Testimony in support of Bill 25-22 – February 7, 2023

Dr. Douglas H. Boucher

Thank you very much for the opportunity to testify today. My name is Doug Boucher, and I have lived since 1997 with my wife Charlotte on the family farm in Dickerson, Maryland. I support the bill as well as the recommendations of the Montgomery County Forest Coalition, of which I'm a member (representing Poolesville Green).

What's distinctive about my testimony today is that I also want to urge you to add a sentence or two to the bill, requesting that the Planning Department create <u>an alternative pathway for reforestation based on natural regeneration</u>. Naturally regenerating forests is much cheaper than tree planting and thus accessible not just to a few, but to many ordinary Montgomery County landowners. Creating such a pathway would make it possible to increase our county's forest cover appreciably and thus would provide important climate benefits for all the county's residents, at very low cost.

My background and experience

Let me briefly tell you who I am and describe the experience on which my testimony is based. I have four roles that are relevant to this legislation:

1) **Landowner** – my wife and I own White Acres Farm in Dickerson, which covers 77 acres and was a dairy farm run by her grandfather, Max White, for several decades. It has been in the family since the 1830s and is typical of the rolling countryside of rural Montgomery County.
2) **Scientist –** I retired five years ago as Director of Climate Research and Analysis for the Union of Concerned Scientists. My decade of work there followed a long career as a

college professor in biology, concentrating on forest and agricultural ecology. I have a Ph.D. from the University of Michigan, and taught at Hood College, the University of Québec and McGill University.

3) **Activist** – I am a Board Member and serve as Treasurer of Poolesville Green, one of the most active environmental groups in the county. Our work has included organizing the electric vehicle event at Poolesville Day each year, which has grown over the past decade to become the largest EV show in the Mid-Atlantic states.
4) **Reforester** – since 2003 I have been reforesting 4 acres of our farm through natural regeneration. Based on our success in this effort, I am now working with the Planning Department to create a larger reforestation project (10 acres) under the county's Forest Conservation Bank program. Because this new project would combine 1 ½ acres of tree planting with 8 ½ acres based mostly on natural regeneration, I have had to make detailed estimates of the costs of reforestation by both methods. (Let me add in passing that I have very much appreciated the excellent cooperation of Kristin Taddei and her colleagues in the Planning Department as we have been developing this project.)

Our success with natural regeneration

The success of our 4-acre natural regeneration project over the past 20 years has been important to my proposal for an alternative pathway of reforestation, so it's worth describing some of its results. A few years ago, I wrote up an illustrated report on the first 15 years of the project, which was done in cooperation with students from Hood College and the Global Ecology Program of Poolesville High School. I'll attach that report as an appendix to my testimony, and just briefly add a few points based on the results since then. Please look at that writeup – and in particular its pictures -- to get an idea of how well the forest has grown back naturally over those 4 acres.

Here are four points to add to that description:

1) The reforestation has been done <u>entirely by natural regeneration, without any tree planting at all</u>. Indeed, within the 2 ½ acre plot in which we have been gathering detailed data, we have observed the rule of not allowing any kind of human manipulation– no cutting of any plants, no fencing to exclude deer or other wildlife, no application of any herbicides – nothing except tagging and measuring the trees as they grew up from seeds.
2) The regenerated forest is more than 99.5% native tree species, and in a <u>far greater abundance than is achieved in tree-planting-based reforestation</u>. The tree density is now 3,240 trees per acre, with 366 of those trees being more than 4 inches in diameter. For comparison, the required number for tree-planting to be considered successful by the Planning Department's criteria, is to have 100 trees per acre, with at least 50 of them measuring 2 inches or more.
3) The growing forest has now begun to make <u>a substantial contribution to combating climate change</u>. The biomass of the trees is now 31.5 tons per acre, and each acre of trees takes 9.1 tons of carbon dioxide out of the atmosphere every year.
4) The forest and the landscape in which it has grown is <u>very typical of rural Montgomery County</u>. It grew back following the harvest of soybeans in fall 2003, on a field that had been used for farming for about 160 years. Scientists have long pointed out that over 95% of the current forests in the eastern U.S. originated from natural regeneration, not from tree planting, and our success shows that this can be done just as well in Montgomery County as it has in the rest of the region.

