Lake and River Enhancement Program (LARE)
Division of Soil Conservation
Indiana Department of Natural Resources (IDNR)

# WATER QUALITY EFFECTS OF FENCING LIVESTOCK OUT OF STREAMS AT THREE LAGRANGE COUNTY DEMONSTRATION SITES (1995 and 1997)

## Executive summary

Small headwater streams on three LaGrange County dairy farms showed a strong relationship between streambank vegetation and diversity of life in the stream. Forested areas had higher quality biological communities at all three farms. The fenced ditch at one farm had a slow low flow stream velocity and supported reasonably diverse aquatic life, probably because the banks were well vegetated with grasses and livestock access was limited to a riprap cattle crossing at the upper end. Livestock access was limited through fencing between 1995 and 1997 sampling dates at feedlots on two farms that provided access to the streams for calves and hogs and in a horse pasture at one farm. Prior to fencing, low levels of oxygen and high nutrients reduced water quality in as a result of nutrients and bank trampling at these three locations.

The quality of stream biological communities statistically improved at feedlots or pastures at all three farms after excluding livestock from the stream. Improvements due to fencing showed a stronger correlation to the degree of initial degradation than to the expense of the fencing materials.

Patterns of improvement at each site were similar regardless of the fencing materials. Temporary fencing and periodic restriction of livestock from the two severely trampled feedlots resulted in more than a three-fold increase in biological quality at Farm #2 and nearly a three-fold increase at Farm #3. Improvement was less dramatic at the pasture site, where the habitat was less degraded initially. Permanent fencing in the pasture resulted in nearly a two-fold increase in stream quality.

Although the fenced ditch was dredged between sampling years, biological community had recovered and improved one year after dredging. Dense grasses were quickly reestablished along the bank and bed of the stream. Upstream fencing may have also reduced the amount of silt transported into the grassed ditch area.

Stream communities were not statistically different in any of the forested areas, indicating that changes in the streams were not related to weather, stream improvements unrelated to livestock management practices or year-to-year variation in reproduction of the stream animals. All areas continued to show some impairment after the project, most likely due to soil erosion and runoff of nutrients or other chemicals overland and through numerous drain tiles.

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## INTRODUCTION

Many organisms are adapted to life in habitats that were historically common in a particular area. The health, or integrity, of a degraded stream community can be measured against the habitat and group of organisms that are found in a nearby undisturbed stream to determine the amount of change caused by human activity. Relatively undisturbed sites that are used for comparison are called "reference" sites. The reference stream should have the following characteristics: 1) of a similar size; 2) not altered by humans; and 3) in a relatively natural state of development.

Stream quality at seven sites around three proposed demonstration projects was assessed by using Protocol II (family level identifications for most organisms) of the US EPA Rapid Bioassessment Protocols for Use in Streams and Rivers (1989). This assessment method measures the quality of several different aspects of the animals living in the stream and can be used to determine an overall score for comparison between streams of the similar sizes.

Some species are more sensitive to different kinds of pollution, including low dissolved oxygen, sediment, nutrients, or toxic chemicals. The HBI (Hilsenhoff Biotic Index) is a rating that indicates the general sensitivity of each species to pollution and habitat change, ranging from "0" = very intolerant/sensitive to "10" = very tolerant/insensitive.

Some species of animals are very selective about what they eat. The presence of these species indicates the availability of their food. Feeding groups indicate the type of material that the organism eats. Feeding groups in aquatic macroinvertebrates include the following categories: 1) gatherers / collectors; 2) filterers ; 3) shredders; 4) scrapers; and 5) predators. Gatherers collect food that has been processed by other organisms. Filterers use nets or feather-like structures to remove particles from the water column. Shredders tear apart and consume plant material. Scrapers eat diatoms and other microscopic algae that grows on rocks or larger plants. Predators eat other organisms. Feeding information is available for most species and can be used to determine the existence and health of a complete biological community with an intact food web.

## METHODS

The quality of the stream sites was compared to data from a high quality reference site in the headwaters of the Upper Tippecanoe River (downstream from Baugher Lake near town of Wilmot in Noble County; Commonwealth, 1994). According to information collected by the Indiana Department of Environmental Management (IDEM), other streams in LaGrange County may present viable sites for comparison. The status of other LaGrange County streams that have been examined by IDEM follows:

| | | |
|---|---|---|
| Fawn River | CR 600W near Scott | slightly impaired |
| Little Elkhart | CR 1000W | moderately impaired |
| Little Elkhart | CR 1000W (L) | slightly impaired |
| Pigeon River | Mongo Lake dam | slightly impaired |
| Pigeon River | Ontario Lake dam | slightly impaired |
| Pigeon River | Scott, IDNR public access | slightly impaired |
| Turkey Creek | Hwy 20, Brushy Prairie | slightly impaired |
| Turkey Creek | Hwy 20, Brushy Prairie (L) | moderately impaired |

Chemical data on the streams were collected at sites that were upstream and downstream of the three dairy farms. Fecal coliforms were counted as number of colony-forming units in 100 ml from samples taken on July 18 and September 18, 1995. Nutrient concentration was measured for ammonia, nitrate, ortho-phosphate, and total phosphorus on July 18, 1995.

Invertebrate biological communities were collected with a surber sampler. Six samples were taken across all major microhabitat types in each site, including pools, riffles, debris packs, woody debris, and vegetation.

## CONDITION OF SAMPLING SITES BEFORE FENCING

Invertebrate biological communities in all three dairy farms showed a distinct pattern related to land use before and after the fencing projects (Figure 1).

**Forested areas had high quality biological communities**

Tree cover was historically common along small streams in most of Indiana. Therefore, abundant and diverse species can be expected in streams with intact riparian forest. The higher number of species (species richness) showed that all forested sites had a set of species that were most like the unimpaired reference site on the Upper Tippecanoe River (Table 1, 2).

Species found in forested areas reflected clear water with abundant food from forest sources. The presence of a larger number of bottom-dwelling filtering species (clams and net-spinning caddisflies, or Hydropsychids) indicated relatively clear water with less siltation at Forest #1 and Forest #2. Shredders (mostly pill bugs and scuds) which consume leaf litter from riparian trees, were also found almost exclusively at these sites. The abundance of shredders and predators at Forest #3 indicated the presence of adequate food from riparian sources to support a fairly complex food chain.

The forested areas supported a number of species that are known to be sensitive to pollution. Five of the 13 species at Forest #2 were relatively intolerant to pollution and habitat change. While Forest #1 had nearly as many species (12) as Forest #2 (13) during late summer, nearly all of these species were fairly tolerant to pollution and habitat change; three-quarters of the species had HBI scores of 8 to 10. Species at Forest #1 may have been affected by accumulated silt and lack of clean gravel substrate in this stream. In late fall, the highest number of species was obtained at Forest #3 (11 species, compared to 8 and 9 at the other forested sites). Seven of the species at Forest #3 were relatively sensitive to pollution. Forest #3 was not sampled during the summer.

**Slow velocity, ponded areas can have reasonably good communities, if vegetated**

Several species in the stream running through Pasture #1 (Hemiptera - water bugs), Grass Ditch #1 (Odonata - damselflies), and Feedlot #3 (Corixidae - water boatmen) were more typical of low flow, or slack-water conditions and are more commonly found in lakes than streams. However, large numbers of flat worms (Turbellaria), mayflies (Baetidae), and occurrence of the rove beetle (Staphylinidae) indicated fairly good water quality at Grass ditch #1.

The main difference in habitat between the poor quality sites (pasture and feedlot) and the higher quality site (grassed ditch) was the presence of abundant vegetation in the ditch and absence or patchiness of vegetation in the feedlot and pasture areas. In addition, stream banks were eroding and sloughing in feedlots, resulting in a wide, shallow, slow-moving stream. Ditch banks were stabilized by thick grassy vegetation surrounding a deeper, narrower, slow-moving stream at low flow.

**Low levels of oxygen and high nutrients reduce water quality in feedlots**

The presence of a large number of Tubificid worms (Oligochaetes) in Pasture #1 and blood worm midges (Chironomidae) in Feedlots #2 and #3 and water boatmen (Corixidae) in Feedlot #3 indicated very low levels of oxygen in the water. All three species have unique adaptations for survival in stagnant water. Worms and "blood worm" midge larvae have hemoglobin in their blood, similar to human blood, which is capable of capturing small amounts of oxygen. The blood of other insects is less effective at removing oxygen from the water. Water boatmen have a plate on the underside of their body in which they can store a bubble of air obtained from the surface, for use like a diver's air tank, and depend very little on the amount of oxygen in the water.

Nutrients in the water and lack of current in pooled water can result in low levels of oxygen. Decay of organic material removes oxygen from the water, especially under warm conditions when the oxygen capacity of water is lower. Collectors, such as bloodworm midges (Chironomidae), dominated the biological community at all feedlot sites, indicating high levels of nutrients and organic material floating in the water. Bloodworm midges constituted 95 percent of the individuals collected in summer and 57 percent in the fall at Feedlot #2 and 31 percent of the individuals found in the fall at Feedlot #3.

