INTRODUCTION

The study was done at **Boone Cliffs Nature Preserve (BCNP)**, which is a 75-acre (30.4 ha) old-growth forest in Northern Kentucky (Burlington, KY). Preserved in 1974 by The Nature

Conservancy, it was formed by the outwash of the Kansan glaciers

(700,000 years ago). The rocky outcrops and shaded ravines provide ecologically diverse habitats and tree communities (Fig. 1, 2). We surveyed a south-facing slope at this Mixed/Western Mesophytic old-growth Forest, which was described as a Sugar Maple-Chinkapin Oak community in 1997.



Figure 1. Rocky outcrops on south-facing slope.

Amur Honeysuckle (Lonicera maacki) is a native shrub to Asia, but was introduced to eastern United States forests in the early 2000s. It outcompetes other understory trees and is changing the composition of these forest communities. Not observed in 1997, it was found in 2019 at BCNP.

Due to the *increased presence of invasive plant species* in the last two decades and the *increased canopy closure*, we anticipated a change in this community. We hope our study can serve as an example of trends that might be found in similar forests, especially affected by invasive honeysuckle.

The **goal** of this study was to collect DBH of canopy trees (DBH of > 3.5 in) and DBH of tree saplings (DBH < than 3.5 in but > 0.5 in) on the same south-facing slope forest that was studied in 1997 and use that data to (a) **predict the future makeup of the forest community** and (b) **assess the decadal-long change in tree and** sapling diversity.

METHODS

- Data were collected (in 1997 and 2019) in the Fall at a southfacing slope of old-growth Mixed/Western Mesophytic forest located in Boone Cliffs Nature Preserve (Burlington, KY) (Fig. 2).
- The six plots were spaced in 30 meter intervals from the center of one plot to the center of the next. Plots had diameters of 22.6 m for a total area of 0.04 ha. (Figs. 3, 4).
- We measured trees by diameter at breast height (DBH) (Fig. 5).
 - **Overstory** Trees: DBH > 3.5 in

Understory Sapling Trees: DBH < 3.5 in and > 0.5 in

• Analyses measures included: Density, Basal Area, and Importance Value (Rel. Density + Rel. Dominance + Rel. Frequency = IV); Jaccard's Similarity Index and Bray and Curtis Similarity Index (between years); Shannon-Weiner Species Diversity (H'), and Species Evenness (J').



Figure 3. The circular layout for the six different plots of the BCNP study.

Twenty-two years of change (1997-2019) in an Old-Growth Forest Community on the South-facing slope at Boone Cliffs Nature Preserve (Burlington, KY)

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RESULTS

Table 1. The number of each tree species and their importance values (IV) from the overstory tree data (DBH > 3.5 in) collected in 1997 and 2019 in the old-growth forest on the southfacing slope at Boone Cliffs Nature Preserve, (BCNP) Burlington, KY.

Species	Common Name		Trees in 2019	IV (1997)	IV (2019)
Acer saccharum	Sugar maple	23	27	66.41	75.06
Celtis occidentalis	Hackberry	14	32	27.27	64.81
Ulmus rubra	Slippery elm	9	6	40.27	28.02
Quercus muhlenbergii	Chinkapin oak	5	7	54.49	26.36
Acer negundo	Boxelder	3	4	12.40	18.8
Fraxinus quadrangulata	Blue Ash	1	3	18.68	17.99
Pantanus occidentalis	American Sycamore	3	1	6.54	16.43
Carya cordiformis	Bitternut hickory	3	2	10.81	11.72
Gymnocladus dioicus	Kentucky coffeetree	1	1	11.46	11.06
Quercus rubra	Northern red oak	1	3	5.06	6.97
Liriodendron tulipifera	Tulip poplar	1	1	6.36	6.66
Fagus grandifolia	American beech	1	1	15.91	5.76
Fraxinus americana	American white ash	1	1	13.77	5.31
Carya ovata	Shagbark hickory	1	1	5.52	5.06
Asimina triloba	Pawpaw	1	0	5.06	0
Totals:		68	90	300.01	300.01

Table 2. The relative frequencies (RF), relative density (RD), relative dominance (RDo), and Importance value (IV=RF+RD+RDo) for the **overstory** trees (DBH <u>></u> 3.5 in) in the old-growth forest on the south-facing slope at Boone Cliffs Nature Preserve, (BCNP) Burlington, KY. Data are from 2019 only.

Species	Common Name	RF2019	RD2019	RDo2019	IV2019
Acer saccharum	Sugar maple	19.35	30.00	25.70	75.06
Celtis occidentalis	Hackberry	16.13	35.56	13.13	64.81
Ulmus rubra	Slippery elm	9.68	6.67	11.67	28.02
Quercus muhlengergii	Chinkapin oak	9.68	7.78	8.90	26.36
Acer negundo	Boxelder	12.90	4.44	1.45	18.80
Fraxinus quadrangulata	Blue Ash	6.45	3.33	8.21	17.99
Plantanus occidentalis	American Sycamore	3.23	1.11	12.09	16.43
Carya cordiformis	Bitternut hickory	3.23	2.22	6.27	11.72
Gymnocladus dioicus	Kentucky coffeetree	3.23	1.11	6.72	11.06
Quercus rubra	Northern red oak	3.23	3.33	0.42	6.97
Liriodendron tulipifera	Tulip poplar	3.23	1.11	2.32	6.66
Fagus grandifolia	American beech	3.23	1.11	1.42	5.76
Fraxinus americana	American white ash	3.23	1.11	0.97	5.31
Carya ovata	Shagbark hickory	3.23	1.11	0.73	5.06
Totals		100.00	100.00	100.00	300 00



Figure 2. Red outline displays the aerial view of the property line of Boone Cliffs Nature Preserve located between latitudes 38 59'39°N and longitudes 84 46'37°W.