The costs of natural regeneration and tree planting

There is no doubt that natural regeneration can successfully recreate forests in Montgomery County. Indeed, the fact that about 100,000 acres of our county is now forested (about 33% of our land area), is almost entirely due to natural regeneration over the past century and a half. But the value of natural regeneration is not simply that it re-creates native forests, but that it does this at an extremely low cost.

Indeed, most of the cost of our 4-acre reforestation has been for doing the research that generated the data I've summarized, which was not necessary for the forest to regenerate. Since we didn't plant any trees, protect them from deer, or apply any herbicides, we had no expenses associated with those kinds of activities. The major expenses were the costs of about 10,000 tree tags and the nails to attach them to trees, plus the poles to mark the coordinates of the 100 by 100 meter research plot. Even if we hadn't been studying it, the forest would have grown back just as well.

Even if one wishes to include the opportunity cost of reforesting the land rather than continuing to rent it to neighboring farmers for soybean, corn and wheat production, the cost would be quite low. At our current rental rate of $ 140/acre (based on competitive bids and quite typical of Montgomery County agriculture), we have sacrificed a total of $ 2,800 per acre over the past 20 years by reforesting. And of course, this doesn't take into account the environmental value of the forest ecosystem we have created.

In contrast, the per-acre cost of tree planting is very high. I'll give you estimates based on the quotes we have gotten in connection with the new 10-acre reforestation project that we are beginning in the spring, as part of the county-administered Forest Mitigation Banking program, Since the size of the trees that must be planted is large (1" caliper, which means they are generally several feet high), they cost about $ 45 each, on average. They are required to be protected from deer browsing, which adds $ 6-8 each to the cost, and they are planted at a density of at least 200 trees per acre. Thus, one has already spent $ 10,400 per acre, even before the trees are put in the ground. The labor of planting will cost an additional $ 5,000 per acre. The cost of preparing and filing the required Forest Conservation Plan, including both detailed sketches of the planting methods and surveying of the area, adds about $ 9,000. There are further expenses for preparing the soil, maintaining the plantation for the required period and other activities. I have not included these due to lack of data, but they may also be substantial.

Altogether, this means that the 4-acre forest which we've created, would have cost us at least $ 70,600 if we had done it by tree planting. By using natural regeneration, we have accomplished this at practically no cost. (Note that the opportunity cost of not renting the land for crops would have been the same by either method).

The high cost of tree planting puts reforestation financially out of reach for most landowners in Montgomery County. The median size of county farms is 26 acres, according the 2017 Census of Agriculture, which means that even if the entire land can be rented for crop production, it would bring in only $ 3,640 annually. If one farms the land oneself rather than renting it, the situation is even worse – that same census showed that the average net revenue for county farms was approximately a <u>negative</u> $ 6,000. That is, on average farms in the county lost several thousand dollars a year.

Therefore, the fact that one might profit by selling credits for considerably more than the cost of reforesting, is irrelevant for most landowners. They just can't afford the large up-front costs to undertake the project in the first place. Only businesses and the small minority of large landowners (30 farms out of 558 in the county have more than 500 acres, and together they own

58% of the county's farmland) can afford to reforest by tree-planting. For the rest of us, it's simply beyond our means.

Findings of the Hughes Center technical report

The Hughes Center report, published last November, shows that the problems we have come across in planning our reforestation efforts are typical of Maryland landowners doing tree-planting for forest mitigation banking. Indeed, the Hughes Center study reported that:

> "Multiple county representatives stated that creating newly planted forest banks is not appealing to landowners. Although bank owners can set their own rates for selling credits, establishing a newly planted forest bank involves high upfront costs that are not recouped for multiple years, until after the forest is established and credits are sold…" (p. 67)

And further on:

> "…many landowners are not interested in establishing banks, as they require a large investment of time and money that may not be recouped for several years." (p. 68):

Even when landowners can come up with the capital to begin a forest mitigation banking project, it does not necessarily lead to a forest being created. As a county representative told the Hughes Center researchers,

> "…well-intentioned tree planting efforts can fail because of the significant time and long-term investment and maintenance required to develop newly planted trees into healthy, mature forests that provide the full suite of desired ecosystem services." (pp. 65-66)

Thus, the Hughes Center report found the same basic problem that we have faced in estimating the costs of reforesting on our land by tree-planting: that the up-front costs are a severe disincentive.

