodiesel. For more information contact: www.ott.doe.gov/rbep/pdfs/poultry_biomass.pdf

➢ **The fate of phosphorus**: Essentially all of the phosphorus contained in poultry litter survives the combustion/gasification process and ends up in the ash (poultry litter has high ash content, averaging approximately twenty percent by weight). The phosphorus-rich ash is considered readily marketable as a conventional fertilizer and is therefore considered a co-product that would enhance the enterprise's economics. Assuming that the ash is sold into markets elsewhere (e.g., to grain producers in other watersheds), then such a scenario would provide an effective means of exporting the phosphorus contained in the litter from areas of concentrated poultry production where concerns have risen regarding potential water quality impacts associated with the phosphorus in land-applied litter.

11.4. Economic considerations

➢ **Product markets**: The economic factor that sets litter-to-electricity systems apart from all other litter conversion technologies is that markets for electricity are available essentially everywhere and that long-term power purchase contracts are "standard operating procedure." In other words, a litter-to-electricity facility represents minimal risk to investors in that long-term product purchase commitments can be established prior to facility financing.

The co-products from cogeneration systems – thermal energy and electrical energy – are both used in large quantities at poultry processing facilities. Thus, co-locating a litter-to-energy facility next to a processing facility may of interest to integrators.

➢ **Product prices**: If sold to the grid, the prices offered for the electrical product is often just the utility's avoided cost. If used to displace otherwise purchased energy, the value of both thermal and electrical products becomes is at almost the full retail or industrial rate (there may be some offsetting standby charges). One hybrid option is to "wheel" the electricity to a target customer(s). The resulting product prices would be at or near the displaced energy cost, less applicable transmission / distribution costs. http://www.eren.doe.gov/state_energy/policy_casestudies_texas.cfm Another option may be

to sell the litter-derived electricity/steam (i.e., renewable energy) at premium prices through "green power" marketing: www.green-e.org, www.cleanenergy.org/greenpower/, www.eren.doe.gov/greenpower/home.shtml.

- **Capital costs**: The current capital costs of bioenergy systems, including litter-to-energy systems, is high (relative to systems using fossil fuels); rough estimates are approximate $3,000 per KW of installed capacity ($3,000,000 per MW).
- **Economies of scale** are critical. According to Fibrowatt, the minimum target size for a facility is 300,000 tons per year (although smaller facilities are certainly technically viable, while larger facilities would be even more cost effective).
- **Public sector incentives**: There is increasing public support for renewable energy systems, including:
  - An existing federal tax credit specifically for production of electricity from poultry litter (the current tax credit rate is $0.017 per kilowatt-hour). The credit is usable for ten years, although the facility must be in service by December 2004 to qualify. The U.S. Senate's version of the 2002 Energy Bill contains a two-year extension for the qualifying period.
  - There are numerous components within the *Farm Security and Rural Investment Act of 2002* (i.e., the "2002 Farm Bill") that support bioenergy activities (e.g., Title IX-Energy). www.usda.gov/farmbill
  - Another public sector incentive is a renewables portfolio standard, or mandate. Such a mandate was established in Texas in 1999 as part of the state's energy deregulation legislation. §25.173[34] requires that 2,000 MW of renewable energy be brought on line in the state by the end of 2008. www.eren.doe.gov/state_energy/policy_casestudies_texas.cfm
  - Subsidies from federal/state programs (e.g., EPA's 319 Nonpoint Source program, NRCS' EQIP) to offset transport costs (e.g., to a value-added conversion facility), nitrogen replacement (for nitrogen within litter exported from the production farm which is therefore *not* applied to the farm's croplands), or bedding replacement.
- **Thermal vs. electrical (or cogeneration) facilities**: The overall system efficiency (i.e., net usable energy produced vs. the theoretical amount of energy contained in the litter feedstocks) of a thermal system is much higher than a system producing electrical energy or a cogeneration system (i.e., a system producing both thermal and electrical products). Accordingly, the economics of a thermal facility are likely to be more attractive than electrical or "cogen" facilities. Thus, where possible, litter-to-energy systems should identify and target thermal markets.
- **Overall enterprise economics**: The economics of litter-to-electricity facilities are not considered attractive without supplemental financial support—i.e., without supplemental finan-

