VFC Index - Watershed (Plan)

Program: Watershed

IDEM Document Type: Plan

Document Date: 5/1/2008

Security Group: Public

Project Name: Limberlost-Loblolly WMP

Plan Type: Watershed Management Plan

HUC Code: 05120101 Upper Wabash

Sponsor: Friends of the Limberlost

Contract #: 5-115

County: Jay

Cross Reference ID: 21442031

Comments: Adams, Wells

Additional WMP Information

Checklist: 2003 Checklist

Grant type: 319

Fiscal Year: 2003

IDEM Approval Date: 5/1/2008

EPA Approval Date:

Project Manager: Leanne Whitesell

Final

Watershed Management Plan

For the Limberlost, Bear, and Loblolly Creek Watersheds

A305-5-115

Mission Statement: To restore the ecological health of the Limberlost Area
"**R**estoration **I**ncentive **P**rogram in **L**imberlost and **L**oblolly" [**RIPLL**]

Project Website: www.limberlost.net

Prepared by:
Commonwealth Biomonitoring
8061 Windham Lake Drive
Indianapolis, IN 46214
www.biomonitor.com

Prepared for:
The Friends of the Limberlost
310 Williams Street
Geneva, IN 46740
260-368-7594

Executive Summary

This Watershed Management Plan was created as a result of a desire by the Friends of the Limberlost State Historic Site to reduce pollution from nonpoint sources and restore the three "Limberlost" watersheds to a more ecologically healthy condition. In order to accomplish this, the group focused its attention on five main areas:

1. Ecological restoration
2. Nonpoint source pollution (sediment and nutrients) from row crop agriculture
3. Nonpoint source pollution (bacteria and nutrients) from livestock farming
4. Stream habitat degradation from channelization and lack of vegetated riparian buffers
5. Education for landowners in the watershed and community members on nonpoint source pollution problems and solutions

The steering committee developed goals to address each of the five topics:

<u>Biological Restoration Goals</u>

1. Restore natural ecological communities in the watersheds wherever possible

<u>Cropland Agriculture Goals</u>

2. Make application of fertilizer more efficient
3. Decrease the use of unnecessary ditching practices on streams in the watershed
4. Increase the use of conservation tillage in the watershed, especially for corn

<u>Livestock Agriculture Goals</u>

5. Promote use of alternative manure management systems
6. Fence livestock from waterways where possible

<u>Riparian Goals</u>

7. Install vegetative buffer strips along all stream channels
8. Restore wetlands wherever possible

<u>Educational Goals</u>

9. Educate the public on the importance of habitat
10. Provide information on proper septic system maintenance
11. Provide information on good manure management practices
12. Encourage the use of environmentally sensitive channel maintenance

No water quality monitoring was conducted as part of this planning process. Instead, the Friends of the Limberlost carried out a comprehensive documentary of stream condition by photographing streams at each road crossing. A total of 175 road crossings were photographed. Thirty-seven of these showed the absence of a vegetative filter strip along one or both sides of the road. Franks Drain in Wabash Township had the highest number of sites (15) lacking filter strips.

As part of this planning grant, the committee also produced two educational brochures (attached in Appendix 4 and 5) and put on four water quality workshops (two on septic systems, one on manure composting, one on aquatic life). While the planning process was underway, the committee found and eliminated a broken sewer connection draining into Loblolly Creek from the Town of Geneva and repaired a leaking septic system for one household. Finally, additional water quality related projects that were carried out by partners in the watershed during the 2-year grant period (summarized in Appendix 6) included:

Jay County grassed waterway project
Limberlost Swamp Restoration projects
Red Gold wetland restoration project

Table of Contents

Acronyms used in this document

BMP	Best Management Practice
EPA	U.S. Environmental Protection Agency
HUC	Hydrologic Unit Code
IDEM	Indiana Department of Environmental Management
DNR	Indiana Department of Natural Resources
NPS	Nonpoint Source Pollution
RIPLL	Restoration Incentive Program for Limberlost and Loblolly
TSS	Total Suspended Solids
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
FSA	Farm Services Agency
NRCS	Natural Resources Conservation Service
SWCD	Soil and Water Conservation District
IBI	Index of Biotic Integrity for fish communities
mIBI	Index of Biotic Integrity for macroinvertebrate communities
QHEI	Qualitative Habitat Evaluation Index
HBI	Hilsenhoff Biotic Index
EPT	Ephemeroptera/Plecoptera/Trichoptera (a biotic index metric)

Limberlost, Bear, and Loblolly Creek
Watershed Management Plan

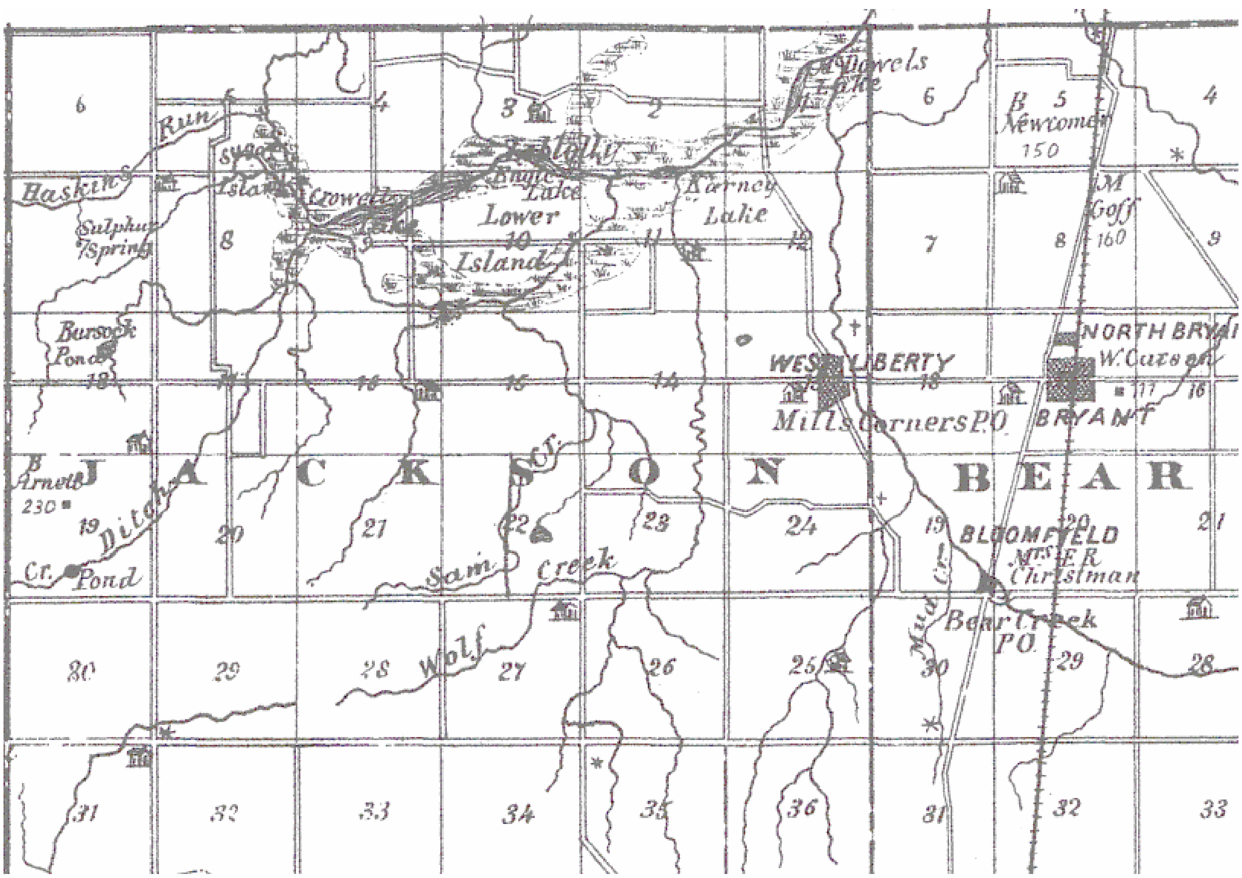
Section I: Introduction to the Project

As it existed in the time of author and naturalist Gene Stratton Porter in the late 1800's, the Limberlost Swamp in northeastern Indiana included at least 13,000 acres of marsh and six shallow natural lakes in the Upper Wabash River Basin. Here's how the area was described by the author in her book *Music of the Wild*, published in 1910:

"I have read of the streams that flow over India's golden sands, down Italy's mountains, and through England's meadows but none of them can sing sweeter songs or have more interest to the inch than the Limberlost. It is born in the heart of swampy wood and thicket, flows over a bed of muck or gravel, the banks are grass and flower-lined, its waters cooled and shaded by sycamore, maple, and willow. In the water fish, turtle, crab, muskrat, and water puppy disport themselves. Along the shores the sandpiper, plover, coot, bittern, heron, and crane take their pleasure and seek their food...The Limberlost is a wonderful musician, singing the song of running water throughout its course, singing that low, somber, sweet little song that you must get very close to the earth to hear…Sometimes it slips into a thicket, the waters grow feverish and fetid, its song is hushed. The bed of the Limberlost in the thicket is ooze and muck, so the water falls silent while slipping over the velvet softness. The many trees and masses of shrubs lower their tones to answer the creek…The thicket seems a natural home for almost every feathered creature. This is because there are trees, bushes, and shrubs with their berries, nuts, and fruits, vines and weeds bearing seed: every variety of insect and worm, and water with its supply of food…When the Limberlost leaves the thicket and comes into the open again, it is sheltered by trees and a big hill and comes singing into the meadows covered closely with cropped velvet grass (green pastures)… Here big fish come adventuring and to spawn, and their splash is part of the music that the family living on the banks hears daily. Mr. Schaffer says that he can stand on his back porch, bait a fish, turn, and drop it into the frying-pan…Of all vegetation along, the river, mallows are the typical flowers, the blooms we see most often and love best. The plants flourish so close to the water that half the roots are washed in the river."

Gene Stratton Porter's description of the Limberlost provides a valuable record of natural conditions, especially in the Loblolly Creek watershed south and west of Geneva. This was the original Limberlost Swamp. A map of the area, produced in 1876 by the cartographer Alfred Andreas (*Illustrated Historical Atlas of the State of Indiana*) is shown in Fig. 1. According to Stratton Porter's written record, the swamp was rich with natural wetland vegetation, included both running and standing water, and abounded in fish and wildlife. By 1920, most of the Limberlost Swamp had been drained for agricultural uses. But annual flooding prevented much of the land from being productive for agriculture.

Fig. 1. The Limberlost area in 1876



Interest in restoring parts of the swamp began in 1990 began when local citizens organized a not-for-profit group called the Friends of the Limberlost State Historic Site.

The “Friends” group was dedicated to preserving the cultural and natural history of the Limberlost Swamp area of northeastern Indiana. A committee called “Limberlost Swamp Remembered” grew out of the Friends organization in 1998 and began to purchase flood-prone areas of the watershed from local farmers. In 2005, the group began to plan for a program they called “RIPLL” (Restoration Incentive Program in Limberlost and Loblolly). Restoration of environmental health of these watersheds was the overriding goal.

In that same year, the Friends received a Section 319 grant from the Indiana Department of Environmental Management to produce a Watershed Management Plan for all six of the 14-digit HUC watersheds in the Limberlost/Loblolly area (shown in Fig. 4):

Upper Loblolly Creek	05120101050010	11,250 acres
Lower Loblolly Creek	05120101050020	13,012 acres
Upper Bear Creek	05120101050030	9,280 acres
Lower Bear Creek	05120101050040	9,433 acres
Upper Limberlost Creek	05120101050050	12,212 acres
Lower Limberlost Creek	05120101050060	14,467 acres

The total drainage area of the Limberlost/Loblolly area includes 69,654 acres in northern Jay, southern Adams, and southeastern Wells Counties of Indiana.

This watershed management plan describes current environmental conditions in the area. It identifies impairments to current uses of local streams and sources of pollutants that contribute to the impairment. It identifies critical areas contributing to pollutant loading.

A key component in the watershed planning process is the building of local partnerships: finding individuals and groups with a common interest in environmental affairs and getting them to work together to set reasonable goals for improvement. Many individuals and agencies were involved in the project. The “Limberlost Swamp Remembered” group formed the RIPLL Steering Committee. The steering committee met once every month to discuss various topics affecting the watershed and to provide input into the watershed management plan. The group was responsible for ensuring local views and values were taken into account during the management plan development. They also assisted in the carrying out of activities, and organizing watershed goals. Concerns were expressed through conversations at meetings and out in the field. Landowners and other concerned citizens not interested in being on the steering committee could call the steering committee or talk with the watershed coordinator about their concerns within the watershed.

The concerns identified at the first steering committee meeting were:

- Ecological restoration
- Drainage/channelization
- Confined livestock feeding
- Pollutant input from manure
- Environmental education
- Mosquito control
- E. coli
- Failed septic systems
- Lack of buffers

Based on importance to the committee, the top concerns were identified as ecological restoration, pollutant input from manure, and septic maintenance. As the project progressed, an additional top concern was voiced: destruction of habitat by current drainage practices and artificial channelization. No other concerns were identified.

The Steering Committee met every month to listen to the project progress reports and provide input. The watershed coordinator [Commonwealth Biomonitoring] solicited input from potential partners who were county officials [surveyor, commissioners, SWCD, sanitarian], local farmers, local radio and newspaper reporters, and local environmental groups. These groups provided input through workshop participation, interviews, stakeholder meetings, and through the project website [www.limberlost.net]. As the project proceeded, there was also input from the Indiana Department of Environmental Management through the TMDL process. A list of all participants who provided input is attached in Appendix 3.

Figure 2: Planning Process

July 2005

Project Begins

August 2005

Develop Steering Committee

Janurary 2006

Develop Concern List

February 2006

Introduce Project, Public Meeting

Spring 2006

Develop Mission, Begin Public Education Programs

Summer 2006

Work on Watershed Mission, Identify Problem Areas,
Continue Public Education Programs

Fall 2006

Develop Goals and Objectives

Winter 2006

Compile Data and Identify Areas of Concern Based on Data

February/March 2006

Write Watershed Management Plan

July 2007

Draft of Watershed Management Plan Submitted to
Indiana Department of Environmental Management for Review

September 2007

Final Draft of Watershed Management turned in for Approval
Completion of Grant

Section II: Description of the Watersheds

The Limberlost/Loblolly Creek watersheds (including Bear Creek) make up 69,654 acres of northern Jay and southern Adams and Wells Counties in northeastern Indiana. These "sub-watersheds" (Fig. 3) flow into the "Upper Wabash River" watershed, shown in Figure 3.

Fig. 3. The Upper Wabash and the Limberlost/Loblolly watersheds

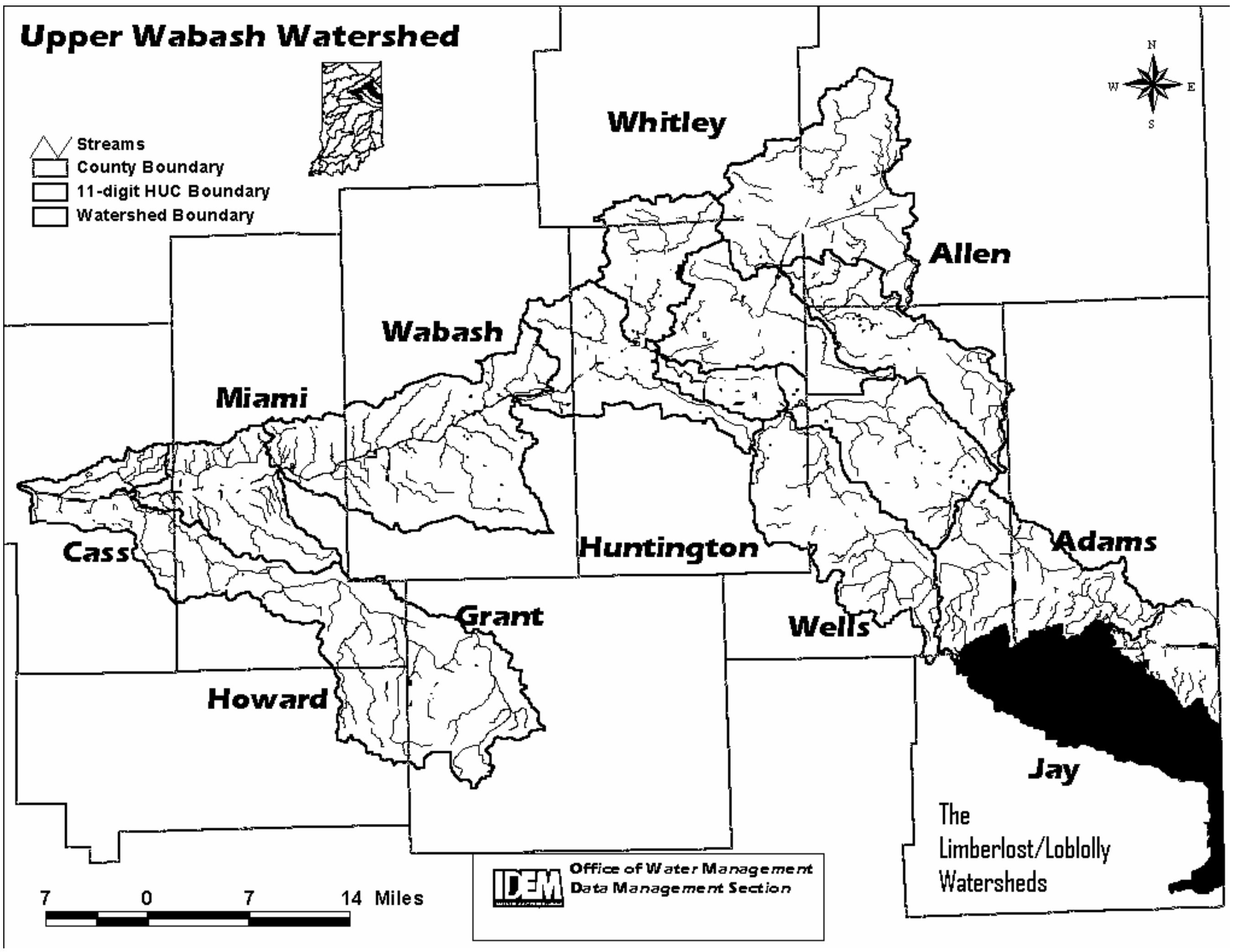
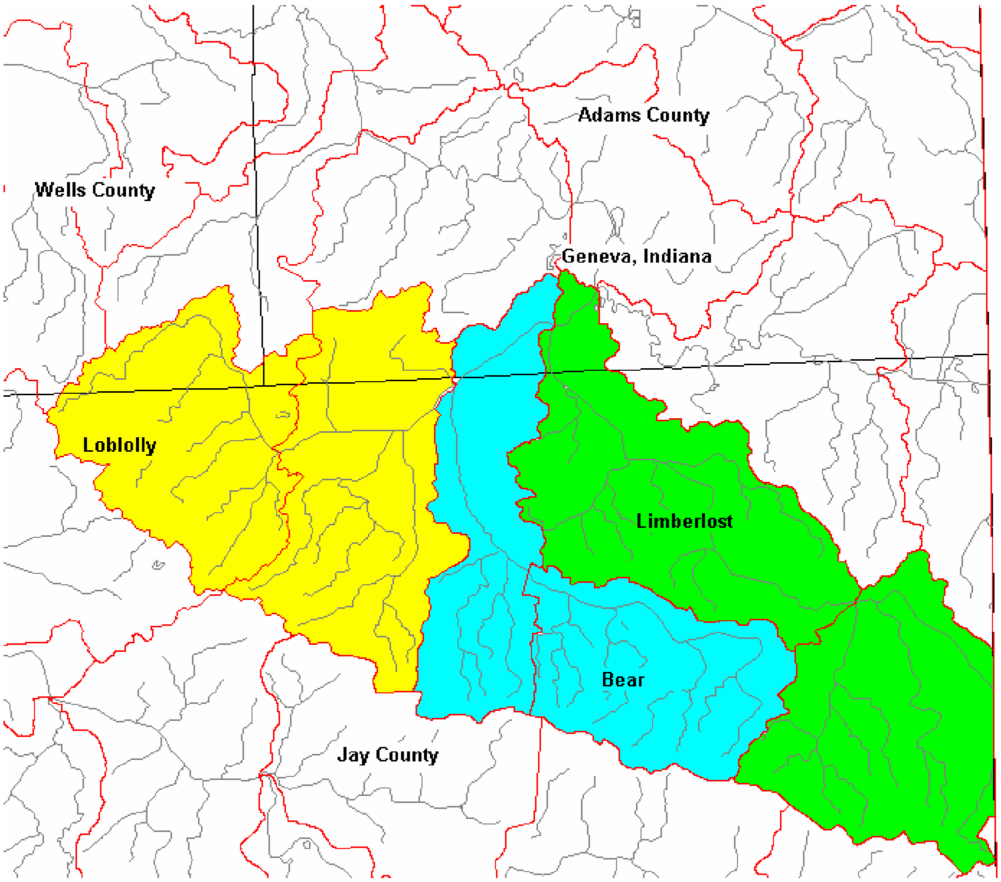


Fig. 4. Local Sub-Watersheds.

Upper and Lower Loblolly Creek (05120101050010 and 20)

Upper and Lower Bear Creek (05120101050030 and 40)

Upper and Lower Limberlost Creek (05120101050050 and 60)



Demographics

According to the U.S. Census Bureau figures for 2000, Jay, Adams, and Wells Counties have an average population density of about forty people per square mile. If this is extrapolated to the size of the Limberlost/Loblolly area, approximately 5000 people reside in the watershed. About 4000 of these live in rural areas. There are two incorporated towns in the watershed: Geneva (population 1390) and Bryant (population 275). The Census Bureau also notes that in the northern Jay County area, about 20% of all residents speak a language other than English in their homes. This segment of the population is almost certainly the Amish residents, who use traditional farming practices.

Final

Land Use

Land use in the Limberlost/Loblolly area [7] is shown in Figure 5. Agricultural uses predominate. Corn and soybeans are the primary crops grown, as shown in Figure 6. Livestock production is also important. According to data collected by the Department of Agriculture in 2002 [2], there are probably about 600,000 chickens, 60,000 turkeys, 30,000 hogs, 3,000 cattle, and 300 horses raised each year in the Limberlost/Loblolly watersheds.