One other important finding of the Hughes Center report has to do with the forthcoming change in the legal situation of using forest retention – as opposed to forest creation – to generate credits that can be sold from a forest mitigation bank. Due to a legal opinion from the Attorney General of Maryland several years ago, forest retention – that is, protecting mature forests that already exist – will no longer be eligible for mitigation bank crediting after 2024. The Hughes Center pointed out that this kind of credit has made up the large majority of credits used in the state:

> "Across all counties, existing forest banks comprise 81.1% of reported forest bank acreage with a total area of 13,997 acres, while planted forests only make up 18.9% of reported forest bank acreage, with an area of 3,261 acres. This suggests that steps may need to be taken at the county or state level to encourage the creation of planted forest banks, now that existing forest banks can no longer be created." (p. 64)

This is the situation state-wide; the Hughes Center's data also shows that it is very much the situation in Montgomery County as well. They found that of the area in the 31 forest mitigation banks credited in Montgomery County, credits for retention of existing forest constituted 1334 acres, while credits for newly created forests made up only 277 acres (Table 20, p. 69). Thus 83% of forest mitigation banking credits were given for retaining acres of existing forest which will be no longer be eligible after next year.

One might think that the reduction in the supply of mitigation banking credits that the phase-out will produce, will be self-correcting due to the normal effects of supply and demand on price – that is, with the supply of credits reduced by more than 80%, the price of credits will go up and thus incentivize more planting of new forests for mitigation credits. But the flaw in this analysis is that the lack of planting is not due to low credit prices. Rather, it's the up-front cost of planting and the delay, of a few to several years, between when investment in the project is begun and when credits from it can be sold. Thus, normal supply-and-demand dynamics in the mitigation credit market can't be expected to solve the problem. What is necessary is an approach that minimizes the up-front costs. Assisted natural regeneration does this.

Recommendation for an amendment to develop an assisted natural regeneration pathway

These considerations, and my experience of successful natural regeneration of a native forest at much lower cost than tree-planting, are the reasons that I urge you to add a small but important amendment to the bill. The amendment would simply request that the Planning Department develop an alternative pathway for reforestation based on assisted natural regeneration, and report back to the County Council on legislation and/or regulations that are needed to implement it. (Note that the state law that established the Forest Conservation Bank program does allow natural regeneration, though it has seldom been used and provides no details of how it can be done.)

I am not a lawyer, and I suggest that you depend on the legal and scientific expertise of the staffs of the County Council and the Planning Department to work out the details of the alternative pathway. I would be happy to work with them on it and can help find other scientists to do so as well. At this point I would simply suggest a few principles that could serve as guidelines in developing the assisted natural regeneration pathway:

1) It should be complementary to the existing program, allowing tree-planting as part of natural regeneration projects but not requiring it.

2) It should have low up-front costs, making it financially accessible to all landowners, whether large or small.
3) It should be based on the "pay-for-performance" principle. This means that reforesters would only receive credits after they have created a forest ecosystem that meets the same requirements as the tree-planting pathway – e.g. native species, few invasives, with a minimum size and density of trees, etc.
4) It should be flexible in terms of how reforesters achieve these requirements. They could depend entirely on natural dispersal of seeds from existing forests, or plant seeds, or plant small seedlings, or any combination of these. They could choose to protect seedlings from deer browsing, or not, and similarly for other management decisions. In other words, the pathway would specify <u>what</u> they need to achieve, but not tell them <u>how</u> they must achieve it. And they would only get paid when they <u>do</u> achieve it.

I expect that as Planning Department staff and the public start discussing the alternative pathway, other ideas will emerge. I would simply encourage that they be evaluated as to whether they further these basic principles: natural regeneration, low cost, pay for performance, and flexibility.

Natural regeneration and affordable housing

Of course, forest mitigation banking is not justa way to reforest. It is also one of the costs that go into developing construction projects, and we all recognize that we have a severe shortage of affordable housing in Montgomery County. Although forest mitigation is not a large proportion of the cost of building housing units, it is a cost and its impact on the supply of affordable housing needs to be considered.

Seen in this light, having an alternative low-cost pathway for forest mitigation has double benefits. It both encourages the creation of new forest, and because it can be done inexpensively and by many more landowners, both large and small, it also reduces the cost of developing affordable housing.