[34] www.puc.state.tx.us/rules/subrules/electric/25.173/25.173.pdf

cial support it is unlikely that investors or entrepreneurs will invest in such enterprises. The amount of supplemental financial support required to breakeven (and to achieve target performance levels by investors) will depend on the factors discussed above, including, in particular, the sales price of the electricity (e.g., avoided cost vs. wholesale vs. displaced retail). Sources of supplemental financial support might include the public sector (e.g., grants from federal or state sources, additional state-level tax credits, other operational support programs) and/or the private sector (e.g., premium prices from green power purchasers, grants or operational support from poultry companies).

11.5. Litter-to-energy experiences

- Since 1992, a private company (Fibrowatt - www.fibrowatt.com) has constructed and operated three power plants in the U.K. that use poultry litter exclusively for fuel (facility sizes range from 12 to 40 megawatts). Fibrowatt has been actively pursuing establishment of a litter-fired facility in the U.S., including a 400,000-ton per year turkey litter-fired facility in Minnesota (construction is anticipated to begin in the Fall of 2002 - www.fibrowatt.com/US-Benson/index.html). The company employs traveling grate / spreader stoker boiler technology, which has been commercially proven at their three facilities to be robust and reliable and certainly usable with litter feedstocks. All of the company's ash is sold as a co-product (www.fibrowatt.com/UK-Corporate/Fibrophos.html).
- In April 2001, Energy Power Resources Ltd (EPR) brought on line a 100,000 (10 MW) litter-to-energy facility, located in Scotland. EPR has several bioenergy facilities in the U.K. and elsewhere, although this is the company's first facility using litter feedstocks. The system employs a fluidized bed boiler, and is claimed to achieve higher system efficiencies and lower stack emissions than traditional combustion systems. EPR is a subsidiary of First Renewables, LTD, which is a major shareholder of Fibrowatt. www.fibrowatt.com/History.html
- Several other developers/vendors of biomass-fired combustion/gasification systems have been promoting their technologies in recent years for use with litter feedstocks, such as:
  - Primenergy (based in Tulsa) www.primenergy.com;
  - DukeSolutions www.duke-energy.com/decorp/content/default.asp;
  - Renewable Energy Corporation CEES/Heuristic Engineering www.renrg.com and www.heuristicengineering.com;
  - Energy Products of Idaho; and BG Technologies, Inc. www.energyproducts.com and www.bgtechnologies.net

  DukeSolutions, in cooperation with Harmony Products (refer to the section on pelletizing), has established a relatively small litter-to-energy facility at a Cargill complex in Harrisonburg, VA (the litter is converted into thermal energy using a Renewable Energy Corporation

system; the thermal energy is used for drying other litter used in the Harmony Products process).

11.6. Potential opportunities in Texas

- **Regional litter-to-electricity facilities*:*** There are three poultry production areas in Texas where sufficient litter is generated to potentially support a large-scale, off-farm litter-to-energy facility: east Texas (the Nacogdoches area), northeast Texas (the Pittsburg area), and south-central Texas (the Gonzales area). Each area could consist of multiple production complexes; in the east Texas and south-central Texas areas, a regional facility could also serve multiple integrators.
- **Thermal/Cogeneration facilities*:*** A smaller-scale system focused primarily or exclusively on thermal output (or thermal and electrical products) could, in theory, be located at any of the poultry processing facilities in Texas (because of the thermal load at the processing facility).
- **On-farm litter-to-energy systems*:*** As a result of several efforts currently underway, litter-fired furnaces for space heating and/or on-farm electrical generation may become available within the 2~3 year timeframe; however, because significant hurdles must still be overcome in order for the systems to be commercially viable, such options should not be relied upon as a surplus litter management option until such time as the systems are proven to technically viable and economically feasible.

