A Survey of Watershed Quality at Blackacre State Nature Preserve, Jefferson County, Kentucky

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Abstract- Urban riparian zones within parks and nature preserves, such as Blackacre State Nature Preserve, play important ecological and economic roles by improving water quality, increasing aesthetic quality of the environment and providing habitat for wildlife. But urban areas also face stresses such as storm water run-off containing various pollutants. Measurements were taken at five points of the Blackacre stream, including the entrance to and exit from the preserve, in order to monitor water quality and to document the filtering effect of this riparian zone. Five of the six ponds were sampled to evaluate their water quality. In addition, samples were taken from two culverts which feed storm water into the Blackacre watershed and occurrence of invasive bush honeysuckle in the riparian zone was mapped. Overall water quality of the stream was found to be good, as defined by Hoosier River Watch protocols, with notable improvement in quality observed from entrance to exit. The stream was also found to support a variety of aquatic organisms. Although the majority of ponds maintained a good quality of water and supported life, one pond had been seriously degraded due to high sedimentation resulting from apparently increased flow through one of the culverts. *E.coli* levels were above the recommended EPA standards for prolonged human contact in the stream (except at the exit) and for all five ponds surveyed. Run-off from livestock pastures into ground water, from aging septic systems and from storm water are likely sources of *E.coli* contamination. High bacterial levels are also a result of high seasonal temperatures. Limited human contact with all water bodies, maintenance of septic systems and reduction of livestock, mitigation of culvert flow, removal of invasives from the riparian zone, and continued monitoring of the watershed were recommended.

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Introduction

The nutrient and pollutant filtering effect of riparian zones has been known for decades (Karr and Schlosser, 1978). Many studies, including Stewart, et al. (2001) and Young and Huryn (1999) looked at the effect of riparian vegetation in filtering nutrients such as phosphates and nitrates entering streams and rivers when excess fertilizers containing those nutrients drained off agricultural land. With the increasing conversion of agricultural land to urbanization, the filtering effects for urban and suburban run-off was also observed (Moglen, 2000 and Paul and Meyer, 2001).

Naiman, R.J., H. Décamps and M.E. McClain (2005) have identified five important functions of riparia: "…(1) a filter and/or modifier for organisms, water, and matter moving within the landscape; (2) a plane for the budgetary accounting of this flux of water, matter, and organisms; (3) an area of enhanced biological productivity, diversity, and aesthetics; (4) an area of specialized habitats, including specialized habitat for birds and other terrestrial biota and a spawning nursery area for aquatic biota; and (5) a zone for various and unique ecosystem functions, such as flood and erosion control within the landscape."

Urban riparia have an important role in filtering and cleaning water as it passes through an urban landscape. Urban landscapes have the added feature of impervious ground cover, such as the concrete and asphalt of roads and parking lots. Riparian zones of parks and urban nature preserves play a role in controlling overflow from these impervious features of urban landscape (Paul and Meyer, 200 and Schueler, 1994).

At the same time, increased flow of water from chemically-treated lawns, septic overflow and expanding areas of impervious, paved surfaces can put considerable stress on the filtering capacity of riparia (Pickett, et al., 2001).

The Tucker Station Road corridor in Jefferson County, Kentucky, east of Louisville, has experienced rapid development in the past decade. The rural character of the area quickly changed after municipal water lines were installed. Farms and woodlands became subdivisions and apartment complexes. This development occurred to the north, east and south of Blackacre State Nature Preserve, which has a watershed that is a tributary to the larger Floyd's Fork watershed. The construction of the four-lane Blankenbaker Parkway on the northern edge of the preserve and expansion of the Bluegrass Industrial Park added to impervious surface that included a railroad track and the two-lane Rehl and Tucker Station Roads.