This positive impact will come about through the interaction of supply and demand in the mitigation banking credit market, but you can make the link stronger and reinforce environmental justice by explicitly connecting assisted natural regeneration credits to building affordable housing. This can be done by making the credits from assisted natural regeneration projects available, either preferentially or exclusively, to development projects that build housing for low- and moderate-income families. I would urge you to ask the Planning Department to explore how this could be done as they develop their recommendations in response to the amendment I am suggesting.

In the longer-term

Finally, let me suggest a fundamental point about reforestation to consider in the longer term. These are not ideas to add to the current bill, but rather changes to consider in future years.

We need to move from a no-net-loss goal to an increased-forest-cover goal. The scientific literature, as summarized in last year's Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6), makes it clear that net zero is necessary but not sufficient to prevent dangerous climate change. Getting greenhouse case emissions down to zero just isn't enough; in the second half of the 21st century, we need to be pulling more carbon out of the atmosphere than we put into it. Converting our global economy from fossil fuels to renewable energy is basic to getting to net zero, but it will have to be accompanied by increasing carbon sequestration – and increasing forest cover is the best option to do that.

Many important environmental policies developed in the twentieth century were based on the principles of offsetting and no-net-loss – e.g. of wetlands, of air pollutants like sulfur dioxide, and in the case of our state law, of forests. Our county program follows the same logic – if developers want to deforest in some areas, they are required to pay for protection and re-creation of forests in other areas. This offsetting mechanism helps maintain the amount of forest in the county, but is too weak to increase it. And indeed, our forest cover has essentially been static over the past three decades. In coming years, we need to be more ambitious.

For now, I would simply encourage you to support the bill and add a simple amendment asking the Planning Department to develop an assisted natural regeneration pathway for reforestation.

Thank you very much for your attention to my testimony. I would like to conclude by inviting members and staff of the Council to visit our 20-year-old naturally regenerated forest in Dickerson. We have already had Councilmember Marilyn Balcombe, our three District 15 members of the Maryland House of Delegates, and Planning Department staff out to see it, and would be happy to welcome the other Councilmembers and their staff to come out and visit it as well. I think you’ll find it both enjoyable and enlightening.

Appendix

A Natural Reforestation Experiment in Montgomery County, Maryland: Results from the First Fifteen Years

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Summary:

This brief report describes the process of natural reforestation, over 15 years, on a farm field left fallow in the fall of 2003. It shows the potential of areas in the Piedmont of Maryland to grow back to forest naturally with little human intervention.

The 4-acre field, which is roughly square with north-south and east-west edges, is part of White Acres Farm, in the northwest corner of Montgomery County, and prior to being fallowed, it had been farmed continuously for about 160 years. In terms of landscape, soil type, and history it is typical of the region. It is bounded on one side by a 75-year old secondary forest, and on another side by a fencerow with large trees of about the same age. These provided the seed sources for the field. No tree-planting or other human disturbance took place over the 15 years of regrowth, other than data collection on establishment of seedlings and their growth into saplings and trees.

Once left fallow, the field grew up in a meadow dominated by grasses, goldenrods and other perennials, but also with a high density of tree seedlings. The most common seedling species, by far, was tuliptree (*Liriodendron tulipifera*), followed by white ash and then box elder. Distance to seed source had a clear impact on seedling densities, which were higher on the north and west sides of the field, near large seed trees. Surprisingly, the seedlings along the west side of the field grew significantly faster than those further east, despite their high density and their being shaded part of each day.

Some seedlings began to reach sapling size after a few years and the beginnings of a new forest canopy – that is, trees with crowns that touched each other and shaded the ground below them -- began to close in Year 6. By Year 10 this canopy covered a fourth of the field, and it rapidly expanded in the next few years, covering 86% of the field by Year 15. The dominant species of this new forest continues to be tuliptree, with a few juniper (red cedar), black cherry and sycamore in the new canopy as well. White ash and box elder remain common but mostly in the understory. Non-native invasive species make up only about 0.2% of the forest in Year 15. Vines – mostly Japanese honeysuckle and bittersweet – are growing on about 10% of the trees.

Deer browsing has had an impact on tree growth, as shown by trees growing faster inside small fenced areas ("deer exclosures") outside the main plot. This effect was especially evident between Years 5 and 10, when seedlings were reaching the sapling stage.

