

A Preliminary Assessment of Forest Status at Blackacre State Nature Preserve, Jefferson County, Kentucky

Susan H. Reigler

Department of Biology, Indiana University Southeast, New Albany, Indiana 47150

Abstract - In October, 2009 an inventory of a forest at Blackacre State Nature Preserve was undertaken by biology students from Indiana University Southeast. Based on DBH of pioneer species Eastern Redcedar (*Juniperus virginiana*) and climax community species Shagbark Hickory (*Carya ovata*) the successional forest was estimated to be just under 60 years old. A total of 36 tree species was recorded. The invasive shrub, Amur bush honeysuckle (*Lonicera maackii*) was found in more than 70% of surveyed quadrants. It was recommended that eradication of the invasive shrub be undertaken, as well as further monitoring for the management and maintenance of the preserve's forest.

Introduction

Blackacre State Nature Preserve, established in 1979, consists of approximately 73 state-owned hectares and 41 hectares owned by the Blackacre Conservancy, Inc. It is located in Jefferson County, Kentucky about 18 miles east of downtown Louisville. Since 1981, it has been used as a site for Environmental Education by the Jefferson County Public Schools.

Due to its proximity to city and suburbs, Blackacre can be characterized as an urban nature reserve. Several reasons to protect and value such green spaces have been identified including for their roles in mitigating air pollution and cityscape heat absorption, in filtering watersheds, and for environmental education (Cranz, 1982). Proximity of parks and preserves also increases surrounding property values, thus generating increased revenue for municipal governments. (Tagnow, 1990). There is also considerable documentation in the medical literature (Mitchell and Popham, 2007; Nielsen and Hansen, 2007; Bell, Wilson and Liu, 2008) that human physical and mental

health is improved by contact with nature, which by definition, is limited in the urban areas where most people live.

Part of a post-Revolutionary War land grant, Blackacre was worked as a farm throughout the nineteenth and twentieth centuries. The current habitats on the preserve include secondary successional forest, tall grass prairie replanted on former hay fields and pasture by the Kentucky State Nature Preserves Commission, limestone glade, and transitional edges between these habitats. Streams run through the preserve and there are six human-made ponds.

One section of forest occupies roughly the northern half of the preserve. The oldest part, with mature hardwoods and native shrub layer, is centered around a ravine carved by two streams, including one fed by a small waterfall. Historically, it was not suitable for cultivation.

In the 30 years since the preserve was dedicated, most of the woodlands and farmland adjacent to Blackacre have been converted to industrial park, subdivisions and shopping centers. This has contributed to stresses on the preserve typical to those experienced by many urban nature reserves. These include decreased immigration of wildlife from surrounding areas, increased human foot traffic, and the pollution of the watershed by chemical run-off from surrounding roads and lawns.

As a result of these factors, the natural habitat at Blackacre is fragmented, creating isolated populations of organisms (Radeloff, et al., 2005). Harsh edges, including railroad track, paved roads, an industrial park and subdivisions along north, east and southern boundaries of the preserve exacerbate this isolation.

The preserve is also plagued by the presence of invasive species, most conspicuously Amur honeysuckle (*Lonicera maackii*). Also referred to as bush honeysuckle, it is listed by the College of Agriculture at the University of Kentucky as the invasive plant species of highest concern in the state (Invasive Species Working Group, 2009). Considering that 39 invasive plant species have been identified in Kentucky as "most problematic," with another 48 species identified as "established" (Mahala, 2008), placing Amur honeysuckle at the top illustrates the very serious threat to native biodiversity it represents.

Amur honeysuckle is an aggressive invasive. It was introduced from China to the United States in the late nineteenth century as an ornamental shrub and entered the Ohio Valley as an invasive species in the early 1960s (Hutchinson and Vankat, 1997). Growing to heights of up to six meters, the shrub produces copious numbers of berries that are readily spread by several species of birds and small rodents. It probably out-competes native species in habitats such as old fields, forest edges and other places where habitat has been disturbed and vegetation is regenerating, because it leafs early in spring and retains leaves quite late into fall. It also has virtually no local species of insect or other predator that feeds on its foliage to any significant extent. The density of bush honeysuckle thickets shades out other vegetation so that biodiversity in areas where it grows is severely reduced. There is also some evidence that it produces an allelopathic substance that prevents growth of other plants near it (Deering and Vankat, 1999). Characterizing it as "ecological cancer" would probably not be too strong a metaphor.