12. Deployment considerations

Aggregation of feedstocks and coordination of subsequent export and marketing activities must be coordinated on a regional basis. The existing independent contract producer structure and the independent litter service provider industry are not conducive to the establishment of centralized and regionally coordinated enterprises. The challenges of establishing a regionally coordinated litter management system are not to be underestimated. The vast majority of litter services (clean-out, collection, hauling and spreading) are currently performed by small, local clean-out contractors. These COCs, utilizing their own equipment, coordinate litter clean-out with producers; they apply the litter to the producers' pastures and hay fields or haul the litter to other pastures in the immediate proximity (typically within five miles) of the production farm for spreading.

Existing COCs could readily be incorporated into a regionally coordinated litter management system, thereby utilizing their expertise and relationships with producers to make operations of the system more customer-friendly while simultaneously increasing the efficiency of their existing operations. Neither producers nor integrators would be directly involved in handling the litter once it is removed from the poultry house. The separateness of this enterprise from direct

industry participants would enable it to focus on its primary purpose (movement of litter), to be *independent of* the business functions of the poultry enterprises and to work with producers and multiple integrators simultaneously.

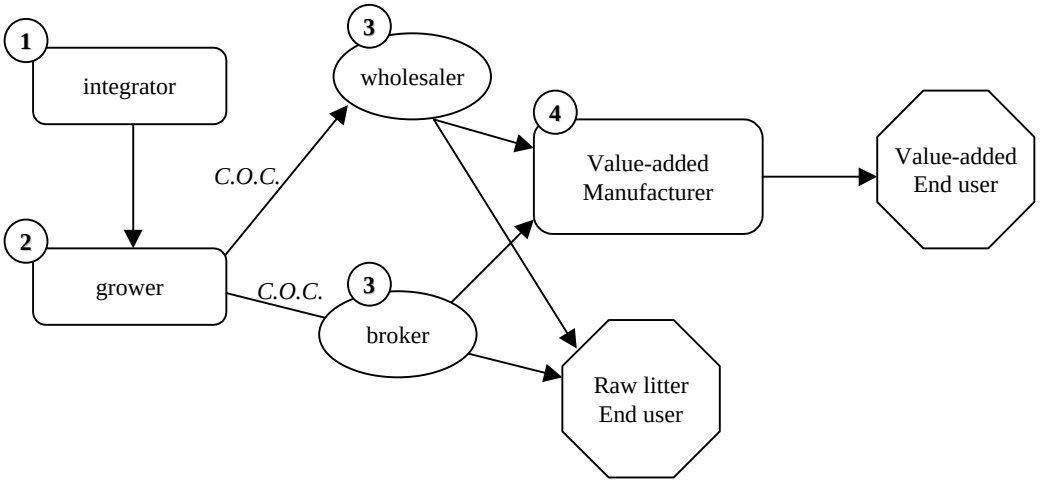
- **The Benefits of a Regional Approach:** A regionally coordinated litter management system would remove operational and management activities of litter handling beyond the farm gate from the producers and integrators. This would result in an entity focused exclusively on litter management and utilization: an enterprise that would be better positioned to achieve litter management goals efficiently while simultaneously helping to stimulate economically sustainable development of litter utilization alternatives.

  Currently, transaction costs for sufficient quantities of litter to make alternatives economically efficient are too high and coordination efforts too onerous to permit individual development of viable off-farm litter management activities. Thus, there exists the definite need for a regionally coordinated litter management enterprise to address the aggregation/assembly function and enable establishment of litter export initiatives to move forward.

- **How a Regional Approach Would Work:** The enterprise would provide, at a minimum, either wholesale or brokerage functions to affect coordination and aggregation of the raw litter and would serve as a contact point to coordinate clean-out and hauling from poultry houses to other locations. It would also coordinate clean-out scheduling between integrators and producers, as necessary, and could also coordinate supplies of raw litter to end-users or handlers and processors of raw litter to ensure supplies as needed.