Fig. 5. Land use [7]

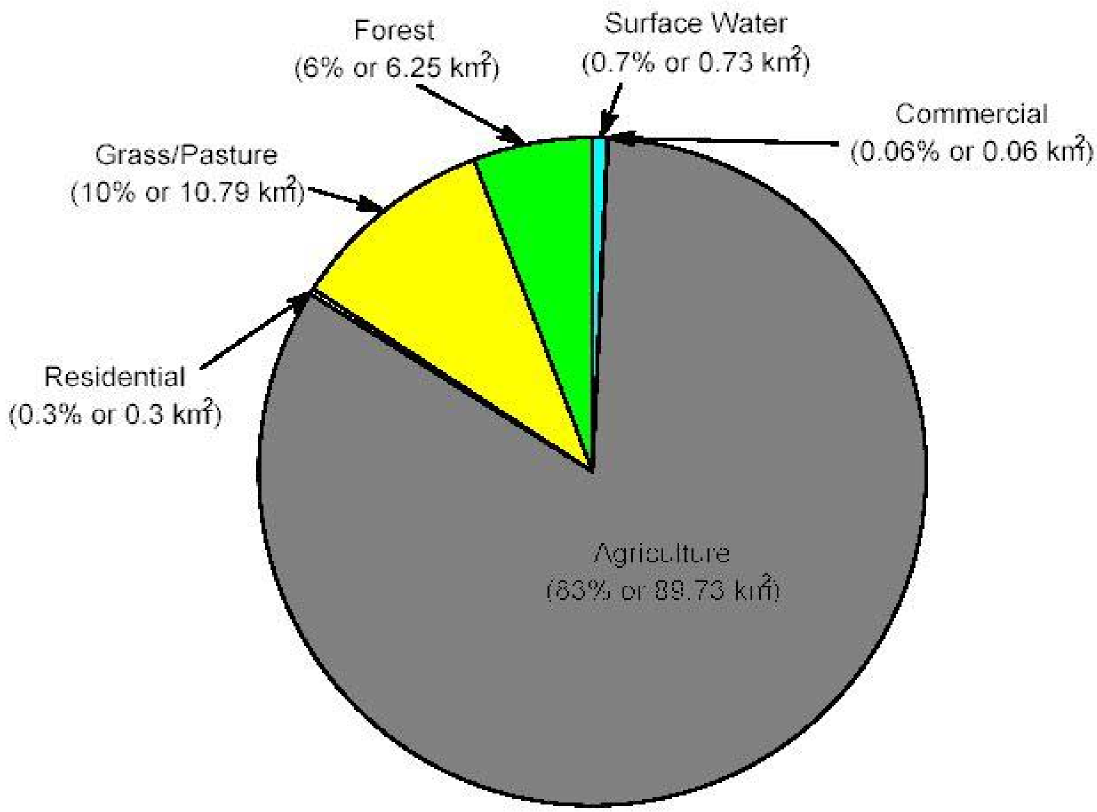
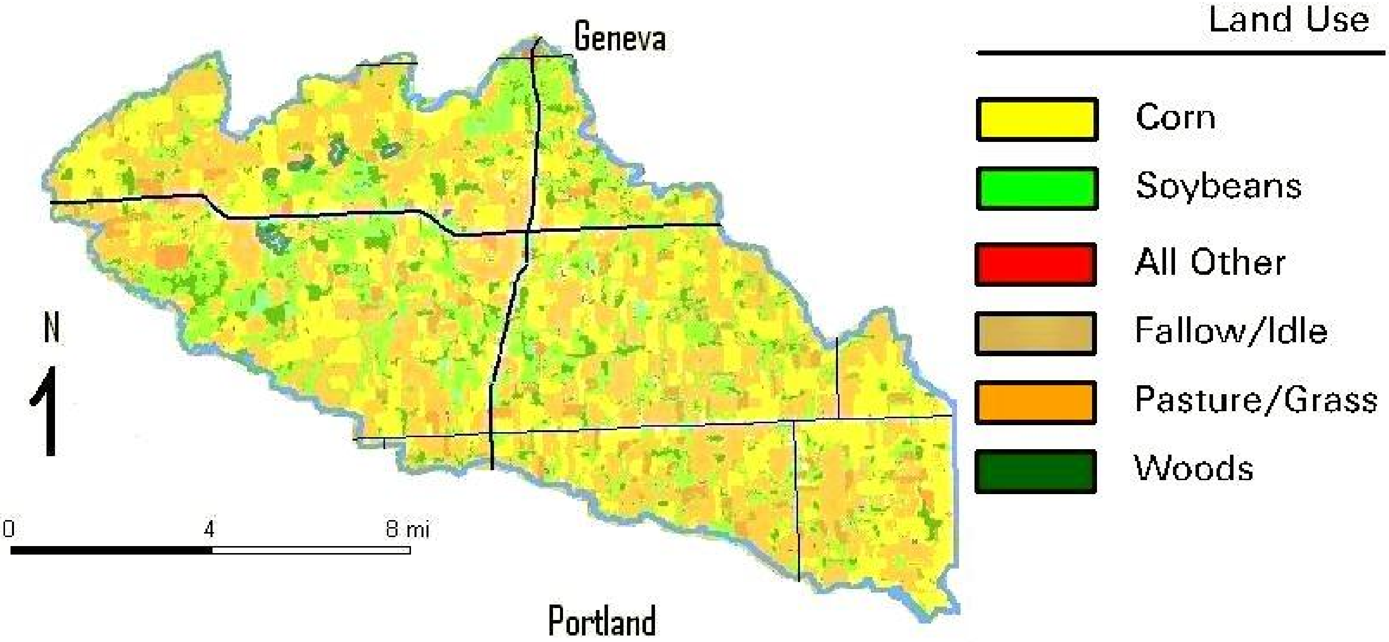


Fig. 6. Major Agricultural Crops [2]



Soils

The soils of the region are dominated by Blount, Glynwood, and Pewamo types [19]. Blount and Glynwood fall into the "highly erodible" category established by the Natural Resources Conservation Service (NRCS) and make up 62% of all soils in the watersheds.

Table 1: Soils in the Watersheds

Soil Types	Description
Blount	Nearly level to moderately sloping, somewhat poorly drained silt loam soils formed in glacial till. Make up 32% of all soils in the area. A Level 2 "highly erodible" soil.
Bono	Nearly level, very poorly drained silty clay soils formed in depressions on lake bottoms. Make up 2% of all soils in the area.
Glynwood	Gently to moderately sloping, well-drained clay loam formed on glacial till plains and moraines. Make up 30% of all soils in the area. A Level 1 "highly erodible" soil.
Houghton	Nearly level, very poorly drained muck soils formed in depressions on lake plains, till plains, and glacial moraines. Make up 0.2% of all soils in the area.
Martinsville	Level to moderately sloping, well-drained loam soils formed in outwash areas of glacial till plains. Make up 0.4% of all soils in the area.
Morley	Strongly sloping, well-drained clay loam soils formed on glacial moraines. Make up 0.3% of all soils in the area. A Level 1 "highly erodible" soil.
Pewamo	Nearly level, poorly drained silty clay soil formed in drainageways and depressions on glacial till plains. Make up 28% of all soils in the area.
Saranac	Nearly level, very poorly drained clay soils formed on bottom land of streams. Make up 2.5% of all soils in the area.
Wallkill	Nearly level very poorly drained silty clay soils formed in depressions on lake plains, till plains, moraines, and stream bottom land. Make up 0.2% of all soils in the area.
Whitaker	Nearly level, somewhat poorly drained silt loam soil formed on glacial outwash terraces. Make up 0.2% of all soils in the area.

Hydric soils that support wetlands include Bono, Houghton, Pewamo, Saranac, and Wallkill types, which make up about one-third of the total watershed area. The only soil type suitable for septic systems is Martinsville, which makes up only a very small proportion of all soils in the area. A map showing general soil associations in the area is shown in Figure 7. Hydric soils are shown in yellow in Fig. 8.

Fig. 7. General Soil Associations [19]

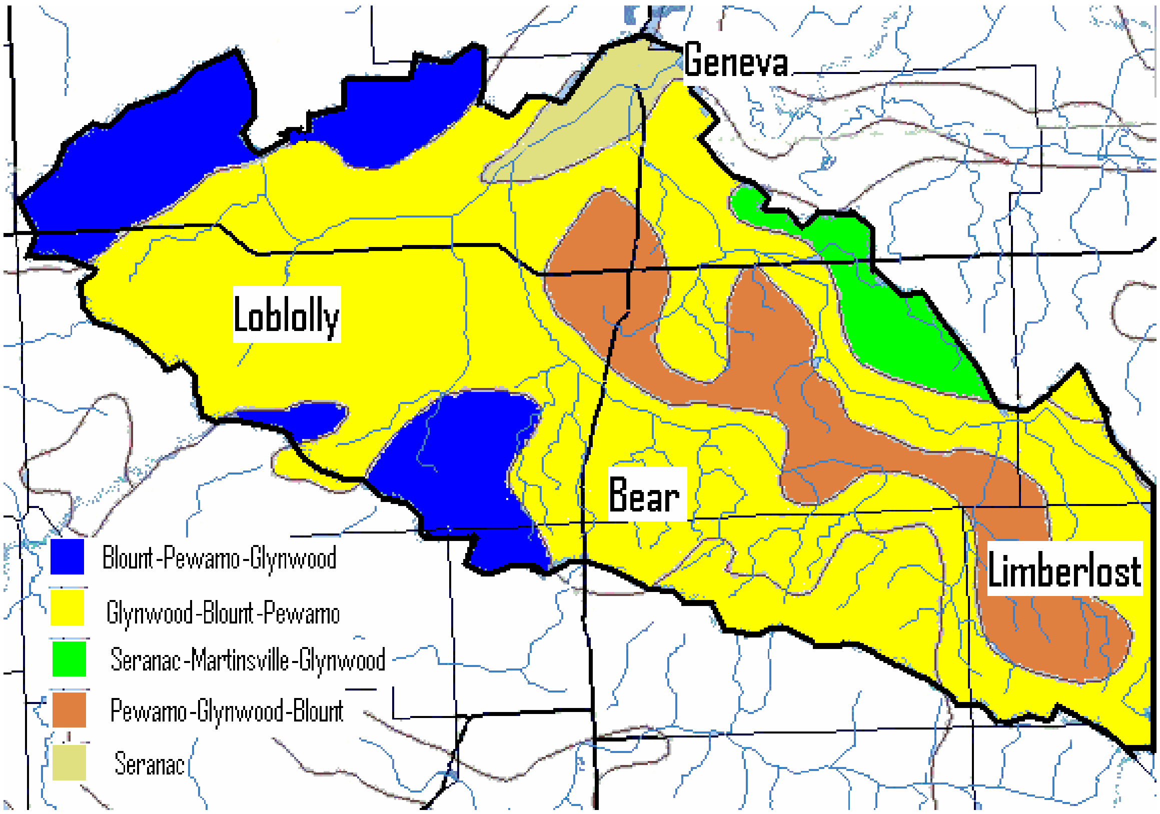
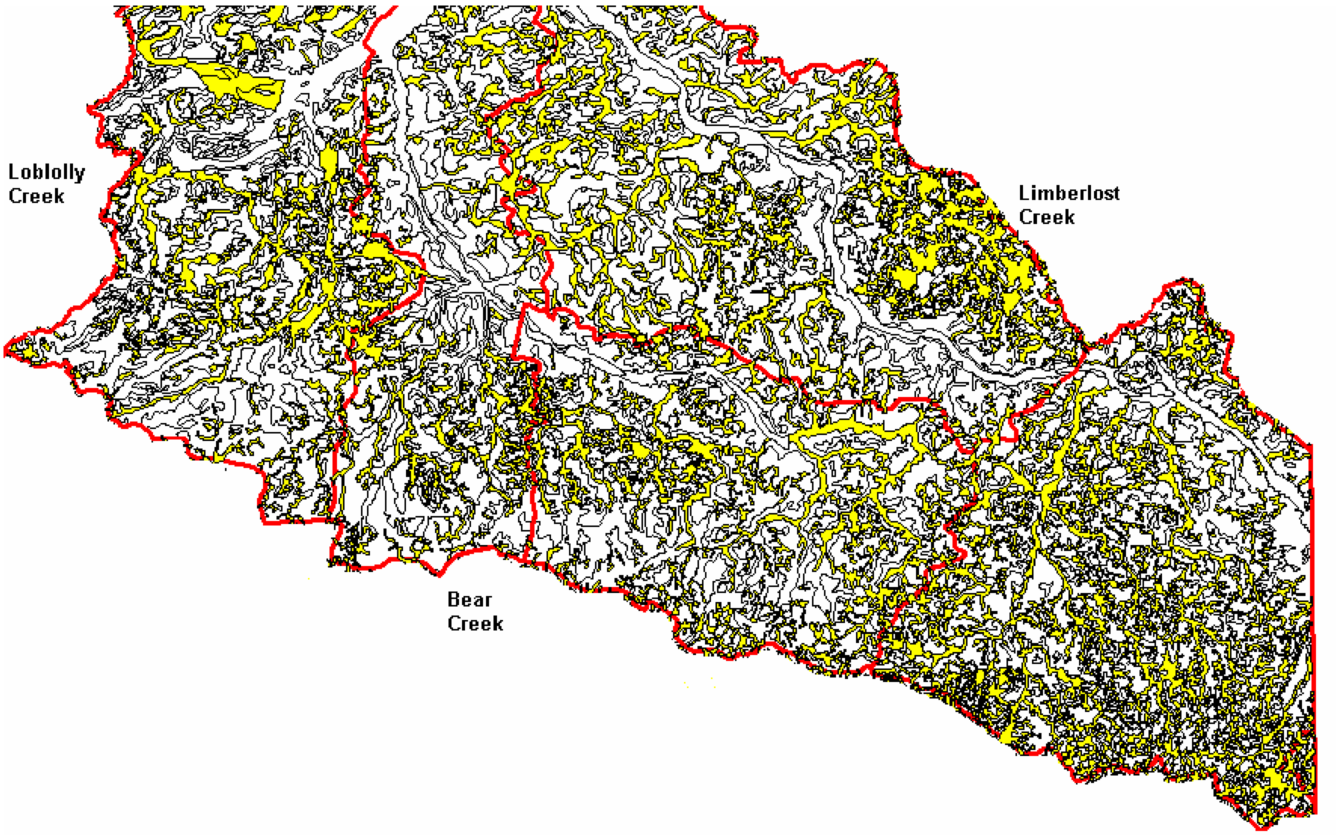


Fig. 8. Hydric soils in the watershed



Septic Systems

It is estimated that about 80% of the population (4000 residents) in the watershed use septic systems for household sewage disposal. The approximately 1000 septic systems pose a potentially large water quality problem in the Limberlost/Loblolly area because almost none of the soils are suitable for proper septic system functioning.

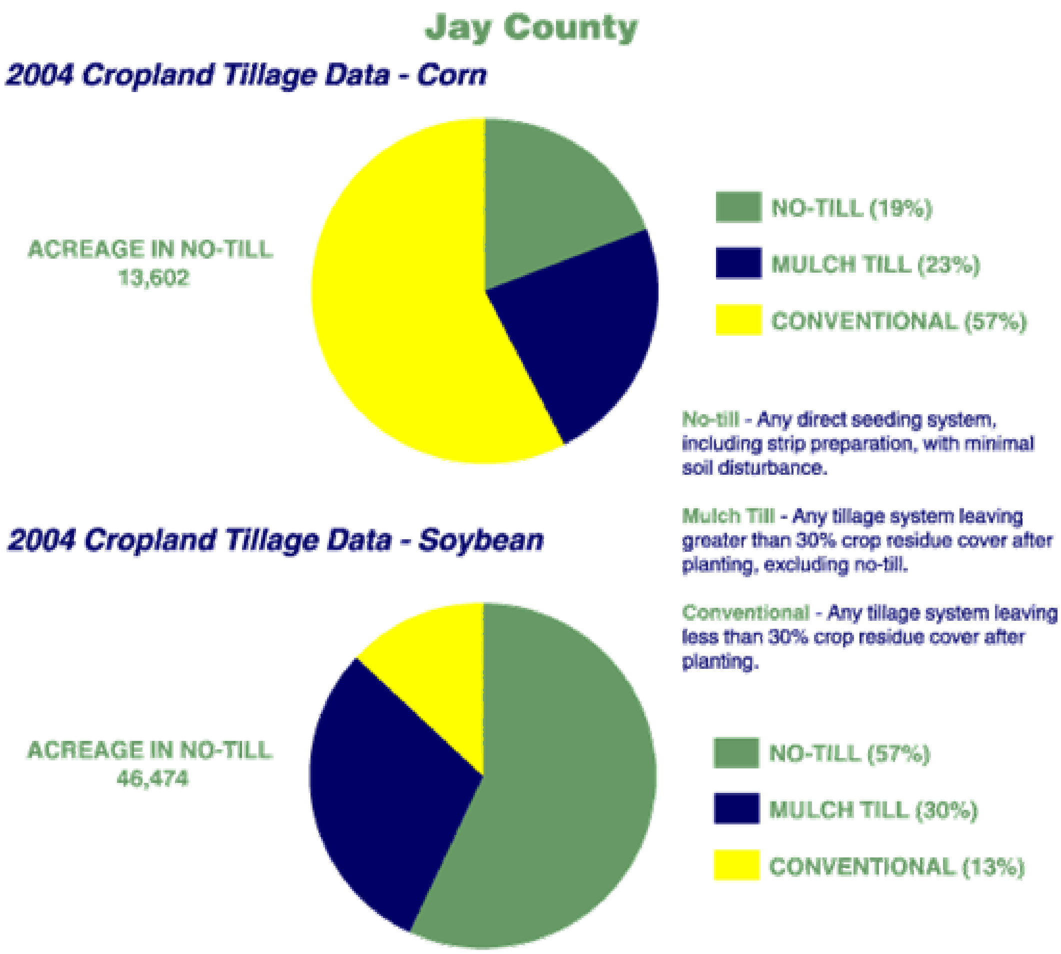
County Sanitarians Dave Houck, Terry Smith, and Heath Butz estimate that about half of all septic systems in the watershed are either not working correctly or are illegally discharging raw sewage. Residents who request permits for new construction are required to have the site approved by a certified soil scientist prior to receiving a construction permit for a new septic system. Part of this project involved producing an educational brochure on proper septic system maintenance. Copies of the brochure are attached in Appendix 5.

Although failing septic systems are probably an important source of E.coli, especially during dry weather, the TMDL for Limberlost Creek [18] estimated that only about 2% of the nutrient loading in the watershed comes from this source.

Tillage Practices

The Indiana Department of Agriculture tracks the use of conventional and no-till practices in each county [2]. The latest figures for Jay County (which probably are representative for the Limberlost/Loblolly area watersheds) are shown in Figure 9.

Fig. 9. Tillage Practices in the Watershed [2]



Final

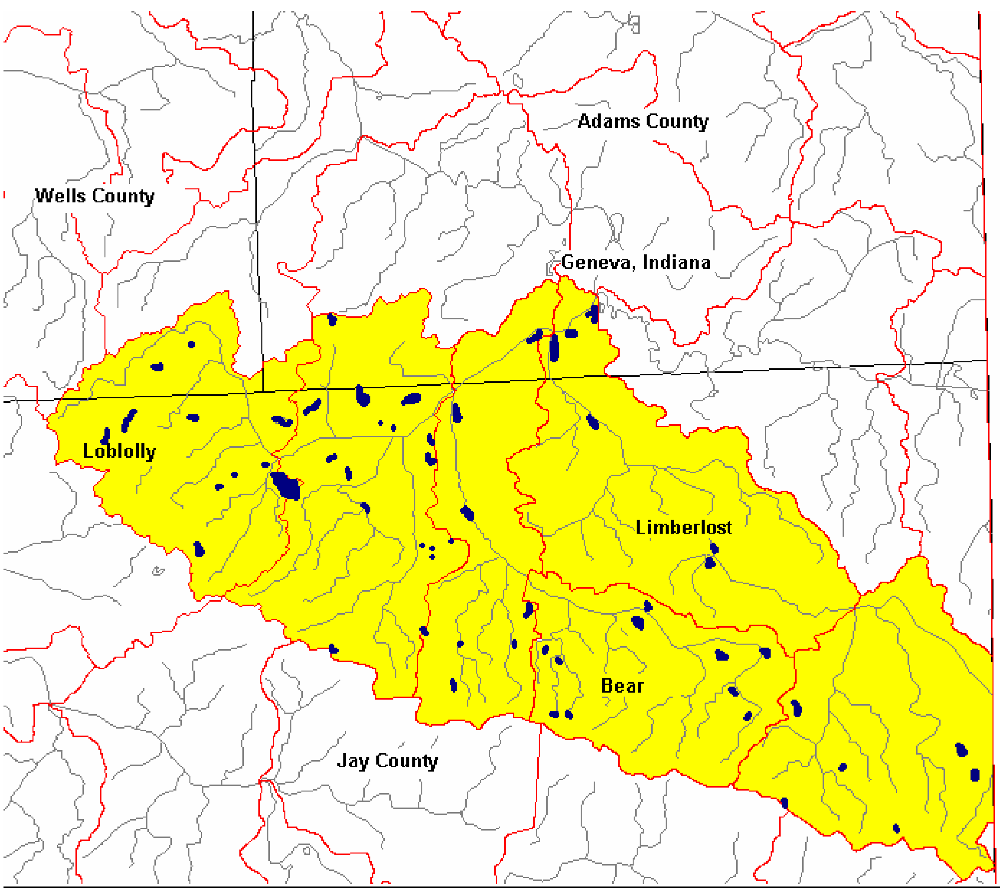
Wetlands

In pre-settlement times, about 25% of Indiana was wetland. Since then, wetlands have been drained or filled and only about 15% of the state's original wetlands remain. Wetlands have well-documented value to the environment. They help in flood control, water quality, groundwater recharge, erosion control, wildlife habitat, wood production, and recreation. The U.S. Army Corps of Engineers defines wetlands as areas that have three common characteristics:

1. Have hydric soils that are formed under predominantly wet conditions
2. Are dominated by plants that prefer wet conditions
3. Are saturated with water for at least 15 consecutive days during the growing season.

A U.S. Fish and Wildlife "wetlands inventory map" showing the area's remaining wetlands is shown in Figure 10. The most concentrated area of wetlands is along the Wabash River but several large tracts, including the Limberlost Wetland Restoration Preserves in the lower Loblolly and Limberlost watersheds, also remain.

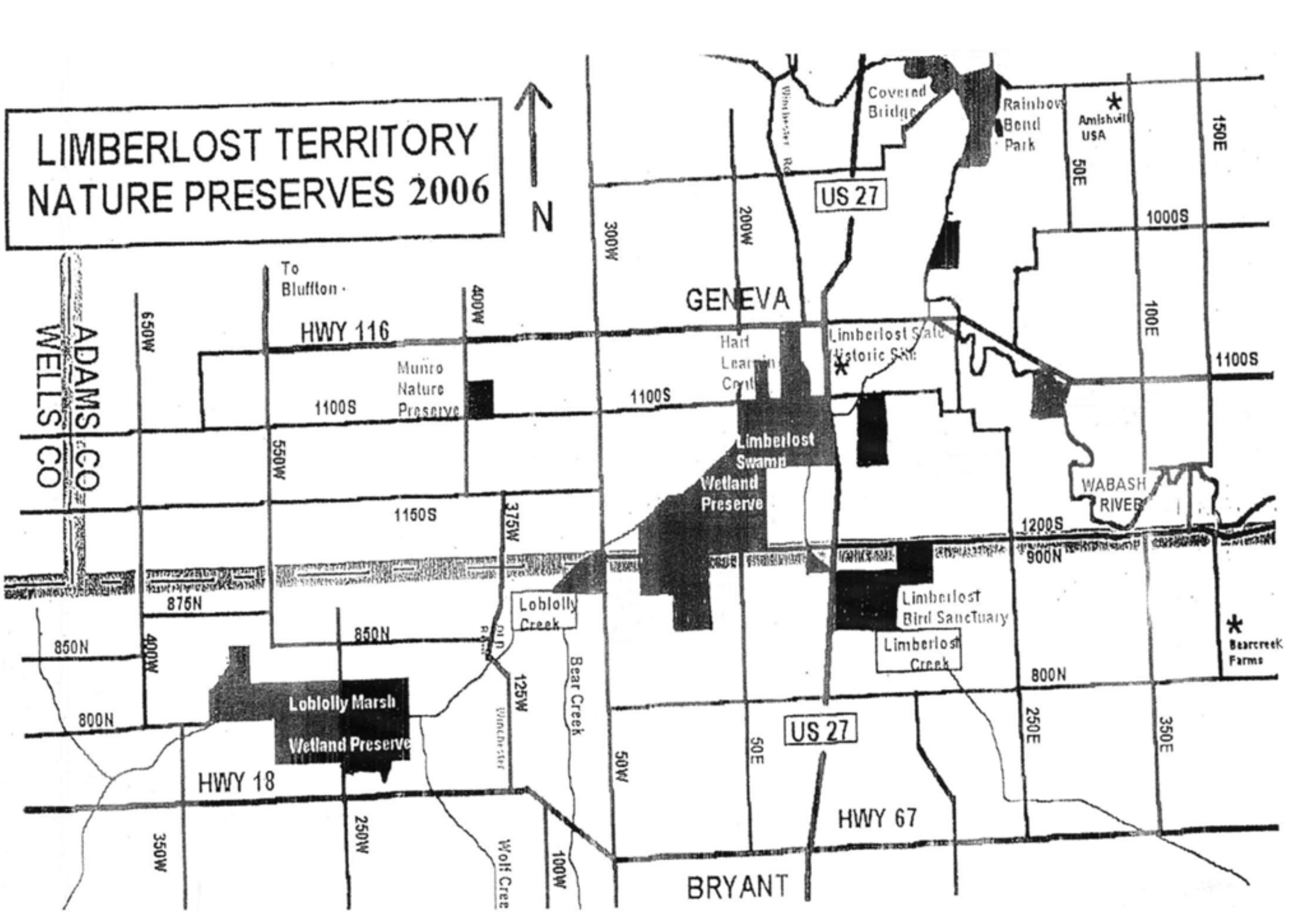
Fig. 10. Remaining wetlands in the Limberlost/Loblolly area (shown in blue)



Protected Areas

The Division of Nature Preserves in the Indiana Department of Natural Resources has assigned a regional ecologist to oversee the re-establishment of natural areas in the Limberlost/Loblolly area. Aided by local conservation groups, the Division of Nature Preserves oversees about 1300 acres of wetland restoration zones near Geneva. A map of the areas protected through 2006 is shown in Fig. 11.