In several ways, the new forest that has grown up resembles the 75-year-old forest on its west side in which many of its parent trees are located. Both are dominated by tuliptree, along with black cherry and with white ash and box elder below, and both have only small numbers of non-native invasive tree species. Naturally, the new forest is still considerably shorter (its average tree height was about 24 feet in Year 15, versus 105 feet for the older forest) and despite substantial mortality it still has 20 times as many trees as in the older forest. Rough estimates indicate that the amount of carbon in the new forest is only about 10% of the amount in the 75-year-old forest, although it is now increasing fairly rapidly.

Thus, over 15 years and without any tree planting, a new native forest has been established and is growing up to resemble the older forest adjacent to it.

Introduction

In October of 2003, as part of my research and teaching work at Hood College, I began a study of forest succession on a field near my house in Montgomery County, Maryland. Together with Hood students and other friends and colleagues, I have been studying forest regrowth on this field over the past 15 years. This short report briefly describes in non-technical terms what we have found and shows the potential of natural reforestation on agricultural land in the Piedmont of Maryland.

The Setting

The field is at the north end of White Acres Farm, which is along Route 28 (Darnestown Road) in Dickerson, Maryland. It is located in the Piedmont region of Maryland at 39.21° N., 77.42° W., and is within Montgomery County's Agricultural Reserve. The setting, a rolling landscape of hills and valleys, is typical of the upper County. The field is on the Penn sandy loam soil type, over a sandstone bedrock, and is similar in fertility to typical farm fields in the region.

Figure 1. Soybeans in the field just before the last harvest, 13 October 2003. The 75-year-old forest is in the background (to the west), and the tip of a smokestack of the Dickerson coal-fired power plant is barely visible in the center of the forest canopy.

White Acres Farm has been owned by members and descendants of the White family since the 1830s, and was a dairy farm run by Max White from 1916 till he died in 1972. From 1973 to 2003 the farmland was rented by two local farmers, Bob Raver and Dave Weitzer, who rotated crops of corn, soybeans and winter wheat on it, generally using no-till methods. The last crop before the field was left fallow in October 2003 was soybeans (Fig. 1).

To the west of the field are several acres of forest that slope down to the floodplain of the Little Monocacy River. By counting tree-rings in cores taken from the largest trees in this forest, we have found that it originated about 1943; this date is confirmed by aerial photos dating from 1951. Thus the forest is now about 75 years old. It is typical of many secondary forests in eastern North America, with an average tree height around 32 m (105 feet) and about 150 trees per acre. (Figure 2).

Figure 2. The 75-year-old forest, looking eastwards from the floodplain of the Little Monocacy.

The canopy of the 75-year-old forest is dominated by tuliptree (*Liriodendron tulipifera*), with smaller numbers of black cherry (*Prunus serotina*). There are also various species of oak, hickory and maple as well as other species such as black gum and beech.

Figure 3. Looking north over the field in November 2004 (Year 1), showing the fencerow trees along the north edge of the field in the background

To the north of the field is a stone fencerow marking the north edge of the White Acres Farm property (Figure 3). Along both sides of the old fence trees have grown up, and based on their sizes, are probably similar in age to those in the 75-year-old forest. They include large tuliptrees, sycamores, red oaks, white ashes, black gums and several species of hickory. The 75-year-old forest on the west and the fencerow trees on north are the likely seed sources for almost all the seedlings that have grown up in the field.

Figure 4. The fallow field just after the soybean harvest, in October 2003, looking northwest.

After the soybean harvest in late October 2003, we let the field go fallow and marked out a 100 by 100 meter research plot (2.5 acres) in the middle of it (Figure 4). Since that time the only human disturbance to this research plot has been the collection of scientific data. No trees or any other plants have been planted in the research plot, and it has been left unfenced. However, in November of 2004 (Year 1), 12 small 2 x 2 m plots were established just outside of the main research plot, with six of them surrounded by fencing (Figure 5) and six of them left open. Comparisons among such “deer-exclosure” plots are a standard method used to evaluate the impact of deer browsing on seedling survival and growth rates.

Figure 5. Two of the fenced deer-exclosure plots along the southern edge of the fallow field on November 29, 2004, just after they were established. The 75-year-old forest is visible behind them on the left side of the photograph. Pink flags inside the exclosures mark seedling locations.

Since 2003 we have identified, counted and measured the seedlings in the field as they grew into saplings and then trees over 15 years. The next section summarizes our main findings about how the field has changed.