Given the documented filtering effects of riparia in general (Stewart, et al., 2001 and Teels, et al., 2006) and urban riparia in particular (Pitt, 2002), water quality in the main Blackacre stream should improve as the water moves through the preserve. Therefore, one object of this study was to test to see if this was the case. A second object was to evaluate the overall quality of the Blackacre watershed, including its ponds, and to document any damage resulting from chemically or biologically contaminated water entering the watershed. The third object was to record the distribution of the invasive shrub, Amur bush honeysuckle (*Lonicera mackii*) in the riparian zone. Finally, recommendations will be made to help guide the future management of the preserve's watershed.

Methods

Blackacre State Nature Preserve consists of 170 acres of forest, glade and meadow. An additional, 100-acre adjacent portion of property, is owned by the Blackacre Conservancy. The Blackacre watershed includes a Class 1 stream that meanders through the preserve from east to west, covering a distance of approximately 1.5 km (~0.94 mile) and six ponds, one of which is on Conservancy property. The length of the stream and the sampling points of each pond were mapped using a Garmin eTrex GPS handheld unit. Maps of the survey area were generated using Google Earth imagery and software, interfaced with Garmin GPS hardware and software.

Samples were collected from five stream points and from five of the six ponds (Figure 1) over a six-week period from early June to mid-July. At the culverts and the waterfall, water levels were too low to obtain certain data, such as dissolved oxygen. Sample readings were averaged for the reported results. Chemical content was evaluated using Hach Water Analysis Kits. (The sixth pond, Sunset Pond, was reduced to a layer of mud and unsuitable for sampling.) Testing was conducted to measure dissolved oxygen, phosphates, nitrates, ammonia nitrogen, temperature, and pH. The research team also measured water and air temperature. Water clarity was assessed at each site with a 60 cm (15 NTU) turbidity tube. Water hardness – total calcium and magnesium – was determined using WaterWorks hardness test strips. Watershed quality was assessed using protocols of the Hoosier Riverwatch Manual (Indiana Department of Natural Resources, 2010) to determine a Water Quality Index. (WQI). This rating was used in order to have a comparison with ratings from sampling done in March, 2010 by students from Indiana University Southeast that the same Hoosier Riverwatch Manual protocols.

Benthic macroinvertebrates were also sampled in the stream and in each of the five ponds tested. Using dip nets, the macroinvertebrates sampled were identified, counted by taxa and each

sampling point was assigned a Pollution Tolerance Index (PTI) rating as calculated in the Hoosier Riverwatch Manual. This index rating was added to the WQI rating to give a more comprehensive evaluation of watershed quality.

In order to test for *E. coli* bacteria, sterile pipettes were used to obtain 5 mL samples from each sampling point of the stream and from each pond. Each sample was added to Coliscan Easy Gel medium which was poured onto a treated Petri plate and incubated at 35^{o} C for 24 hours. Purple to blue *E. coli* colonies were counted and their numbers expressed in Coliform Units (CFU) per 100 mL.

Five storm water culverts positioned under a Norfolk Southern Railroad track have outflows into the northern portion of Blackacre (See Figure 1). One of these, which feeds Jackson's Pond, is on private property. The other four are within the preserve's boundaries. Sedimentation measurements of the water channels of two of the storm water culverts, which have had increased flow rates within the last several months causing erosion and downstream sedimentation, were measured. Measurement was taken by placing metal fence posts in the steam bed, marking the level of the substrate on each and measuring the amount of sedimentation after a .06 inch rainfall.

The invasive plant species, bush honeysuckle (*Lonicera maackii),* is unfortunately found on much of the Blackacre State Nature Preserve. The presence of bush honeysuckle along the banks of the stream was tracked and noted using the Garmin handheld GPS. Each point was labeled Bh, for bush honeysuckle, and assigned a sequential number. Each labeled point was then assigned a level of density rating (1-little to no bush honeysuckle present, 2-bush honeysuckle present, but sparsely populated and mostly below 5 ft. in height, 3-densely populated bush honeysuckle of varying heights and widths).