Fig. 11. Limberlost/Loblolly Nature Preserves



Endangered, Threatened, and Rare Species

The Division of Nature Preserves in the Indiana Department of Natural Resources maintains a database of endangered, threatened, and rare species records for Indiana. The following species in the Nature Preserves database have been documented from the Limberlost/Loblolly area:

Plants
- *Armoracia aquatica* [lake cress] – State Endangered

Insects
- *Macromia wabashensis* [Wabash belted skimmer dragonfly] - Rare

Amphibians
- *Rana pipiens* [northern leopard frog] – State special concern

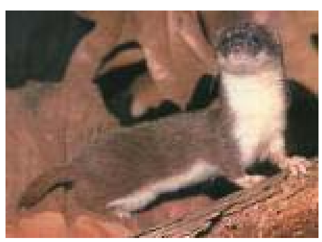
Reptiles
- *Nerodia erythrogaster neglecta* [copperbelly water snake] – State Endangered
- *Sistrurus catenatus catenatus* [eastern massasauga] – State Endangered
- *Clinophis kirtlandii* [Kirtland's snake] – State Endangered
- *Thamnophis proximus* [western ribbon snake] – State special concern

Birds
- *Nycticorax nycticorax* [black-crowned night-heron] – State Endangered
- *Tyto alba* [barn owl] – State Endangered

Mammals
- *Mustela nivalis* [least weasel] – State special concern
- *Myotis sodalis* [Indiana bat] – Federal endangered

Almost all of these rare plants and animals are closely associated with or completely dependent on freshwater environments such as streams, lakes, or wetlands during part or all of their lifecycle. Photographs of some of the more interesting animals are shown below:

Kirtland's snake



Least weasel

Wabash skimmer

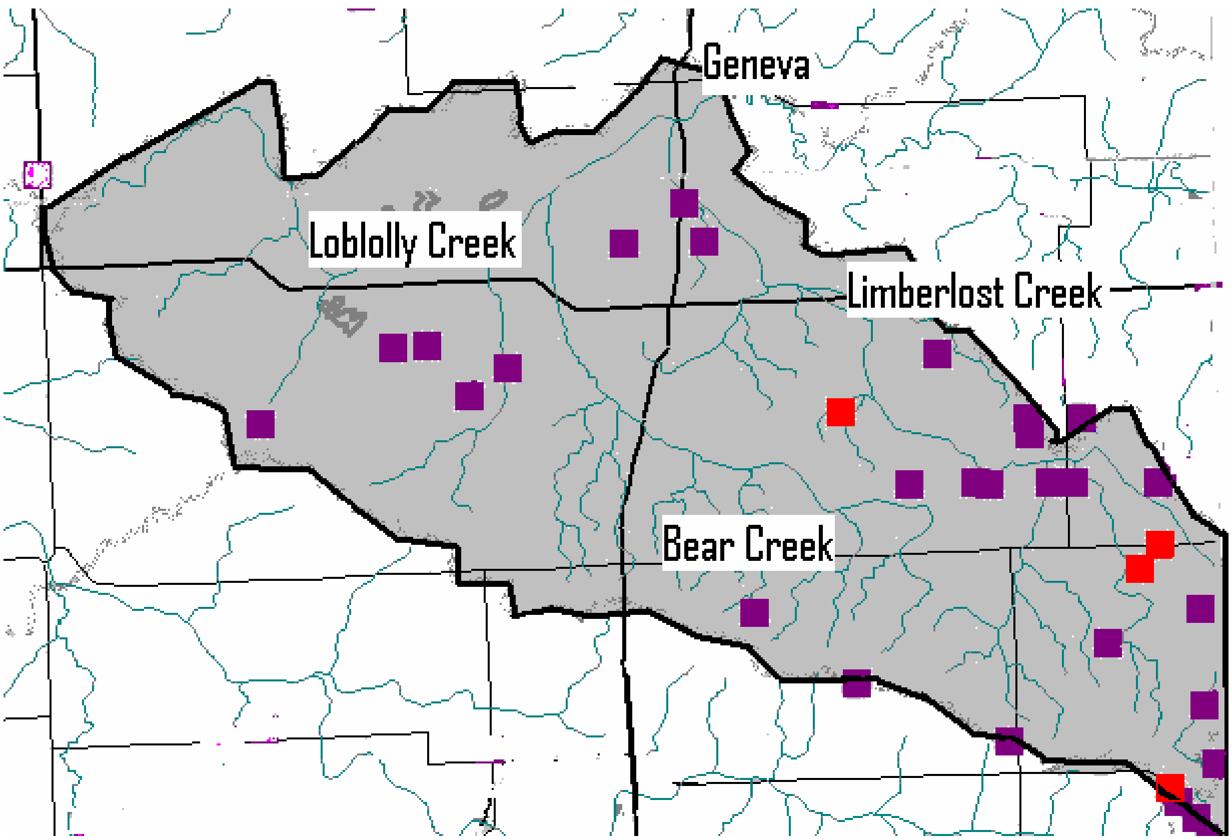
Black-crowned night heron

Final

Confined Feeding Operations in the Watersheds

Confined feeding operations (CFOs) are defined by Indiana water quality regulations as businesses which raise livestock above specified numbers within a confined space where less than 50% of the space is vegetated. The numbers of animals that qualify as a CFO vary with the type of livestock raised. CFOs are regulated by special permits issued by IDEM. The Limberlost/Loblolly watersheds have a very high number of CFOs compared to other similar areas in Indiana. The locations of thirty-one CFOs (including four larger CAFOs or "confined animal feeding operations) in the watershed are shown in Fig. 12. None of them are currently in violation of their permits.

Fig. 12. Confined Feeding Operations (larger CAFOs are identified in red)



Final

According to the estimates produced by the project's "Manure Management Brochure" (Appendix 4), livestock in the watershed produce approximately 2 million pounds of manure every day. The amount of manure represents approximately 5000 tons of nutrients (4500 tons of nitrogen, 500 tons of phosphorus) that may escape to the watershed every year.

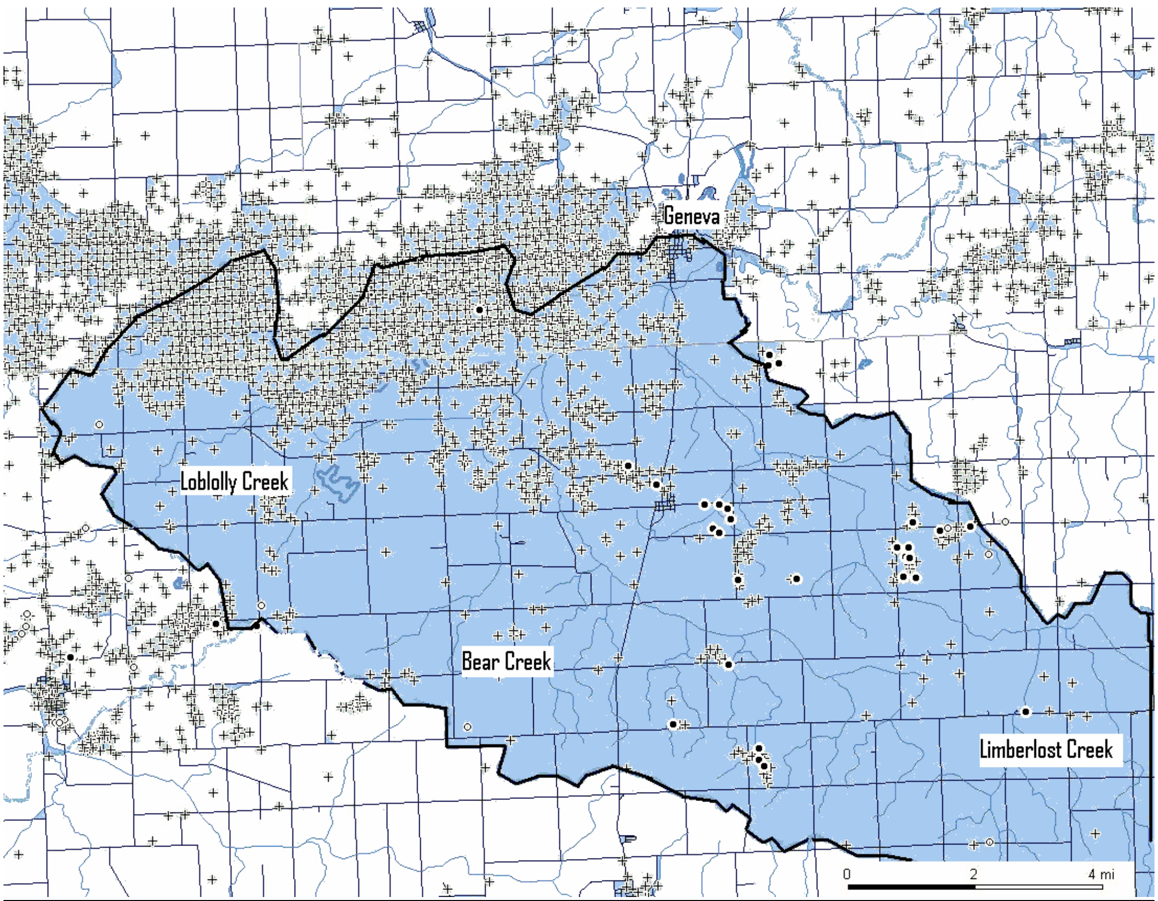
Manure management is often a concern in areas of intense livestock production. Local land application has been the primary manure disposal method employed in this region. Although effective in returning nutrients to cropland, over-application of manure to land may result in excessive nutrient and bacteria loading. Alternative methods of manure disposal may be necessary in the Limberlost/Loblolly watershed, which has such a high density of livestock.

Final

Abandoned Oil and Gas Wells

In the late 1800s, gas and oil was discovered in the Limberlost/Loblolly area. Numerous wells were drilled to exploit the fossil fuels located underground there. Many of these old wells were never capped and the potential for brine water contamination from underground exists there (IDEM, 2004). Part of Limberlost Creek has been determined by the Indiana Department of Environmental Management [IDEM] to have impaired aquatic communities. Some of this impairment may be caused by excessive chloride that may be originating from some of these old wells (7). The location of these wells, as determined by Indiana Geological Survey Records (16) is shown in Figure 13.

Fig. 13. Abandoned oil and gas wells



Drainage Practices

Indiana drainage laws allow each county to specify “legal drains” that are maintained by the county surveyor to enhance drainage and make adjacent lands less wet for farming and other human activities. All surface streams in the Limberlost/Loblolly area are designated as legal drains by the county drainage boards of Jay, Adams, and Wells Counties. Drainage projects in Adams and Wells Counties are carried out by contractors. According to County Surveyor Brad Daniels, Jay County is unique in Indiana in having its own staff to carry out all drainage maintenance activities. The surveyor’s office has two excavators, a bulldozer, and a staff of eight people to work on both drainage tile and open ditch maintenance, as well as to do logjam removal. There is currently no set maintenance schedule but work is done whenever adjacent landowners request it. During the excavation necessary in maintaining open ditches, the surveyor’s office crew removes vegetation from only one side of the ditch, leaving the other side to help maintain shade and vegetative bank stabilization. Excavation sites are seeded in grasses immediately after the project is completed. A photograph of a typical ditch maintenance project in the Limberlost Creek watershed near CR 600 N and 350 E is shown in Fig. 14.

Fig. 14. A ditch maintenance project in progress (October 2006)

Conservation Programs Administered by the Farm Services Agency (USDA)

Since 1980, the U.S. Department of Agriculture's Farm Services Agency has administered conservation programs in the Limberlost/Loblolly area that are designed to reduce erosion and nonpoint source pollution. During that time, about 1.6 million dollars have been spent on these types of projects within the watershed. According to District Conservationist Scott Mynsberge, the most commonly funded projects are filter strips (vegetative buffers) along streams, field borders, grassed waterways, erosion control structures, conversion of farmable wetland to grass, shallow water structures for wildlife, and waste pits.

A summary of the continuing outreach of this program in Jay County is shown in the Appendix.

Wastewater Discharges

Wastewater discharges are allowed by permits issued by IDEM through the NPDES program. There are two permitted discharges in the Limberlost/Loblolly area. One is to the Town of Bryant for the town's sewage treatment plant. This is a waste stabilization lagoon system discharging less than 30,000 gallons per day to a tributary of Limberlost Creek. The other NPDES permit is to Red Gold, a tomato food processor in Geneva. Wastewater from this facility is discharged directly to Loblolly Creek near its confluence with the Wabash River. Both of these dischargers regularly meet the limits established in their permits and do not appear to be contributing to water quality problems in the watershed.

Section III: Identifying Waterbody Impairments and Benchmarks

This section gives an overview of the water quality data collected in the watershed as well as scientific information gathered in the past. It also summarizes the results of the water quality parameters studied in the watershed. The results of the habitat and visual inventory are included in this section.

Existing Data

EXISTING BIOLOGICAL DATA

Information about the biology of a stream is extremely important in identifying physical and chemical impairments [1]. The Indiana Department of Environmental Management has collected biological data in the watershed [unpublished file information] for the following parameters:

Fish Index of Biotic Integrity (IBI) – 66 sites

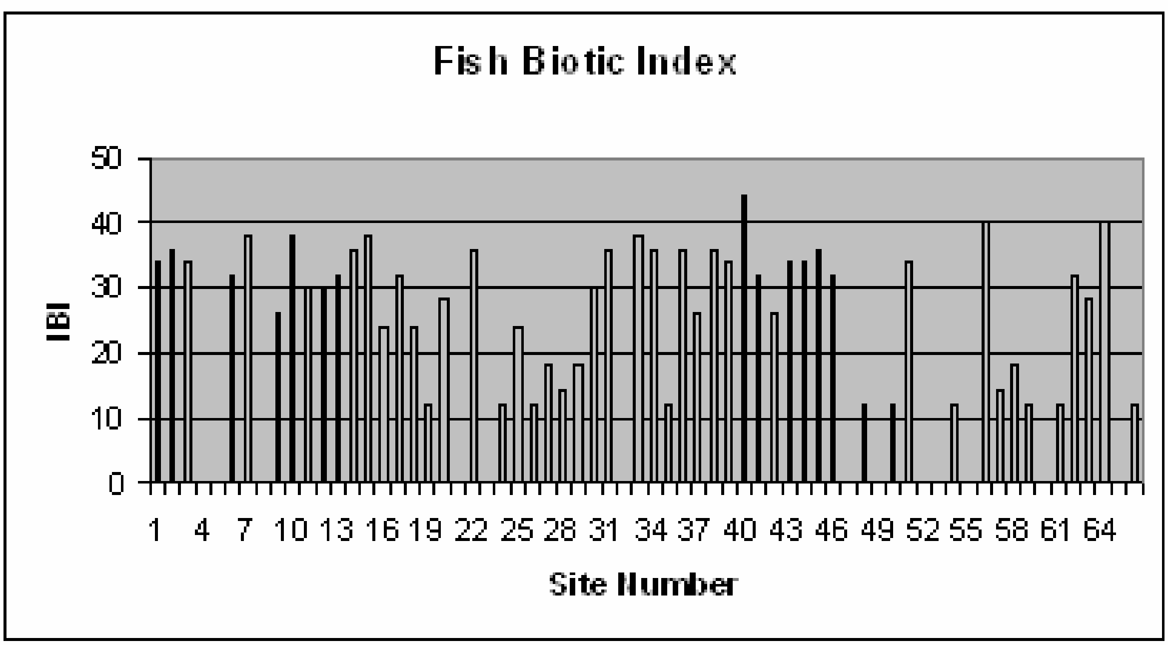
Macroinvertebrate Index of Biotic Integrity (mIBI) – 4 sites

Qualitative Habitat Evaluation Index (QHEI) – 66 sites

Fish Data

IDEM's sampling sites for fish are shown in Appendix 1. Results of the Fish IBI scores are summarized in Fig. 15. Sites with IBI scores greater than 40 are relatively healthy, while scores less than 20 indicate sites with severe impairment.

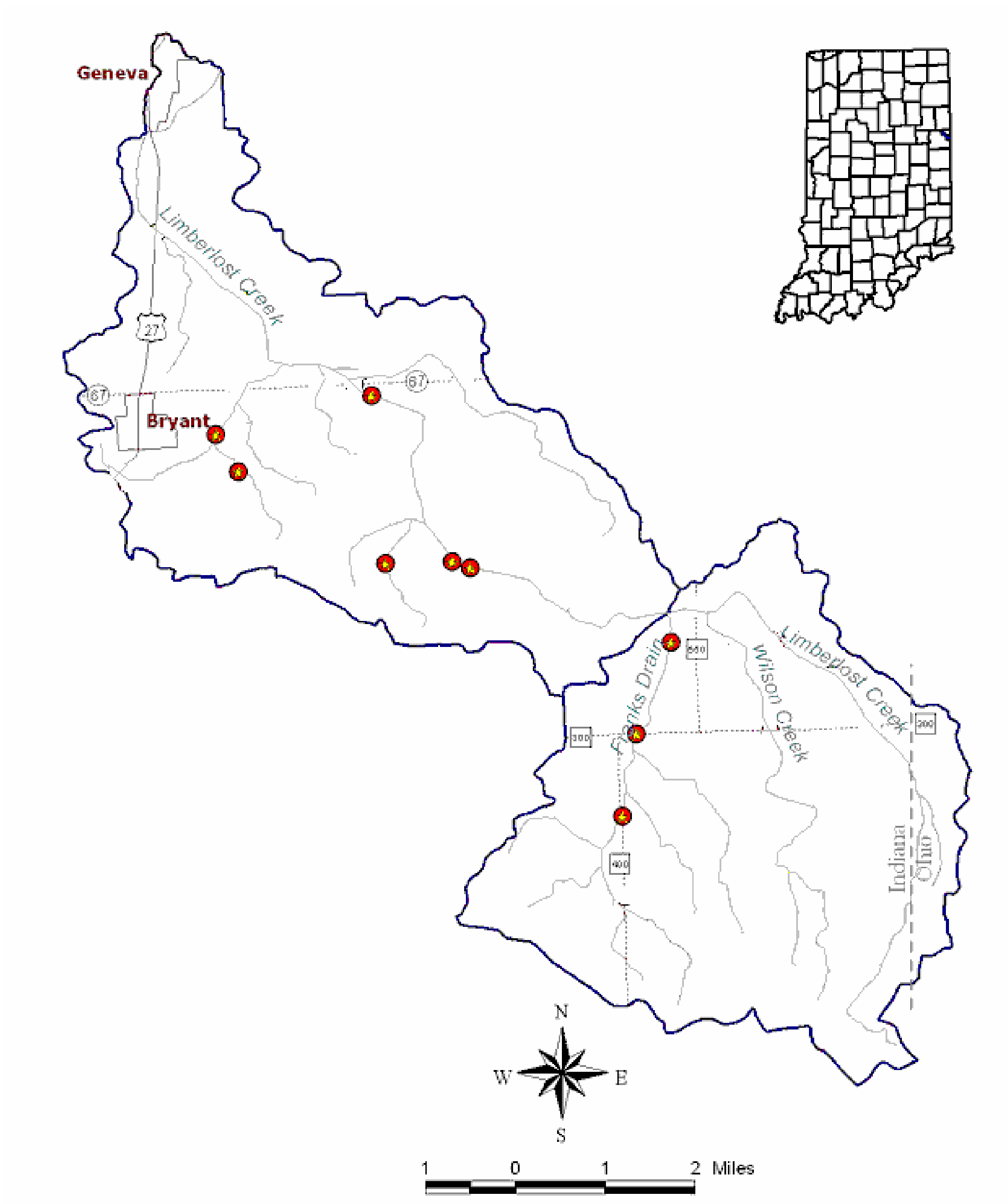
Fig. 15. IBI Scores



Final

Sites with IBI scores significantly lower than their habitat (QHEI) scores are usually affected by poor water quality [1]. The lowest IBI scores that occurred where habitat was at least marginally acceptable in the Limberlost Creek watershed were in Franks Drain and areas downstream from this tributary. Another area with lower than normal IBI scores occurred in Perry Ditch south of Bryant. These sites are shown in Fig. 16. Because of the observed water quality impairment, the watersheds draining these streams are considered “critical areas” in Section VI.

Fig. 16. Lowest Fish IBI Scores in Limberlost Creek [7]



Macroinvertebrate Data

Results of the IDEM macroinvertebrate sampling are summarized in Table 2. HBI (Hilsenhoff Biotic Index) values greater than 6 indicate the presence of sewage-related pollution. An mIBI value greater than 4 indicates a relatively healthy waterbody. When taking the available habitat into account, the macroinvertebrate communities at three of the four sites did not show any serious impairment and sewage-related pollution did not appear to be a problem. Excessive sediment may have been a potential problem at all sites, since the low ratio of "EPT" taxa to chironomids is a frequent indictor of sediment effects [7]. The macroinvertebrate community in Frank's Drain was especially noticeable in having a biotic index lower than its habitat would allow. This re-affirms its identity as a "critical area" in Section VI.

Table 2. Habitat and Biotic Index Values

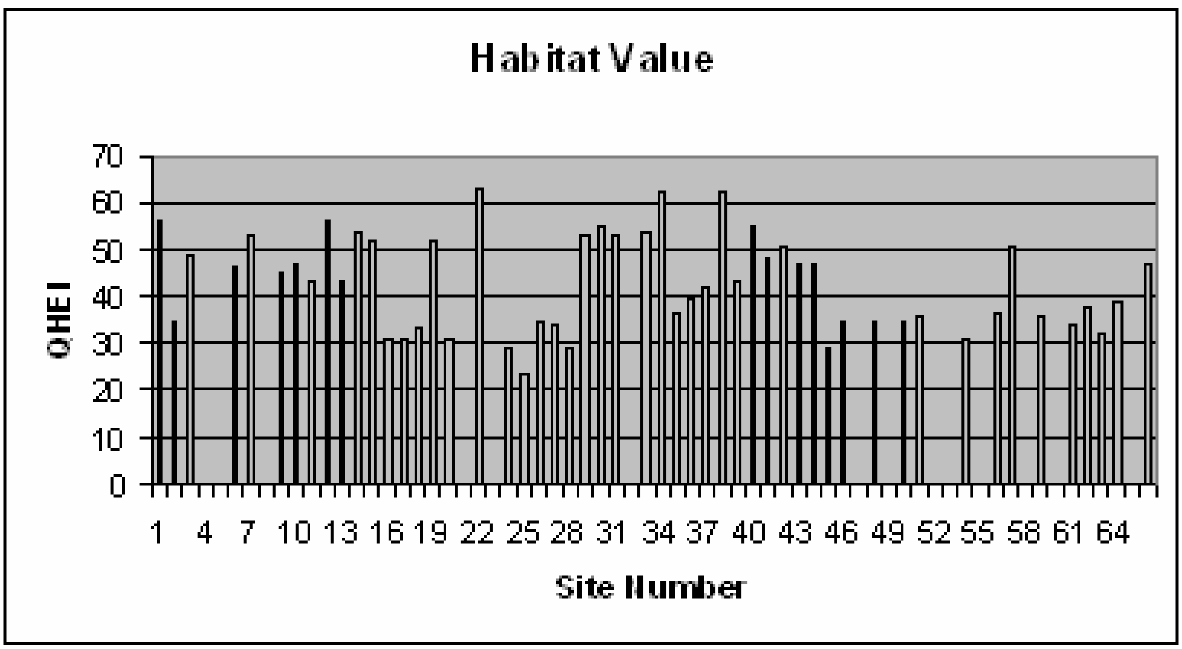
		Date	HBI	mIBI	QHEI
1	Limberlost Cr. (CR 185 E)	1998	4.7	4.7	57
2	Limberlost Cr. (CR 20 E)	1991	4.8	4.8	44
3	Wolf Creek (Hwy 18)	1998	5.5	3.6	50
4	Frank's Drain (CR 60 S)	1998	5.0	3.8	65

In 2005 macroinvertebrates were collected at six sites in the watershed as part of the Upper Wabash River Watershed Management Plan [17], The sampling sites are shown in Fig. 21. There were 3 sites on Limberlost Creek and 3 sites on Loblolly Creek. The mIBI scores ranged from 4.3 to 6.1, indicating relatively healthy conditions, despite lack of good habitat at most sites.