A large drain tile was discharging a high volume of silty water into the stream between the forested sampling site and the Feedlot #2 when the fall sample was collected. This silt may settled in the feedlot, due to slower flow.

Nutrient levels and fecal coliform contamination measured above and below the dairy farms showed a trend toward decreased water quality in downstream areas at all three sites. In comparison to other Indiana streams, the sites were chemically degraded (Table 3). For comparison, the average concentrations from the first 50 Indiana streams listed in 1991 IDEM monitoring records were 0.17 mg/l total phosphorus, 2.00 mg/l nitrate, 0.20 mg/l ammonia, and 1,054 colonies/100ml fecal coliforms (IDEM, 1991).

Fecal coliforms originate in warm-blooded animals and thrive in warm water conditions. Therefore, coliform contamination will increase with presence of animal waste where livestock have access to streams and summer concentrations can be expected to be higher than during the fall. This pattern was clear at Dairies #2 and #3 where fecal contamination was 6 to 7 times higher below the farm during the summer, but was relatively low during the fall (Figure 2). Fecal contamination below these farms is higher than would be found statistically in 95 percent* of Indiana streams. Coliforms at Dairy #1 showed no significantly difference above and below the farm during summer sampling. However, fecal contamination at this site showed a dramatic increase during fall sampling (67 times higher than the average and 3 times higher than the downstream site at Dairy #2).

*Values including one unit standard deviation (SD), which statistically contains 66 percent of the sites, are: 0.17±0.23 SD mg/l total phosphorus, 2.00±1.04 SD mg/l nitrate, 0.20±0.18 SD mg/l ammonia, and 1,054±2,214 SD colonies/100ml fecal coliforms. Adding two times the standard deviation to the original number gives the statistical value that would include 95 percent of the streams.

Concentrations of ammonia, nitrate, ortho-phosphorus, and total phosphorus were higher downstream of farms, with the exception of a decrease in ortho-phosphorus downstream of Dairy #3 (Figure 3). Nitrates were below the Indiana average at all locations, except below Dairy #3 where concentrations were nearly double the average state value and above the value that would statistically include two-thirds of Indiana streams. At no site were nitrates above the safety standard of 10 mg/l. Ammonia levels were at or below average above Dairies #2 and #3, but over twice the concentration that would statistically be found in 95 percent of Indiana streams *above* Dairy #1, indicating some source of ammonia other than the livestock. Ammonia concentrations increased by 10 to 12 times below the Dairies #2 and #3. (No value was available below Dairy #1.) Total phosphorus levels were 3 to 5 times the average above and 7 to 9 times the average below the dairies.

**<u>All areas showed some impairment before fencing</u>**

Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Tricoptera) are particularly sensitive to pollution and habitat degradation. The absence of species from these groups, commonly referred to as the "EPT" taxa, constituted the most significant difference between the higher quality sites in this area and more pristine reference sites in Indiana headwater streams and indicated that even the best stream sites in this study were somewhat degraded.

No site contained a very high diversity of EPT species, although Grass ditch #1 had one mayfly species common to ponded areas, mayfly pupae were found at Forest #2, and Forest #3 had one mayfly and two caddisfly species. Although the Forest #1 scored relatively well overall, most of the species were shredders that feed on leaves and other organic material. Sedimentation apparently prevented the sensitive EPT taxa from inhabiting the stream bottom in this forested area.

In general, forested sites and the grassed ditch had biological scores that were two to four times higher than the downstream pastures and feedlots in the summer (Table 4,5). Biological scores of the feedlots and pasture improved somewhat in the fall, probably due to lower stream temperatures and less runoff from surrounding areas (Table 6). While Forest #1 showed similar scores in summer and fall, both Forest #2 and Grassed ditch #1 scores dropped towards fall. These last two sites may be affected by point source pollution, such as septic discharge and livestock manure, which would be more concentrated under low flow conditions in the fall. Both sites had high fecal coliform levels and increases in nutrient levels, especially ammonia and dissolved ortho-phosphate levels. All of these factors indicated fecal pollution, but do not distinguish between human and animal sources.

## EFFECTS OF LIVESTOCK FENCING ON STREAMS

The degree of fencing at each of the three project sites ranged from a single strand electric fence that allowed access to the stream at several points to permanent fencing in combination with spring development and an offsite watering tank. Livestock did not have access to forested sites at any of the three farms at any time during the study.

**<u>Changes in habitat condition at each farm</u>**

**Farm #1:**

The "grassed ditch" was located immediately downstream and across a county road from the "pasture" area. The grassed ditch had been fenced with permanent barbed wire and wooden posts so that livestock were excluded at all times during the study. The ditch was dredged and revegetated between 1995 and 1997. Thick grasses covered the ditch banks and stream bed through this section during all sampling periods. A cattle crossing with a limestone riprap bed was located immediately above the sample section.

Permanent fencing was installed to exclude horses from the stream and an offstream watering tank was provided using spring development. The substrate in the stream section changed from soft organic silt over the full length through the pasture to clean gravel in most sections. A culvert at a pasture crossing continued to hold some sediment upstream but had clean gravel downstream.

**Farm #2:**
The feedlot area at Farm #2 was located downstream and around a small bend from the forested area. The upper section of the feedlot consisted of a concrete pad covering one side of the stream between the barn and the water. The sampling area was just downstream and fenced as a separate section that provided full access to one side of the stream by calves. The stream bank area was very sparsely vegetated with sand, gravel, and a few larger slabs in 1995.

Between 1995 and 1997, calves were not maintained in the area and short vegetation covered most of the bank. The bed changed from organic silt over sand to relatively clean sand and gravel. One fairly large central mudminnow (*Umbra limi*) was inadvertantly collected in the sampler in 1997. Central mudminnows are highly tolerant to low dissolved oxygen levels, survive high water temperatures in stagnant pools, temporary increases in turbidity, and prefer soft substrates (Becker, 1983).

**Farm #3:**
The feedlot in Farm #3 was located across a gravel road and immediately downstream of the forested area. The feedlot supplied direct access for hogs on one side of the stream and dairy calves on the other side of the stream. The stream bed consisted of a layer of soft silt and organic matter over sand and gravel.

After the 1995 sample, periodic combined use of electric fence and hog wire prevented full access to one or both sides of the stream throughout most of 1996 and 1997, allowing a narrow band of grasses to grow along the stream. The sand and gravel substrate was less embedded with silt where livestock were excluded. A number of mottled sculpin (*Cottus bairdi*) were inadvertantly caught in the sampler in 1997. Sculpin are found in cold headwater streams and generally avoid highly disturbed streams (Becker, 1983). Sculpin are important role in survival of some clam species by hosting their larvae as the mature on the fish gills.

<u>**Changes in biological communities at each farm**</u>

**The quality of stream biological communities statistically improved at feedlots or pastures at all three farms after excluding livestock from the stream (Figure 4). Improvements due to fencing showed a stronger correlation to the degree of initial degradation than to the expense of the fencing materials.**

Patterns of improvement at each site were similar regardless of the fencing materials (Figure 5). Temporary fencing and periodic restriction of livestock from the two severely trampled feedlots resulted in more than a three-fold increase in biological quality at Farm #2 and nearly a three-fold increase at Farm #3. Improvement was less dramatic at the pasture site, where the habitat was less degraded initially. Permanent fencing in the pasture resulted in nearly a two-fold increase in stream quality.

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Stream communities were not statistically different in any of the forested areas, indicating that changes in the streams were not related to weather, stream improvements unrelated to livestock management practices or year-to-year variation in reproduction of the stream animals.