Results

Samples taken from the ponds and stream indicated that water hardness, the measurement of total calcium and magnesium, was high to very high, ranging from 185-425 mg/L. The stream, which flows over limestone, had alkaline pH ranging from 7.5-8.2. Orthophosphates, nitrates, and ammonia nitrogen results were all within normal ranges. The water quality of the stream (WQI) was 50-55 flowing into the preserve from the east, 58-59 in the middle, and 72 in the west exiting Blackacre (Table 1). Using the ruler function of Google Earth to trace the length of the stream, sinuosity (K = actual stream path/straight line from source to exit on preserve), the meandering quality of the stream, was calculated to be 1.61/1.20 = 1.34. This figure shows a high amount of sinuosity.

Figures for pH and hardness for the ponds also reflected the limestone solute in the water. The pH reading ranged from 7.2 (Sunrise Pond) to 8.1(Dragonfly Pond). Hardness range was from 180 mg/L to 263 mg/L. None of the ponds showed elevated levels of run-off indictors. The WQI ranged from Medium (64-66.50) in Jackson's, Cattail and Dragonfly Ponds to Good (70.4 – 74.5) in Sunrise and Springhouse Ponds. (See Table 2.)

The Hoosier Riverwatch Water Quality Index (WQI) rating are 90-100 (Excellent), 70-89 (Good), 50-69 (Medium), 25-49 (Bad) and 0-24 (Very Bad.) This index was chosen because the stream had been evaluated using that index in March, 2010 by the IUS Applied Conservation Biology class and therefore provided a basis for comparison.

The results from the stream showed the *E. coli* levels to be above EPA standards for safe human contact (125 CFU/100 mL or less) in all locations with the exception of the stream exit. The results from high to low CFU/100 mL: Waterfall- 8000, North Fork- 6240, Bridge Area-

5467, Culvert 4- 1620, Culvert 1- 1360, and Stream Exit- 20. (Table 1). All ponds showed levels of *E. coli* above EPA standards. The results from high to low CFU/100 mL: Jackson's Pond- 2700, Sunrise Pond- 1180, Springhouse Pond- 694, Dragonfly Pond- 667, and Cattail Pond- 260 (see Table 2).

A variety of macroinvertebrates were found in the stream and in the majority of the ponds. The stream received a Pollution Tolerance Index (PTI) rating of 42, which is considered Excellent (see Table 1). Minnows and multiple species of frogs, including green frogs, bullfrogs and cricket frogs, were the vertebrates found in the stream. Of the ponds, three received a Pollution Tolerance Index rating in the Excellent range (Jackson's Pond, Dragonfly Pond, and Sunrise Pond). Springhouse Pond received a Good PTI rating. Cattail Pond received a Bad rating (see Table 2). Three species of fish (channel catfish, green sunfish, large mouth bass) were observed in Jackson's, Dragonfly and Springhouse Pond, as were snapping turtles, bullfrogs, green frogs and cricket frogs, and several species of dragonfly and damselfly. During one sampling session, a great blue heron was seen fishing by the side of Jackson's Pond.

Erosion is a concern in the northern part of the watershed. Deep channels, in some places up to three meters, have been carved out by water from outflows of Culverts 3 and 4. Roots of large trees along the channel banks have been exposed. Most striking has been the siltation of Cattail Pond. In fall, 2009, the pond, while shallow, supported a variety of organisms including insects and frogs. Currently the pond supports almost no macroinvertebrates and no vertebrates. (Figures 3 and 4).

Using the level of density rating (Levels 1-3, as established in Methods) for determining the presence of bush honeysuckle, it was found that 58.5% of the stream banks contain densely

populated areas of mature bush honeysuckle (Level 3). Another 37.5% of the stream had areas of sparsely populated bush honeysuckle, both young and mature in size (Level 2). Only 4% of the stream banks were found to have little to no bush honeysuckle presence.