Aquatic Habitat Data

Results of the IDEM habitat evaluations at the 66 sites sampled in 2003 (shown in more detail in Appendix 1) are summarized in Fig. 17. Habitat values less than 50 indicate sites that are severely modified and can not support healthy aquatic communities. Most of the sites examined had impacted habitat. Sites with the highest habitat values that should continue to be protected from habitat destruction include Frank's Ditch, Limberlost Creek, and Wolf Creek. Sites with the lowest habitat values, where habitat enhancements may improve environmental quality, include Davidson Ditch, Slentzer Perry Ditch, and Wilson Creek. The watersheds draining these streams are considered "critical areas" in Section VI.

Fig. 17. Habitat Scores

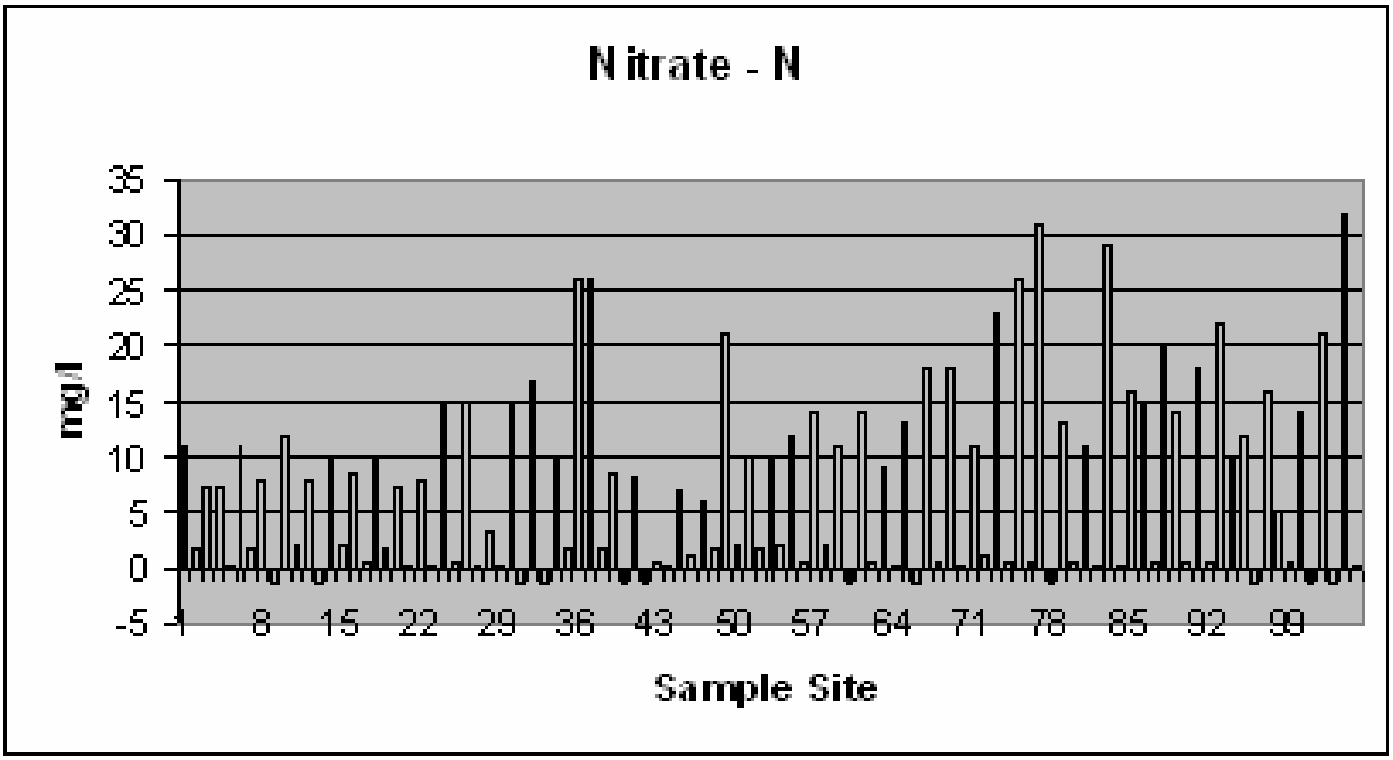


As part of this watershed management planning effort, a visual/photographic inventory was made of each stream where a bridge crossing was present. Although habitat was not quantified in this survey, the presence or absence of riparian vegetation and vegetative filter strips was noted. These sites are further identified and discussed in Section V.

EXISTING WATER QUALITY DATA

The Indiana Department of Environmental Management has collected water quality data in the watershed during 2003 [7]. A summary of their data for nitrate (collected from 66 sites and two summer sampling periods in the Limberlost watershed) is shown in Fig. 18. Sampling sites are shown in detail in Appendix 1 and 2. Nitrate values greater than 10 mg/l exceed Indiana's drinking water standard [3]. Nitrate values greater than 2 mg/l exceed EPA water quality recommendations designed to prevent nuisance algal blooms [4].

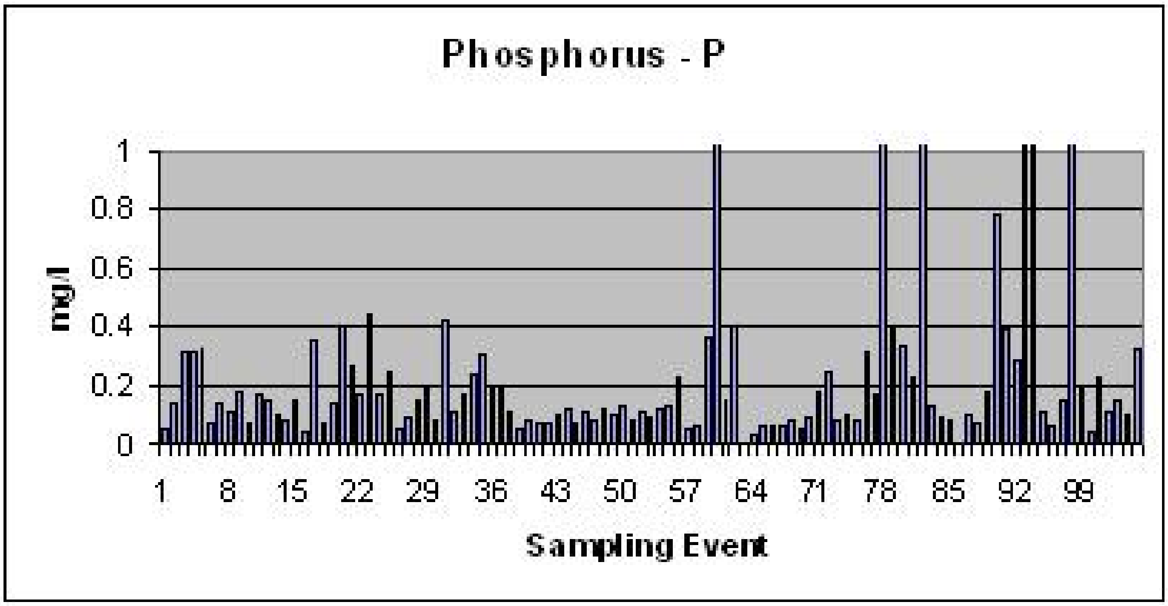
Fig. 18. Nitrate Concentrations



About a third of the samples collected exceeded the 10 mg/l water quality standard. The highest nitrate concentrations (greater than 25 mg/l) occurred in Wilson Creek, the East Prong of Limberlost Creek, and Hartzell Ditch. These watersheds are considered "critical areas" in Section VI.

A summary of IDEM data for total phosphorus [7] is shown in Fig. 19. Phosphorus concentrations greater than 0.1 mg/l exceed EPA's recommended criteria to protect against excessive algal blooms [4].

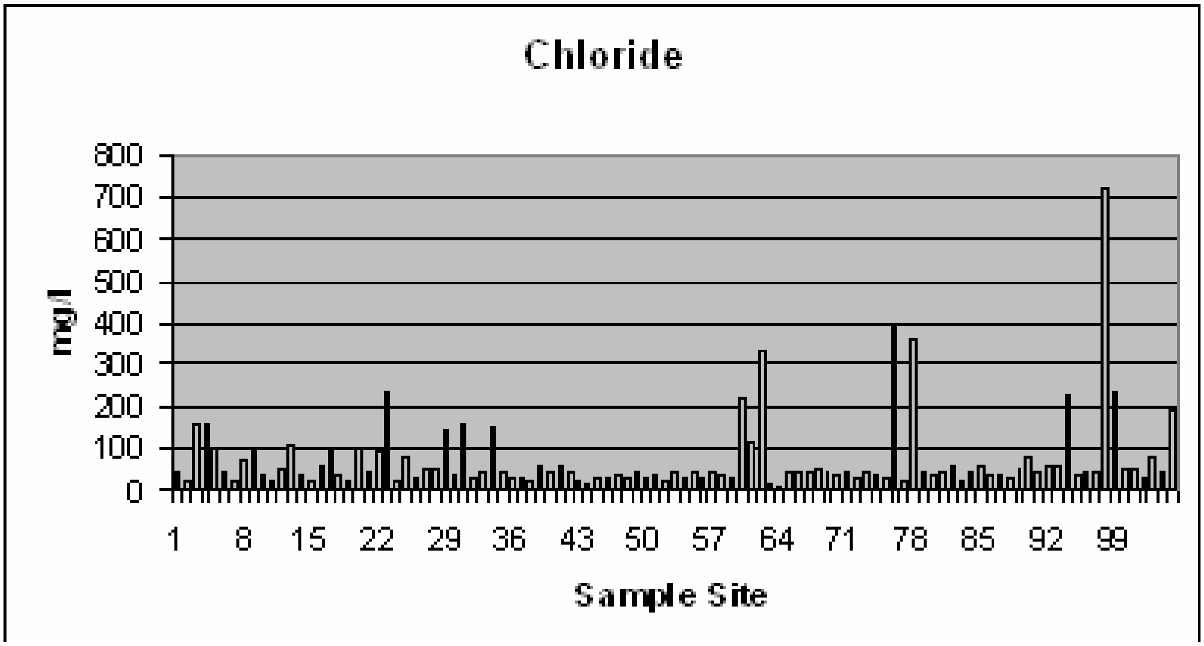
Fig. 19. Phosphorus Concentrations from 2003 IDEM study



Most sites exceeded 0.1 mg/l. The highest phosphorus concentrations (greater than 1 mg/l) occurred in Pape Hafner Ditch, Wilson Creek, Grissom Ditch, and the uppermost reaches of Limberlost Creek. These watersheds are considered "critical areas" in Section VI.

Fig. 20 summarizes data for chloride concentrations in the watershed. Chloride concentrations that exceed 250 mg/l may cause impairment to aquatic communities [5].

Fig. 20. Chloride Concentrations



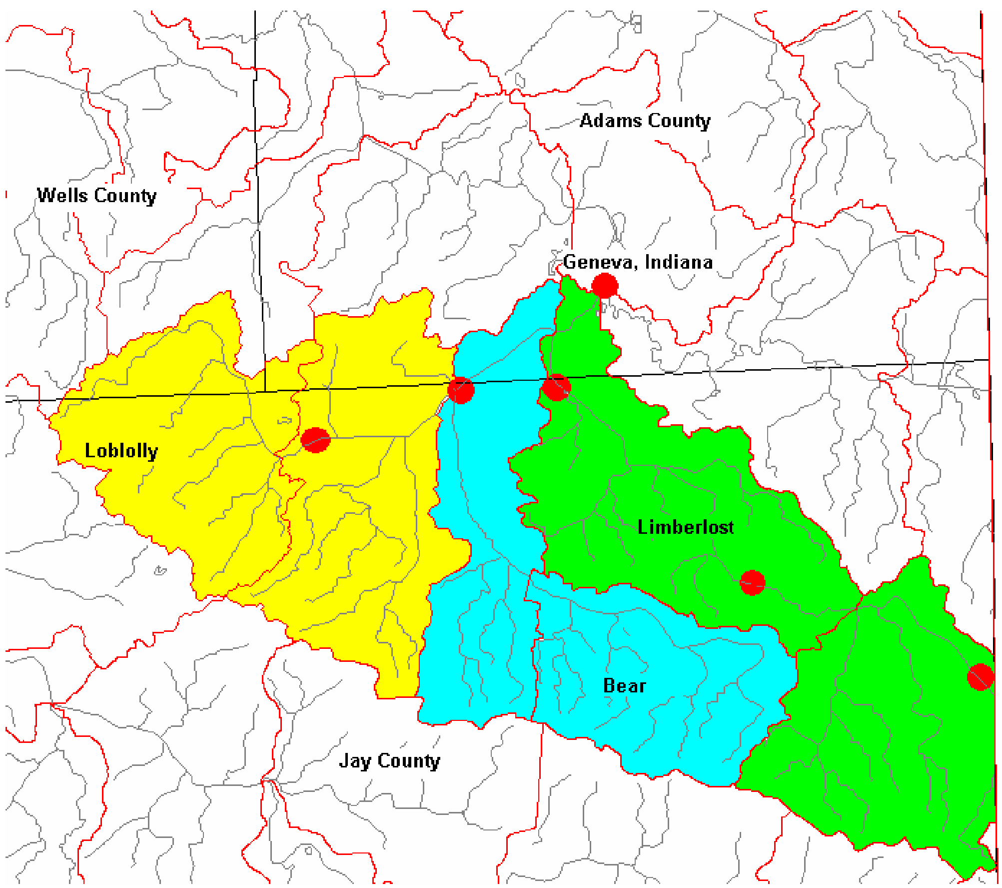
The highest chloride concentrations (greater than 300 mg/l) occurred in Wilson Creek, the East Prong of Limberlost Creek, and Grissom Creek. All of these sites also had high nutrient concentrations and are listed in the "critical areas" identified in Section VI.

Although water quality data indicated that abandoned leaking oil wells may be a problem in the watershed, this didn't appear to be true. After many interviews of local residents and several days in the field making spot checks of conductivity (a sign of high salt content), no instances of leaking wells were discovered. Therefore, no additional attention will be given to this area as a potential "target" for improvement.

The Indiana Department of Environmental Management used the chemical and biological data presented above to classify Limberlost Creek as having "impaired biotic communities" and placed the stream on the state's impaired waterbodies or 303(d) list [6]. A TMDL (Total Maximum Daily Load calculation) was then prepared for Limberlost Creek in 2007 [18]. The TMDL assumed that biotic communities are impaired primarily by excessive sediment and nutrients. There are no water quality standards for total suspended solids, phosphorus, or nitrogen. The TMDL document used benchmarks to determine the needed load reductions. The goals developed by the steering committee will address reductions for these parameters which have been concluded to occur due to runoff. The majority of runoff concerns focus on agricultural land use, which is the primary land use in the watershed.

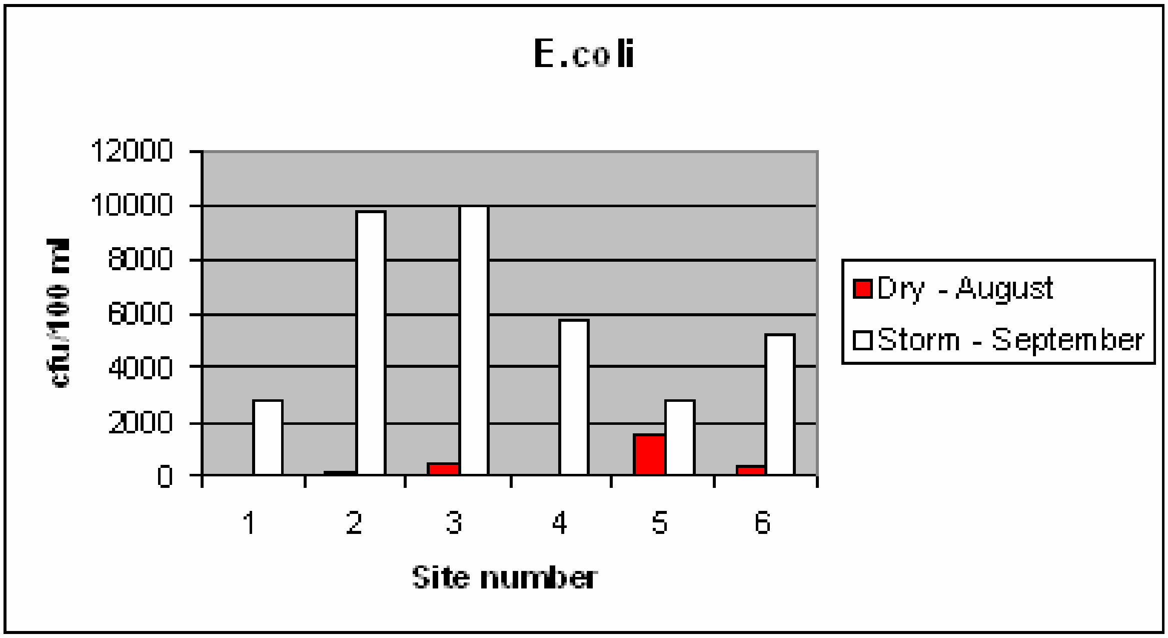
The Upper Wabash River Watershed Management Plan also collected water quality data in the watershed at six sites during 2005 [17]. Parameters included nitrate, phosphorus, and E.coli. Sampling sites in used in this study are shown in Fig. 21.

Fig. 21. Sampling Sites in a 2005 Watershed Management Plan



The nitrate and phosphorus data confirmed IDEM data that these two pollutants frequently exceed desirable concentrations. The E.coli data from this study are summarized in Fig. 22. Values greater than 235 cfu/100 ml are potentially harmful to those who swim or wade in the water and exceed Indiana water quality standards for recreation [5].

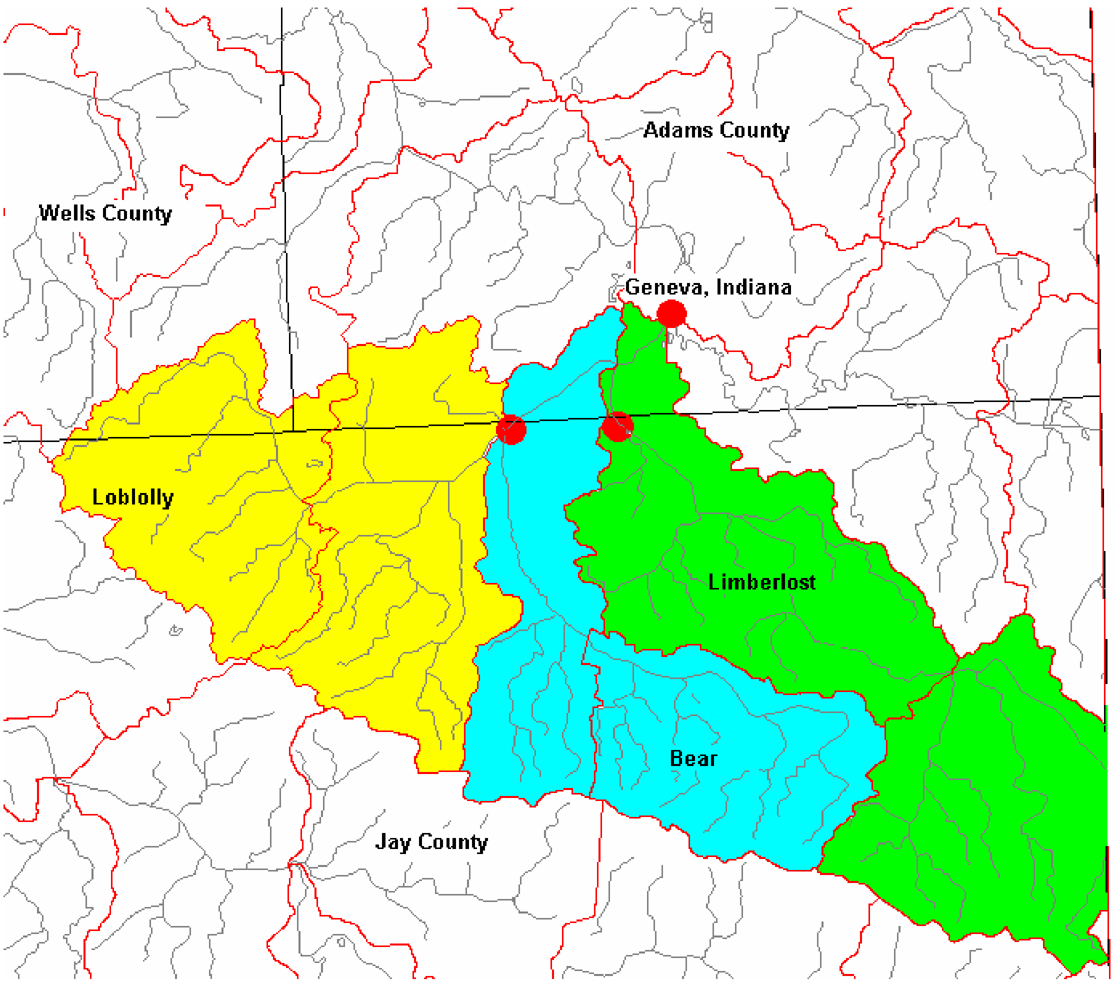
Fig. 22. E. coli data from 2005 study



E.coli values were highest during wet weather and exceeded the standard at all six sites. Sites 3, 5, and 6, where E.coli exceeded Indiana water quality standards during both dry and wet weather are shown in Fig. 23. They include Loblolly Creek at it's confluence with the Wabash River (this site includes all three watersheds), Limberlost Creek at CR 900 N, and Loblolly Creek at CR 50 W.

These findings confirm the Steering Committee's concerns that E.coli contamination is a problem in the watersheds, especially during wet weather at sites near the Adams/Jay County line in the lower part of the 11-digit Limberlost/Loblolly area.

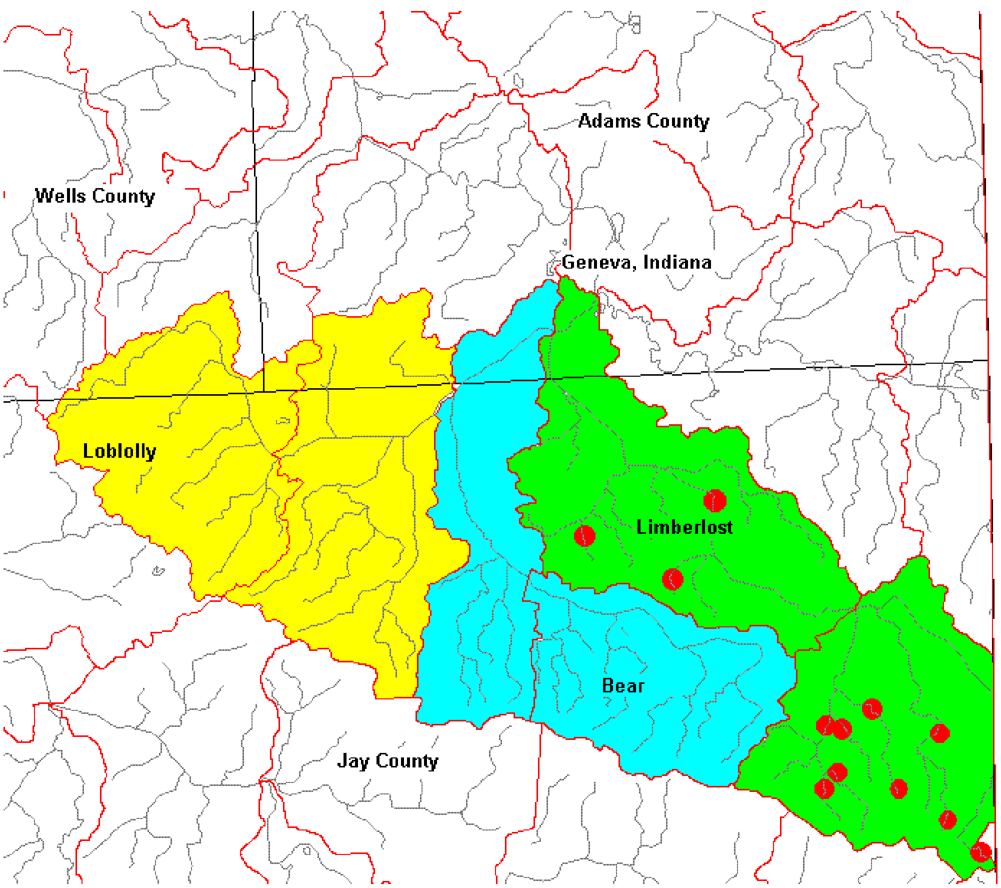
Fig. 23. Sites most affected by E.coli



Section IV. Identifying Problems

Chemical contamination by excessive nutrient and sediment loading has been identified as a problem. Excessive nutrient and sediment loading causes water quality standards or goals to be exceeded. It also contributes to impairment of biological communities. A summary of sites that are especially impacted by high sediment, nitrate and phosphorus, concentrations in the Limberlost Creek watershed is shown in Figure 24. Affected streams include Limberlost Creek, West Prong, East Prong, Wilson Creek, and Grissom Ditch. The watersheds draining these streams are identified as "critical areas" in Section VI.