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Table 1. Feeding group and pollution tolerance of species collected by use of a Surber sampler in five habitats at two LaGrange County demonstration sites on August and October of 1995 and 1997. (HBI indicates pollution tolerance from "0" = sensitive to pollution to "10" = pollution tolerant.)

| taxon | feeding group | tolerance (HBI) |
|---|---|---|
| **Amphipoda - scuds** | | |
| *Gammarus* | shredder | 4 |
| **Coleoptera - beetles** | | |
| Dytiscidae (*Agabus*) | predator | 8 |
| Dytiscidae (*Coptotomus*) | predator | 8 |
| Elmidae (*Macronychus*) | shredder | 4 |
| Elmidae (*Optioservus*) | scraper | 4 |
| Elmidae (*Promoresia*) | scraper | 4 |
| Elmidae (*Stenelmis*) | scraper | 4 |
| Haliplidae (*Haliplus*) | shredder | 6 |
| Haliplidae (*Peltodytes*) | shredder | 6 |
| Hydrophilidae (*Tropisternus*) | predator | 4 |
| Staphylinid (*Stenus*) | predator | 4 |
| **Decapoda – crayfish** | | |
| *Orconectes* | predator | 6 |
| **Diptera - flies** | | |
| Athericidae (*Atherix*) | predator | 6 |
| Chironomidae (*Chironomus*) | gatherer | 8 |
| Chironomidae (*Cricotopus*) | gatherer | 6 |
| Chironomidae (*Pseudodiamesa*) | gatherer | 6 |
| Ptychopteridae (*Ptychoptera*) | gatherer | 3 |
| Simuliidae | filterer | 6 |
| Tabanidae (*Chrysops*) | gatherer | 6 |
| Tabanidae (*Tabanus*) | predator | 6 |
| Tipulidae (*Tipula*) | shredder | 3 |
| Tipulidae (*Hexatoma*) | predator | 2 |
| **Ephemeroptera - mayflies** | | |
| Baetidae (*Baetis*) | scraper | 3 |
| Baetidae (*Callibaetis*) | gatherer | 4 |
| Baetidae (*Cloeon*) | scraper | 4 |
| Baetiscidae (*Baetisca*) | gatherer | 3 |
| Caenidae (*Caenis*) | gatherer | 7 |
| **Gastropoda - snails** | | |
| *Aplexa* | scraper | 4 |
| *Gyraulus* | scraper | 8 |
| *Lymnaea* | scraper | 6 |
| *Physa* | scraper | 8 |
| *Physella* | scraper | 8 |
| *Planorbella* | scraper | 8 |

Table 1 (cont.). Feeding group and pollution tolerance of species collected.

| | | |
|---|---|---|
| **Hemiptera – true bugs** | | |
| Belostomatidae (*Belostoma*) | predator | 8 |
| Corixidae (*Cymatia*) | predator | 8 |
| Corixidae (*Sigara*) | gatherer | 8 |
| **Hirudinea - leeches** | | |
| *Erpobdella* (grey) | predator | 4 |
| *Glossiphonia* (brown & white) | predator | 4 |
| *Helobdella* (white) | predator | 10 |
| **Isopoda - pill bugs** | | |
| *Caecidotea* | shredder | 8 |
| **Megaloptera – dobsonflies and alderflies** | | |
| Sialidae (*Sialis*) | predator | 4 |
| **Odonata – dragonflies and damselflies** | | |
| Aeschnidae (*Aeshna*) | predator | 2 |
| Aeschnidae (*Boyeria*) | predator | 3 |
| Calopterygidae (*Calopteryx*) | predator | 5 |
| Coenagrionidae (*Enallagma*) | predator | 9 |
| Libellulidae (*Libellula*) | predator | 9 |
| **Oligochaeta – worms** | | |
| Tubificidae | gatherer | 8 |
| **Pelecypoda - clams** | | |
| Sphaeriidae (*Pisidium*) | filterer | 5 |
| **Trichoptera - caddisflies** | | |
| Hydropsychidae (*Hydropsyche*) | filterer | 4 |
| Limnephilidae (*Neophylax*) | scraper | 4 |
| Phryganeidae (*Ptilostomis*) | shredder | 4 |
| **Turbellaria - flat worms** | | |
| *Dugesia* (brown) | predator | 4 |
| *Phagocata* (white) | predator | 4 |
| **Total number of species** | | 53 |

Table 2. Number of individuals collected per square meter by use of a Surber sampler in five habitats at two LaGrange County demonstration sites on August 22, 1995. (HBI indicates pollution tolerance from "0" = sensitive to pollution to "10" = pollution tolerant.)

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| taxon | 6/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| **Amphipoda - scuds** | | | | | | | not sampled | |
| *Gammarus* | | 5 | | | 23 | | | |
| *Hyalella* | 8 | | | | | | | |
| **Coleoptera - beetles** | | | | | | | | |
| Dytiscidae (*Agabus*) | | | | | | | | |
| Dytiscidae (*Coptotomus*) | | | | 1 | | | | |
| Elmidae (*Macronychus*) | 3 | | | | | | | |
| Elmidae (*Optioservus*) | | | | | 9 | | | |
| Elmidae (*Stenelmis*) | 1 | | | | | | | |
| Haliplidae (*Haliplus*) | | | | | | | | |
| Haliplidae (*Peltodytes*) | | | | 2 | | | | |
| Hydrophilidae (*Tropisternus*) | | | | | | | | |
| Staphylinid (*Stenus*) | | | 1 | | | | | |
| **Decapoda – crayfish** | | | | | | | | |
| *Orconectes* | | | | | | | | |
| **Diptera - flies** | | | | | | | | |
| Athericidae (*Atherix*) | | | | | 12 | | | |
| Chironomidae (*Chironomus*) | | 26 | | 5 | 16 | 61 | | |
| Chironomidae (*Cricotopus*) | | | | | | | | |
| Chironomidae (*other species*) | 16 | | | | | | | |
| Ptychopteridae (*Ptychoptera*) | | | | | | | | |
| Simuliidae | | | | 1 | | | | |
| Tabanidae (*Chrysops*) | | | | | 1 | | | |
| Tabanidae (*Tabanus*) | | 1 | | | | | | |
| Tipulidae (*Tipula*) | | | | | | | | |
| Tipulidae (*Hexatoma*) | | | | | | | | |
| **Ephemeroptera - mayflies** | | | | | | | | |
| Baetidae (*Baetis*) | | | | | 9 | | | |
| Baetidae (*Callibaetis*) | | | | | | | | |
| Baetidae (*Cloeon*) | | | 67 | | | | | |
| Baetidae (*Pseudocloeon*) | 1 | | | | | | | |
| Baetiscidae (*Baetisca*) | | | | | | | | |
| Caenidae (*Caenis*) | | | | | | | | |
| Heptageniidae (*Stenonema*) | 1 | | | | | | | |
| **Gastropoda – snails** | | | | | | | | |
| Ancyclidae (*Ferrissia*) | 1 | | | | | | | |
| Hydrobiidae (*Amnicola*) | 7 | | | | | | | |
| Lymnaediae (*Lymnaea*) | | 2 | | | 1 | | | |
| Physidae (*Aplexa*) | | | | | | | | |
| Physidae (*Physa*) | | 8 | 2 | | 1 | | | |
| Physidae (*Physella*) | | | | | | | | |
| Planorbidae (*Gyraulus*) | 3 | 2 | | | 3 | | | |
| Planorbidae (*Planorbella*) | | | | | | | | |
| Pleuroceridae (*other species*) | 1 | | | | | | | |
| **Hemiptera – true bugs** | | | | | | | | |
| Belostomatidae (*Belostoma*) | | | | | | | | |
| Corixidae (*Cymatia*) | | | | | | | | |

Table 2 (cont.) Number of individuals collected per square meter on August 22, 1995.

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| **taxon** | **6/94** | **forest** | **ditch** | **pasture** | **forest** | **feedlot** | **forest** | **feedlot** |
| Corixidae (*Sigara*) | | 2 | | 3 | | | | |
| **Hirudinea - leeches** | | | | | | | | |
| *Erpobdella* (grey) | | 6 | 3 | | | | | |
| *Glossiphonia* (brown & white) | | | | | | | | |
| *Helobdella* (white) | | 8 | | | | 1 | | |
| **Isopoda - pill bugs** | | | | | | | | |
| *Caecidotea* | 22 | | | | | | | |
| **Megaloptera – dobsonflies and alderflies** | | | | | | | | |
| Sialidae (*Sialis*) | | | | | | | | |
| **Odonata – dragonflies and damselflies** | | | | | | | | |
| Aeschnidae (*Aeshna*) | | | | | | | | |
| Aeschnidae (*Boyeria*) | | | | | | | | |
| Calopterygidae (*Calopteryx*) | | | | | | | | |
| Coenagrionidae (*Enallagma*) | | | 76 | | 1 | | | |
| **Oligochaeta – worms** | | | | | | | | |
| Tubificidae | | 13 | 11 | 747 | 11 | | | |
| **Pelecypoda - clams** | | | | | | | | |
| Sphaeriidae (*Pisidium*) | | 39 | | | 69 | 2 | | |
| **Plecoptera – stoneflies** | | | | | | | | |
| Perlidae (*Phasganophora*) | 32 | | | | | | | |
| **Trichoptera - caddisflies** | | | | | | | | |
| Hydropsychidae (*Hydropsyche*) | | | | | 21 | | | |
| Leptoceridae (*Ceraclea*) | 4 | | | | | | | |
| Limnephilidae (*Neophylax*) | | | | | | | | |
| Phryganeidae (*Ptilostomis*) | | | | | | | | |
| **Turbellaria - flat worms** | | | | | | | | |
| *Dugesia* (brown) | | 51 | 437 | 9 | | | | |
| *Phagocata* (white) | | | | | | | | |
| **Total # of species** | **15** | **12** | **7** | **7** | **13** | **3** | **not sampled** | |
| **Total # of individuals** | **100** | **163** | **597** | **768** | **177** | **64** | | |

Table 3. Number of individuals collected per square meter by use of a Surber sampler in five habitats at two LaGrange County demonstration sites on October 17, 1995. (HBI indicates pollution tolerance from "0" = sensitive to pollution to "10" = tolerant.)