The goal of this study was to begin to assess the current status of the forest at Blackacre by measuring the diversity of the tree species (including comparison of the number of pioneer species to climax species), determining the general age of the forest (using tree size, abundance, and density), and by documenting the extent of Amur honeysuckle invasion (presence in proportion of area studied). This information can then be applied toward management decisions to promote the sustainability of the forest, as well as to suggest additional types of surveys and monitoring.

Methods

Blackacre was located using Google Earth and a forest area in the northern half of the preserve was delineated using the GE Path software. The total area was 177,658 m² (~17.77 ha). The resulting map was then overlaid with a numbered grid consisting of 81 quadrants and 24 random numbers were generated using Microsoft Excel to determine data survey points within the grid. Geographical coordinates (survey points) were determined for each of the grid quadrants and four points each were assigned to six teams, each consisting of four individuals, who were members of Dr. Omar Attum's Ecology (M473) class from Indiana University Southeast.

During the afternoon of 5 October, 2009 the teams of students used Garmin eTrex Venture HC GPS receivers to locate survey points. For each survey point, a five meter radius from the point was measured using a forestry tape measure and a circle using this radius was described. Therefore, the point sample area ($\pi r^2 = A$) of each team was $3.14 \times 5^2 = 78.5 \text{ m}^2$.

Each tree of sapling size or greater, within these 78.5 m² areas, was identified using a variety of keys and field guides (including Sibley, 2009). Dead trees were not included. Diameter at breast height (DBH) of each tree was recorded in centimeters. This was used to calculate age distribution. The presence or absence of Amur honeysuckle was also noted and recorded for each sampling point.

The total area of sampling coverage was 1727m² (~0.17 ha). This represented 22 points of 78.5 m² each. (Two of the original 24 were not reached that afternoon.) Thus, the sampled area was approximately 1% of the total study site of 177,658 m² or 17.77 hectares. (0.17 ha of 17.77 ha).

Abundance of total trees, as well as abundance of each tree species identified, was calculated by dividing the number of trees sampled by the area of sample coverage (1727m²) to determine density and then multiplying this density by the total forest area :
Abundance = Density X 177,658 m². (See Table 1.)

Results

Species Diversity and Tree Abundance

The sample area was found to contain 238 individuals larger than seedlings representing 36 species of trees (Table 1). The most abundant species were Eastern Redcedar (*Juniperus virginiana*) and Common Pawpaw (*Asimina triloba*) representing 18.1% and 10.15% respectively of total trees observed.

The least common species, each representing 0.4% of the number of trees, were Tuliptree (*Liriodendron tulipifera*), American Witch-hazel (*Hamamelis virginiana*), Sweetgum (*Liquidambar styraciflua*), Kentucky Coffeetree (*Gymnocladus dioicus*), Black Locust (*Robinia pseudoacacia*), Black Walnut (*Juglans nigra*), Butternut (*J. cinerea*), Pignut Hickory (*C. glabra*), American Hornbeam (*Carpinus caroliniana*), Chinkapin Oak (*Q. muehlenbergii*), Red Mulberry (*Morus rubra*), Red Maple (*Acer rubrum*), and Black Ash (*Fraxinus nigra*).

Estimated tree population of the study area based on calculations was 24,114 trees, with an overall density of 1,357 trees/ha.

Using Simpson's Index of Diversity (Magurran, 1988) where 1 = maximum diversity (each individual organism is a different species) and 0 = no diversity (all individuals belong to the same species) the tree species diversity of the surveyed forest was 0.933.

$$D = \frac{\sum n(n-1)}{N(N-1)} \quad D = \frac{3783}{238(238-1)} \quad D = 0.067 \quad 1 - 0.067 = 0.933$$

Table 1. Forest composition of Blackacre State Nature Preserve - Jefferson County, KY