  Appropriate coordination would enable raw litter to be stored in the poultry houses until needed, thus minimizing the necessity of additional storage facilities through a "just-in-time" inventory system. Coordinating or performing contracting/subcontracting with end-users, handlers and processors would lower transaction costs by streamlining the necessary processes between and among the various parties involved. Participants in the entire marketing channel could have access to these services. The functions of such an enterprise are shown in Figure 17.

Figure 17.Off-farm litter management and third-party enterprise functions



Various operational activities (primarily logistical and administrative) must also be coordinated to effectively implement a regionally coordinated litter management enterprise. Logistical considerations may be grouped into on-farm and off-farm logistics. On-farm logistics primarily involve scheduling of clean-out and hauling activities (and, possibly, some on-farm storage); predominant factors include coordination with flock removal/placement, type of poultry involved, biosecurity, and seasonal considerations. Off-farm logistics also involve extensive handling, transportation and facility siting decisions. For a more detailed discussion of regionally coordinated litter management enterprises (including an in-depth discussion of the roles of the public and private sectors in deployment of a regionally coordinated litter management enterprise), refer to "Off-Farm Litter Management and Third Party Enterprises", released by FORM in April 2000.[35]

[35] http://www.organix.org/Projects/clme/clme.htm

13. Observations and Conclusions

- Traditional spreading of litter on [or near] production farms using nitrogen-based application rates has led to accumulation of phosphorus in those soils. Such accumulation has reached levels on many farms that increase the possibility of movement of the surplus phosphorus from the application fields into surface waters. It is anticipated that widespread existence of high soil-phosphorus levels on poultry farms will become increasingly evident as farms obtain new or revised comprehensive nutrient management plans. Thus, development of those plans will increasingly result in designation of *surplus* litter (i.e., that material that cannot be applied on the farm's lands without exceeding soil-phosphorus levels established by TNRCC or other nutrient management criteria established by TSSWCB or NRCS).
- Environmental concerns associated with these traditional litter management practices will increasing require alternative strategies for managing surplus litter.
- On-farm conservation and best management practices that have been deployed in the past ten years cannot avoid soil-phosphorus accumulation in many situations, particularly on farms that apply litter to pasturelands for subsequent cattle production (because of the phosphorus-recycling phenomenon associated with such farming systems).
- The only long-term and sustainable approach in managing surplus phosphorus will be to remove the surplus material from the farm. Depending on other circumstances, surplus phosphorus may also need to be exported from the watershed or area of concentrated poultry production.
- Where feasible, local markets for surplus raw litter should be developed or expanded. However, spreading of litter on nearby croplands may be limited in some areas of concentrated poultry production because most (if not all) of the croplands have already been used for litter application and may have reached high (or even excessive) soil-phosphorus levels.
- In such instances, new markets for the surplus raw litter will be needed. Raw litter markets need to be as close as possible to the production farms in order to minimize transportation costs (and possible logistical challenges associated with spreading of raw litter in distant markets).
- One possible raw litter option, particularly for the east Texas region, may be to apply litter to forestlands. Fertilization of timber lands has been increasing as market pressures have led the forest products industry to minimize timber production cycles. Timber fertilization includes phosphorus applications, and litter has been shown to be a viable source of nutrients (including phosphorus) for both hardwoods and softwoods. However, application of litter on forestlands requires specialized (and expensive) equipment; coupled with the uncertainty of markets (approximately 12,000 acres per year can be fertilized with one application unit), such investments are considered risky. Thus, it is unlikely that any private entrepreneur will pursue such raw litter markets unless a substantial

commitment is made by the forest products industry in east Texas for purchase and use of poultry litter.