Discussion

Relatively high levels of both pH and water hardness can be attributed to the ample amount of limestone found at Blackacre. Orthophosphates, nitrates, and ammonia nitrogen can all be indicators of run-off pollution from lawns and cultivated fields. All amounts detected were well below levels that would indicate such run-off. The change in the WQI from the 50-55 in the eastern portion of the stream to 72 at the stream exit shows significant filtering effects of the Blackacre riparian zone.

E. coli levels are measured because they indicate presence of human and livestock waste, which can be associated with a variety of pathogens. The *E. coli* colonies were significantly higher in this study than in the study conducted in March of this year when counts along the length of the stream were only 18-24 colonies/100mL (Reigler, 2010). One reason is the season. In summer, water temperatures are highest and flow is lowest, creating an optimal breeding ground for bacteria (Haley, et al., 2009). The water is also shallow where the levels are this highest allowing a high surface area volume in those areas (Beaudeau, et al., 2001)

Storm water entering the preserve is a possible source for the *E. coli*, as would be human waste entering from outdated or improperly functioning septic systems (Steffy and Kilham, 2004). When systems have not been pumped regularly or improper maintenance has been performed, the wastewater can flow through the soil or overland to the nearest ditch or stream

allowing contamination. This is a common problem with homes built before 1950 (Frankenberger, 2010).

Several homes to the east and north of Blackacre may have such septic systems, as well as the septic system serving the two dwellings on Blackacre itself. The preserve's system is located near the geographic center of the property and uphill from much of the stream watershed. (See Figure 1.)

Another possible contamination source is from livestock waste (Young and Huryn, 1999). Dragonfly Pond is uphill from Blackacre's septic system and is not fed by a stream. But it is downhill from a livestock pasture. The Blackacre landscape has numerous sinkholes, so material on the surface can readily find its way into groundwater. It is important to note that most of the diseases caused by *E. coli* are transmitted from animals to humans (Kloot, 2007). Livestock waste seeping into groundwater could account for bacterial levels in the Springhouse Pond, also downhill from the livestock pastures and fed by a spring. The *E. coli* counts in those two ponds were similar to one another, 667 CFU in Dragonfly Pond and 694 CFU in Springhouse Pond.

High levels of *E. coli* in Jackson's Pond could be coming from storm water. (Moglen, 2000). The pond is fed by a culvert on private property north of Blackacre (marked Culvert + in Figure 1). High counts were also measured at other culverts and in Sunrise Pond. Sunrise Pond is downstream from older homes on Tucker Station Road.

The *E. coli* numbers in Cattail Pond are lower than in any other pond. Heavy siltation of the pond may very well be the reason. Much of the bacteria content is filtered in the silt before reaching what little water remains. Absolutely lowest numbers of *E. coli* were found where the

stream left Blackacre, indicating that the riparian zone of the preserve is having a beneficial filtering effect (Beaudeau, et al., 2001).

Biological monitoring – the sampling of benthic macroinvertebrates – is a quick, effective, and inexpensive way to examine the quality of water in a watershed and to monitor its changes over time (Moore and Palmer, 2005 and Resh et al., 1998). The stream's high Pollution Tolerance Index rating is an indication of macroinvertebrate species richness and density. The PTI rating is based on the number of taxa found and the tolerance levels to pollution of certain macroinvertebrates (Indiana Department of Natural Resources, 2010). None of the samples taken turned up macroinvertebrates that fell under the index rating of very tolerant to pollution; good news for the Blackacre watershed.

In order to get a greater variety of species in our sampling, we sampled from both riffles and pools in the stream, as was recommended by Hauer and Resh (1998). All of the ponds sampled, with the exception of one, received Good to Excellent Pollution Tolerance Index ratings, which indicates good water quality. Cattail Pond was sampled last fall and was found to have an abundance of macroinvertebrates (Reigler, 2010). However, this summer when sampled, only two species were found and it received a Pollution Tolerance Index rating of two (considered Bad). This is believed to be due to excessive sedimentation coming from Culvert 4. It is important to continue biological monitoring of the watershed at least biannually (Quarterly would be better.) in order to detect any changes that could signal a rise in nonpoint source runoff pollution or point source discharge (Lenat, 1988).