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FURTHER CONTACT

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Table 3. Density per Size Class, Density per Species and Total Density per Size
 Class of **understory** trees (DBH of < 3.5 in and \geq 0.5 in) from the old-growth forest on the south-facing ridge at Boone Cliffs Nature Preserve (BCNP), Burlington, KY. (Size-Class 3 = 0.5 - 1.4 in, Size-Class 4 = 1.5 - 2.4in, Size-Class 5 = 2.5 - 3.4 in). Data are from 2019 only.

Species	Common Name	Size Class 3 (#/ha)	Size Class 4 (#/ha)	Size Class 5 (#/ha)	Total (#/ha)
Lindera benzoin	Spicebush	220.8	37.5	0.0	258.3
Lonicera maackii	Amur honeysuckle	241.7	8.3	0.0	250.0
Asimina triloba	Pawpaw	158.3	33.3	0.0	191.6
Celtis occidentalis	Hackberry	87.5	58.3	20.8	166.6
Acer saccharum	Sugar maple	29.2	45.8	33.3	108.3
Acer negundo	Boxelder	25.0	0.0	4.2	29.2
Fraxinus quadrangulata	Blue ash	8.3	0.0	0.0	8.3
Ulmus rubra	Slippery elm	0.0	0.0	4.2	4.2

Table 4. Similarity indices comparing the two years of BCNP data
 (for overstory trees \geq 3.5 in DBH).

Indices Used	Comparison Value
Jaccard's Similarity Index (1997 vs. 2019)	81.80%
Bray and Curtis Similarity Index (1997 vs. 2019)	93.33

Table 5. Summation indices of Diversity over two sample years of BCNP
 forest community data on the south-facing slope.

		1997	2019
Total Forest Density	trees/ha	283.3	375
Total Forest Basal Area	m2/ha	21.57	28.87
Shannon-Weiner Diversity Index	H'	2.06	1.85
Species Richness	S	15	14
Evenness	J	0.76	0.7



Figure 4. Preparing to sample the overstory and understory tree communities on a south-facing slope at BCNP (October 2019).





- community.

CONCLUSIONS

ANALYSIS

Though changes were seen across 20 years, the **2019 community was still** similar to 1997 using the Bray-Curtis Similarity Index (93.3%) and Jaccard's Similarity Index (81.8%).

Sugar maple continues to be the most dominant species and has increased its overstory Importance Value since 1997 (from 69.2 to 75.1). Indicative of south-facing slopes – with dry, rocky soils – in diverse forests of the region, we found Chinkapin Oak (Quercus muehlenbergii) and a variety of subdominants (*Carya* spp., *Ulmus rubra, Fraxinus quadrangulata*) in the tree

Hackberry greatly increased in IV from 27.27 (in 1997) to 64.81 (in 2019); and was observed in five of six plots. This increase may have been due to an increase in shade, allowing for the intermediate-shade-tolerant species to become more dominant (Burns and Honkala 1990).

In the understory, the appearance and relatively high density of Amur honeysuckle (250 shrubs/ha) suggests ongoing impacts on the native species.

Our diversity values (Table 5) are not as high as most eastern US old-growth forests, but that is likely due to sampling only one community of this forest (i.e., south-facing slope)

Both overall tree density and overall basal area have increased, which suggests (a) understory tree species are growing into the overstory size class and (b) other existing overstory tree species are increasing in size.



The overstory tree community on this south-facing slope is still considered old-growth, is similar to 1997, and is still dominated by Sugar Maple. However, the sub-dominant has shifted from Chinkapin Oak (1997) to Hackberry (2019), which has a greater tolerance for shade in a community with increasing canopy closure. American Ash and Blue Ash were still present in small densities, but EAB will likely affect these trees the next few years.

In the understory, the most dense **shrubs** were *Spicebush, Amur* honeysuckle, and Pawpaw. While the two native species were previously recorded, the invasive Amur honeysucke was not recorded at all in 1997, but is now the second-most dense shrub **species**. With a simultaneous increase in (a) honeysuckle cover and (b) overall shade, a **further decrease in recruitment and** contribution of *Quercus* in the overstory is likely.

Tree saplings that are shade-tolerant (i.e., *Acer, Celtis*) were the most dominant (Table 3) – which suggests the **future overstory will** continue to be dominated by Sugar Maple-Hackberry.

We hope our study can serve as an example of dynamic trends in similar eastern US forests with increased shade (due to historical fire suppression and other factors) and invasive shrub species.

SELECTED REFERENCES

Burns RM. Honkala BH. 1990. Silvics of North America Volume 2. Hardwoods. USDA Forest Service. https://www.srs.fs.usda.gov/pubs/misc/ag_654/table_of_contents.

Bryant WS. 1978. Vegetation of the Boone County Cliffs Nature Preserve, a Forest on a Kansan Outwash Deposit in Northern Kentucky. Trans KY Acad Sci 39 (21): 12-22

Bryant WS, Galbraith SL, Held ME. 2004. Natural Terrestrial Vegetation of Boone County, Kentucky: Classification, Ordination, and Description. J KY Acad Sci 65(2): 132-139.

Kentucky State Nature Preserves Commission. 2012. Boone County Cliffs State Nature Preserve. http://naturepreserves.ky.gov/naturepreserves/Documents/brochures/BooneCountyCliffsBrochure_bw.pd f (accessed April 10, 2018).

Margulies E, Bauer L, Ibanez I. 2017. Buying Time: Preliminary assessment of biocontrol recovery of native forest vegetation in the aftermath of the invasive Emerald Ash Borer. Forests 8(10): 369.