- Other possible markets for raw litter in Texas include rice lands (particularly the cut portions after laser leveling), mine land reclamation, and distant forage, crop, or pasturelands (relative to such agricultural lands in the vicinity of poultry production areas).
- The economics of raw litter marketing can be challenging and perhaps not feasible, depending primarily on the market distance (i.e., the cost of transporting the litter) and market prices for the litter; markets for raw litter often do not acknowledge the full spectrum of agronomic benefits associated with litter (e.g., the non-NPK benefits) and therefore do not reflect the product's full economic value.
- Regardless of the target market(s) pursued for raw litter, individual producers do no have the resources to effectively market their material off-farm. Moreover, existing service providers also have limited resources and need help with market development and expansion. Assistance efforts such as the Litter Hotline established under this Project can help ensure export of surplus raw litter.
- If raw litter markets are not available or not feasible, then processed litter options should be considered. Various conversion technologies are available that can convert the litter into value-added products and/or enhance the exportability of the surplus phosphorus contained within the litter.
- Conversion of litter into litter-derived products can increase the exportability of the material by opening up new markets for the LDPs. Pursuit of litter conversion technologies and manufacturing of LDPs should be market-focused, i.e., such approaches should not be pursued if the risks of product marketing are excessive ("Don't make it if you can't sell it!").
- On-farm conversion systems are attractive in theory; however, no such systems are considered feasible under current economic conditions. Two primary approaches for on-farm conversion include litter-to-energy and composting. In either case, the surplus phosphorus (in whatever form it is in after the conversion process) must be exported from the production farm (and perhaps out of the watershed or area of concentrated poultry production).
- Regarding on-farm composting, key considerations include:
  - Quantity of feedstocks – it is unlikely that sufficient litter is generated on a single poultry farm to justify investment in composting equipment).
  - Product markets – the farmer will also have to develop markets for the compost products, probably in competition with existing compost products).
  - Quality control – production of high and consistent quality products is essential for market penetration and sustainability. This requires composting expertise (either by the farmer, or by engaging a composting specialist).

- Technical challenges – additional carbon (e.g., wood chips) is needed for effective composting of broiler litter; effective on-site mixing of the carbon with the litter would be challenging.

For these reasons, on-farm composting is unlikely to be feasible and is not recommended as a surplus litter/phosphorus management strategy for the typical poultry producer.

- Regarding on-farm litter-to-energy, key considerations include:
  - Quantity of feedstocks – the amount of litter generated on a broiler farm is typically sufficient to provide more than the thermal and electrical energy requirements for that farm—approximately 60% of the litter would be required to provide 100% of the farm's energy needs.
  - Product markets – the on-farm energy markets are obvious, although the surplus phosphorus in the ash generated by the process will need to be exported from the farm.
  - Quality control – production of high and consistent quality electrical and thermal output is essential for on-farm use (and particularly if surplus electricity is sold into the grid). This requires an effective conversion system and effective operation (monitoring, maintenance, and trouble-shooting).
  - Technical challenges – currently there are no on-farm bioenergy systems that are robust, reliable, and can effectively use litter feedstocks.

  For these reasons, on-farm litter-to-energy is not currently feasible, although efforts are underway to develop and commercialize such systems within 2~4 years.

- Off-farm litter conversion technologies are considered more attractive in that:
  - Economies of scale can be achieved – the potential for achieving economic viability is greater.
  - Centralized systems can relieve producers of the hassle and liability associated with surplus litter management.
  - Processing, marketing, and management expertise can be employed.
  - Opportunities for obtaining public sector support may be enhanced.
  - A large-scale, regionally-coordinated approach could be coordinated and management by a third-party enterprise (e.g., a nonprofit "litter bank").
- Off-farm (centralized) litter conversion technologies include:
  - Composting.
  - Pelletizing (and other forms of densification).
  - Energy (combustion, gasification, anaerobic digestion).

- Other (e.g., chemical treatment).