Common Name	Latin Name	N	Density (Trees/ha)	Abundance	Proportion %	P/C
Eastern Redcedar	<i>Juniperus virginiana</i>	43	249	4424	18.1	P
Common Pawpaw	<i>Asimina triloba</i>	24	139	2470	10.1	C
Tuliptree	<i>Liriodendron tulipifera</i>	1	5	89	0.4	C
American Witch-hazel	<i>Hamamelis virginiana</i>	1	5	89	0.4	C
Sweetgum	<i>Liquidambar styraciflua</i>	1	5	89	0.4	C
Kentucky Coffeetree	<i>Gymnocladus dioicus</i>	1	5	89	0.4	C
Honeylocust	<i>Gleditsia triacanthos</i>	3	17	302	1.2	C
Black Locust	<i>Robinia pseudoacacia</i>	1	5	89	0.4	P
Eastern Redbud	<i>Cercis canadensis</i>	8	46	817	3.3	P
Black Walnut	<i>Juglans nigra</i>	1	5	89	0.4	C
Butternut	<i>J. cinerea</i>	1	5	89	0.4	C
Shagbark Hickory	<i>Carya ovata</i>	16	93	1653	6.7	C
Shellbark Hickory	<i>C. laciniosa</i>	4	23	409	1.6	C
Pignut Hickory	<i>C. glabra</i>	1	5	89	0.4	C
American Hornbeam	<i>Carpinus caroliniana</i>	1	5	89	0.4	C
American Beech	<i>Fagus grandifolia</i>	2	11	195	0.8	C
American Chestnut	<i>Castanea dentata</i>	3	17	302	1.2	C
Northern Red Oak	<i>Quercus rubra</i>	3	17	302	1.2	C
Eastern Black Oak	<i>Q. velutina</i>	7	40	711	3.0	C
Eastern White Oak	<i>Q. alba</i>	7	40	711	3.0	C
Chinkapin Oak	<i>Q. muehlenbergii</i>	1	5	89	0.4	C
Common Post Oak	<i>Q. stellata</i>	5	29	515	2.1	C
Eastern Cottonwood	<i>Populus deltoides</i>	4	23	409	1.6	P
Red Mulberry	<i>Morus rubra</i>	1	5	89	0.4	C
Southern Hackberry	<i>Celtis laevigata</i>	17	98	1741	7.1	P
American Elm	<i>Ulmus americana</i>	4	23	409	1.6	C
Slippery Elm	<i>U. rubra</i>	8	46	817	3.3	C
Red Maple	<i>Acer rubrum</i>	1	5	89	0.4	C
Silver Maple	<i>A. saccharinum</i>	15	87	1546	6.3	C
Sugar Maple	<i>A. saccharum</i>	13	75	1333	5.4	C
Black Maple	<i>A. nigrum</i>	10	58	1031	4.2	C
Boxelder	<i>A. negundo</i>	13	75	1333	5.4	C
Flowering Dogwood	<i>Cornus florida</i>	2	11	195	0.8	C
White Ash	<i>Fraxinus americana</i>	5	29	515	2.1	C
Green Ash	<i>F. pennsylvanica</i>	8	46	81	3.3	C
Black Ash	<i>F. nigra</i>	1	5	89	0.4	C

Total Species 36 Total Tree Numbers 238 Est. Total Pop. 24,114

Each sample plot = 0.1727 ha Total Study Site = 17.77 ha Total Tree Density = 1357/ha

N = Number of Trees Recorded at Sample Waypoints P= Pioneer Species C= Climax Species

Forest Age

Measurements that can be used to estimate the age of a forest include the size of the trees and the abundance of pioneer (successional) species to old growth (climax) species. Over time, the fast-growing, rapidly maturing and short-lived pioneer species will be replaced by slow-growing, late-maturing and long-lived climax species. In a temperate deciduous forest, these climax species will include both large, mature hardwood trees comprising the canopy layer and smaller trees in the shrub or understory layer. As the forest ages and trees become larger with maturity, the average DBH becomes larger and the density (individuals/ m²) becomes smaller.

Of the 36 species identified, four were pioneer species and 32 were climax species (Table 1), (Burns and Honkala, 1990). The relationship between a pioneer species, Eastern Redcedar size (DBH) and abundance was compared (Figure 1), as was the relationship between size of Eastern Redcedars, to combined tree abundance. (Figure 2). For a climax species, Shagbark Hickory, the relationship between overall tree density and mean shagbark size was measured (Figure 3).