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| taxon | 10/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| **Amphipoda - scuds** | | | | | | | | |
| *Gammarus* | 17 | 10 | | | 28 | 4 | 77 | |
| **Coleoptera - beetles** | | | | | | | | |
| Dytiscidae (*Agabus*) | | | | | | | | |
| Dytiscidae (*Coptotomus*) | | | | | | | 42 | |
| Elmidae (*Dubiraphia*) | 2 | | | | | | | |
| Elmidae (*Macronychus*) | 1 | | | | | | | |
| Elmidae (*Optioservus*) | | | | | | | | |
| Elmidae (*Stenelmis*) | 16 | | | | | | | |
| Haliplidae (*Haliplus*) | | | | | | | | |
| Haliplidae (*Peltodytes*) | | | | | | | 2 | |
| Hydrophilidae (*Tropisternus*) | | | | | | | | |
| Staphylinid (*Stenus*) | | | | | | | | |
| **Decapoda – crayfish** | | | | | | | | |
| *Orconectes* | | | | | | | | |
| **Diptera – flies** | | | | | | | | |
| Athericidae (*Atherix*) | | | | | | | | |
| Chironomidae (*Chironomus*) | | | 3 | 6 | 2 | 15 | | 37 |
| Chironomidae (*Cricotopus*) | | | | | | | | |
| Chironomidae (*other species*) | 4 | | | | | | | |
| Ptychopteridae (*Ptychoptera*) | | | | | 7 | | | |
| Simuliidae | | | | | | | | |
| Tabanidae (*Chrysops*) | | | | | | | | |
| Tabanidae (*Tabanus*) | | | | | | | | |
| Tipulidae (*Tipula*) | | | | 1 | | | 2 | |
| Tipulidae (*Hexatoma*) | | | | | | | | 1 |
| **Ephemeroptera - mayflies** | | | | | | | | |
| Baetidae (*Baetis*) | 1 | | | | | | | |
| Baetidae (*Callibaetis*) | | | 1 | | 3 | | 3 | 2 |
| Baetidae (*Cloeon*) | | | | | | | | |
| Baetiscidae (*Baetisca*) | | | | | | | | |
| Caenidae (*Caenis*) | | | | | | | | |
| Heptageniidae (*Stenacron*) | 3 | | | | | | | |
| **Gastropoda - snails** | | | | | | | | |
| Ancyclidae (*Ferrissia*) | 1 | | | | | | | |
| Hydrobiidae (*Amnicola*) | 1 | | | | | | | |
| Lymnaediae (*Lymnaea*) | | 1 | | 1 | | | | |
| Physidae (*Aplexa*) | | | | | | | | |
| Physidae (*Physa*) | | 5 | 1 | | 2 | 1 | 2 | |
| Physidae (*Physella*) | | | | | | | | |
| Planorbidae (*Gyraulus*) | 4 | 1 | | | | | | |
| Planorbidae (*Planorbella*) | | | | | | | | |
| Pleuroceridae (*Elimia*) | 12 | | | | | | | |
| **Hemiptera – true bugs** | | | | | | | | |
| Belostomatidae (*Belostoma*) | | | | | | | | |
| Corixidae (*Cymatia*) | | | | | | | | |
| Corixidae (*Sigara*) | | | | 1 | | | 3 | 69 |

Table 3 (cont.) Number of individuals collected per square meter on October 17, 1995.

| taxon | reference 10/94 | #1 forest | #1 ditch | #1 pasture | #2 forest | #2 feedlot | #3 forest | #3 feedlot |
|---|---|---|---|---|---|---|---|---|
| **Hirudinea - leeches** | | | | | | | | |
| *Erpobdella* (grey) | | 2 | 3 | | | | | |
| *Glossiphonia* (brown & white) | | | | | | | | |
| *Helobdella* (white) | | 5 | | | | | | |
| **Isopoda - pill bugs** | | | | | | | | |
| *Caecidotea* | | | | | | | | |
| *Lyrceus* | 7 | | | | | | | |
| **Lepidoptera – moths** | | | | | | | | |
| Pyralidae (*Parargyractis*) | 1 | | | | | | | |
| **Megaloptera – dobsonflies and alderflies** | | | | | | | | |
| Sialidae (*Sialis*) | | | | | | | | |
| **Odonata – dragonflies and damselflies** | | | | | | | | |
| Aeschnidae (*Aeshna*) | | | | | | | 1 | |
| Aeschnidae (*Boyeria*) | | | | | | | | |
| Calopterygidae (*Calopteryx*) | 1 | | | | 1 | | 3 | |
| Coenagrionidae (*Enallagma*) | | | 10 | 3 | | | | |
| **Oligochaeta – worms** | | | | | | | | |
| Tubificidae | | 1 | | 9 | 1 | 5 | | 2 |
| **Pelecypoda - clams** | | | | | | | | |
| Sphaeriidae (*Pisidium*) | | 17 | | 1 | 28 | | | |
| Sphaeriidae (*Sphaerium*) | 1 | | | | | | | |
| **Trichoptera - caddisflies** | | | | | | | | |
| Helicopsychidae (*Helicopsyche*) | 15 | | | | | | | |
| Hydropsychidae (*Hydropsyche*) | | | | | | 1 | 9 | |
| Hydropsychidae (*Cheumatopsyche*) | 6 | | | | | | | |
| Leptoceridae (*Ceraclea*) | 1 | | | | | | | |
| Limnephilidae (*Neophylax*) | | | | | | | | |
| Phryganeidae (*Ptilostomis*) | | | | | | | 6 | |
| Philopotamidae (*Chimarra*) | 2 | | | | | | | |
| **Turbellaria - flat worms** | | | | | | | | |
| *Dugesia* (brown) | 4 | 26 | 57 | | | | | 8 |
| *Phagocata* (white) | | | | 56 | | | | |
| **Total # of species** | **22** | **9** | **6** | **8** | **8** | **5** | **11** | **6** |
| **Total # of individuals** | **100** | **68** | **75** | **78** | **72** | **26** | **150** | **119** |

Table 4. Number of individuals collected per square meter by use of a Surber sampler in five habitats at two LaGrange County demonstration sites on August 21, 1997. (HBI indicates pollution tolerance from "0" = sensitive to pollution to "10" = pollution tolerant.)

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| taxon | 6/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| **Amphipoda - scuds** | | | | | | | | |
| *Gammarus* | | 30 | 78 | 4 | 87 | 344 | 74 | 167 |
| *Hyalella* | 8 | | | | | | | |
| **Coleoptera - beetles** | | | | | | | | |
| Dytiscidae (*Agabus*) | | | | | | | | 2 |
| Dytiscidae (*Coptotomus*) | | | 67 | | | | | |
| Elmidae (*Macronychus*) | 3 | | | | 2 | | | |
| Elmidae (*Optioservus*) | | | | | | | | 2 |
| Elmidae (*Promoresia*) | | 2 | | | | | | |
| Elmidae (*Stenelmis*) | 1 | 4 | | | | | | |
| Haliplidae (*Haliplus*) | | | | 2 | | | | |
| Haliplidae (*Peltodytes*) | | | 50 | | | | | 2 |
| Hydrophilidae (*Tropisternus*) | | | 4 | 2 | | | | |
| Staphylinid (*Stenus*) | | | | | | | | |
| **Decapoda – crayfish** | | | | | | | | |
| *Orconectes* | | | | 2 | | | | 2 |
| **Diptera - flies** | | | | | | | | |
| Athericidae (*Atherix*) | | | | | | | | |
| Chironomidae (*Chironomus*) | | 13 | 28 | 26 | | 2 | 6 | 19 |
| Chironomidae (*Cricotopus*) | | 7 | 7 | 15 | 4 | | | 4 |
| Chironomidae (*other species*) | 16 | | 2 | | | | | |
| Ptychopteridae (*Ptychoptera*) | | | | | | | | |
| Simuliidae | | | 2 | 296 | | | | |
| Tabanidae (*Chrysops*) | | | | | | | | |
| Tabanidae (*Tabanus*) | | | | | | | | |
| Tipulidae (*Tipula sp. 1*) | | | | | | 4 | | 4 |
| Tipulidae (*Tipula sp. 2*) | | | | | | | | 4 |
| Tipulidae (*Hexatoma*) | | | | | | | | |
| **Ephemeroptera - mayflies** | | | | | | | | |
| Baetidae (*Baetis*) | | | | 22 | 2 | 31 | 4 | 2 |
| Baetidae (*Callibaetis*) | | | | | | | | |
| Baetidae (*Cloeon*) | | | | | | | | |
| Baetidae (*Pseudocloeon*) | 1 | | | | | | | |
| Baetiscidae (*Baetisca*) | | | | | | | | |
| Caenidae (*Caenis*) | | | 6 | 2 | | | | |
| Heptageniidae (*Stenonema*) | 1 | | | | | | | |
| **Gastropoda - snails** | | | | | | | | |
| Ancyclidae (*Ferrissia*) | 1 | | | | | | | |
| Hydrobiidae *(Amnicola)* | 7 | | | | | | | |
| Lymnaediae (*Lymnaea*) | | 2 | 2 | | 2 | | | |
| Physidae *(Aplexa)* | | | | | | | | |
| Physidae *(Physa)* | | | | | | | | |
| Physidae *(Physella)* | | 2 | 20 | 6 | | | 6 | 7 |
| Planorbidae *(Gyraulus)* | 3 | | 2 | 2 | | | | |
| Planorbidae *(Planorbella)* | | 4 | | 2 | 4 | | 2 | |

Table 4 (cont.) Number of species collected per square meter on August 21, 1997.