Fig. 24. Sites most affected by excessive nutrient loading



Available water quality data show that nutrient and sediment loading leads to impaired aquatic communities in some local streams. In addition, degraded habitat impairs the ability of some local streams to support healthy aquatic communities. Finally, too many E.coli in the water causes a potential health hazard and impairs the use of some local streams for recreation. Based on these concerns, the steering committee developed the following problem statements:

1. Over-application of manure to fields results in runoff of excess nutrients and E.coli into waterbodies.
2. Conventional tillage methods leave soil exposed and susceptible to runoff forming sedimentation and nutrient loading of waterbodies in the watershed.
3. The lack of vegetated buffer impacts the health of waterbodies. The lack of buffer results in increased erosion, algae blooms, decreased stream habitat, decreased aesthetic qualities, and sedimentation.
4. Livestock without controlled access to waterbodies cause sedimentation from breakdown of stream banks. Increased nutrients are also introduced from the livestock themselves as they enter the water causing algae blooms and increased numbers of pathogens (E.coli).
5. Failing septic system contribute to pathogen (E.coli) and nutrient loading.
6. Conventional drainage maintenance practices carried out without a pre-determined plan may contribute to water quality problems and impaired aquatic communities.

Table 3 summarizes the concerns and potential stressors:

Table 3: Environmental Problems and Potential Stressors

Problem	Stressors
Large amounts of manure from livestock	E.coli Nutrients
Conventional Tillage	Sediment Nutrients
Lack of Vegetative Buffers	Sediment Nutrients Habitat Loss
Livestock Access to Streams	Sediment Nutrients E.coli
Failing Septic Systems	Nutrients E.coli
Conventional Drain Maintenance	Habitat Loss

Section V: Identifying Sources of Stressors

Chemical or Sediment (Nonpoint Source) Pollution

In developing a plan to manage water quality, it is necessary to target "stressors" that cause the biggest problems. The following chemical stressors are most important in the watershed. They are presented in order of importance, based on the amount of deviation of the present maximum value from the target value:

	Target Value	**Present Value (average)**
Excessive E.coli	<235 colonies/100 ml	>1,000 colonies/100 ml
Excessive Phosphorus	0.1 mg/l	0.15 mg/l
Excessive Nitrate	10 mg/l	14 mg/l
Excessive Sediment	EPT/Chironomid ratio Greater than 12	EPT/Chironomid ratio less than 2

Excessive E.coli, sediment or nutrient inputs within the watersheds probably originate from the following sources within the watershed:

- Low use of conservation tillage, especially in corn production
- Conventional livestock production and manure management systems where livestock density is very high. Over-application of manure to land in the watershed may result. Manure management plans have not been fully developed for this area.
- Failing septic systems and unsuitable soils for septic systems
- Lack of vegetative buffer strips and waterways in agricultural areas

Habitat Destruction

To keep local streams in good enough condition to support aquatic life, it will be important to prevent habitat alteration that results in QHEI values less than 50. Habitat destruction often results from the following causes:

- Unrestricted access to streams by livestock
- Artificial channelization for drainage
- Filling of wetlands
- Removal of shading tree canopy

One of the tasks involved in this project was a survey of streams in the watershed from bridge crossings. At each bridge crossing, the condition of the stream was documented with one or more photographs. Copies of all photographs and a narrative for each site are included in Appendix 11.

A total of 175 bridge crossings were photographed. Of these, 37 sites were identified as having no vegetative filter strips present along the stream borders or having unrestricted access by livestock. The largest number of these sites (15) were in the Frank's Drain subwatershed in Jay County, Wabash and Noble Townships. Example photographs of sites lacking filter strips or which could benefit by a grassed waterway are shown in Fig. 25.

Fig. 25. Examples of sites lacking filter strips or needing grassed waterways

SECTION VI: Identifying Critical Areas

Existing Loading Estimates

The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) was developed for the U.S. Environmental Protection Agency (USEPA) to estimate loadings from nonpoint sources [11]. Watershed size was entered into the spreadsheet after the proper state, county, and eight digit watershed. The parameters were figured included land use acres for each practice, amount of agricultural animals, septic system data, hydrological group. According to this model, the six Limberlost subwatersheds will currently generate the following pollutant loads:

Nitrogen	270 tons per year
Phosphorus	68 tons per year
Sediment	27,000 tons per year

The largest source of loading from all pollutants is cropland. Sediment loading from this source is approximately 92%. Other important sources of loadings of nitrogen and phosphorus come from feedlots (6%), pastureland (5%) and failing septic systems (2%). E.coli loading cannot be calculated with this model. From previous studies [e.g. 20], it is estimated that more than half the dry weather loading of E.coli comes from failing septic systems. The Limberlost Creek sub-watershed has the highest loading estimates.

Target Areas and Prioritization

Target areas in the watersheds are areas that have the greatest likelihood of being a source of nutrient input, soil loss, and/or poor habitat. They are selected based on the sources/stressors causing the greatest damage and can be addressed in the next three to five years.

Several streams were identified previously by available chemistry and biology data from Limberlost Creek as being “critical areas” with identified impairments. These streams are within the circled area shown in Fig. 26 and presented individually by waterbody name below:

Franks Drain: Impaired Aquatic Communities

Perry Ditch: Impaired Aquatic Communities

Wilson Ditch: Impaired Habitat, nitrate, phosphorus

Davidson Ditch: Impaired Habitat

East Prong: nitrate

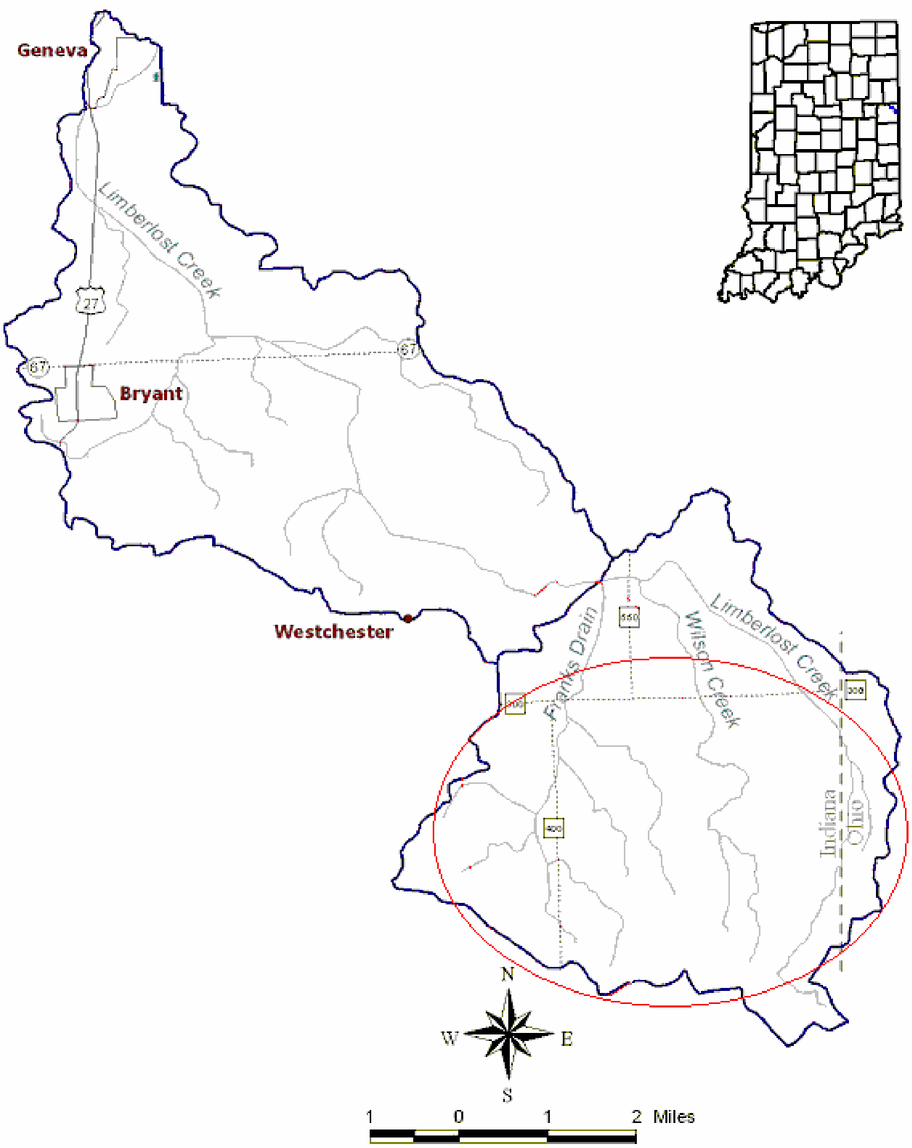
Hartzell Ditch: nitrate

Pape Hafner Ditch: phosphorus

Grissom Ditch: phosphorus

Upper Limberlost: phosphorus

Fig. 26. Target Areas for Management in Limberlost Creek

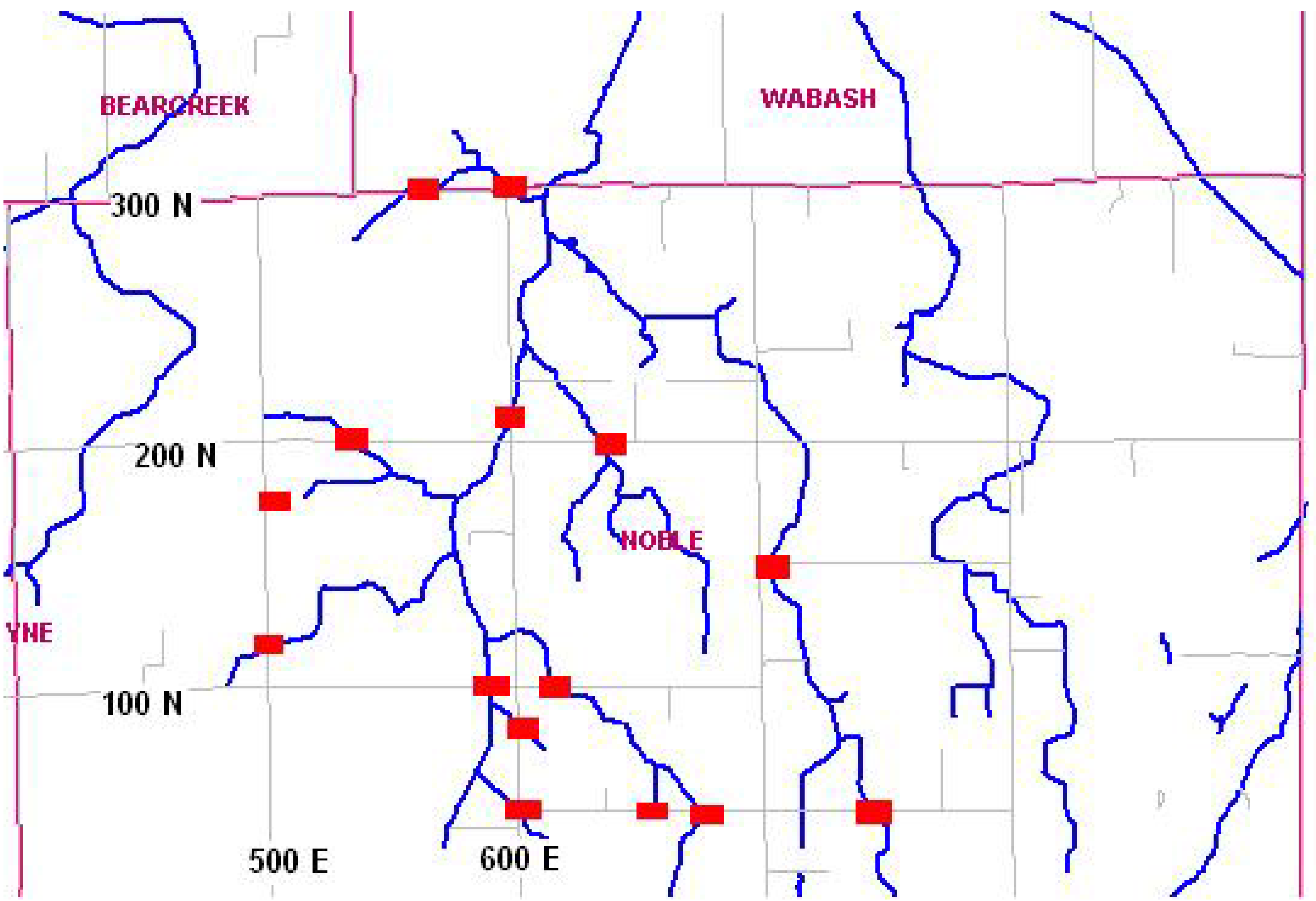


Goals for these target areas:

- Incorporate modern manure management practices
- Repair or replace septic systems that are not working properly
- Install vegetative buffer strips and waterways where they are absent
- Reduce the number of farms acres using conventional tillage

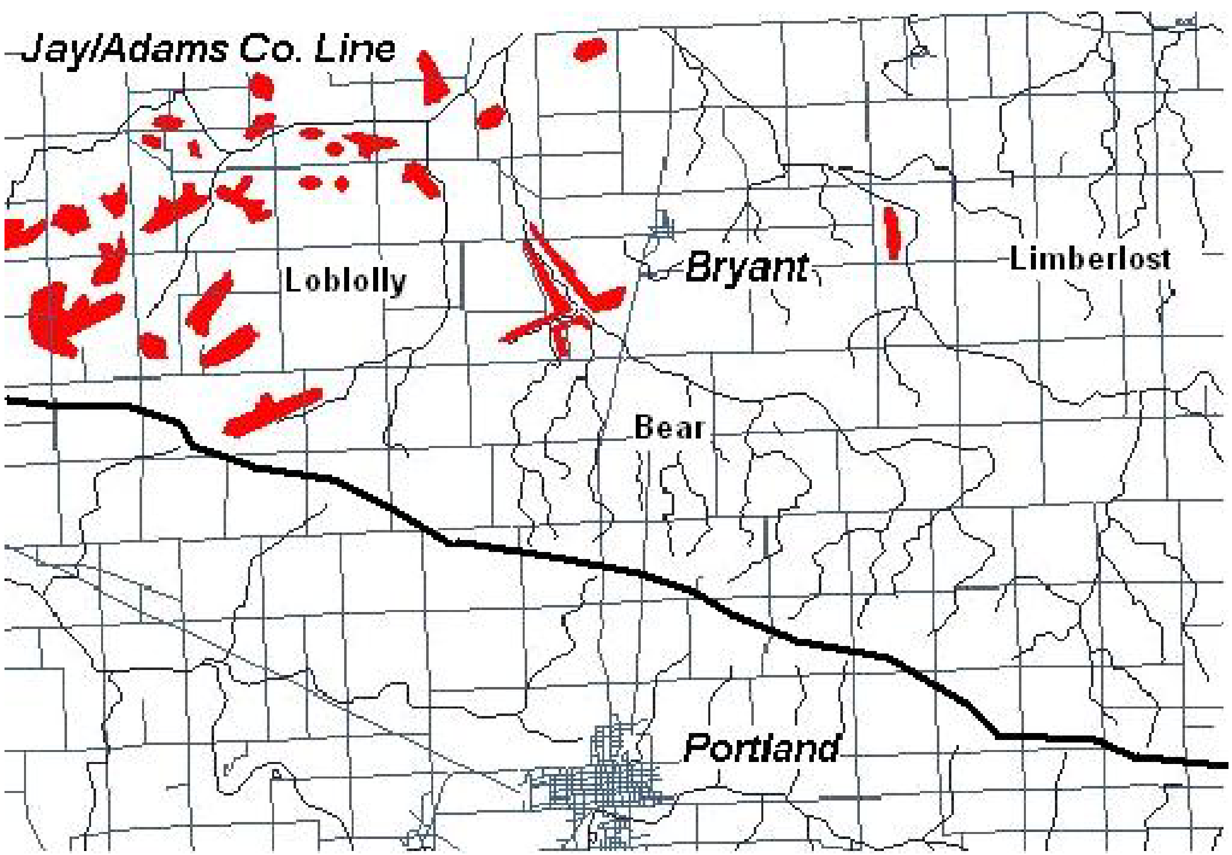
Sites within Frank's Drain where filter strips were absent in the photographic inventory are shown in Fig. 27. These sites should be placed on high priority for management.

Fig. 27. Sites where filter strips were absent in Frank's Drain



Little water quality monitoring has been done in two of the three subwatersheds in the Limberlost area, so it is more difficult to prioritize individual areas for improvement in these areas. However, areas in agricultural production that have highly erodible soils on steep slopes would have the greatest potential for runoff. These areas would be identified as “critical” and protecting them by taking them out of agricultural production or encouraging the use of conservation tillage practices would be a high priority. Glynwood and Morley soils on slopes greater than 10% (most likely to erode) are shown in Fig. 28. Tillable land on between Haskins Run and Votaw Ditch in the Upper Loblolly watershed should receive high priority for management. These areas are in Jay County, Jackson Township, Sections 5, 10, 13, 16, 17, 19, 20. 21, 28, 29, and 30. Another high priority area is the tillable land on erodible soils along Bear Creek in Jackson Township Sections 13 and 24 and Bear Creek Township Section 19.

Fig. 28. Highly Erodible Soils within the Limberlost/Loblolly Area



Other High Priority Goals

Other land use practices that are considered to have potentially negative impacts on water quality in the watershed (in order of importance) are:

1. Traditional manure management practices of land application and no soil testing
2. Failing septic systems
3. Unnecessary drainage practices
4. Unrestricted livestock access to streams

Modern manure management practices should be encouraged at all the confined feeding operation sites shown in Figure 12. Modern practices that should be encouraged in these areas are anaerobic digestion of manure (see Appendix 8), soil testing, and composting.

Failing septic systems are currently being repaired or replaced throughout the Limberlost area through successful programs being carried out by county health departments. The highest priority should be placed on those systems currently identified as “failing.”

Drainage for agricultural uses is widely practiced in the Limberlost/Loblolly area. A certain amount of channelization is inevitable. However, there is currently no formal planning process for when or how this is done. Frequent need to maintain drains is an indicator of excessive sediment input. A drainage plan should be written and followed after input from local citizens.

Some stream segments in the Limberlost/Loblolly area still have unrestricted access by livestock. This provides convenient watering but has the potential for significant water quality problems and habitat degradation. Fencing to restrict access by livestock to local streams should be encouraged.

SECTION VII: Setting Goals & Selecting Indicators

Goal development

Based on the problem statements in Section 4, the steering committee developed goals to improve water quality problems and habitat quality. Land use practices that have the greatest potential for increasing water quality in this area are:

1. Wetland restoration
2. Grassed waterways and vegetative buffers along streams
3. Alternative manure management systems

   Proper septic system maintenance

4. Alternative stream drainage practices

The committee also recognized the need for educating the local populace about some of these practices. As a result, the committee developed the following goals to employ the practices above:

Biological Restoration Goals

1. Restore natural ecological communities in the watersheds wherever possible

Cropland Agriculture Goals to Reduce Pollutant Loading from Cropland Agriculture

2. Make application of fertilizer more efficient
3. Decrease the use of unnecessary ditching practices on streams in the watershed
4. Increase the use of conservation tillage in the watershed, especially for corn

Livestock Agriculture Goals to Reduce Pollutant Loading from Livestock Agriculture

5. Promote use of alternative manure management systems
6. Fence livestock from waterways where possible

Riparian Goals to Improve Water Quality Through Increased Buffering of Surface Waters

7. Install vegetative buffer strips along all stream channels
8. Restore wetlands wherever possible

Educational Goals

9. Educate the public on the importance of habitat
10. Provide information on proper septic system maintenance
11. Provide information on good manure management practices
12. Encourage the use of environmentally sensitive channel maintenance

Goal 1: Ecological Restoration Goals

To restore habitat in the watershed that would be adequate to support a healthy animal community. IDNR Division of Nature Preserves employee Ken Brunswick prepared a list of animals that could be expected in the watershed if it was ecologically restored. There is no target date possible for meeting this goal but success can be measured by documenting the return of individual species. The list is included in Appendix 9.

Goal 2: Row Crop Agriculture Goals

Objective #1: Make application of fertilizer more efficient.

Problem	Benchmark	Target	Target Date
Fertilizer (both chemical and manure) may sometimes be applied in excessive amounts, causing nitrate and phosphorus levels to rise in streams	Water Quality Indicator Now: N > 10 mg/l P > 0.3 mg/l No soil testing	Water Quality Indictor N < 10 mg/l P < 0.3 mg/l 100% soil testing	December 2012

Objective #2: Decrease the use of unnecessary ditching practices.

Problem	Benchmark	Target	Target Date
Ditching for crop drainage may contribute to nutrient and sediment loading	There is presently no plan in place for ditch maintenance	Ditch maintenance will occur according to a written plan	December 2012

Objective #3: Encourage no-till on 50% of corn and 90% of beans

Problem	Benchmark	Target	Target Date
Conventional tillage results in higher erosion than "no-till" methods	Now: 19% of no till on corn 57% of no till on beans	50% on corn 90% on beans	December 2012

Goal 3: Livestock Agriculture Goals

Objective #1. Promote use of alternative manure management

Problem	Benchmark	Target	Target Date
Manure production is very high and improper disposal may harm water quality.	Manure management now depends primarily on lagoon storage. Land application occurs on soils already high in nutrients.	50% of manure is composted or digested prior to application. Land application occurs only on areas where nutrients are needed.	December 2012

Objective #2: Fence livestock from waterways where applicable.

Problem	Benchmark	Target	Target Date
Unrestricted access to streams by livestock destroys streambank vegetation and may contribute to excessive sediment, nutrients, and E.coli	Presently, access to streams by pastured livestock is primarily unrestricted. Water Quality Indicator: E.coli > 235 per 100 ml	All streams with pastured livestock will be fenced to reduce direct access. Indicator: E.coli < 235/100 ml	December 2012

Goal 4: Riparian Zone Goals

Objective #1: Install vegetated buffer strips

Problem	Benchmark	Target	Target Date
Streams without vegetated riparian buffer strips have higher nutrient and sediment inputs	Water Quality Indicators: Now: N > 10 mg/l P > 0.3 mg/l Many sites with no buffers.	Water Quality Indicators N < 10 mg/l P < 0.3 mg/l No sites without buffers.	December 2012

Objective #2: Restore wetlands wherever possible

Problem	Benchmark	Target	Target Date
Filled wetlands reduce the water quality benefits provided by wetlands.	1000 acres of restored wetlands in the watersheds	2000 acres of restored wetland in the watersheds	December 2012

Goal 5: Education Goals

Objective #1: Educate the public on the importance of enhancing & maintaining aquatic habitat.

Problem	Benchmark	Target	Target Date
Many people do not understand how important local "ditches" can be for the environment.	Unnecessary ditching occurs	Ditching occurs only when drainage is poor and is done in a way that preserves habitat. QHEI never goes below 40.	December 2010

Objective #2: Provide information on proper septic system maintenance

Problem	Benchmark	Target	Target Date
Poor local soils make operation of septic systems difficult.	25% of failing septic systems Water Quality Indicator: E.coli > 235 per 100 ml	No failing septic systems Water Quality: E.coli < 235/100 ml	December 2012

Objective #3: Provide information on good manure management practices

Problem	Benchmark	Target	Target Date
New management methods can help address potential water quality problems associated with manure.	Few composting facilities used and there are no anaerobic digesters for manure treatment. The development of an economic study (e.g Appendix 8) would be a sign of success.	Five new composting facilities or anaerobic digesters in place	December 2012

Objective #4: Encourage environmentally sensitive channel maintenance

Problem	Benchmark	Target	Target Date
Ditch maintenance can be done on a schedule using methods that are less harmful to aquatic life.	Presently, there is no scheduled ditch maintenance. It is done on a "demand" basis. Use of the "Palmiter Method" or equivalent (App. 7) would be a sign of success.	The County Surveyor's office will have training in new practices and work on a schedule of maintenance	December 2010

Section VIII: Choosing Measures to Apply

All of the measures recommended in Section 6 (critical areas) will be effective in improving water quality. Each one of these measures should be encouraged. Implementation will often be determined by the willingness of local landowners and county officials to adopt them.