The Growth of the New Forest

By June of 2004, eight months after the field was left fallow, it had begun to be covered by meadow vegetation, with large numbers of seedlings, each just a few inches tall, beginning to appear. Their numbers continued to increase over the next few years, and by Year 3 they had reached a density of about 4.5 seedlings per square meter – i.e. 18,000 per acre. Three-fourths of the seedling community were tuliptrees, with substantial numbers of white ash (*Fraxinus americana*) and box elder (*Acer negundo*) as well (Figure 6).

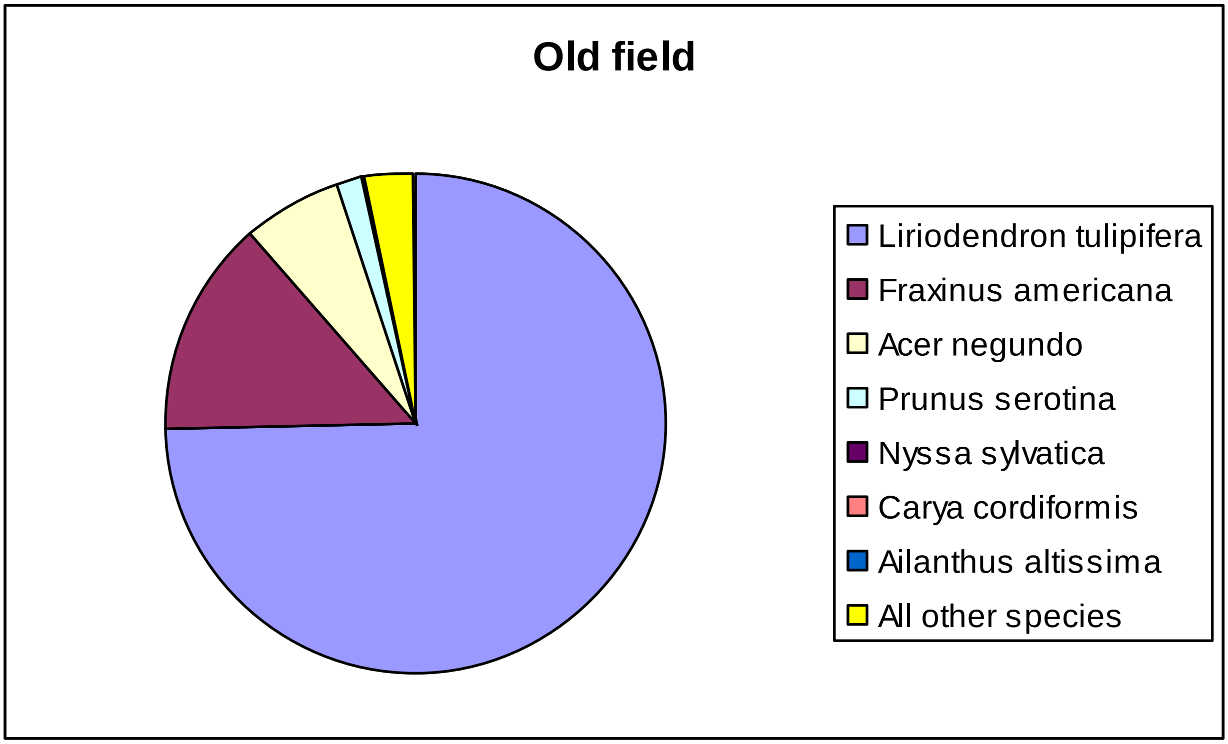
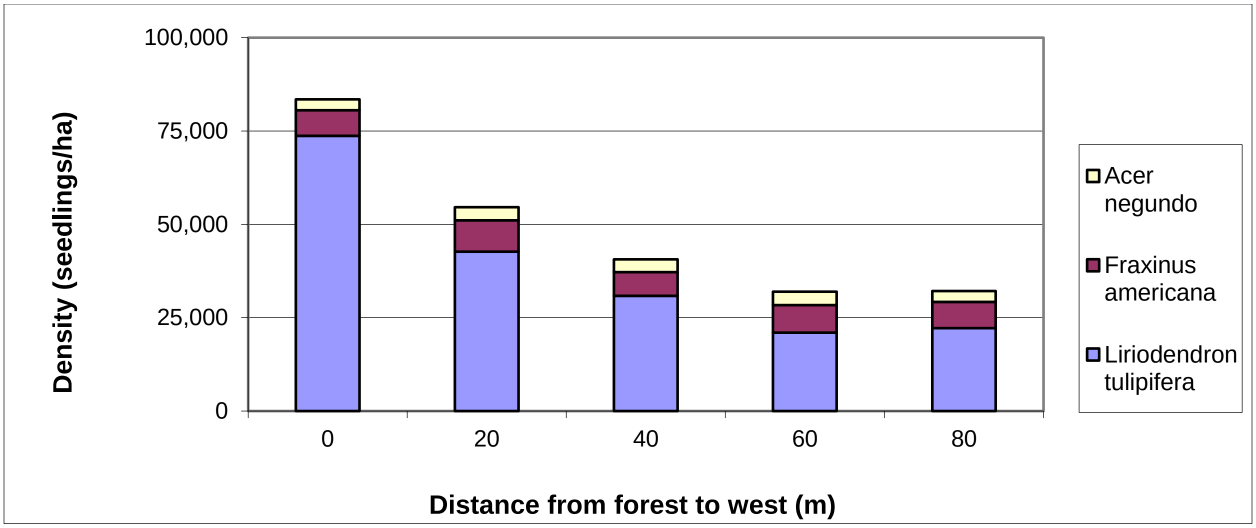