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| taxon | 6/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| Pleuroceridae (*other species*) | 1 | | | | | | | |
| **Hemiptera – true bugs** | | | | | | | | |
| Belostomatidae (*Belostoma*) | | | | | | | | |
| Corixidae (*Cymatia*) | | | | | | | | |
| Corixidae (*Sigara*) | | | 209 | 9 | | | 2 | |
| **Hirudinea - leeches** | | | | | | | | |
| *Erpobdella* (grey) | | | 2 | | | | 2 | 2 |
| *Glossiphonia* (brown & white) | | | 2 | | | | | |
| *Helobdella* (white) | | 4 | 7 | | | | | |
| **Isopoda - pill bugs** | | | | | | | | |
| *Caecidotea* | 22 | | | | 2 | | | |
| **Megaloptera – dobsonflies and alderflies** | | | | | | | | |
| Sialidae (*Sialis*) | | | 2 | 4 | | | | |
| **Odonata – dragonflies and damselflies** | | | | | | | | |
| Aeschnidae (*Aeshna*) | | | | | | | | |
| Aeschnidae (*Boyeria*) | | | | | 6 | | | |
| Calopterygidae (*Calopteryx*) | | | | | | | | 2 |
| Coenagrionidae (*Enallagma*) | | | | 4 | | | | |
| Libellulidae (*Libellula*) | | | 2 | | | | | |
| **Oligochaeta – worms** | | | | | | | | |
| Tubificidae | | | 2 | | | 4 | | 2 |
| **Pelecypoda - clams** | | | | | | | | |
| Sphaeriidae (*Pisidium*) | | 98 | | | 56 | 2 | 2 | |
| **Plecoptera – stoneflies** | | | | | | | | |
| Perlidae (*Phasganophora*) | 32 | | | | | | | |
| **Trichoptera - caddisflies** | | | | | | | | |
| Hydropsychidae (*Hydropsyche*) | | | | | 4 | 37 | 2 | 33 |
| Leptoceridae (*Ceraclea*) | 4 | | | | | | | |
| Limnephilidae (*Neophylax*) | | | | 2 | | | 4 | |
| Phryganeidae (*Ptilostomis*) | | | | | | | 2 | |
| **Turbellaria - flat worms** | | | | | | | | |
| *Dugesia* (brown) | | | | 6 | | | | |
| *Phagocata* (white) | | 6 | 9 | | | | | |
| **Total # of species** | **15** | **11** | **20** | **17** | **9** | **8** | **11** | **15** |
| **Total # of individuals** | **100** | **172** | **503** | **406** | **169** | **431** | **106** | **254** |

Table 5. Number of species collected per square meter by use of a Surber sampler in five habitats at two LaGrange County demonstration sites on October 21, 1997. (HBI indicates pollution tolerance from "0" = sensitive to pollution to "10" = tolerant.)

| | **reference** | **#1** | | | **#2** | | **#3** | |
|---|---|---|---|---|---|---|---|---|
| **taxon** | **10/94** | **forest** | **ditch** | **pasture** | **forest** | **feedlot** | **forest** | **feedlot** |
| **Amphipoda - scuds** | | | | | | | | |
| *Gammarus* | 17 | 126 | 598 | 102 | 59 | 415 | 133 | 44 |
| **Coleoptera - beetles** | | | | | | | | |
| Dytiscidae (*Agabus*) | | | 102 | | | | 2 | |
| Dytiscidae (*Coptotomus*) | | | 2 | | | | | |
| Elmidae (*Dubiraphia*) | 2 | | | | | | | |
| Elmidae (*Macronychus*) | 1 | | | | | | | |
| Elmidae (*Optioservus*) | | | | | | | | |
| Elmidae (*Stenelmis*) | 16 | 7 | | | | | | |
| Haliplidae (*Haliplus*) | | | | | | | | |
| Haliplidae (*Peltodytes*) | | | 2 | 2 | | | 2 | |
| Hydrophilidae (*Tropisternus*) | | | | | | | | |
| Staphylinid (*Stenus*) | | | | | | | | |
| **Decapoda – crayfish** | | | | | | | | |
| *Orconectes* | | | | | | | | |
| **Diptera - flies** | | | | | | | | |
| Athericidae (*Atherix*) | | | | | 2 | | | |
| Chironomidae (*Chironomus*) | | 2 | 4 | 9 | | | 2 | 9 |
| Chironomidae (*Cricotopus*) | | | 6 | | 15 | 6 | | 4 |
| Chironomidae (*other species*) | 4 | | | | 2 | | | |
| Ptychopteridae (*Ptychoptera*) | | | | | | | | |
| Simuliidae | | | 2 | 67 | 4 | 4 | | |
| Tabanidae (*Chrysops*) | | | | | | | | |
| Tabanidae (*Tabanus*) | | | | | | | | |
| Tipulidae (*Tipula*) | | | | | | | | 2 |
| Tipulidae (*Hexatoma*) | | | | | | | | |
| **Ephemeroptera - mayflies** | | | | | | | | |
| Baetidae (*Baetis*) | 1 | | | | | | | |
| Baetidae (*Callibaetis*) | | | 128 | 2 | 6 | 24 | 2 | 17 |
| Baetidae (*Cloeon*) | | | | | | | | |
| Baetiscidae (*Baetisca*) | | | | | | | | |
| Caenidae (*Caenis*) | | | | | | | | |
| Heptageniidae (*Stenacron*) | 3 | | | | | | | |
| **Gastropoda - snails** | | | | | | | | |
| Ancyclidae (*Ferrissia*) | 1 | | | | | | | |
| Hydrobiidae (*Amnicola*) | 1 | 2 | | | | | | |
| Lymnaediae (*Lymnaea*) | | | | | | | | 2 |
| Physidae (*Aplexa*) | | | | | | | 2 | |
| Physidae (*Physa*) | | | | | | | | |
| Physidae (*Physella*) | | 7 | 2 | | | | 9 | 2 |
| Planorbidae (*Gyraulus*) | 4 | 4 | | | | | | |
| Planorbidae (*Planorbella*) | | 4 | | | 2 | | | |
| Pleuroceridae (*Elimia*) | 12 | | | | | | | |
| **Hemiptera – true bugs** | | | | | | | | |
| Belostomatidae (*Belostoma*) | | | 4 | | | | | |
| Corixidae (*Cymatia*) | | | | | | | | |
| Corixidae (*Sigara*) | | 2 | 6 | 6 | | 4 | | |

Table 5 (cont.) Number of species collected per square meter on October 21, 1997.