➢ Regarding centralized litter composting:

- Quantity of feedstocks – The target entry size for a commercial-scale composting enterprise is about 20,000 tons of feedstocks per year. At an average of 125 tons per year of litter [and cake] per house and four houses per farm, a centralized composting operation could serve 40 farms (or 80 farms, if, on average, each farm exports 50% of its litter).
- Product markets – The facility would compete with other compost products in existing markets; new markets are opening up by TxDOT for roadside erosion control (including planned expansion of TxDOT's program in east Texas).
- Quality control – Focus on production of high and consistent quality products could be ensured by engaging composting expertise.
- Technical challenges – Additional carbon (e.g., wood chips) is needed for effective composting of broiler litter. The cost of acquiring and the challenge of effective mixing of additional carbon are substantial.
- Economic realities – A composting enterprise using litter feedstocks would likely have to pay for the feedstock (at least for clean-out and delivery costs, and probably for the actual material). In contrast, municipal composting operations typically get paid to receive their feedstocks. Nonetheless, the products from both enterprises would be often be competing in the marketplace…under these circumstances, the economic challenges facing the litter composting operation are obvious.

➢ Regarding centralized litter pelletizing:

- Although pelletized litter has numerous agronomic benefits, market prices for the products have to be high to cover the high costs of processing and marketing. Accordingly, commercial experience has been fraught with failures—most of the facilities constructed within the past fifteen years in the U.S. are either closed or struggling.

➢ Regarding centralized litter-to-energy:

- Manure can be converted into biogas through anaerobic digestion, although the technology is not suitable for poultry litter (because of its low moisture content, high ash content, and high lignin and cellulose content) and has never been successfully demonstrated with litter feedstocks.
- Litter could be converted into ethanol, although the cellulose-to-ethanol conversion technologies are still in research and development stages and not yet commercially viable; moreover, litter is a low-priority feedstock for these emerging technologies (from both physical and economic perspectives).

- Litter can be converted into thermal and/or electrical energy through a thermo-chemical process (e.g., combustion, gasification), followed by a conventional steam-driven turbine-generator system. In round figures, approximately 100,000 tons of litter can generate 10 MW of electricity.
- Through combustion/gasification, one hundred percent of the phosphorus is captured in the ash (along with all of the potash, calcium, and micro-nutrients). The resulting ash co-product is a homogeneous, high bulk density, readily transportable and marketable material (estimated value of $50 per ton, wholesale), and an excellent medium for export of the captured surplus phosphorus (the phosphorus content of the ash is approximately 20%).
- The technology is commercially proven—there are four large-scale litter-to-energy facilities (all located in the UK). Facility sizes range from 12 MW to over 40 MW; online operational experience ranges from over one year to over twelve years. Thus, the technological risk associated with litter-to-electricity facilities is almost nonexistent
- Markets for the primary product—electricity—are omnipresent. The unique aspect of this litter-derived product is that long-term purchase commitments are readily available (power purchase agreements are standard practice for industrial consumers).
- If the electricity is sold to the utility, then the price of the power will likely be low (i.e., at or near the utility's avoided cost). However, since production of electricity from litter is considered a form of renewable energy, the utility may be willing to pay a premium for the power. This may be the case in Texas, where the energy industry is mandated to generate 2,000 MW of renewable-based electricity by 2009.
- Another option is to wheel the power to specific large-volume (industrial) customers (the higher prices would be offset somewhat by transmission/distribution charges).
- Another option is to sell the electricity through a green power program. There are numerous programs underway around the country where consumers voluntarily pay above-market rates for renewable-based electricity.
- Establishing long-term power purchase agreements with premium green-power pricing would minimize the financial risk associated with such an enterprise.

➢ Of all the large-scale, off-farm surplus litter management conversion technologies, litter-to-electricity is deemed to be the most attractive because it entails minimal technical and financial risk, relative to all other options. Thus, this option represents maximum potential confidence levels for investors.