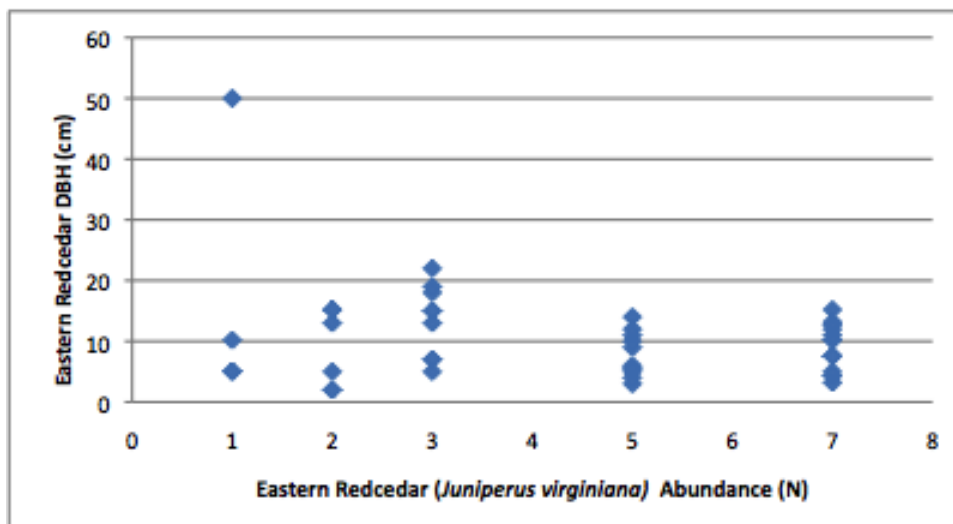


Figure 1. Relationship between Eastern Redcedar (*Juniperus virginiana*) DBH (cm) and Abundance (N)

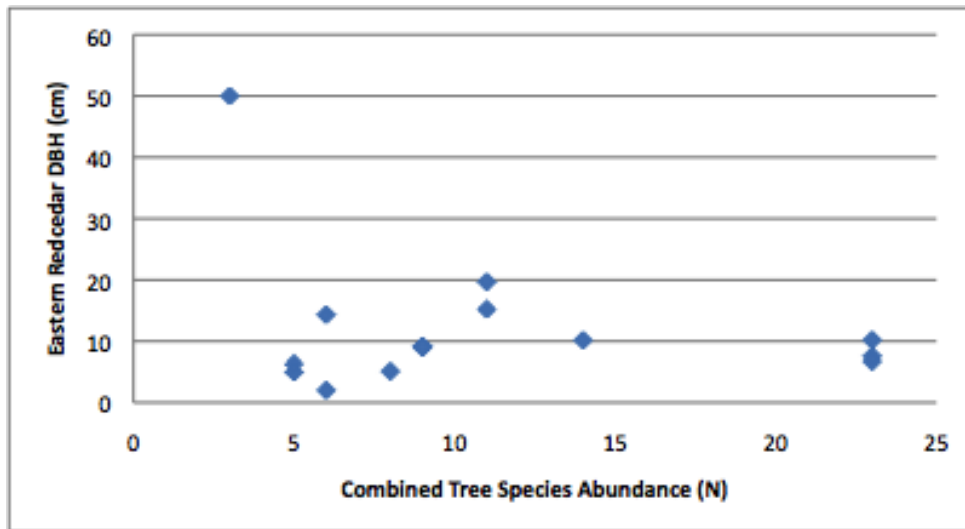
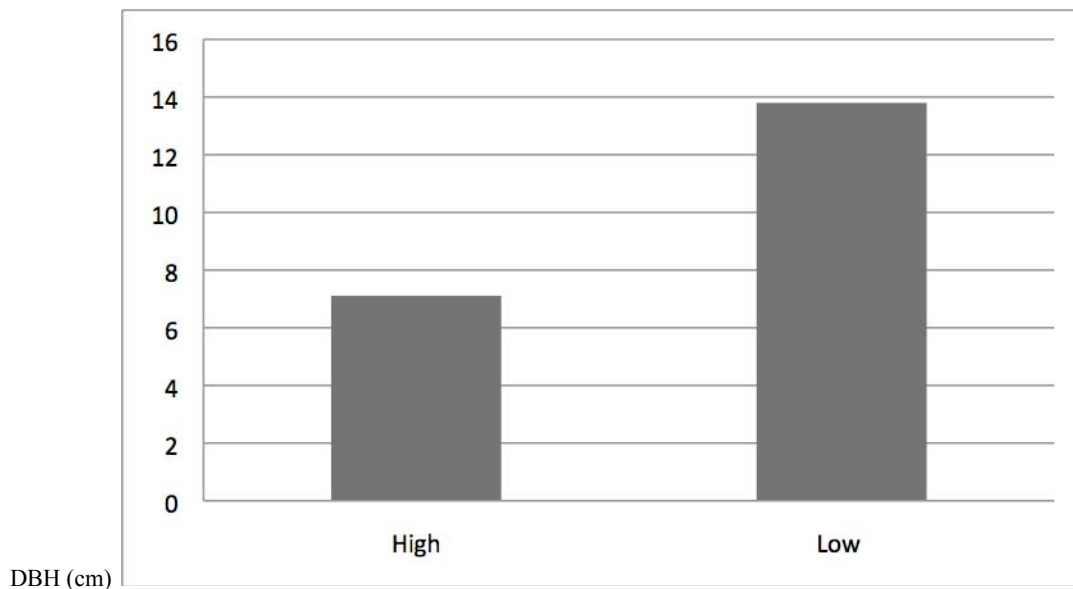