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| taxon | 10/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| **Hirudinea - leeches** | | | | | | | | |
| *Erpobdella* (grey) | | 4 | | | | | | |
| *Glossiphonia* (brown & white) | | | 2 | | | | | |
| *Helobdella* (white) | | | 2 | | | | | |
| **Isopoda - pill bugs** | | | | | | | | |
| *Caecidotea* | | | | | | | | |
| *Lyrceus* | 7 | | | | | | | |
| **Lepidoptera – moths** | | | | | | | | |
| Pyralidae (*Parargyractis*) | 1 | | | | | | | |
| **Megaloptera – dobsonflies and alderflies** | | | | | | | | |
| Sialidae (*Sialis*) | | | | | | | 4 | |
| **Odonata – dragonflies and damselflies** | | | | | | | | |
| Aeschnidae (*Aeshna*) | | | | | | | | |
| Aeschnidae (*Boyeria*) | | | | | | 2 | 2 | |
| Calopterygidae (*Calopteryx*) | 1 | | | | 4 | 20 | | |
| Coenagrionidae (*Enallagma*) | | | 13 | | | | | |
| **Oligochaeta – worms** | | | | | | | | |
| Tubificidae | | 4 | | | 2 | 9 | | 4 |
| **Pelecypoda - clams** | | | | | | | | |
| Sphaeriidae (*Pisidium*) | | | | | 46 | 191 | 4 | |
| Sphaeriidae (*Sphaerium*) | 1 | | | | | | | |
| **Trichoptera - caddisflies** | | | | | | | | |
| Helicopsychidae (*Helicopsyche*) | 15 | | | | | | | |
| Hydropsychidae (*Hydropsyche*) | | | | | 6 | 126 | | 11 |
| Hydropsychidae (*Cheumatopsyche*) | 6 | | | | | | | |
| Leptoceridae (*Ceraclea*) | 1 | | | | | | | |
| Limnephilidae (*Neophylax*) | | | | | | | 4 | |
| Phryganeidae (*Ptilostomis*) | | | | | | 4 | 4 | |
| Philopotamidae (*Chimarra*) | 2 | | | | | | | |
| **Turbellaria - flat worms** | | | | | | | | |
| *Dugesia* (brown) | 4 | | | 7 | | | | |
| *Phagocata* (white) | | 2 | | | | | | |
| **Total # of species** | **22** | **11** | **14** | **7** | **11** | **11** | **12** | **9** |
| **Total # of individuals** | **100** | **164** | **873** | **195** | **148** | **805** | **170** | **95** |

Table 6. Water quality data upstream ("up") and downstream ("down") of three demonstration farms in LaGrange County. Data were collected on July 18, 1995, unless otherwise specified. Fecal coliform is given in colonies per 100 ml. All other tests are given in mg/l.

| | #1 | | #2 | | #3 | |
|---|---|---|---|---|---|---|
| | up | down | up | down | up | down |
| Fecal coliform (7/18/95) | 1,055 | 6,388 | 3,000 | 21,000 | 2,500 | 1,850 |
| Fecal coliform (9/18/95) | 240 | 1,200 | 1,000 | 240 | 480 | 71,000 |
| Ammonia (mg/l) | 0.26 | 2.5 | 0.07 | 0.85 | 1.54 | --- |
| Nitrate (mg/l) | 1.4 | 3.6 | 1.1 | 1.4 | 1.5 | --- |
| Ortho-phosphorus (mg/l) | 0.78 | 0.2 | 0.27 | 0.45 | 0.22 | 0.67 |
| Total phosphorus (mg/l) | 0.54 | 1.56 | 0.79 | 1.12 | 0.88 | 1.13 |

Table 7. Scoring for biological assessment of five LaGrange County demonstration sites on August 22, 1995. (EPT = Ephemeroptera, Plecoptera, Tricoptera; score for each metric ranges from "0" = poor to "6" = good; impairment ranges from "none" at reference sites through "sli" = slight, "mod" = moderate, "sev" = severe).

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| **value for each metric** | **6/94** | **forest** | **ditch** | **pasture** | **forest** | **feedlot** | **forest** | **feedlot** |
| richness | 15 | 12 | 7 | 7 | 13 | 3 | --- | --- |
| Hilsenhoff Biotic Index | 5.1 | 6.18 | 4.77 | 7.95 | 5.27 | 7.95 | --- | --- |
| scrapers : filterers | 17 | 0.31 | 69 | 1 | 0.26 | 0.5 | --- | --- |
| EPT : chironomids | 2.4 | 0.04 | 67 | 0.2 | 1.88 | 0.02 | --- | --- |
| % dominant taxon | 30 | 31.3 | 73.2 | 97.3 | 39 | 95.3 | --- | --- |
| EPT | 4 | 0 | 1 | 0 | 2 | 0 | --- | --- |
| Community Loss Index | | | 1.14 | 1.14 | | 3.67 | --- | --- |
| % shredders | 53 | 3.1 | 0 | 0 | 13 | 0 | --- | --- |

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| **score for each metric** | **6/94** | **forest** | **ditch** | **pasture** | **forest** | **feedlot** | **forest** | **feedlot** |
| richness | 6 | 6 | 2 | 2 | 6 | 0 | --- | --- |
| Hilsenhoff Biotic Index | 6 | 4 | 6 | 2 | 6 | 2 | --- | --- |
| scrapers : filterers | 6 | 0 | 6 | 0 | 0 | 0 | --- | --- |
| EPT : chironomids | 6 | 0 | 6 | 0 | 6 | 0 | --- | --- |
| % dominant taxon | 4 | 2 | 0 | 0 | 2 | 0 | --- | --- |
| EPT | 6 | 0 | 0 | 0 | 1 | 0 | --- | --- |
| Community Loss Index | 6 | 4 | 2 | 2 | 4 | 0 | --- | --- |
| % shredders | 6 | 0 | 0 | 0 | 2 | 0 | --- | --- |
| **PERCENT OF REFERENCE SITE:** (reference site would score 100) | | **35** | **48** | **13** | **59** | **4** | --- | --- |
| **IMPAIRMENT (before):** | | **MOD** | **MOD** | **SEV** | **SLI** | **SEV** | | |

Table 8. Scoring for biological assessment of five LaGrange County demonstration sites on October 17, 1995. (EPT = Ephemeroptera, Plecoptera, Tricoptera; score for each metric ranges from "0" = poor to "6" = good; impairment ranges from "none" at reference sites through "sli" = slight, "mod" = moderate, "sev" = severe).

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| **value for each metric** | **10/94** | **forest** | **ditch** | **pasture** | **forest** | **feedlot** | **forest** | **feedlot** |
| richness (species #) | 22 | 9 | 6 | 8 | 8 | 5 | 11 | 6 |
| Hilsenhoff Biotic Index | 5.2 | 5.32 | 5.12 | 5.04 | 4.58 | 7.24 | 5.28 | 7.63 |
| scrapers : filterers ratio | 4.6 | 0.41 | 1 | 1 | 0.07 | 1 | 0.22 | 0 |
| EPT : chironomids ratio | 7 | 0 | 0.33 | 0.17 | 5 | 0.07 | 18 | 0.05 |
| % dominant taxon | 17 | 38.2 | 76 | 71.8 | 38.9 | 57.7 | 51.3 | 58 |
| EPT (species #) | 6 | 0 | 1 | 0 | 1 | 1 | 3 | 1 |
| Community Loss Index | | 2.11 | 3.5 | 2.75 | 2.5 | 4.2 | 1.82 | 3.5 |
| % shredders | 8 | 14.7 | 0 | 1.3 | 38.9 | 15.4 | 58 | 0 |

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| **score for each metric** | **10/94** | **forest** | **ditch** | **pasture** | **forest** | **feedlot** | **forest** | **feedlot** |
| richness (species #) | 6 | 2 | 0 | 0 | 0 | 0 | 2 | 0 |
| Hilsenhoff Biotic Index | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 6 |
| scrapers : filterers ratio | 6 | 0 | 2 | 2 | 0 | 2 | 0 | 0 |
| EPT : chironomids ratio | 6 | 0 | 0 | 0 | 4 | 0 | 6 | 0 |
| % dominant taxon | 6 | 2 | 0 | 0 | 2 | 0 | 0 | 0 |
| EPT (species #) | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Community Loss Index | 6 | 2 | 2 | 2 | 2 | 0 | 2 | 2 |
| % shredders | 6 | 6 | 0 | 0 | 6 | 6 | 6 | 0 |
| **PERCENT OF REFERENCE SITE:** (reference site would score 100) | | **38** | **21** | **21** | **42** | **25** | **48** | **17** |
| **IMPAIRMENT (before):** | | **MOD** | **MOD** | **MOD** | **MOD** | **MOD** | **MOD** | **SEV** |

Table 9. Scoring for biological assessment of five LaGrange County demonstration sites on August 21, 1997. (EPT = Ephemeroptera, Plecoptera, Tricoptera; score for each metric ranges from "0" = poor to "6" = good; impairment ranges from "none" at reference sites through "sli" = slight, "mod" = moderate, "sev" = severe).