It is anticipated that ecological restoration (Goal 1), ongoing wetland restorations (Goal 4, Objective 2), the continued establishment of vegetative filter strips (Goal 4, Objective 1), and manure management planning (Goal 3, Objective 1) are of the highest priority and are the most likely measures to be carried out in the next 3 years.

Within 5 years, additional measures that may reasonably be expected to be applied include:

Soil testing programs for nutrients (Goal 3, Objective 1)
Increasing use of conservation tillage (Goal 2, Objective 3)
Additional fencing of livestock from waterways (Goal 3, Objective 2)
Establishment of drainage plans in each county (Goal 5, Objective 4)

A summary of the most likely BMPs to be applied and their potential effects on pollutant loading are shown in Table 4.

Table 4. BMPs and Associated Load Reduction Estimates

BMP	Proposed Quantity	Pollutant Reduction Estimate (tons)	Reference for BMP Efficiency
1. Wetland Restorations	1000 acres	Nitrogen 6 Phosphorus 1 Sediment 300	70% efficiency [21]
2. Riparian Buffer Strips	15 acres (on 10,000 additional acres of adjacent cropland	Nitrogen 20 Phosphorus 4 Sediment 2000	50% efficiency [22]
3. Manure Management Plans	30 plans	Nitrogen 50 Phosphorus 5	[22]
4. Soil Testing	Annual tests prior to fertilizer application on 100 farms	Nitrogen ? Phosphorus ?	Not Applicable
5. Conservation Tillage	20,000 new acres for corn 20,000 new acres for beans	Nitrogen 30 Phosphorus 5 Sediment 3000	40% efficiency [23]
6. Livestock Fencing	10 new fenced areas (10 acres of protected riparian zone)	Nitrogen 1 Phosphorus Sediment 100	90% efficiency [24]
TOTAL (rounded)		Nitrogen 100 Phosphorus 15 Sediment 5500	

Section IX: Calculating Load Reductions

Cropland & Riparian Reductions

Practices that should be implemented in the watershed to reduce sediment and nutrient loads are shown previously in Section VIII and include:

Riparian Buffer Strips (100% of all streams. Emphasize 15 sites in Fig. 27).
Soil Testing for Nutrients (100% of all farms applying fertilizer)
Conservation Tillage (50% increase in acres using this practice)

Livestock Reductions

Practices to be implemented in the watershed to reduce pathogen and nutrient loads are shown previously in Section VIII include:

Livestock Fencing (no livestock with unrestricted access to streams)
Livestock Stream Crossings (10 stream crossings)
Manure Management Planning (100% of all farms regulated by NPDES permit)

The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) program [11] was used to calculate load reductions that may be expected to occur from implementing these practices. The program uses information on land use, acres for each land use practice, number of livestock, septic system data, and hydrological group. Data used in the program are shown in Appendix 10. The program calculates nutrient and sediment loads from different land used and the load reductions that would result from the implementation of various best management practices (BMP's). The sediment and pollutant load reductions that result from the implementation of BMP's are computed using the known BMP efficiencies. Selections of various BMPs are limited in the STEPL model and do not include practices such as wetland restorations, livestock fencing, manure management planning, or soil testing. Therefore, results of STEPL modeling may underestimate loading reductions if unlisted practices are an important part of the plan.

Results of the STEPL model predictions are summarized in Table 5. According to the model, if the BMPs listed in Section VIII are implemented, pollutant loading of phosphorus, nitrogen, and sediment should each be reduced by about 25%. It is interesting to note that the pounds (or tons) per year load reductions predicted by the model are similar to those predicted in Table 4 of Section VIII.

Indicators for meeting the watershed goals include lowered concentrations of suspended solids, nitrate, and phosphorous. Currently, all of these are above desirable levels. The STEPL model predicts that with the installation of best management practices, water quality will improve dramatically (Fig. 29 and 30). According to the model, the average nitrate and phosphorus concentrations in the watershed should be able to meet water quality goals (10 mg/l for nitrate, 0.1 mg/l for phosphorus) after BMP implementation. Although the STEPL model does not predict biological effects, elimination of 7,500 tons of sediment loading per year should also improve a key biological indicator (EPT/Chironomid Ratio) as listed in Section V.

Fig. 29. Predicted nutrient load reductions with BMP implementation

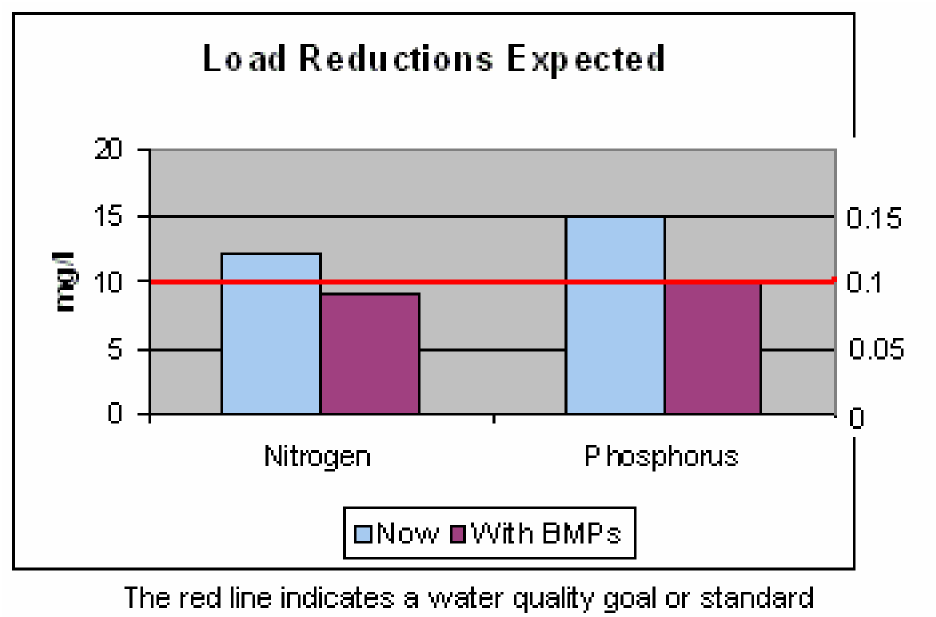


Fig. 30. Predicted sediment load reduction with BMP implementation

STEPL does not predict E.coli reductions with BMP implementation and specific sources of E.coli are difficult to determine without expensive source tracking techniques. We know that the watershed has both poor soils for septic systems and also a large population of livestock. Both of these may be important contributors of E.coli loading. Fig. 22 suggests that runoff-related loading is far most important than dry weather loading, suggesting that livestock sources are more important than human sources.

Two of the planned BMPs shown in Fig. 4 are known to reduce pathogen loading, including E.coli. Up-to-date manure management plans for the 31 CFOs will prevent land application of manure during runoff events, when bacteria are most like to wash into nearby waterways. Fencing livestock away from streams will also reduce manure runoff. Additional BMPs that are recommended in the plan but may be more than five years from implementation are manure composting and anaerobic digestion (goal 3, objective 1). Both these long-term BMPs are known to kill most pathogens in manure and would be very effective in reducing E.coli loading.

Although not as scientifically grounded as nutrient load reductions, keeping E.coli in manure out of local waterbodies could produce a 99% E.coli load reduction in the watershed. This rough estimate is simply based on the "livestock to human" ratio in the watershed. Livestock outnumber humans more than 100 to 1 in the Limberlost/Loblolly area. If this assumption is true, we should expect the storm event loading of E.coli observed in Fig. 22 (concentrations of up to 10,000 cfu/100 ml) to be reduced to less than 100 cfu/100 ml (below Indiana water quality standards) after BMP implementation.

Table 5: STEPL Nutrient and Sediment Load Reductions with Implementation of Conservation Practices

Total Load

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year
Total	568000	141000	28000	134000	38000	7700	434000	103000	20500

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban and Septic	1060	160	25
Cropland	341000	86400	19700
Pastureland	23000	2200	460
Feedlots	59000	9900	0
Septic	8200	3200	0

	Percent Reduction in Loading after BMPs
Nitrogen	24
Phosphorus	27
Sediment	27

Section X: Implementation

Action Register

For cost estimates, those considered “low” would be less than $1000. Those in the “medium” category would be between $1000 and $10,000. Those in the “high” category could cost more than $10,000.

Goal 1: Restore natural ecological communities. This is a high priority goal for implementation. It is already the primary goal of the “Limberlost Swamp Remembered” committee of the Friends of the Limberlost.

Objective: Restore the environmental health of the area’s waterways.

Action	Cost Estimate	Funding Source(s)	Responsible Group	Indicator(s)
Continue the work of the Friends of the Limberlost Swamp Remembered to restore and monitor natural communities	Medium	Natural Resource funding grants	Friends of the Limberlost	Annual report of the committee, which will include progress reports.
Invite landowners participate in restorations	Low	None needed	Friends of the Limberlost, NRCS	Number of participants at the end of each year

Goal 2: Row Crop Agriculture Goals.

Objective: Reduce nitrogen and phosphorus inputs to streams by more efficient application of fertilizer. .

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Encourage soil testing	Low	None needed	NRCS Cooperative Extension Private consultants	Number of samples tested
Develop a manure management plan for those using manure	Low	None needed	NRCS SWCD Private consultants	Number of plans developed

Objective: Create a program that promotes drainage projects only when needed.

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Encourage the use of a ditch maintenance schedule	Low	319	County Surveyors	Record and publicize the production of a ditch maintenance plan

Objective: Create a program that promotes conservation tillage

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Have record of tillage transect data	Low	SWCD	NRCS SWCD	Record tillage transect data when updated
Map watershed for conservation tillage	Low	Purdue	NRCS SWCD DNR	Report increases in conservation tillage when tillage transect data is updated
Develop criteria for cost-share program	Low	319 Grant	SWCD NRCS	Report when criteria is developed
Advertise the cost-share program in newspaper and newsletter	Medium	319 Grant	SWCD	Report advertising efforts quarterly
Provide information about criteria	Low	319 Grant	SWCD Ag Extension	Report advertising efforts quarterly
Implement cost-share program	High. The cost of other cost-share programs has exceeded $100,000.	319 Grant	NRCS FSA DNR	Report all projects that utilize the cost-share money quarterly
Advertise dates of no-till meetings and information that will be covered	Medium	319 Grant, SWCD	SWCD NRCS DNR Ag Extension & 4H	Report attendance and dates of no-till meetings quarterly

Goal 3: Livestock agriculture goals.

Objective: Reduce water quality problems associated with manure runoff

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Gather information on composting and anaerobic digesters	Low	319 Grant	SWCD Ag Extension FSA NRCS IDEM	Record and catalog all information gathered
Compile informational handout to distribute to landowners and publish in a newsletter	Low	319 Grant	SWCD FSA NRCS	Report number of handouts sent out and taken at events quarterly
Set date for farm tour that uses one of the alternative manure management practices	Low	319 Grant	SWCD NRCS DNR FSA	Report when farm tour is scheduled
Notify landowners of the tour	Low	319 Grant	SWCD NRCS DNR FSA	Report how many individuals notified
Hold tour of a farm with alternative manure management	Medium	319 Grant	SWCD Landowner NRCS DNR FSA	Report number of participants at the tour

Objective: Fence livestock from waterways where possible to decreasing nutrient, sediment, and E.coli concentrations

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Develop cost-share program	Low	319 Grant	SWCD NRCS	Report when program is developed
Promote program	Medium	319 Grant	SWCD	Report advertising efforts quarterly
Meet with landowners	Low	319 Grant	SWCD Ag Extension NRCS	Report number landowners met with quarterly
Implement cost-share program	High. The cost of other cost-share programs has exceeded $100,000.	319 Grant	NRCS FSA DNR	Report all projects completed that utilize the cost-share money quarterly

Goal 4: Riparian zone goals. This is a high priority item for implementation.

Objective: Increase stream buffers 40% to reduce nutrient and sediment inputs to waterways

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Advertise CRP programs	Low	319 Grant	SWCD NRCS DNR FSA	Report advertising efforts quarterly
Inform landowners by meeting one on one	Low	319 Grant	SWCD NRCS DNR FSA	Report number of individuals met with one on one quarterly

Objective: Restore wetlands wherever possible to provide water quality and habitat improvements.

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Continue the work of the Friends of the Limberlost Swamp Remembered to buy and restore wetlands	High. Wetland restorations may cost more than $5000 per acre.	Natural Resource funding grants	NRCS SWCD	Annual report of the committee
Invite landowners participate in restorations	Low	None needed	NRCS SWCD	Number of participants at the end of each year

Goal 4: Education goals

Objective: Provide education on the importance of enhancing and maintaining aquatic habitat

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Develop a habitat program	Medium	319 Grant	SWCD Ag Extension	Report program development
Advertise program	Low	319 Grant	SWCD	Report number of places advertised quarterly
Host program	Medium	319 Grant	SWCD	Report number of adults taught quarterly

Objective: Provide information on proper septic system maintenance

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Pass out brochures already produced	Low	None needed	Local county sanitarians Local soil scientists	Report program development

Objective: Provide information on good manure management practices to reduce runoff from manure and its associated water quality problems

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Educate farmers on the economics of composting and anaerobic digesters. A case study is attached in Appendix 8.	Medium	319 Grant	Local consultants Purdue USEPA Agstar program	Report program development
Pass out brochures already produced	Low	None needed	SWCD	Report program development

Objective: Provide training to the local county surveyors and drainage boards on "best management practices" for ecologically healthy watersheds

Action	Cost Estimate	Funding Source(s)	Responsible Groups	Indicator(s)
Provide a training program for environmentally friendly channel maintenance techniques. An example of this is attached in Appendix 7.	Medium	319 Grant	DNR Division of Water IDEM	Report program development
Encourage the use of "2-stage ditches"	Medium	319 Grant	DNR Division of Water IDEM The Nature Conservancy	Report program development

Section XI: Monitoring Indicators of Progress in the Management Plan

Water Quality and Habitat

The Indiana Department of Environmental Management will monitor fish, habitat, and chemistry in Limberlost Creek to determine the success of TMDL implementation and as part of the 303(d) impaired waterbodies program. The results of this monitoring will be used to determine whether water quality has improved as the plan is implemented.

Education

The Friends of the Limberlost have already produced educational brochures on septic system maintenance and manure management. These are being distributed at the Historic Site cabin in Geneva and at the Soil and Water Conservation District office in Portland. The Friends plan to submit grant requests for educational projects dealing with channel maintenance. Indications of progress will be requests for additional brochures and the successful beginning of a channel maintenance plan.

Load Reductions

Load reductions will be figured using the IDEM Load Reduction Estimate Worksheets. When BMPs are installed using funds from the Section 319 program, worksheets will be filled out the predict load reductions. Load reduction worksheets will continue to be filled out by the SWCD for every BMP installed in the watershed. All of the conservation practices that are installed in the watershed will meet NRCS technical guide standards. Local agencies, along with the NRCS, will provide technical assistance to landowners and operators on the BMPs implemented throughout the watershed.

Interim Implementation Milestones

The plan calls for practices that will result in water quality improvements within five years. The following "interim milestones" will help determine whether progress is being made:

2008: One new wetland restoration areas has been identified
Soil testing is done prior to fertilizer application on 50% of all farms

2009: Manure management plans are in place for 50% of all livestock operations
A grant to produce a plan for drainage maintenance has been approved

2010: The number of acres in conservation tillage has increased to 25% for corn and 75% for beans
At least one drainage project has been carried out using the Palmiter Method

2011 Livestock fencing projects have been carried out on five new farms
500 new acres of wetland have been restored

Section XII: Management Plan Evaluation and Adapting to Changes

The Steering Committee (the Limberlost Swamp Remembered section of the Friends of the Limberlost) will meet periodically throughout the Implementation Phase of the project to review the process and track progress. The Management Plan will be updated on an as need basis to show accomplishments and add additional information. All updates will be agreed on by the Steering Committee. There will be copies of the Management Plan available to the public at the SWCD offices and at the Geneva Public Library.

References

1. Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for use in Streams and Wadable Rivers: periphyton, benthic macroinvertebrates and fish, Second Edition. EPA 841-B-99-002. Environmental Protection Agency; Office of Water, Washington, D.C.

2. U.S. Department of Agriculture, 2002. Census of agriculture. Jay County, Indiana profile. http://www.nass.usda.gov/in.

3. National Agricultural Statistics Service, 2000. Cropland data layer (satellite photo analysis). U.S. Dept. of Agriculture, Washington, D.C.

4. Indiana Business Research Center at the Indiana University Kelley School of Business (IBRC). 1990. Population County by Decade by County: 1900 to 1990. Available online. http://www.stats.indiana.edu/web/county/popct_cty90.html

5. Indiana Register, Nov. 1, 1996. Indiana Water Quality Standards. Article 2. Indiana Administrative Code. Title 327 Water Pollution Control Board, Indianapolis, IN.

6. IDEM Office of Water Quality, 2006. Updated List of Impaired Waters Under Section 303(d) of the CWA. Indiana Department of Environmental Management. Indianapolis, Indiana.

7. IDEM Office of Water Quality, 2004. A multivariate approach to source identification of biological impairment of aquatic communities: a case study of Limberlost Creek in Jay County. IDEM 32/03/001/2004. Indiana Department of Environmental Management. Indianapolis, Indiana.

8. Ohio Environmental Protection Agency (Ohio EPA). 1987. Biological Criteria for the Protection of Aquatic Life: Volumes I-III. Ohio Environmental Protection Agency: Columbus, Ohio.

9. Rankin, E.T. 1989. The Qualitative Habitat Evaluation Index (QHEI): Rationale, methods, and application. Ecological Assessment Section, Ohio Environmental Protection Agency. Columbus, Ohio.

10. Simon, T.P. 1991. Development of Index of Biotic Integrity Expectations for the Ecoregion of Indiana. V. Eastern Corn Belt Plain. U.S. Environmental Protection Agency. Region V. Water Division. Watershed and Non-Point Branch. Chicago, Illinois. EPA 905/R-96/004.

11. Tetra Tech, Inc. 2003. Spreadsheet Tool for the Estimation of Pollutant Load (STEPL). Version 2.2. Developed for U.S. Environmental Protection Agency. Available online. http://it.tetratech-ffx.com/stepl/.

12. United States Environmental Protection Agency (USEPA). 1979. Methods for Chemical Analysis of Water and Wastes, 1979. EPA-600 4-79-020. USEPA: Cincinnati.

13. United States Environmental Protection Agency (USEPA). 2003. Nutrient criteria - Ambient water quality recommendations: rivers and streams. Office of Water, Washington, D.C.

14. Indiana Historical Society, 1968. Maps of Indiana Counties in 1876. Reprinted from the Illustrated Historical Atlas of the State of Indiana. Indianapolis, IN.

15. Stratton-Porter, G., 1910. Music of the Wild. Eaton and Mains Publishing House, NY.

16. Indiana Geological Survey, 2004. Geographic information system data from the Indiana Geological Survey [Bloomington, IN] at www.igs.indiana.edu/arcims/statewide/index.html.

17. Christopher Burke Engineering, 2007. Upper Wabash River Watershed Management Plan. Prepared for the Upper Wabash River Basin Commission (Bluffton, IN) and the Indiana Department of Environmental Management (Indianapolis, IN).

18. Tetra Tech, 2007. Limberlost Creek Watershed Sediment and Nutrient TMDL Development. Prepared for the Indiana Department of Environmental Management (Indianapolis, IN).

19. U.S. Department of Agriculture, 1986. Soil Survey of Blackford and Jay Counties, Indiana. Soil Conservation Service, Indianapolis, IN.

20. U.S. EPA, 2005. National management measures to control nonpoint source pollution from urban areas. EPA-841-B-05-004.

21. Brown, W. & T. Schueler, 1997. National pollutant removal performance database for stormwater BMPs. Center for Watershed Protection, Silver Spring, MD.

22. Smolen, M.D. et al., 1990. Nonpoint source impact assessment. Report 90-5, Water Pollution Control Federation Research Foundation, Alexandria, VA.

23. Baker, J.L. and H.P. Johnson, 1983. Evaluating the effectiveness of BMPs from field studies. Agric. Mgmt. & Water Qual. 15: 281-304.

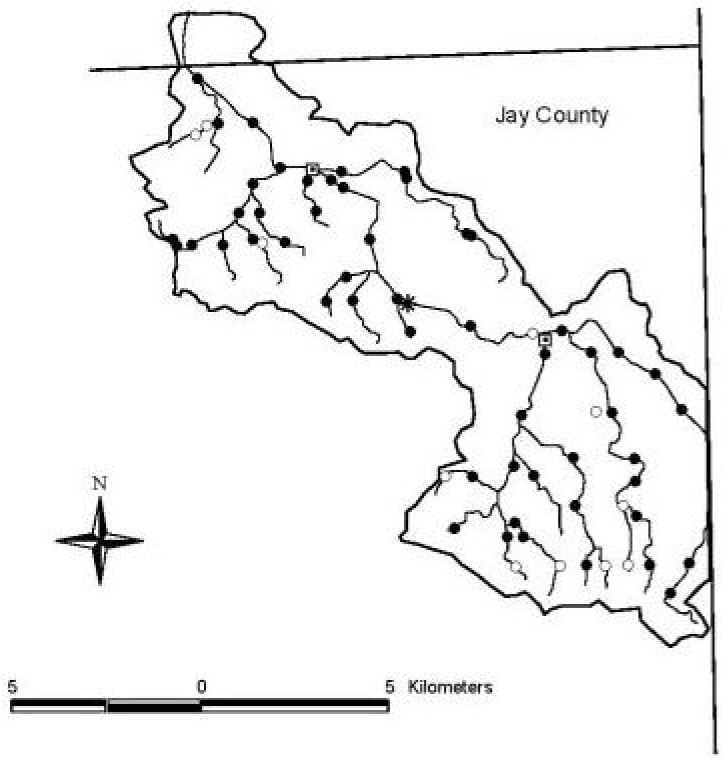
24. Waters, T.F., 1995. Sediment in streams. Amer. Fish. Soc. Monograph 7. Bethesda, MD.