Figure 2. Relationship between eastern Redcedar (*Juniperus virginiana*) DBH (cm) and combined tree species abundance.



High = 1 tree/3.57 m² Low = 1 tree/ 7.13 m²

Figure 3. Relationship between Overall Tree Density (trees/m²) and Mean DBH of Shagbark Hickory (*Carya ovata*)

The even distribution both of size among the Redcedars (Figure 1) and the relationship between Redcedar size and overall tree abundance indicates lack of both intraspecific and interspecific competition. In other words, the trees have not reached the size where they will be competing for space and nutrients, which means the forest is relatively young (Packham and Harding, 1982).

Redcedar reaches reproductive maturity at 6-10 DBH. Age in years can vary depending upon soil, rainfall and other conditions. (Swihart and Picone, 1998). Shagbark hickory, however, usually reaches maturity at age 60 years (Burns and Honkala, 1990). Since nearly all individuals of this species are estimated to be under 60, this also suggests the relative youth of the forest.

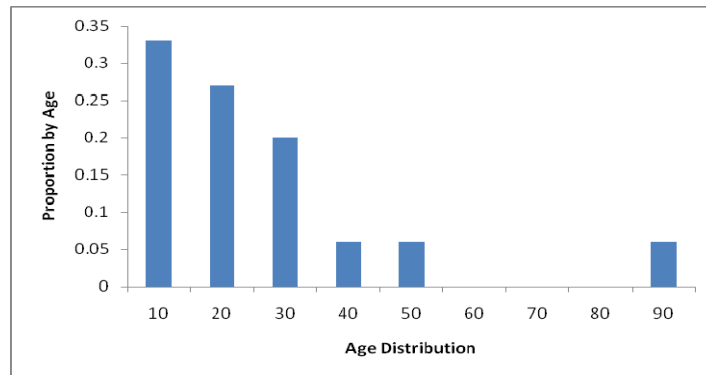


Figure 4. Age Distribution (in years) of Shagbark Hickory (*Carya ovata*)

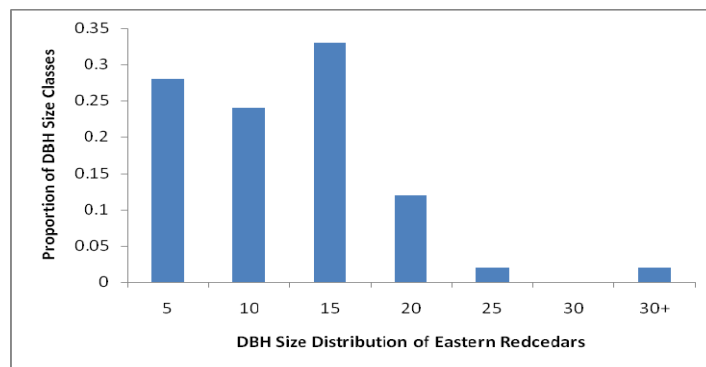


Figure 5. DBH Size Distribution of Eastern Redcedar (*Juniperus virginiana*)

Where the mean DBH of the Shagbark Hickories is small, population density is high and where mean DBH is large, population density is lower (Figure 3), showing that this climax species population is in the process of maturing and selection of better adapted individuals is taking place.

Based upon density, extent of competition, and ages of the pioneer species Eastern Redcedar population (Figure 4) and of the climax species Shagbark Hickory population (Figure 5), the overall age of the forest is young. It is probably less than 60 years old.

Amur Honeysuckle Presence

The forest surveyed is bisected into two patches of approximately equal area by a gravel road that runs to the northern boundary of Blackacre. A railroad track and a two-lane paved road delineate this boundary. Due to conditions, including sunlight, needed for its germination and growth, Amur honeysuckle can be expected at forest edges (Hutchinson and Vankat, 1997). It was recorded in 75% of the points surveyed in one patch and 70% of the points in the other. The relatively narrow shape of the forest means that large areas, virtually all of the forest, are influenced by edge effect.