The invasive shrub, Amur bush honeysuckle (*Lonicera maackii)* has become a serious problem in state parks and nature preserves. Young to mid-successional forests, forests with

canopy disturbances, forest edges and riparian zones are all areas with high invasion rates of bush honeysuckle (Hutchinson & Vancat, 1997). Over half of the length of the stream at Blackacre has dense populations of bush honeysuckle covering its banks. Very little of the stream banks are free of the invasive plant. Vegetation in riparian zones can have a great effect on overall stream health (Teels, *et. al.* 2006). Natural stream vegetation protects against excessive erosion and provides bank stability, provides organic matter, wood and cover for stream inhabitants, provides nutrient management and a "buffer" from nonpoint source pollution (Teels, *et. al.* 2006).

To have so much of the stream's riparian zone consist of bush honeysuckle is detrimental to the overall health of the stream. The bush honeysuckle crowds out native trees and herbaceous plants, lowering the natural plant diversity of the area (Hutchinson & Vankat, 1997). Bush honeysuckle does not provide adequate organic matter and wood that is needed for many stream insect and animal species. The invasive plant provides shade to the stream, but where it is densely populated, it provides too much shade. A healthy stream must have patches of both sunshine and shade in order to support a diverse mixture of aquatic species (Hauer and Hill, 1998). Bush honeysuckle also changes the acidity levels of the soil and is said to "poison the soil" around it, making it harder for native plants to compete (Deering and Vankat, 1999). It is recommended that the stream riparian zone be managed to reduce bush honeysuckle invasion and presence via eradication of the invasive plant.

There are at least four sampling points (Bh 14, 16, 18, and 19) where removal would be ill-advised. Honeysuckle growth was so dense at Bh 14 and 19 that removing them all would cause bank instability. Bh 16 and 18 had steep embankments on one side of the stream bank where erosion would certainly increase if any vegetation were removed. Any control must be

done in a manner that would replace the invasive with native species immediately after invasive removal.

Most other areas along the stream could benefit from the removal of the bush honeysuckle, allowing the native herbaceous plants like milkweed, jewelweed and native trees to regain a hold on the banks of the stream.

Management Recommendations

This survey of the Blackacre watershed found that the overall quality of the stream and most ponds, as suitable habitat for wildlife, was good. The riparian zone also has a substantial filtering effect on water as it flows through the stream.

However, three areas of concern were identified. They are listed here with management recommendations:

1. *E coli* levels

While levels too high for safe sustained human contact were detected, summer temperatures and low flow and water levels are a factor in the numbers. Nonetheless, any students having contact with water for environmental studies during warm months should wear latex gloves.

Actual pin-pointing of sources of *E. coli* in watersheds is difficult (Kloot, 2007), but some likely sources were identified. Neighbors should be contacted about their septic systems and the Blackacre Conservancy should maintain the homestead septic system as recommended by professionals. Reduction in number of livestock in the barn pasture may also lead to reduction of *E. coli* levels in two ponds.

2. Erosion at Culvert Outfalls

Since the Commonwealth of Kentucky owns Blackacre State Nature Preserve, a staff member of the Kentucky State Nature Preserves Commission has already contacted Norfolk Southern Railroad (builders of the culverts) and the Metropolitan Sewer District (which monitors surface water movement) about mitigating the increased flow through Culverts 3 and 4. This will include the placement of rock out the outflows to slow flow rates. Restoration of Cattail Pond is a concern that will require further study.

3. Riparian Zone Invasive Species

The presence of Amur bush honeysuckle along a large portion of the stream degrades the stream habitat quality. Trained personnel, professional and/or volunteer should be engaged to remove as much as is possible without damaging the stream bank.