Appendices

Appendix 1. Fish IBI and QHEI Data from IDEM [7]

ID	EventID	Location	Latitude	Longitude	IBI	QHEI
1	03T001	Limberlost Creek, SR 27	40º 34' 00.46"	84º 57' 34.51"	42 34	56 56
2	03T002	Pontius Ditch, SR 20 S.	40º 33' 21.20"	84º 57' 13.69"	40 36	38 33
3	03T003	Limberlost Creek, CR 20 S.	40º 33' 21.85"	84º 56' 32.06"	34 34	49 49
4	03T004	Houser Ditch, SR 27	40º 33' 12.44"	84º 57' 39.73"	Dry Dry	Dry Dry
5	03T005	Limberlost Creek, CR 20 S.	40º 33' 21.85"	84º 56' 31.86"	Dry Dry	Dry Dry
6	03T006	Perry Ditch, SR 67	40º 32' 28.96"	84º 56' 34.56"	32 32	46 46
7	03T007	Limberlost Creek, CR 165 E.	40º 32' 42.58"	84º 56' 02.50"	34 38	53 53
8	03T008	Houser Ditch, CR 20 S.	40º 33' 20.87"	84º 57' 21.82"	Dry Dry	Dry Dry
9	03T009	Montgomery Ditch, SR 67	40º 32' 29.61"	84º 55' 33.17"	30 26	45 45
10	03T010	Limberlost Creek, SR 67	40º 32' 30.09"	84º 55' 06.53"	33 38	47 47
11	03T011	Davidson Ditch, CR 175 E.	40º 32' 37.23"	84º 54' 54.66"	16 30	43 43
12	03T012	Limberlost Creek, CR 175 E.	40º 32' 23.28"	84º 54' 53.81"	20 30	56 56
13	03T013	Montgomery Ditch, CR 30 S.	40º 32' 03.64"	84º 55' 24.00"	18 32	43 43
14	03T014	Perry Ditch, CR 30 S.	40º 32' 02.99"	84º 56' 52.68"	32 36	54 54
15	03T015	Wheeller Ditch, CR 30 S.	40º 32' 03.16"	84º 56' 28.32"	24 38	52 52
16	03T016	Perry Ditch, SR 27	40º 31' 42.71"	84º 58' 06.37"	32 24	30 32
17	03T017	Perry Ditch, SR 40 S.	40º 31' 36.38"	84º 57' 45.14"	31 32	32 32
18	03T018	Perry Ditch, CR 40 S.	40º 31' 35.73"	84º 58' 01.16"	20 24	33 33
19	03T019	Metzner Ditch, CR 161 E.	40º 31' 41.09"	84º 56' 36.23"	15 12	52 52
20	03T020	Metzner Ditch, CR 40 S.	40º 31' 37.19"	84º 56' 00.42"	26 28	29 33
21	03T021	Wheeler Ditch, CR 40 S.	40º 31' 36.87"	84º 56' 24.37"	Dry Dry	Dry Dry
22	03T022	Limberlost Creek, CR 40 S.	40º 31' 38.16"	84º 54' 24.89"	30 36	66 61
23	03T023	West Mortimore 40 S.	40º 31' 38.49"	84º 53' 33.89"	Dry Dry	Dry Dry
24	03T024	Davidson Ditch, SR 67	40º 32' 30.90"	84º 53' 42.21"	18 12	29 29
25	03T025	Davidson Ditch, CR 185 E.	40º 32' 35.28"	84º 53' 45.12"	22 24	22 25
26	03T026	Pape Haffner Ditch, CR 175	40º 31' 05.40"	84º 54' 52.36"	14 12	33 38
27	03T027	Slentzer Perry Ditch, CR 40	40º 31' 39.47"	84º 52' 31.02"	NS 18	34 34
28	03T028	Slentzer Perry CR 195 E	40º 31' 41.09"	84º 52' 35.80"	14 14	29 29
29	03T029	trib. of Pape Haffner Ditch	40º 30' 45.59"	84º 54' 45.90"	24 18	53 53
30	03T030	Limberlost Creek, CR 50 S.	40º 30' 45.92"	84º 53' 55.53"	34 30	56 53
31	03T031	Limberlost Creek, CR 195 E.	40º 30' 19.95"	84º 52' 34.15"	26 36	52 54
32	03T032	Limberlost Creek, CR 205 E.	40º 30' 12.98"	84º 51' 25.65"	Dry Dry	Dry Dry
33	03T033	Limberlost Creek, CR 209 E.	40º 30' 15.26"	84º 50' 51.73"	26 38	55 53
34	03T034	Franks Ditch, CR 60 S.	40º 29' 55.95"	84º 51' 10.68"	28 36	63 61
35	03T035	Pape Haffner Ditch, CR 50 S	40º 30' 45.26"	84º 55' 14.44"	NS 12	37 37
36	03T036	Oakley Ditch, CR 40 S.	40º 31' 36.71"	84º 57' 09.74"	24 36	40 40
37	03T037	trib. of Limberlost CR 185 E.	40º 30' 17.69"	84º 53' 42.62"	NS 26	42 42
38	03T038	Franks Drain, CR 70	40º 29' 03.70"	84º 51' 38.78"	28 36	62 61
39	03T039	Wilson Creek, CR 70	40º 29' 03.05"	84º 49' 56.55"	26 34	44 43
40	03T040	Wilson Creek, CR 60 S.	40º 29' 55.78"	84º 50' 19.87"	30 44	54 56
41	03T041	Limberlost Creek, CR 60 S.	40º 29' 55.78"	84º 49' 50.73"	12 32	46 49
42	03T042	West Prong, CR 205 E.	40º 28' 15.99"	84º 51' 50.64"	32 26	51 51
43	03T043	East Prong, CR 213 E.	40º 28' 25.24"	84º 50' 42.36"	28 34	47 47
44	03T044	Wilson Creek, CR 223 E.	40º 28' 23.46"	84º 49' 33.67"	14 34	47 47
45	03T045	Limberlost Creek, CR 225 E.	40º 29' 34.69"	84º 49" 08.90"	24 36	29 29
46	03T046	Limberlost Creek, CR 70	40º 29' 04.51"	84º 48' 39.53"	26 32	35 35
47	03T047	trib. of Wilson Creek, CR 70	40º 29' 03.37"	84º 50' 23.00"	Dry Dry	Dry Dry
48	03T048	Wilson Creek, CR 223 E.	40º 28' 02.68"	84º 49' 33.26"	12 12	35 35
49	03T049	Wilson Creek, CR 84 S.	40º 27' 42.89"	84º 49' 45.31"	Dry Dry	Dry Dry
50	03T050	Wilson Creek, CR 223 E.	40º 27' 35.42"	84º 49' 33.26"	22 12	35 35
51	03T051	East Prong, CR 84 S.	40º 27' 43.37"	84º 50' 39.64"	32 34	36 36
52	03T052	trib. of Wilson Cr. CR 96 S.	40º 26' 50.97"	84º 49' 43.45"	Dry Dry	Dry Dry
53	03T053	trib. of East Prong, CR 96 S.	40º 26' 51.13"	84º 50' 13.00"	Dry Dry	Dry Dry
54	03T054	trib. of East Prong, CR 96 S.	40º 26' 51.13"	84º 50' 30.50"	22 12	31 31
55	03T055	Grissom Ditch, CR 96 S.	40º 26' 51.46"	84º 51' 00.87"	Dry Dry	Dry Dry
56	03T056	Wilson Creek, CR 96 S.	40º 26' 50.80"	84º 49' 18.04"	30 40	37 37
57	03T057	Limberlost Creek, CR 96 S.	40º 26' 50.80"	84º 48' 33.71"	12 14	52 50
58	03T058	Limberlost Creek, CR 100 S.	40º 26' 25.33"	84º 48' 54.53"	18 18	44 44
59	03T059	Young Ditch, CR 80 S.	40º 28' 10.63"	84º 52' 35.38"	NS 12	36 36
60	03T060	Young Ditch, CR 80 S.	40º 28' 10.63"	84º 53' 06.39"	Dry Dry	Dry Dry
61	03T061	trib. of West Prong, 191 E.	40º 27' 26.34"	84º 52' 58.29"	NS 12	34 34
62	03T062	Grissom Ditch, CR 203 E.	40º 27' 29.42"	84º 51' 50.01"	16 32	38 38
63	03T063	West Prong, CR 90 S.	40º 27' 18.06"	84º 51' 57.51"	24 28	32 32
64	03T064	Grissom Ditch, CR 90 S.	40º 27' 17.90"	84º 51' 40.42"	38 40	39 39
65	03T065	trib. of West Pr, CR 203 E.	40º 26' 51.46"	84º 51' 49.38"	Dry Dry	Dry Dry
66	03T066	Hartzel Ditch, CR 80 S.	40º 28' 09.82"	84º 51' 25.24"	NS 12	47 47

Map of IDEM Sampling Sites [7]



Fish Species Collected by IDEM in Limberlost Creek [7]

Dorosoma cepedianum
Carassius auratus
Notropis ludibundus
Phenacobius mirabilis
Pimephales notatus
Cyprinella spiloptera
Catostomus commersoni
Erimyzon oblongus
Ameiurus melas
Ameiurus nebulosus
Lepomis cyanellus
Lepomis humilis
Lepomis megalotis
Etheostoma spectabile
Etheostoma blennioides
Aplodinotus grunniens
Cyprinus carpio
Semotilus atromaculatus
Ericymba stramineus
Campostoma anomalum
Pimephales promelas
Lythrurus umbratilis
Carpiodes carpio
Moxostoma erythrurum
Ameiurus natalis
Fundulus notatus
Lepomis macrochirus
Micropterus punctulatus
Pomoxis annularis
Etheostoma nigrum
Percina maculata

Appendix 2. Water Chemistry Data Summary – IDEM Limberlost Creek Data [7]

Variable	JUNE 2003			AUGUST 2003		
	Mean	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
DO (mg/L)	9.4	6.0	13.0	8.8	4.4	13.8
Percent Saturation	103	63	143	104	48	181
Temp (ºC)	19.6	14.5	23.4	23.6	18.5	30.8
Conductivity (uS/cm)	881	630	1137	1017	559	2301
Turbidity (NTU)	38	7.6	337	44	6.2	196
Total Solids (mg/L)	621	447	992	711	369	1850
Total Suspended Solids (mg/L)	27	5.0	142	34	8.0	138
Sulfate (mg/L)	100	37	292	142	34	817
Chloride (mg/L)	49	25	152	89	8.8	396
Hardness (mg/L)	410	274	582	423	242	1100
Nickel (ug/L)	5	4	8	5	2	11
Aluminum (ug/L)	765	105	2810	1007	132	6460
Iron (ug/L)	918	102	3270	1304	149	4360
Ammonia-Nitrogen (mg/L)	0.08	0.05	34.0	0.34	0.05	7.6
Nitrate+Nitrite-N (mg/L)	13.7	0.30	32.0	0.92	0.05	9.9
pH (SU)	8.2	7.6	8.9	8.1	7.7	8.6
Total Phosphorus (mg/L)	0.12	0.02	0.40	1.05	0.03	31.0

Appendix 3. Steering Committee and other Participants

Listed below are individuals and organizations who have actively participated in planning and public education process:

Limberlost Swamp Remembered (Steering Committee)

Marla Freeman

Jim Laux

Dwayne Michael

Sid Austin

Francis Austin

Ken Brunswick

Dwayne Ford

David Kramer

Dan Orr

U.S. Fish and Wildlife Service

Forest Clark

GP and GS Porter Society

Willis and Ruth Brown

Sanitarians

Dave Houck – Jay County

Terry Smith – Adams County

Heath Butz – Wells County

Denise Wright – Indiana Department of Health

Soil and Water Conservation Districts

Carl Walker – Jay County

Michelle Arvin – Adams County

County Elected Officials

Brad Daniels – Jay County Surveyor

Local Farmers

Mike Ninde

Christian Burkholder

Rex Journay

The Heitkamp family

George Minnich

Public Involvement

The public was informed of the watershed planning process through radio, cable television, the Internet, and three local newspapers. Public meetings were announced quarterly in these media. Copies of all documents produced as part of this outreach are included in the project Final Report. Public meeting dates, sites, topics, and number of participants are shown below:

Date	Site	Topic	Attendance
September 22, 2005	Bryant community center	Project goals	35
December 8, 2005	Geneva library	Watershed features	4 (snow storm)
March 20, 2006	Geneva library	TMDL	20
September 10, 2006	Bryant Loblolly Days	Watershed Education	150+
September 10, 2006	Fifer Field Day	Septic Systems	15
March 15, 2007	Geneva library	TMDL	35
May 15, 2007	Christian Burkholder farm	Manure composting	6
May 22, 2007	Limberlost Cabin	Freshwater mussels	20
September 6, 2007	Bryant Loblolly Days	Watershed Education	150+

Newspaper articles were written to inform the readers about the progress of the project. Copies of all newsletters can be found in the Appendix.

What kinds of information do I need to develop a plan?

Soil types

Soil nutrient test values

Manure test values

Crops to plant

Crop production goals

Numbers of livestock present

Livestock feed used

Manure storage facility specifications

Acres available for manure application

Manure equipment specifications

More information on manure management planning:

- A free computer model is available at: www.agry.purdue.edu/mmp

Manure storage and compost facilities are eligible for 75% cost-share funds. Contact your local SWCD office.

- Purdue University Extension [www.ces.purdue.edu/waterquality]

A service is available to match manure producers with manure users. Check out www.ansc.purdue.edu/manurelocator

- Soil and manure testing laboratories www.in.gov/idem/ctap/labs.html

IDEM Confined Feeding Program

www.in.gov/idem/land/cfo

Friends of the Limberlost

310 Williams Street
Geneva, Indiana 46740

Phone: 260- 368- 7594
Email: coordinator@limberlost.net

Friends of the Limberlost

MANURE MANAGEMENT PLANNING FOR WATER QUALITY

Produced as part of a Water Quality Grant from the Indiana Department of Environmental Management and the U.S. EPA.
by
Commonwealth Biomonitoring 2005

Final

Information about the "Limberlost" Watersheds

The three watersheds involved in this project are shown in the map to the right. They include almost 70,000 acres.

Within this area of northern Jay and southern Wells and Adams Counties, livestock production is very important economically. Jay County is in the top five chicken producers in all of Indiana.

There are no real "census" figures for the actual number of livestock within the Limberlost watersheds. However, if the numbers for Jay County are adjusted to the fit the Limberlost watershed size, these are the numbers most likely present:

600,000 chickens

60,000 turkeys

30,000 hogs

3,000 cattle

300 horses

All together, this number of livestock generate approximately 2 million pounds of manure every day. Figuring out what to do with a large amount of potential fertilizer [5000 tons of phosphorus and nitrogen per year] without harming water quality is a big task.

Field Nutrients: Manure Management for Fifty Cattle

Operation: Hobby Farm *State:* Indiana

Corn crop is planted in this field

100 acres available for manure application

Nutrient Needs	***Yield Goal***	***Acres***	***N***	***P205***	***K20***
	200 Bu	100	245	0	95
Crop Nutrient Removal		100	0	74	54

Date	***Manure Applied***	***Acres***	***N***	***P205***	***K20***
May 06	12,950 Gal	4.6	229	389	389
Apr 06	12,950 Gal	3.1	235	389	389
Mar 06	12,950 Gal	10.8	241	389	389

Summary	***N***	***P205***	***K20***
Total Nutrients Applied	44	72	72
Balance After Removal	-201	-2	18

At the end of the year, soil nitrogen levels on 100 acres have decreased, while phosphorus levels are relatively unchanged. Soil potassium levels have increased.

Next year, legume planting is recommended for this field to re-supply necessary nitrogen.

Streams in the Limberlost watersheds have high nitrogen, phosphorus, and bacteria levels. These are all major components of manure. Our goal is to keep 5000 tons of nutrients produced in the watershed per year out of the water.

The print-out to the left is an example of how manure management planning can help farmers make good decisions about when, where, and how much manure to apply to get the greatest economic and environmental benefit. It was produced by a computer program available free from the Purdue University Agronomy Department.

Stockpiling manure so it can be applied at the appropriate time and rate is important for protecting water quality. Manure storage or composting facilities are eligible for grant assistance from USDA.

Important Steps in Maintaining a Working Septic System

Do:

Pump out the tank at least every two years.

Install a riser for access to the septic tank

Plant and mow grass over the absorption (drain) field.

Reduce water use.

Watch for signs of trouble (odor, slow draining, standing water on the drain field.

Don't:

Drive over the drain field

Plant trees over the drain field

Overload the system with water (e.g. many loads of laundry per day)

Put grease, garbage, or harmful chemicals down the drain.

For more information on local septic system operation and maintenance:

County Health Department Sanitarians:

Jay County 260-726-8080

Adams County 260-724-5326

Wells County 260-824-6489

Indiana Department of Health

Sanitary Engineering 317-233-7177

Purdue Cooperative Extension Service

Jay County 260-726-4707

Adams County 260-724-1656

Wells County 260-824-6412

See the local Yellow Pages for septic system contractors and licensed haulers.

Friends of the Limberlost

310 Williams Street
Geneva, Indiana 46740

Phone: 260- 368- 7594
Email: coordinator@limberlost.net

Friends of the Limberlost

PROPER SEPTIC SYSTEM OPERATION AND MAINTENANCE

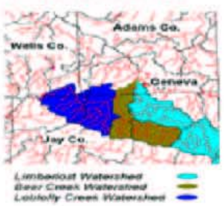
Produced as part of a Water Quality Grant from the Indiana Department of Environmental Management and the U.S. EPA.

by
Commonwealth Biomonitoring 2006

Septic Systems in the Limberlost Watersheds

Nearly all of the "Limberlost" area south of Geneva, Indiana is rural and has no sewers. Most residential sewage in this area is treated by individual household septic systems. This type of wastewater treatment relies on the ability of soils to absorb water and allow native soil bacteria to treat the waste and remove disease-causing pathogens.

Unfortunately, the soils in the Limberlost area are not well suited for septic systems. Failing septic systems can contribute to water pollution. It's wise to make sure the systems are properly maintained to keep local waterways clean.



The three watersheds in the Limberlost area are shown in the map above. Within this 70,000 acre area there are roughly 1000 septic systems.

What Causes Septic Systems to Fail?

There are several reasons why septic systems may not operate well:

Poor Design: Older systems may not have a drain field. Instead, water from the septic tank goes by pipe directly into a local stream.

Improper Maintenance: Septic tanks must be pumped out regularly. The drain field has to be protected and maintained to work properly.

Poor Soils: Almost all soils in the Limberlost area have low "permeability" (they don't let water move through them very quickly). Good drain fields have to be very large to work properly.

Problems Caused by Failing Septic Systems

Disease

Algae Blooms

Fish Kills

Septic Systems and Local Permits

Because failing septic systems have such a high potential for causing environmental harm, the State of Indiana regulates their construction through a permit process. Permits for single family homes are issued through the county health departments.

The first step in installing or repairing a septic system for a home is to contact the health department in the county where you live (see phone numbers listed in this brochure). A health department representative can give you proper advice on how to proceed. Usually, the homeowner, health department representative, a septic system designer, and a soil scientist will meet at the lot, evaluate local conditions, and prepare a plan as part of a construction permit.

Appendix 6

Projects to Protect Water Quality Carried out by Project Partners

1. Jay County SWCD
2. Red Gold
3. IDNR Division of Nature Preserves

Final

Jay County Conservation Project Clean Water Indiana 2006 Grant Recipient
Filter Strips - The Right Choice!

1. Development/printing of a tri-fold brochure outlining detailed information on filter strip installation and benefits with step-by-step guidance from start to finish;

2. Intensive involvement with the County Drainage Board and County Surveyor in identifying landowners whose ditches have been or scheduled to be cleaned by the county. Once areas are identified, direct contact with landowner through the US Mail Service and personal visits to explain the benefits of installing a filter strip beside the cleaned ditch and other ditches on landowners ground;

3. Conduct a local conservation Tour in the Fall of 2006 highlighting filter strips and other conservation practices. Those invited to participate would include the State Representative, County Council, County Commissioners, County Surveyor, County Solid Waste District, City Mayors and Purdue Extension Service. At the conclusion of the local tour, a meal for the participants and the opportunity for further education of conservation measures to be discussed. This tour/meal is an instrument used by the SWCD to lay groundwork with the local legislative audience who control county dollars for future and continual financial support. Those assisting with this endeavor would include the SWCD staff and Supervisors, NRCS, USDNFSA.

4. Conduct a county-wide workshop focusing on Filter Strips. The subject matter "Filterstrips - the Right Choice!" will include a meal for participants and an educational workshop provided by the SWCD, NRCS and USDNFSA;

Jay SWCD
Left to right:
Bettie Jacobs,
Dan Dunten, and
Carl Walker

5. Media coverage and local advertisement of the Conservation Tour & Filter Strip Workshop by the local newspapers and radio station;

6. Prepare a table-top display promoting filter strip installation to be displayed at county community events to that could include Ag Week activities, Ag Day Breakfast, Farmers Dinner, County Fair, Pennville Fair, Loblolly Days, SWCD Annual Meeting and etc.

7. Media coverage promoting the SWCD owned conservation equipment (seeder and straw mulcher) available for rent and used for the seeding of filter strips, waterways, pond banks and etc.

8. Payment of $200.00 to the Jay County SWCD for each filter strip signed up between the dates of April 1, 2006 and December 31, 2006 (with a "ceiling" of 20 filter strip sign-ups during the nine month period).

A Good Neighbor: Red Gold's Environmental Efforts in the Limberlost Watershed

The south side of Geneva, Indiana is the site of one of the Indiana-based Red Gold tomato canning facilities. The Geneva plant was built in 1944 and purchased by Red Gold in 1995. The facility buys tomatoes from local farmers and manufactures tomato products such as tomato juice, salsa, spaghetti sauce, and pizza sauce.

The Red Gold plant lies alongside Limberlost Creek, near its confluence with the Wabash River. Here, Red Gold sees water from the entire Limberlost Watershed flow past its doors. When it floods, Red Gold sees it all.

One of the company's efforts over the past 10 years has been to separate its storm water from its day-to-day wastewater used in the canning process. Storm water runoff from the company's buildings and parking lot is treated to remove sediments and pollutants before they run off into the stream.

In addition the company's wastewater is now treated by an artificial wetland system to remove oxygen-demanding substances and solids. The water coming out of the wastewater treatment system is clear and oxygen-rich.

In a further effort to improve the local environment, Red Gold has joined with the U.S. Department of Agriculture in setting aside 80 acres of its property for a natural wetland restoration project. Both the artificial and natural wetland systems now contribute to water quality improvements in the Limberlost watershed. And they complement the wetland restoration work begun by the Friends of the Limberlost.

An aerial photograph of the Red Gold plant and adjacent wetlands used for water quality improvements.

A photograph of the wetland restoration project Red Gold has initiated along Limberlost Creek near Geneva.

Limberlost Swamp Remembered Project – DNR Division of Nature Preserves

Friends of the Limberlost State Historic Site, Inc. (Friends) is a 501(c)(3) not-for-profit organization that supports the development of the Limberlost State Historic Site in Geneva. The Limberlost Swamp Remembered Project supports the development and restoration of the Limberlost Swamp. Limberlost Swamp Remembered is a standing Committee of Friends of the Limberlost State Historic Site, Inc.

The Limberlost State Historic Site is owned by the DNR Division of Indiana State Museum and Historic Sites. It is the former home of Gene Stratton-Porter, a best-selling author and naturalist who brought international attention to the loss of the Limberlost Swamp. The historic site features Mrs. Porter's cabin, carriage house and dooryard.

The Limberlost Swamp Remembered (LSR) Project was created out of a grassroots effort to return some of the drained Limberlost area back into restored wetlands. The original 13,000-acre swamp, located yards from the Porter's home, was completely drained by the early 20th century, but the farmland created was marginal and continued to flood periodically. As drainage improved in the uplands, flooding and crop losses increased in the drained wetlands.

Over time, the land became increasingly unproductive due to floods. In 1992, several farmers agreed to restore their property with the Wetland Reserve Program (WRP). The Limberlost Swamp Remembered Project purchased their property after the WRP easement was recorded on their land.

The Limberlost Swamp Remembered Project works closely with DNR Division of Nature Preserves, and they are focused on the process of restoring nearly 1,400 acres of the former wetland. 1112 acres of this land has a permanent Wetland Reserve Program easement on it with the Department of Agriculture.

Since 2003, the properties have been transferred to DNR Division of Nature Preserves and nearly 700 acres are in various stages of restoration. State rare, endangered, and threatened native plants and animal species are returning to the restored wetlands.

Today, many groups of adults and children visit the restored wetlands, and they are encouraged to be a participant in land stewardship by becoming involved in a variety of ways. They may volunteer and help plant trees or do fundraising for the restoration project at Limberlost or in their own community. We expect that by raising the community's awareness about what is happening within the Limberlost Watershed, future generations will make better informed decisions about conservation and the environment of wetlands.

Limberlost State Historic Site

The Limberlost State Historic Site is located where Gene Stratton-Porter, a best-selling author, naturalist, and photographer from the early 20th century wrote her 1909 classic, "Girl of the Limberlost", five nature studies including "Moths of the Limberlost" 1912, and inspired four nature studies written after leaving the Limberlost area including "Friends in Feathers" 1917. Her work and passion for nature brought international attention to the Limberlost Swamp and helped inspire future generations of environmentalists, naturalists and conservationists.

Today, the historic site features Mrs. Porter's home, carriage house, and dooryard. It is difficult to discuss the body of her work as a naturalist within the confines of this suburban setting. In response to this need, Limberlost State Historic Site one of Indiana's twelve historic sites is addressing Indiana's natural history and environment. A new 18' x 20' Wetland Education Center with exhibit panels and program space was converted from the Carriage House at the site. In 2008, the Indiana State Museum and Historic Sites will build a Visitor's Center with a classroom to expand programming and events at Limberlost State Historic Site.