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| value for each metric | 6/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| richness (species #) | 15 | 11 | 20 | 17 | 9 | 8 | 11 | 15 |
| Hilsenhoff Biotic Index | 5.1 | 5.25 | 7 | 6 | 4.5 | 4.01 | 4.58 | 4.5 |
| scrapers : filterers ratio | 17 | 0.14 | 12 | 0.04 | 0.1 | 0.03 | 1 | 0.27 |
| EPT : chironomids ratio | 2.4 | 0.05 | 0.16 | 0.59 | 1.5 | 7.56 | 2 | 1.52 |
| % dominant taxon | 30 | 57 | 41.6 | 72.9 | 51.5 | 79.8 | 69.8 | 65.7 |
| EPT (species #) | 4 | 0 | 1 | 3 | 2 | 2 | 4 | 2 |
| Community Loss Index | | 1.27 | 0.65 | 0.35 | 1.67 | 1.88 | 1.36 | 1 |
| % shredders | 53 | 17.4 | 25.4 | 0.82 | 53.8 | 80.7 | 71.7 | 69.7 |

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| score for each metric | 6/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| richness (species #) | 6 | 4 | 6 | 6 | 4 | 2 | 4 | 6 |
| Hilsenhoff Biotic Index | 6 | 6 | 4 | 4 | 6 | 6 | 6 | 4 |
| scrapers : filterers ratio | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |
| EPT : chironomids ratio | 6 | 0 | 0 | 0 | 4 | 6 | 6 | 4 |
| % dominant taxon | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| EPT (species #) | 6 | 0 | 0 | 2 | 1 | 1 | 6 | 1 |
| Community Loss Index | 6 | 4 | 4 | 4 | 2 | 2 | 4 | 4 |
| % shredders | 6 | 2 | 4 | 0 | 6 | 6 | 6 | 6 |
| **PERCENT OF REFERENCE SITE:** (reference site would score 100) | | **35** | **61** | **35** | **50** | **50** | **70** | **54** |
| **IMPAIRMENT (after):** | | **MOD** | **SLI** | **MOD** | **MOD** | **MOD** | **SLI** | **SLI** |

Table 10. Scoring for biological assessment of five LaGrange County demonstration sites on October 21, 1997. (EPT = Ephemeroptera, Plecoptera, Tricoptera; score for each metric ranges from "0" = poor to "6" = good).

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| value for each metric | 10/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| richness (species #) | 22 | 11 | 14 | 7 | 11 | 11 | 12 | 9 |
| Hilsenhoff Biotic Index | 5.2 | 4.63 | 4.65 | 5.01 | 4.7 | 4.35 | 4.33 | 4.74 |
| scrapers : filterers ratio | 4.6 | 24 | 1 | 0.01 | 0.04 | 0 | 1 | 0.36 |
| EPT : chironomids ratio | 7 | 0.5 | 12.8 | 0.22 | 0.71 | 25.67 | 5 | 2.15 |
| % dominant taxon | 17 | 76.8 | 68.5 | 52.3 | 39.9 | 51.6 | 78.2 | 46.3 |
| EPT (species #) | 6 | 0 | 1 | 1 | 2 | 3 | 3 | 2 |
| Community Loss Index | --- | 1.64 | 1.5 | 2.86 | 1.91 | 1.82 | 1.75 | 2.33 |
| % shredders | 8 | 76.8 | 68.7 | 53.3 | 39.9 | 52 | 81.8 | 48.4 |

| | reference | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|---|
| score for each metric | 10/94 | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| richness (species #) | 6 | 2 | 4 | 0 | 2 | 2 | 2 | 2 |
| Hilsenhoff Biotic Index | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| scrapers : filterers ratio | 6 | 6 | 2 | 0 | 0 | 0 | 2 | 0 |
| EPT : chironomids ratio | 6 | 0 | 6 | 0 | 0 | 6 | 4 | 2 |
| % dominant taxon | 6 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| EPT (species #) | 6 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| Community Loss Index | 6 | 2 | 4 | 2 | 2 | 2 | 2 | 2 |
| % shredders | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| **PERCENT OF REFERENCE SITE:** (reference site would score 100) | | **46** | **58** | **29** | **38** | **48** | **48** | **38** |
| **IMPAIRMENT (after):** | | **MOD** | **SLI** | **MOD** | **MOD** | **MOD** | **MOD** | **MOD** |

Table 11. LaGrange County demonstration sites listed in order from highest to lowest quality relative to a high quality reference site on the Upper Tippecanoe River. (Numbers give percent of reference quality for each site.)

| | #1 | | | #2 | | #3 | |
|---|---|---|---|---|---|---|---|
| date | forest | ditch | pasture | forest | feedlot | forest | feedlot |
| Aug 95 (before) | 35 | 48 | 13 | 59 | 4 | -- | -- |
| Aug 97 (after) | 35 | 61 | 35 | 50 | 50 | 70 | 54 |
| | | | | | | | |
| Oct 95 (before) | 38 | 21 | 21 | 42 | 25 | 48 | 17 |
| Oct 97 (after) | 46 | 58 | 29 | 38 | 48 | 48 | 38 |

Figure 1. Illustration of typical species found at each type of sampling site.

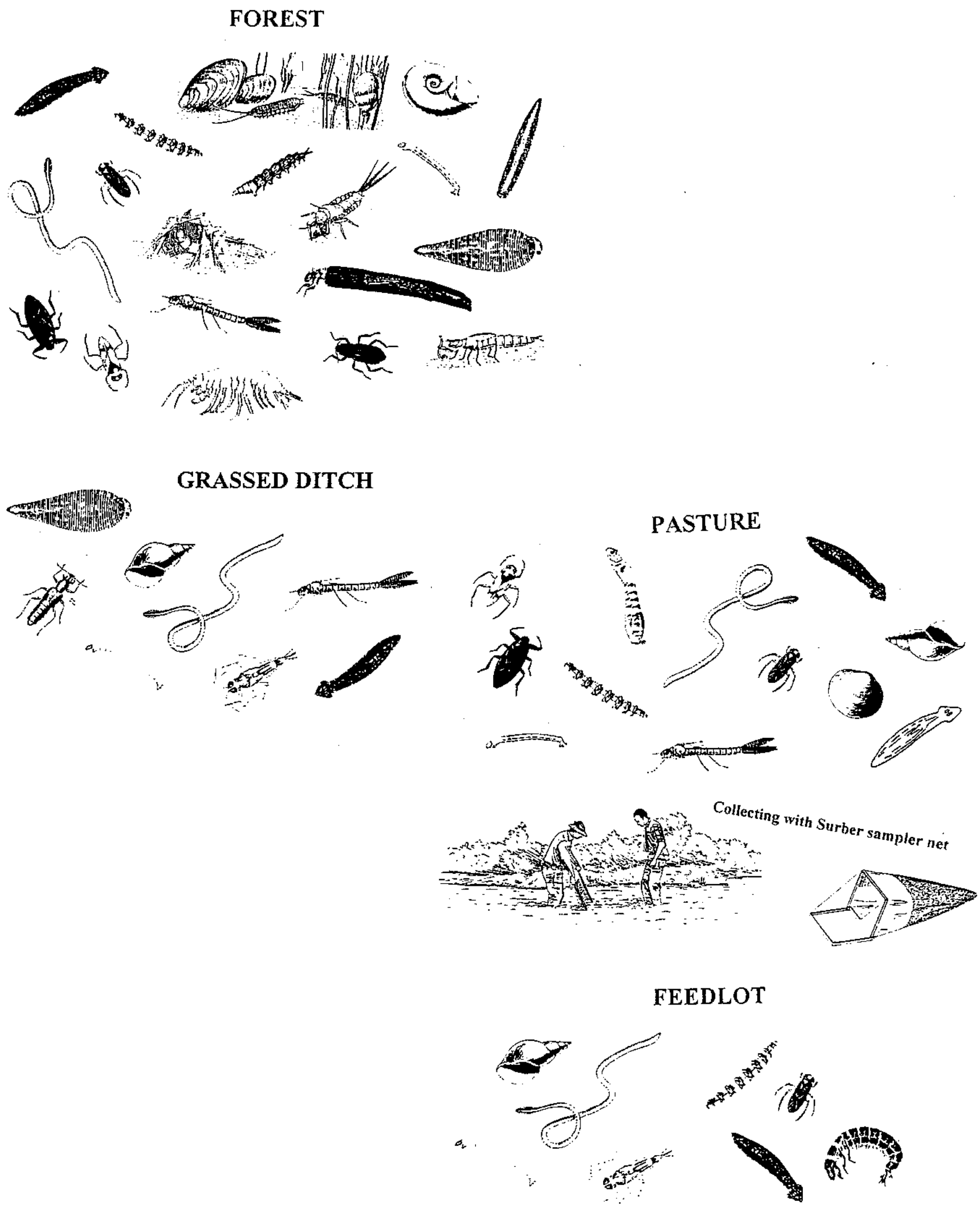

Figure 2. Fecal coliforms upstream and downstream of three LaGrange County dairy farms on July 18 and September 18, 1995 (before fencing).