Field observation of Amur honeysuckle presence does show, however, that the largest and densest growth is near outer forest edges (Figure 6). Only the very innermost area, the ravine below and north of the waterfall, is nearly free of Amur honeysuckle. (Figure 7). This area was not represented in the randomly selected points.



Fig. 6. Interior portion of Blackacre forest free of invasives. Understory comprised of Pawpaw (*Asimina triloba*) and Redbuds (*Cercis canadensis*). 31 October, 2009.



Fig. 7. Edge of Blackacre forest with understory dominated by invasive Bush honeysuckle (*Lonicera maackii*). 24 November, 2009.

Discussion

This survey suggests that the Blackacre forest is a young forest undergoing ecological succession. Some 30.5% of recorded individuals were pioneer species and 69.5% were climax species. Of these climax species many, based on DBH, have not yet reached reproductive maturity (Burns and Honkala, 1990), which will enable the forest to sustain itself. The process of succession towards a mature, sustainable hardwood forest, rich in biodiversity, is also under threat of substantial disruption by invasive Amur honeysuckle (*Lonicera maackii*).

In order to measure the status of succession, representative pioneer species (Eastern Redcedar, *Juniperus virginiana*) and representative climax species (Shagbark Hickory, *Carya ovata*) were chosen based upon their abundance. The DBH of the Redcedar and Shagbark Hickory population, related to overall abundance, demonstrated the succession process. In the areas where Redcedars predominated, succession is relatively new. Evenness and abundance of Shagbark Hickories show that they have become established over other species, and are in the process of becoming an established canopy species.

While the diversity of tree species is high, 0.933 (Simpson's Index of Diversity), the pattern of diversity is not even. Of the 36 species recorded, 13 were represented by only one individual each. This comprised a mere 5.2% of the overall tree population.

On the other hand, 13 species, comprising 41.2 % of the tree population, were members of three genera characteristic of mature hardwood forests in the Ohio Valley (Stein, Kutner and Adams, 2000), namely hickory (*Carya*), oak (*Quercus*) and maple (*Acer*).

Native shrub layer is also well represented in some areas of the forest given the fact that 10.1% of the trees recorded were Common Pawpaw (*Asimina triloba*). So the potential for a mature forest that will support a diversity of tree and associated diverse spring wildflower species and native bird species is present (Barnes, et.al., 1998).

Bias in tree records should be noted. Many of the recorders of the field data were inexperienced in tree identification, meaning that some species may have been misidentified. For example, it is highly unlikely, indeed impossible, that mature American Chestnuts (*Castanea dentata*) would be found here. The chestnut blight eliminated mature individuals decades ago. Immature individuals persist and a small number have been observed at Blackacre (Reigler, 2008). But, trees that were recorded as American Chestnuts were very probably American Beeches (*Fagus grandifolia*), which have similarly-shaped leaves. A second bias would have resulted from not recording seedlings, which can be difficult to identify.

A third bias, which may have affected species distribution and diversity data included small sample size (1% of area) and the random distribution of sample points. Many forest tree species recorded at Blackacre (Reigler, 2008) were not recorded in this survey, including Sycamore (*Platanus occidentalis*), Black Walnut (*Juglans nigra*), and Pin Oak (*Quercus palustris*). A survey that would include 10% of the forest would reveal a more accurate species distribution profile.

The most important factor affecting management and protection of the Blackacre forest is the presence of Amur honeysuckle and the threat it poses to biodiversity as it out-competes and eliminates other shrub species important as food plants for native insects, birds and mammals. It also destroys woodland wildflower habitat (Woods, 1993).

This could have a profound impact on Blackacre State Nature Preserve in its role as an environmental education center and site for public activities such as birding and wildflower observation. Low biodiversity and lack of ecological sustainability would greatly diminish the value of Blackacre for these activities.

Given the widespread growth of Amur honeysuckle and the young age of the forest, immediate steps should be taken to eradicate the honeysuckle. Priority should be given to the areas of the forest nearest the growth of native shrub layer (Common Pawpaw, Redbud and Flowing Dogwood). When Amur honeysuckle bushes are under a meter high, they are not yet producing seeds and are easily removed (Deering and Vankat, 1999). Since the honeysuckle retains green leaves into November and early December, long after native woody plants have lost their leaves, it is easy to identify and eradicate Amur honeysuckle during these months.