DNR Division of Nature Preserves

In 1992, concerned citizens, spearheaded by Ken Brunswick, led a grass-roots campaign to restore large portions of the former Limberlost Wetlands. Today this project has increased from one farm with marginal cropland to nearly 1,400 acres. 700 of these acres are in various stages of restoration and the remaining 700 acres are in the planning process. Ken Brunswick is now the East Central Regional Ecologist with the DNR Division of Nature Preserves. Ken's region includes all of the counties in the Upper Wabash River Basin Commission (UWRBC).

Draining of Limberlost Swamp and other wetlands in east central Indiana seemed like the right thing to do in the late 19th and early 20th centuries, but it led to many problems that persist today and continue to plague the farmers and the communities in the watershed. A group of farmers and others became interested in returning non-productive fields that constantly flooded back into restored wetlands. Long term, their number one goal was a greater participation in decisions about ground water quality, surface water quality, flood control, erosion, and expanded biological diversity in east central Indiana.

Originally the Limberlost Swamp was over 13,000 acres in Adams and Jay counties in the Limberlost and Loblolly Watershed in east central Indiana. In the nearly 20 years from the time Gene Stratton-Porter moved into the Limberlost Cabin with her family until they moved in 1914, the Limberlost Swamp was drained through the vigorous labors of area farmers and state and local laws. She spent her days learning as much as she could about the Limberlost's environment before it was drained.

The Limberlost's environment is well documented in Gene Stratton-Porter's nine nature studies. She states the names of plants and birds in the Limberlost at the time of her writings. Today, we have the losses of the wetland environment and the diminishing water quality and increased flooding that goes hand in hand with these losses.

Other environmental questions we ask are:

- Why have groundwater levels in the aquifers dropped since the drainage of the wetlands? Most of the people in the area get their water from a well and need the constant replenishing of the aquifer for their water supply.
- Why has water quality in the area streams decreased? This poor water quality limits our use of these streams for recreation and other needs.
- Why does the area flood more often and with greater intensity than in the past? The Upper Wabash River Basin Commission was formed to try to find a way to reduce the area flooding. The Limberlost and Loblolly Wetlands serve as an area where water can be stored without causing property damages to area landowners and residents.

The environmental goals of the Limberlost Swamp Remembered Wetland Restoration Project are to reduce flooding, erosion, improve surface water quality, and groundwater quality in the Limberlost and Loblolly Watershed.

The following is a list of wetland areas in various stages of restoration and the different kinds of wetlands in each purchase. Included in the list are their uses for wetland environmental education:

1. Original 12 acres of the Limberlost Bird Sanctuary 1947 – restored 8-acre flatwoods wetland in its 60th year of natural regeneration and 4-acre Nature Preserve. This area has trails and shows some pre-drainage forest.
2. 143 acres in the Loblolly Marsh in Jay County 1996 – restored marsh with a wetland overlook and an Americans with Disabilities Act trail to be completed in 2007.
3. 45 acres in the Loblolly Marsh in Jay County 1996 – restored pothole has Americans with Disabilities Act trail and boardwalk over a restored wetland. This area is excellent for aquatic insect studies.
4. 240 acres in the Loblolly Marsh in Jay County 1997 – restored marsh and potholes to teach geology. The 25-acre woodland is arrayed with many native plants and several rare species.
5. 38 acres in the Limberlost Swamp in Adams County 1998 – restored floodplain wetlands show nearly a decade of restoration regeneration.
6. 152 acres in the Limberlost Swamp in Adams County 1999 – restored potholes and a swamp Nature Preserve. This property is very secluded and will provide a refuge for the wildlife in the area.
7. 327 acres in the Limberlost Swamp in Adams County 2000 – partially restored
8. 26 acres of the Limberlost Bird Sanctuary Addition 2000 – restored forest land shows 6 years of regeneration and a wildlife watering facility.
9. 9 acres in the Limberlost Swamp in Adams County 2001 – partially restored
10. 65 acres in the Wabash River Area in Adams County 2001 – restored floodplains has Americans with Disabilities Act trails to the Wabash River's edge, a canoe launch for river studies, an Americans with Disabilities Act trail to a restored oxbow wetland, Native American Indian restored historic trail and river ford.
11. 24 acres in the Wabash River Area in Adams County 2001 – mature floodplain wetland forest with proposed Americans with Disabilities Act trail
12. 8 acre oxbow island in the Wabash River Area in Adams County 2002 – Nature Preserve mature floodplain forest on an oxbow with Great Blue Heronry
13. 27 acres in the Limberlost Swamp in Adams County 2003 – planning
14. 20 acres in the Limberlost Swamp in Adams County 2005 – planning
15. 39 acres of the Limberlost Bird Sanctuary Addition 2005 – restored
16. 113 acres in the Limberlost Swamp in Adams County 2005 – planning
17. 58 acres in the Limberlost Swamp in Adams County 2005 – planning
18. 14 acres of the Limberlost Bird Sanctuary Addition 2006 – planning
19. 15 acres of the Limberlost Bird Sanctuary Addition 2006 – planning
20. 70 acres in early contractual purchase agreement during 2007-08 – future purchases will continually improve the water quality and reduce the intensity of the flooding losses.

Appendix 7.

The Palmiter Method of Channel Maintenance

George Palmiter, a railroad switchman and canoeist, devised ways of stabilizing the banks and unclogging the channels of debris-and silt-laden streams in northwestern Ohio. The Palmiter method has received nationwide publicity and has been applied to streams in North Carolina, Mississippi Michigan, and Illinois. Palmiter received the Conservationist of the Year Award from *Outdoor Life* in 1977 and a Rockefeller Public Service Award in 1979.

Palmiter's method provides a way of restoring the hydraulic capacity of streams and reducing low-intensity flooding without resorting to channelization or removal of riparian vegetation. In fact, riparian trees are left in place or planted to shade the stream, to reduce the excessive growth of shrubs and aquatic plants that retard flow, and to increase the frequency of low floods. Shading has the further beneficial effect of lowering the summer water temperature, to the benefit of fish communities The living trees anchor the banks and provide a source of food, in the form of leaf litter, for invertebrates and fish to feed on. Downed logs and root wads provide habitat structure for fish and solid substrate for the invertebrates.

The Palmiter method has been applied primarily in low-gradient alluvial streams and small rivers where logjams cause sediment deposition and increased flooding upstream and bank erosion where the stream cuts a new channel around the jam. George Palmiter's guiding principle is "make the river do the work." He makes the midchannel bars upstream of the obstruction vulnerable to erosion by removing any protective layer of woody debris and vegetation, directing flow toward the bar, and creating "starter" channels to initiate scour. The centers of the logjams are cut into smaller pieces and allowed to float downstream, while the buried ends remain as flow deflectors to keep the main current directed away from the bank. These natural deflectors are sometimes supplemented with root wads or fallen trees that are cabled to the bank.

Appendix 8. Anaerobic Digester Case Study

Does Manure Have Energy Value?

In our last newsletter, we estimated that the Limberlost watershed has enough livestock to generate 300,000 tons of manure each year. According to estimates from Purdue University, this amount of manure as fertilizer has a potential market value of $15 million dollars annually. It's fertilizer value is too good to waste.

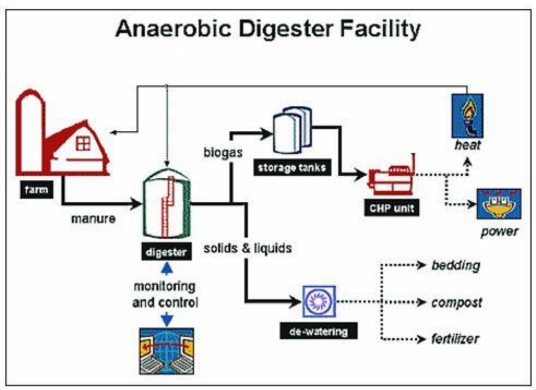
Another value of manure that hasn't been fully explored yet is its energy potential. Manure contains plenty of carbon molecules that bacteria can easily convert to methane gas through a biological process called anaerobic digestion. Methane is highly flammable and has been used all over the world for driving electrical power generators.

According to economists, a ton of manure has a potential energy value of $60. That's an additional $18 million dollars of annual value from Limberlost manure. And enough power for 15,000 homes.

How much would it cost to harvest this energy? Costs are highly dependent on how much manure is available at a local site. The larger the amount, the less the cost per unit. It is rarely economically feasible to truck the manure off-site. A farm in Oregon spent about a million dollars for an anaerobic digester servicing 3000 cattle. It has paid off $200,000 annually in energy savings.

Another potential benefit of harvesting energy from methane is the reduction of "greenhouse gases." Methane is one of the suspected culprits in global warming, so using the methane before it vents off into the atmosphere could also reduce greenhouse gas loading.

According to estimates from other areas, the potential energy from the manure of 3000 cattle could generate enough electricity to power 150 homes. The energy is harvested by a process called "anaerobic digestion."



Anaerobic Digestion of Manure

From Cornell University Fact Sheet FS-2 by Bothi and Aldrich (www.manuremanagement.cornell.edu)

Anaerobic digestion is a microbiological process that converts organic carbon to a "biogas" composed primarily of methane and carbon dioxide. A growing number of larger-scale dairies are anaerobically digesting manure to reduce odors and produce biogas for heating and/or electricity generation.
The Town of Perry is located in Wyoming County, the largest milk-producing county in New York State. Perry recognized the importance of improving manure waste management practices in the region, and organized a study of the feasibility of collaborative anaerobic digestion among four of the larger neighboring dairy operations in the county.

The four dairy farms involved in the study were Emerling, True, Sunny Knoll, and Dueppengiesser. All of these farms are subject to Concentrated Animal Feeding Operation regulations. The primary goal of each farm was to find a solution to odor problems. Other objectives taken into consideration included reducing the potential for negative impacts on the environment from existing practices, increasing the use of by-products from the breakdown of manure, and increasing the number of industries in Perry by providing local sources of energy and by-products.

Who Should Consider A System Like This?

1. Farms in need of odor control.
2. Farms where manure can be collected and transported easily.
3. Farms with capital available for initial investment.
4. Farms with technical interest and skills for the system operation and maintenance.
5. Farms with adequate cropland for nutrients.
6. Farms looking to maximize the use of byproducts.
7. Farms seeking to reduce the potential for negative environmental impacts.

Which Options Were Evaluated?

The initial evaluation included determining the present and projected manure production and current infrastructure for each farm. Surveys were sent to the four farms as well as to other farms in the area to gather opinions on digester ownership, collaboration, and manure transportation (16 surveys were returned). Energy audits of each farm were performed to evaluate natural gas and electricity consumption. Daily biogas production was estimated using the method developed by Lusk (1998). The economic analysis performed by ACS included construction and operating costs, annual benefits, and simple payback in years. The four options considered in this study were:

A. One digester shared by all farms.
B. One digester shared by two nearby farms.
C. One digester on each farm with collaboration in other ways.
D. Collaboration to recruit an independent business to provide digestion services for farms.

Results

A centrally located digester shared by all four farms was the least feasible option, due to low energy benefits, logistical concerns and high transportation costs. In addition, the survey revealed a clear consensus that sharing digester ownership was least desirable, especially if digester maintenance and supervision was shared among the farms. Operating one digester shared by two neighboring farms was found to be feasible but not without problems. Collaboration issues raised in the study depend on the distance between farms, and between the farms and other businesses or markets for excess energy. Liabilities and further logistical complications also have a significant impact on the bottom line. Below are the key collaboration issues examined by the study for Option B, where two farms share a single digester:

(1) **Sale of all electricity and heat generated**. Option B would be more feasible if there was a local market for excess heat energy, and if the electricity could be sold back to the grid at a premium (i.e. as green energy) or to some other special market.

(2) **Off-farm sale of all energy by-products including gas, hot water or chilled water.** Installing the equipment necessary to upgrade and transport the energy by-products may be economically feasible. The greatest obstacle for this option is the distance between the farms (generators) and the off-farm markets. Obtaining right-of-ways and crossing permits may be difficult.

(3) **Electricity distributed to farms** would likely provide the greatest cost savings to each farm, since the farms would save more on electricity costs than they would gain from selling it in the current market. The challenge here would be setting up a system to transfer the electricity between two farms, whether through a utility or installing and maintaining a private power line system. This becomes less feasible with increased distance between farms as well as the presence of municipal roads or state highways between locations
.

(4) **Gas piped back to farms.** The cost of cleaning, pressurizing, and piping the gas back to the farms from a centrally located digester was not in itself prohibitive; however, as described under point (2), piping the gas runs into serious logistical challenges.

(5) **All post-digestion solids separated and returned to the farms for bedding.**
The economic benefits indicate that sharing separated solids for bedding is highly feasible if the biosecurity concerns can be adequately addressed. The annual savings on bedding would potentially free up funds for paying off annual capital costs and for operation and maintenance of the digester.

(6) **Post-digestion solids separated and marketed.**
Once biosecurity and end-product quality issues have been addressed, the sale of excess digested solids in specialized market niches could compliment farm revenues.

(7) **Post-digestion solids separated, composted and marketed.**
Taking the previous option one step further, composting the solids before sale can reduce viability of weed seeds and pathogen content, and add market value to the solids.

(8) **Recruit partner to build a new, nearby company to use excess energy or byproducts.**
The closer the market for by-products, the more revenue the farm is able to generate. The presence of a business adjacent to the farm could reduce logistical problems while providing a secure market and additional revenue to the farms. Although biosecurity and logistical problems complicate these issues, collaboration between farms should reduce the capital and operating costs the farms would incur as opposed to building and operating digesters separately.

Option C, to construct and operate one digester on each farm, was the most feasible based on costeffectiveness and energy efficiency. Six key issues for collaboration were considered:

(1) **Joint marketing of electricity.** There may be advantages for the farms to collectively market their electricity. One possibility, which requires more analysis, is for the participating farms to join an existing electric marketing company or cooperative.

(2) **Joint marketing of biogas, hot and/or chilled water.** The four farms could collaborate marketing their excess energy, or all of their energy production in the case of opting to not generate power on-site. This option faces a number of challenges. If all the energy from each digester was sold, another source of heat for the digester would be required, likely being more costly to the farm than the income from energy sales. In addition, the costs of installing and maintaining pipelines, and possible pre-treatment equipment for the biogas, hot water, and/or chilled water would be substantial, given the distances between the farms and any potential markets.

(3) **Gas piped to a common cogeneration site.** It was estimated that it would cost a minimum of

$230,000 for the five miles of gas pipe required to connect the four farms. Adding this cost to the difficulties of locating a route (negotiating highways, right-of-ways and other obstacles) led to the conclusion that gas piping was not viable for these farms.

(4) **Joint composting and marketing of separated solids.** Each farm could bring their digested solids to a central location for composting, processing and packaging. The farms would then work together to market their final product for bedding or other uses.

(5) **Joint digester design, construction, management and maintenance.** If all four farms could agree on a similar digester design, construction costs were estimated to be lowered by $70,000 per farm. A common design would facilitate the hiring of a single technician to maintain the digesters.

(6) **Recruit partner or outside business to build a new, nearby company to use excess energy or by-products.** The main challenge would be to find a business with compatible energy needs and site acceptance. Zoning laws may also need to be addressed for the collocation of agricultural and commercial businesses. This line of thought could lead to a new model for business development in Perry.

The final option (D), to collaborate or recruit an independent business to provide digestion services for each of the farms, was evaluated in detail by Microgy Cogeneration Systems, Inc.. Microgy proposed to significantly increase gas production by mixing food processing waste with dairy in the digesters, and to market electricity as green power through an energy service corporation. Based on its plans and assumptions, Microgy determined that privately financing, constructing and operating a digester on each farm would be economically, technically and environmentally feasible. Similar to the other options, the private company would generate by-products from the digested manure and food waste for return back to the farms.

Summary

The initial idea of having a single, collaborative digester (Option A) turned out to have limited reliable energy benefits, the highest transportation costs, the most complicated logistical issues, and was not found to be feasible. Option B, having two farms share one digester, was found to be possible, but not without hurdles related to moving materials between the farms. Option C, having one digester on each of the four farms with collaboration in other ways, was found to be the most economically and logistically feasible option at this time. Option D, an outside company owning and managing separate digesters on each farm, was also reported to be feasible.

Appendix 9. List of target animals in the watershed. Their presence will indicate evidence of environmental restoration

AMPHIBIANS

Salamanders (Order Caudata)

1.	Spotted Salamander	*Ambystoma maculatum*
2.	Marbled Salamander	*Ambystoma opacum*
3.	Smallmouth Salamander	*Ambystoma texanum*
4.	Eastern Tiger Salamander	*Ambystoma tigrinum*
5.	Northern Dusky Salamander	*Desmognathus f. fuscus*
6.	Southern Two-lined Salamander	*Eurycea cirrigera*
7.	Four-toed Salamander	*Hemidactylium scutatum*
8.	Common Mudpuppy	*Necturus maculosus*
9.	Red-spotted newt	*Notophthalmus viridescens*
10.	Redback Salamander	*Plethodon cinereus*
11.	Eastern Zigzag Salamander	*Plethodon d. dorsalsis*
12.	Northern Slimy Salamander	*Plethodon glutinous*
13.	Ravine Salamander	*Plethodon richmondii*
14.	Northern Red Salamander	*Pseudotriton r.ruber*

Frogs and Toads (Order Anura)

1.	Blanchard's Cricket Frog	*Acris crepitans blanchardii*
2.	American Toad	*Bufo americanus*
3.	Fowler's Toad	*Bufo woodhouseii fowleri*
4.	Eastern Gray Treefrog	*Hyla versicolor*
5.	Cope's Gray Treefrog	*Hyla chrysoscelis*
6.	Northern Spring Peeper	*Pseudacris c. crucifer*
7.	Bullfrog	*Rana catesbeiana*

8. Green Frog — *Rana clamitans melanota*
9. Wood Frog — *Rana sylvatica*
10. Northern Leopard Frog — *Rana pipiens*

REPTILES

Turtles (Order Testudines)

1. Eastern Spiny Soft-Shell — *Apalone spinifera spinifera*
2. Snapping Turtle — *Chelydra serpentina*
3. Midland Painted Turtle — *Chrysemys picta marginata*
4. Spotted Turtle — *Clemmys guttata*
5. Common Map Turtle — *Graptemys geographica*
6. Common Musk Turtle (stinkpot) — *Stemotherus odoratus*
7. Eastern Box Turtle — *Terrapene carolina carolina*

Lizards (Order Squamata, Sub-order Lacertila)

1. Five-lined Skink — *Eumeces fasciatus*
2. Broadhead Skink — *Eumeces laticeps*

Snakes (Order Squamata, Sub-order Serpentes)

1. Blue Racer — *Coluber constictor foxii*
2. Northern Ringneck Snake — *Diadophis punctatus edwardii*
3. Black Rat Snake — *Elaphe obsoleta obsolete*
4. Eastern Hognose Snake — *Heterodon platirhinos*
5. Eastern Milk Snake — *Lampropeltis t. triangulum*
6. Northern Banded Water Snake — *Nerodia sipedon sipedon*
7. Queen Snake — *Regina septemvittata*
8. Midland Brown Snake — *Storeria dekayi wrightorum*
9. Northern Redbelly — *Thamnophis butleri*
11. Eastern Garter Snake — *Thamnophis sirtalis*

12. Eastern Ribbon Snake *Thamnophis s. saurilus*

MAMMALS

1. Virginia Opposum *Didelphis virginiana*
2. Northern Short-tailed Shrew *Blarina brevicauda*
3. Least Shrew *Cryptotis parva*
4. Eastern Mole *Scalopus aquaticus*
5. Big Brown Bat *Eptesicus fuscus*
6. Silver-haired Bat *Lasionycteris noctivagans*
7. Red Bat *Lasiurus borealis*
8. Hoary Bat *Lasiurus cinereus*
9. Southeastern Myotis *Myotis austroriparius*
10. Gray Myotis *Myotis grisescens*
11. Leib's Bat *Myotis leibi*
12. Little Brown Myotis *Myotis lucifugus*
13. Northern Long-eared Myotis *Myotis septentrionalis*
14. Indiana Myotis *Myotis sodalist*
15. Evening Bat *Nycticeius humeralis*
16. Eastern Pipistrelle *Pipistrellus subflavus*
17. Raccoon *Procyon lotor*
18. Northern River Otter *Lontra Canadensis*
19. Striped Skunk *Mephitis mephitis*
20. Long-tailed Weasel *Mustela frenata*
21. Least Weasel *Mustela nivalis*
22. American Mink *Mustela vison*
23. Coyote *Canis latrans*
24. Common Gray Fox *Urocyon cinereoargenteus*
25. Red Fox *Vulpes vulpes*
26. Bobcat *Lynx rufus*
27. Southern Flying Squirrel *Glaucomys volans*
28. Woodchuck *Marmota monax*
29. Eastern Gray Squirrel *Sciurus carolinensis*

Final

30. Eastern Fox Squirrel	*Sciurus niger*
31. Franklin's Ground Squirrel	*Spermophilus franklinii*
32. Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*
33. Eastern Chipmunk	*Tamias striatus*
34. Red Squirrel	*Tamiasciurus hudsonicus*
35. Plains Pocket Gopher	*Geomys bursarius*
36. Beaver	*Castor canadensis*
37. Prairie Vole	*Microtus ochrogaster*
38. Meadow Vole	*Microtus pennsylvanicus*
39. Woodland (Pine) Vole	*Microtus pinetorum*
40. Muskrat	*Ondatra zibethicus*
41. White-footed Mouse	*Peromyscus leucopus*
42. Deer Mouse	*Peromyscus maniculatus*
43. Eastern Harvest Mouse	*Reithrodontomys humeralis*
44. Western Harvest Mouse	*Reithrodontomys megalotis*
45. Southern Bog Lemming	*Synaptomys cooperi*
46. House Mouse	*Mus musculus*
47. Norway Rat	*Rattus norvegicus*
48. Black Rat (Roof Rat)	*Rattus rattus*
49. Meadow Jumping Mouse	*Zapus hudsonius*
50. Swamp Rabbit	*Sylvilagus aquaticus*
51. Eastern Cottontail	*Sylvilagus floridanus*
52. White-tailed Deer	*Odocoileus virginianus*

Appendix 10:

STEPL Model – Data Inputs

STEPL Input Sheet: Values in RED are required input. Change worksheets by clicking on tabs at the bottom. You entered

Show optional input tables? Yes No

☑ **Treat all the subwatersheds as parts of a single watershed** ☑ **Groundwater load calcul**

TRUE

State	**County**	**Weather Station (for rain correction factors)**
Indiana	Jay	Portland

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pastureland	Forest	Wetlands	Feedlots	Feedlot Percent Paved	Total
Limberlost	10	23000	2400	1570	1000	100		28080
Bear	1	23000	1000	1500	1000	10		26511
Loblolly	1	23000	1000	2000	8000	10		34011
							0-24%	0

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck
W1	500	300	11000	100	100	1290000	0	0
W2	100	100	100	100	100	100	100	100
W3	100	100	100	100	100	100	100	100
Total	700	500	11200	300	300	1290200	200	200

3. Input septic system and illegal direct wastewater discharge data

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	Wastewater Direct Discharge, # of People	Direct Discharge Reduction, %
W1	1800	2.5	10	0	0
W2	600	2.5	10	0	0
W3	600	2.5	10	0	0
W4					

4. Modify the Universal Soil Loss Equation (USLE) parameters

Watershed	Cropland					Pastureland		
	R	K	LS	C	P	R	K	LS
W1	160.000	0.386	0.236	0.233	1.000	160.000	0.386	0.236
W2	160.000	0.386	0.236	0.233	1.000	160.000	0.386	0.236
W3	160.000	0.386	0.236	0.233	1.000	160.000	0.386	0.236
W4								

BMP Implementation

1. BMPs and efficiencies for different pollutants on CROPLAND, ND=No Data

Watershed	**Cropland**					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0.275	0.225	ND	0.375		50
W2	0.275	0.225	ND	0.375		50
W3	0.275	0.225	ND	0.375		50
W4	0	0	ND	0	Reduced Tillage Systems	

2. BMPs and efficiencies for different pollutants on FEEDLOTS, ND=No Data

Watershed	**Feedlots**					
	N	P	BOD	Sediment	BMPs	%Area BMP Applied
W1	0.45	0.7	ND	ND		100
W2	ND	0.85	ND	ND		100
W3	ND	0.85	ND	ND		100
W4	ND	0	ND	ND	Filter strip	

Appendix 11.

Photographs and Narrative of 175 Bridge Crossings in the Watershed (submitted as a compact disc)