After mitigation steps are taken, another survey of the watershed should be conducted to monitor the effects. The professor who teaches Hydrology at Indiana University Southeast has expressed an interest in having his class conduct a survey in fall, 2010. Students in the spring, 2011 Applied Conservation Biology class could also conduct a survey.

TABLE 1. STREAM

Metric	Culvert 1	N. Fork	Waterfall	Bridge Area	Culvert 4	Exit
E. coli (colonies/100mL)	1360	6240	8000	5467	1620	20
Air Temperature (^oC)	24.4	24.4.	24.4	25.7	24.4	24.4
Water Temperature (^oC)	28.0	26.0	29.0	18.0	31.0	25
Dissolved O_2 (mg/L)	____	____	___	3.5	____	5.6
pH	____	7.9	8.2	7.7	8.3	7.5
Hardness (mg/L)	____	300	300	185	425	250
Orthophosphate (mg/L)	____	0.06	0.04	0.25	0.14	0.1
Nitrates (mg/L)	____	0.0	0.0	0.0	0.25	0.0
Ammonia Nitrogen (mg/L)	____	1.4	0.2	1.35	0.3	0.2
Turbidity (NTU's)	____	____	____	18	___	17
Water Quality Index (WQI)	____	55	50	58.7	59.5	72

Pollution Tolerance Index Rating (PTI) = 42 for the length of the stream

TABLE 2. PONDS

Metric	Jackson's	Springhouse	Dragonfly	Cattail	Sunrise
E. coli (colonies/100mL)	2700	694	667	260	1180
Air Temperature (^oC)	24.4	24.4	24.4	24.4	24.4
Water Temperature (^oC)	22.7	16.0	24.0	27	22
Dissolved O_2 (mg/L)	5.5	7.0	4.6	3.4	12.0
pH	7.5	7.3	8.1	7.5	7.2
Hardness (mg/L)	263	250	180	250	180
Orthophosphate (mg/L)	0.25	0.25	0.25	0.25	0.25
Nitrates (mg/L)	0.25	0.25	0.25	0.0	0.25
Ammonia Nitrogen (mg/L)	0.07	0.3	0.15	0.0	0.0
Turbidity (NTU's)	19	17	15	15	18
Water Quality Index (WQI)	64	74.5	66.5	64	70.4
Pollution Tolerance Index Rating (PTI)	23	17	29	2	28

WQI	Excellent: 90-100	Good: 70-89	Medium: 50-69	Bad: 25-49	Very Bad: 0-24
PTI	Excellent: 23 or More	Good: 17-22	Fair: 11-16	Bad: 1 or Less	

E. coli levels for prolonged contact (recreation) should average 125 colonies/100 mL or less from sampled averaged over 30 days with no counts higher than 235 colonies/100 mL.

Table 3. **Density Index Rating of Bush Honeysuckle sampling points along banks of the stream, including stream sampling points.**

Sampling Point	Density Index Rating
Bh 1 (Culvert 1)	3
Bh 2	3
Bh 3	3
Bh 4	3
N. Fork Stream	2
Waterfall	2
Bh 5	3
Bh 6	2
Bh 7	3
Bh 8	1
Bh 9	3
Bridge Area	3
Bh 10	2
Bh 11	3
Bh 12	2
Bh 13	2
Bh 14	3
Bh 15	3
Bh 16	2
Bh 17	2
Bh 18	3
Bh 19	3
Bh 20	3
Stream Exit	2

DEI of 1 – little to no bush honeysuckle present; 2 – sparsely populated and under 5 ft. in height; 3 – densely populated bush honeysuckle of varying heights and widths.

Results – 4% of points sampled had little to no bush honeysuckle, 37.5% of points sampled had sparsely populated bush honeysuckle, 58.5% of points sampled were dense and thick with bush honeysuckle

Figure 1. Water sampling points.