➢ However, under current economic conditions, none of the surplus litter management options described herein (including litter-to-electricity) are considered economically viable. Therefore, deployment of any such option would require supplemental financial support (from

the public and/or private sectors). Moreover, without such supplemental support it is unlikely that any private entrepreneur will establish a large-scale surplus litter management program in Texas.

- One strategy for proceeding with deployment of a large-scale surplus litter management program under current conditions is to establish a third-party nonprofit organization that would serve as the deployment vehicle for a regional initiative. There are numerous potential benefits associated with such a strategy:
  - A nonprofit organization is an attractive mechanism for securing additional financial support to ensure enterprise viability (from both the public and the private sectors).
  - Given the transparent nature of a nonprofit organization, use of this structure should optimize potential support and "buy-in" from various stakeholders and interested parties.
  - The nonprofit provides opportunities for tax-free bond financing of the conversion facility.
  - The Litter Bank will purchase litter from participating growers, thereby transferring ownership, responsibility, and liability associated with the litter from the grower to the enterprise.
  - Growers who sell 100% of their litter to the Litter Bank should not need to obtain [or comply with] a comprehensive nutrient management plan, since no litter would be used on-farm.
- A public-private partnership providing supplemental financial support to a nonprofit "litter bank" that would establish a litter-to-electricity facility serving an entire region of poultry production is considered a viable approach for deploying a large-scale surplus litter management program that could effectively address water quality concerns (through export of the surplus phosphorus in the form of the ash co-product) while also helping ensure the economic viability of the region's poultry industry (by transferring surplus litter management responsibilities and liabilities from the growers and providing a mechanism for supplement investments required for break-even financial performance).

14. Recommendations

- As the poultry industry in Texas comes under increasing scrutiny regarding environmental concerns and potential regulatory constraints vis-à-vis traditional on-farm litter management practices, the industry should consider deployment of a large-scale litter-to-electricity facility through establishment an operation of a regional litter bank. To minimize effort and cost, it may be possible to establish a "branch bank" of the Ozark Litter Bank currently being established (to serve the northwest Arkansas / northeast Oklahoma / southwest Missouri region of concentrated poultry production).
- Specific activities that should be undertaken as follow-up to this Project include:
  - **Industry coordination**: The poultry industry and the technical assistance agencies in Texas should continue to assess options for addressing surplus litter management concerns. One mechanism to accomplish this would be to establish a task force focused on surplus litter management issues and options. Similar mechanisms used elsewhere have been shown to be effective in coordinating efforts to identify and evaluate both technological options as well as strategic approaches.
  - **Litter Hotline** – the "match-making" mechanism established under this Project needs to be continued. FORM has transferred the rights and responsibilities of the Hotline (***www.litterhotline.com***) to Stephen F. Austin University – Department of Agriculture (SFA-DA)[36]; however, additional financial support may be needed by SFA-DA for hotline operations.
  - **Litter and forestlands** – The efforts to monitor the demonstration plot established in 2001 under this Project that have been underway at SFA – College of Forestry[37] should be continued; additional financial support may be needed by SFA for monitoring efforts. Additional demonstrations also appear warranted, since forestlands represent the only significant opportunity for expanding local raw litter markets in east Texas.
  - **Litter and rice lands**: Since another priority target market for raw litter is on rice lands (such a market might serve both the east Texas and south-central Texas poultry production areas), a demonstration of the benefits of using litter on rice lands could be an effective means of developing such markets.
  - **Litter and forage lands**: Yet another target market for raw litter is on forage lands (particularly the areas of intensive forage production between the Nacogdoches area and Interstate-35); a demonstration of the benefits of using litter on forage lands could be an effective means of developing such markets.
  - **Statewide symposium**: A symposium or conference should be convened at which the poultry industry, technical assistance agencies, and other interested parties could learn

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[37] Contact Dr. Kenneth Farrish, Associate Professor, SFA College of Forestry

more about the issues and options presented herein, discuss the need for surplus litter management options, and develop strategies for deploying surplus litter management initiatives.