A more detailed survey of Amur honeysuckle distribution throughout Blackacre, and a population estimate, should be undertaken to determine the costs of eliminating the invasive. There are also several strategies for control (Anderson, 1990), so studies to determine which would be most effective are needed. Strategies for restoration of native shrub layer also need to be reviewed (Hartman and McCarthy, 2004). Given that both eradication and restoration are labor-intensive, and therefore expensive processes, areas in need of greatest invasive control need to be identified and given priority in order to facilitate the sustainable growth of the nature preserve's forest ecosystem and to protect the species diversity important to maintaining Blackacre as a Kentucky State Nature Preserve and as an environmental science education site.

Literature Cited

- ANDERSON, B.D. 1990. Bush honeysuckle: vegetation management manual guidelines. Illinois Nature Preserves Commission, Springfield.
- BARNES, B.V., D.R. ZAK, S. R. DENTON, AND S.H. SPURR. 1998 Forest Ecology, 4th edition. Wiley Press, New York.
- BELL, J.F., J.S. WILSON, AND G.C. LIU. 2008. Neighborhood greenness and 2-year changes in body mass index of children and youth. *American Journal of Preventive Medicine* 35 (6): 547-553.
- BURNS, R.M AND HONKALA, B.H. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. □U.S. Department of Agriculture, Forest Service, Washington, DC.
- CRANZ, G. 1982. The Politics of Park Design: A History of Urban Parks in America. MIT Press, Cambridge, Mass.
- DEERING, R.H. AND J.L. VANKAT. 1999. Forest colonization and developmental growth of the invasive shrub *Lonicera maackii*. *The American Midland Naturalist* 141: 43-50.
- HARTMAN, K.M. AND B.C. MCCARTHY. 2004. Restoration of a forest understory after the removal of an invasive shrub, Amur honeysuckle (*Lonicera maackii*). *Restoration Ecology* 12:154-165.
- HUTCHINSON, T.F. AND J.L. VANKAT. 1997. Invasibility and effects of Amur honeysuckle in Southwestern Ohio forests. *Conservation Biology* 11 (5): 1117-1124.
- INVASIVE SPECIES WORKING GROUP. 2009. Top 14 Invasive Species in Kentucky. College of Agriculture, University of Kentucky, Lexington.
- MAGURRAN, A.E. 1988. Ecological Diversity and Its Measurement . Chapman and Hall, London.
- MAHALA, M. 2008. Kentucky Terrestrial Nuisance Species Management Plan 2008. Kentucky Department of Fish and Wildlife Resources, Frankfort.
- MITCHELL, R. AND F. POPHAM. 2007. Greenspace, urbanity and health: relationships in England. *Journal of Epidemiology and Community Health* 61 (8): 681- 683.
- NIELSEN, T.S. AND K.B. HANSEN. 2007. Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators. *Health Place* 13 (4): 839-850.
- PACKHAM, J.R. AND D.J.L. HARDING. 1982. Ecology of Woodland Processes. Edward

- Arnold Ltd. London.
- RADELOFF, V.C., R.B. HAMMER, AND S.I. STEWART. 2005. Rural and suburban sprawl in the US Midwest from 1940 to 2000 and its relation to forest fragmentation. *Conservation Biology* 19 (3): 793-805.
- REIGLER, S. 2008. A checklist of trees, shrubs & vines, Blackacre State Nature Preserve Jefferson County, Kentucky. Blackacre Foundation, Louisville.
- SIBLEY, D. A. 2009. *The Sibley Guide to Trees*. Alfred A. Knopf, New York.
- STEIN, B.A., L.S. KUTNER, AND J.S. ADAMS, EDITORS, 2000. *Precious Heritage: The Status of Biodiversity in the United States*. Oxford University Press, Oxford
- SWIHART, R.K. AND PICONE, P.M. 1998. Selection of mature growth stages of coniferous browse in temperate forests by white-tailed deer (*Odocoileus virginianus*). *The American Midland Naturalist* 139: 269-274
- TAGTOW, R. 1990. The need for urban forests. *American City and County* 105:74-75.
- WOODS, K.D. 1993. Effects of invasion by *Lonicera tatarica* L. on herbs and trees in four New England forests. *American Midland Naturalist* 130:62-74.