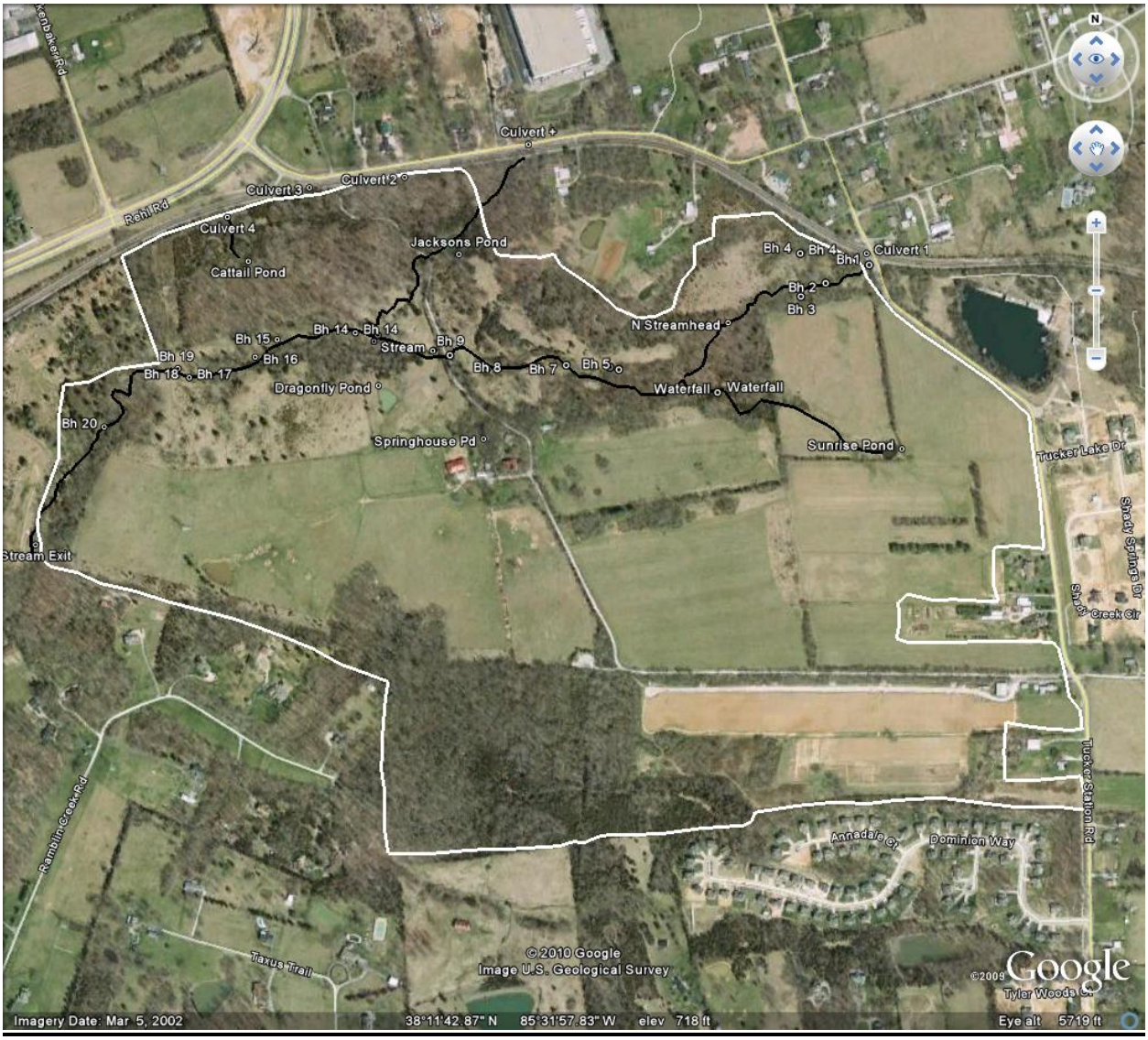

Figure 2. Bush Honeysuckle in Riparian Zone. Bh=presence of plant.

Figure 3. Cattail Pond in June, 2010 showing siltation.

Figure 4. Cattail Pond in October, 2009 showing no siltation.

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