- **Additional outreach and education**: a) Copies of this report should be distributed to poultry industry participants and technical assistance agencies (including, for example, conservation district offices, NRCS staff, and TAEX staff); b) Another method of conveying some of the information set forth herein would be through development and dissemination of a poster (e.g., a poster that uses colored graphics with text annotations); and c) Additional workshops are needed to ensure that poultry producers and companies understand the issues and options associated with surplus litter management (alternately, such topics need to be included in other workshops convened for poultry industry participants).

Two of the partners on this Project – **SFA Department of Agriculture** and the **Pineywoods Resource Conservation and Development Council** – have expressed their desire to pursue some or all of the follow-up activities discussed above, provided that financial assistance can be secure to support such efforts.

15. Appendices

Appendix A. Physical Description and Compositional Analysis of Broiler Litter

Variable	Units	Dry Wt. Basis	As-Is Basis
Water Content	g/g	0.46	0.26
pH		7.88	---
E.C.	uS/cm	6783	---
Alkalinity	Mg	21160	14317
Total Elemental Analysis			
TKN	mg/kg	45399	31257
K	mg/kg	33118	22749
Na	mg/kg	8401	5807
S	mg/kg	7682	5270
TP	mg/kg	22121	15201
Ca	mg/kg	34309	23508
Mg	mg/kg	6995	4796
Fe	mg/kg	942	651
B	mg/kg	55.6	38.4
Cu	mg/kg	526	365
Al	mg/kg	706	489
Mn	mg/kg	653	453
As	mg/kg	44.8	30.9
Se	mg/kg	16.2	11.1
Ni	mg/kg	16.5	11.3
Mo	mg/kg	5.71	3.94
Cr	mg/kg	8.28	5.71
Co	mg/kg	4.28	2.95
Water Soluble Components			
Soluble C	mg/kg	39775	27243
SOC	mg/kg	38697	26504
Sol. NH4-N	mg/kg	5302	3854
Exch. NH4-N	mg/kg	1981	1471
Sol. NO3-N	mg/kg	486	330
Zn	mg/kg	39.8	27.3
Pb	mg/kg	1.79	1.23
Cd	mg/kg	0.326	0.228

Broiler litter is a combination of bedding material and manure. Bedding materials in northwest Arkansas generally consist of pine shavings, rice hulls, or both. The physical characteristics of the litter vary according to the type of bedding material used. The chemical characteristics of broiler litter vary according to the diet of the birds, the length of the grow-out cycle, and the methods of handling and storage. This table provides the mean concentration of broiler litter constituents on a dry weight and an as-is basis from an analysis of 64 samples in Arkansas.[38]

[38] Moore, et.al. 1995. Final Report Southeastern Poultry and Egg Association

Appendix B. On-Farm Litter-to-Energy Sample Calculations

basic assumptions		
Energy content of litter	4,600	Btu/pound (@ 25% moisture content)
Energy content of litter	9,200,000	Btu/ton (@ 25% moisture content)
litter production	125	tons per year per house
Energy content of litter	1,150,000,000	Btu per year per house
propane consumption	3,000	gallons per year per house
energy content of propane	90,000	Btu per gallon
thermal energy consumption	270,000,000	Btu per year per house

thermal energy (i.e., space heating)		
estimated thermal system efficiency	75%	
net energy input required	360,000,000	Btu per year per house
remaining energy available	790,000,000	Btu per year per house
(i.e., total energy contained in the litter less the amount used for thermal purposes)		

electrical energy production & consumption		
estimated electrical system efficiency	25%	
net electrical energy	197,500,000	Btu per year per house
conversion factor: 1.0 Btu =	0.000293	kW
total electrical production	57,868	kWh per year
theoretical operating time	8,760	hours per year
system "on-line" factor	98%	
net operating time per year	8,585	hours per year
average energy output	6.7	kW
estimated electrical load	2.7	kW
excess electrical production	4.0	kW