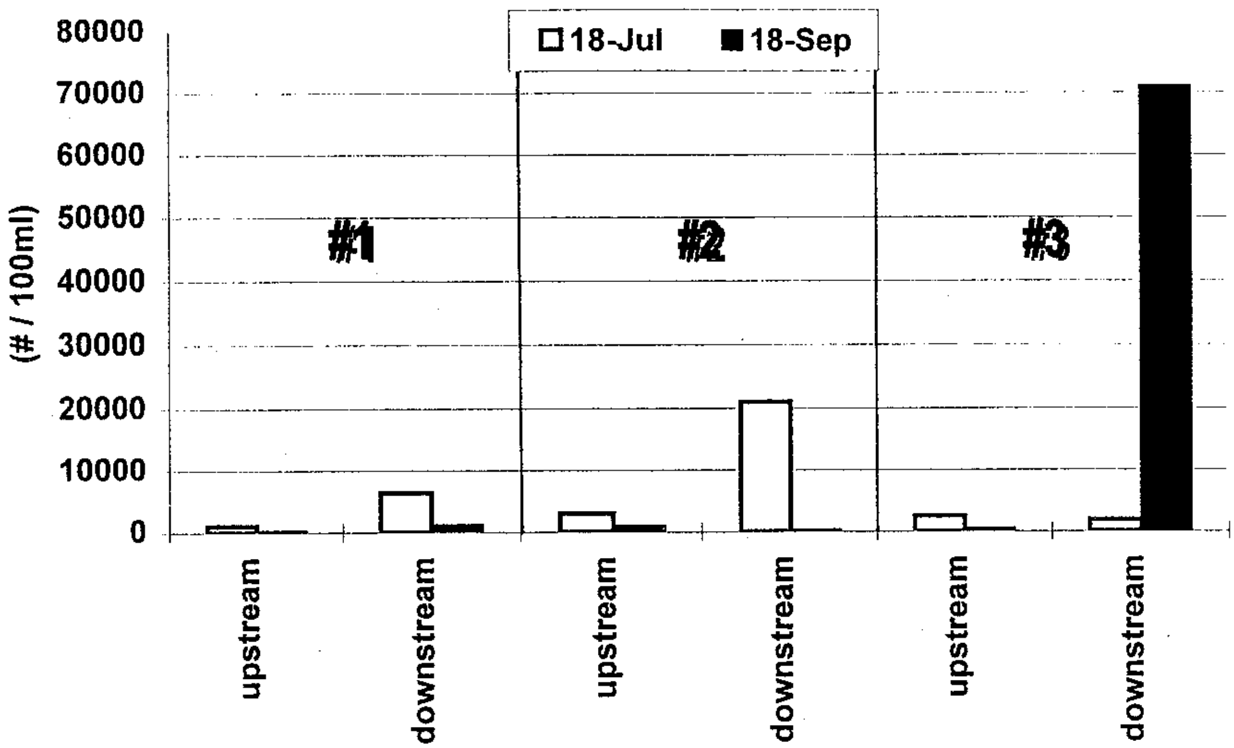

Figure 3. Nutrients upstream and downstream of three LaGrange County dairy farms on July 18, 1995 (before fencing).

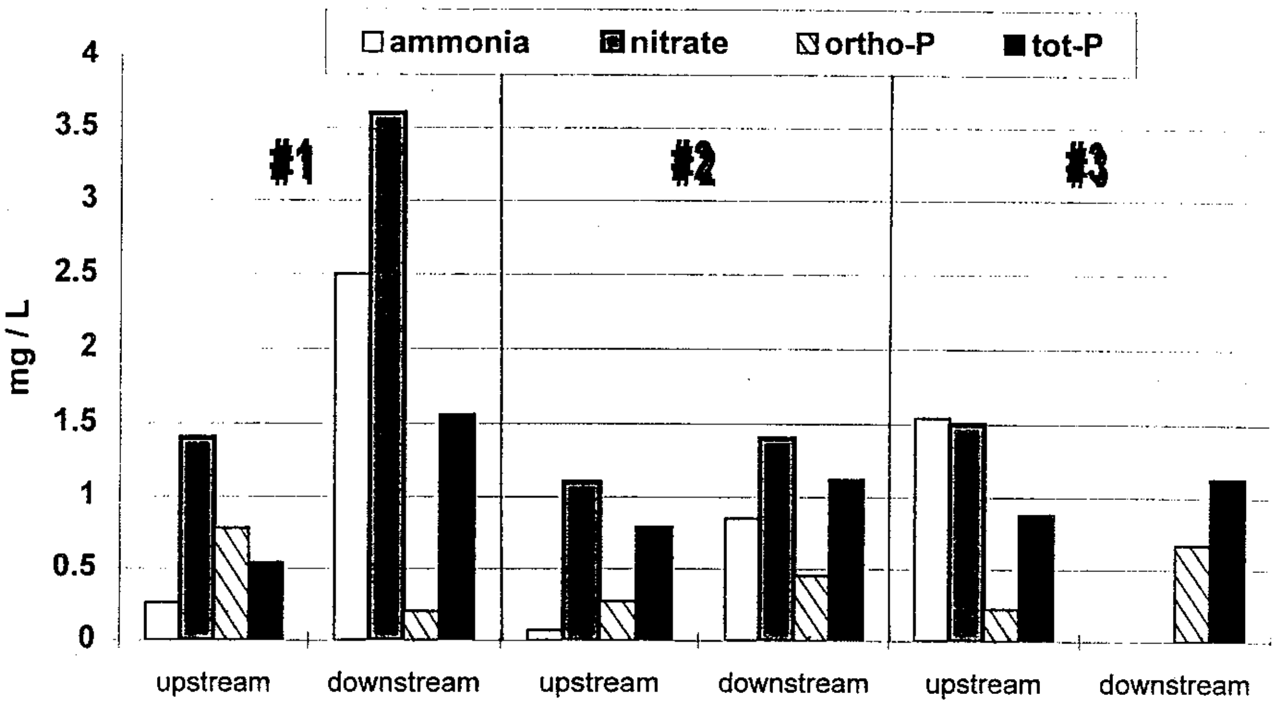

Figure 4. Average biological quality as a percent of reference site quality in areas representing three types of livestock management practices. Scores are averaged for three LaGrange County dairy farms in 1995 (before fencing) and 1997 (one year after fencing). Error bars span one standard deviation. An "*" indicates a statistical difference. An "N.S." indicates no statistical difference.

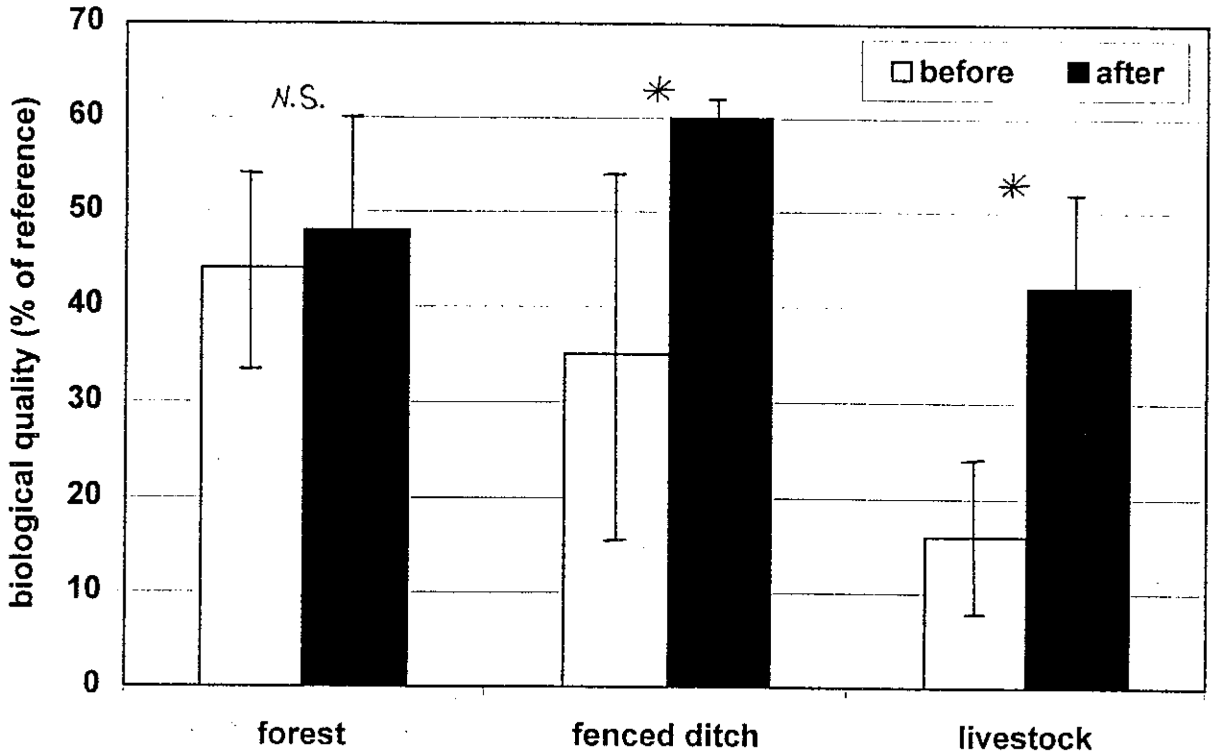

Figure 5. Average biological quality as a percent of reference site quality at sampling sites in three LaGrange County dairy farms in 1995 (before fencing) and 1997 (one year after fencing). Scores are averaged across two seasons (August and October) in each year. Error bars span one standard deviation. An "*" indicates a statistical difference. An "N.S." indicates no statistical difference.