Figure 6. Percentages of tree seedlings in the field in Year 3. The most common species were tuliptree (*Liriodendron*), white ash (*Fraxinus*) and box elder (*Acer*), with lesser numbers of black cherry (*Prunus*), black gum (*Nyssa*), bitternut hickory (*Carya*) and tree-of-heaven (*Ailanthus)*.

By this time the meadow vegetation was dominated by perennial herbaceous species such as grasses and goldenrods, and brambles (principally black raspberry and wineberry) had started to appear as well.

The seedling community showed clear differences across the field, with higher densities on the sides that were closer to the old forest (the west edge) or the fencerow trees (the north edge) (Figure 7). Surprisingly, despite their high density and the partial shade of the forest on them for part of the day, the seedlings closest to the forest actually grew faster than those in the middle of the field. By Year 3, already 40% of the seedlings near the old forest had reach 50 cm in height (i.e., knee-high), while only 1-2% of the seedlings elsewhere in the field were this tall.



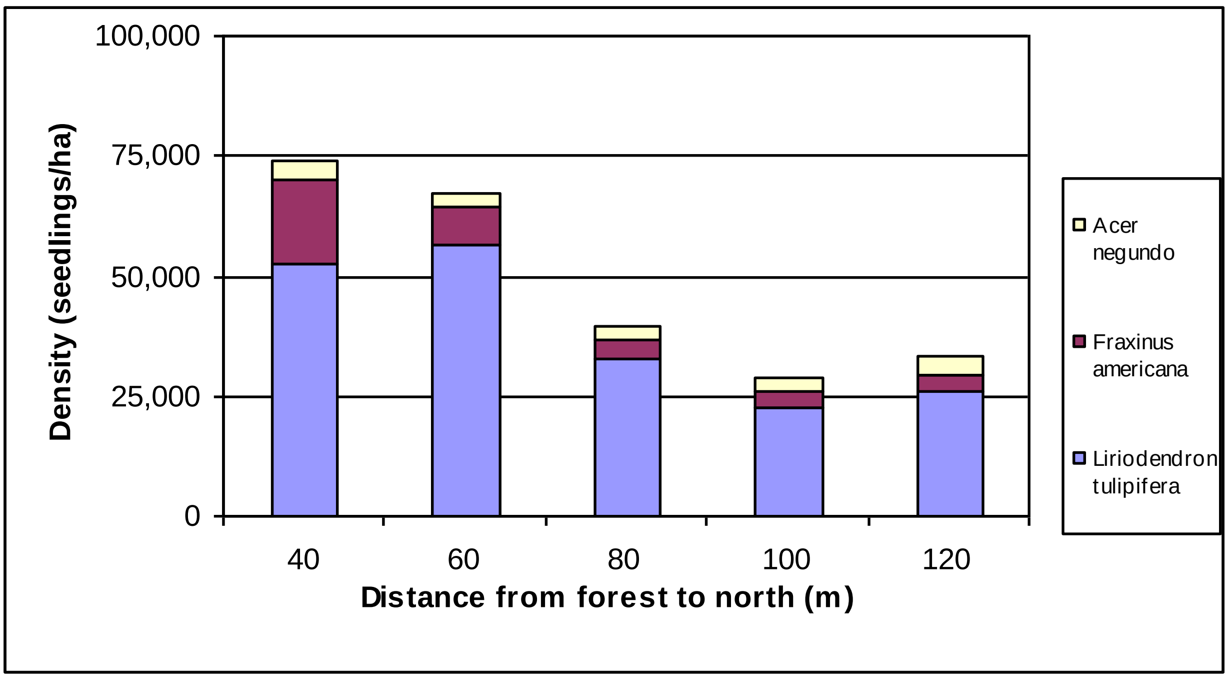


Figure 7. Seedling density versus distance to the 75-year-old forest to the west (top graph) and versus distance to the fencerow trees to the north (bottom graph)

Over the next several years seedlings throughout the field grew to sapling size, and by Year 6 a new low and dense canopy had formed along the western edge of the field. By Year 10 about 25% of the area of the field was covered by this forest canopy, and over the next five years its area expanded rapidly to cover 86% of the field by Year 15 (Figure 8).

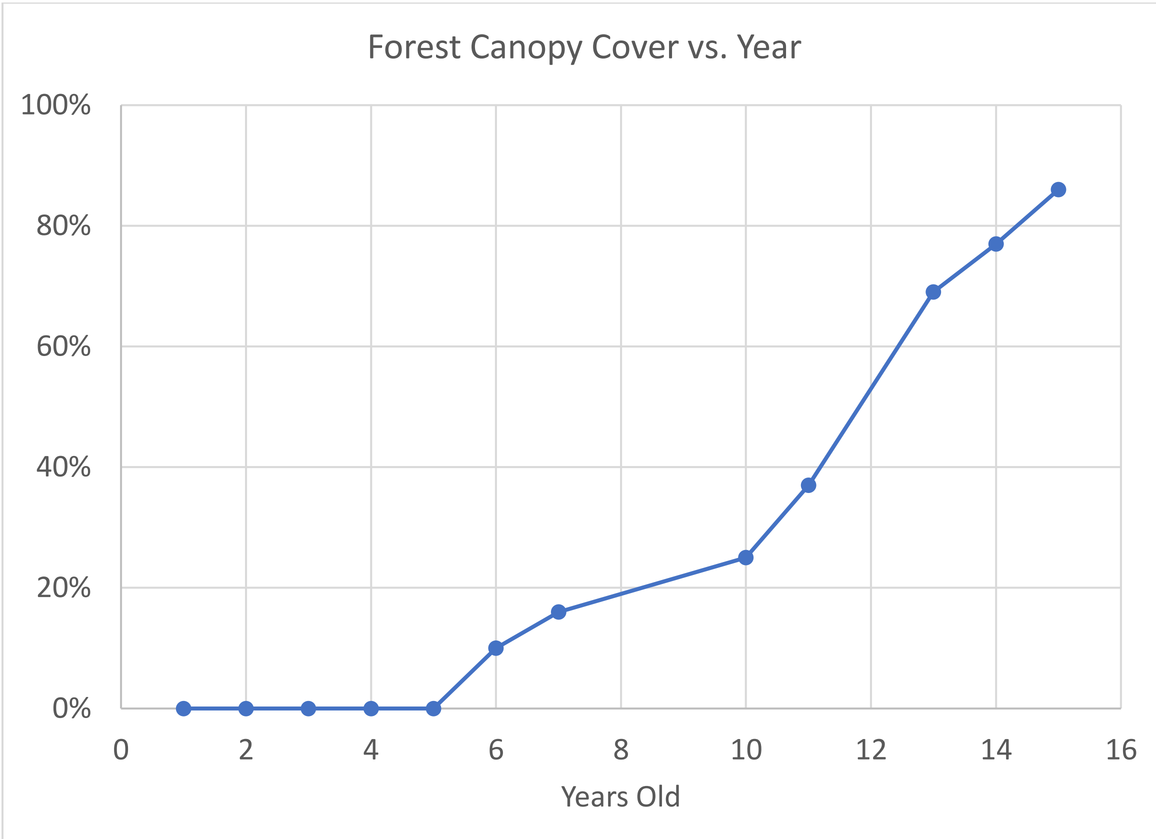


Figure 8. The percent of the field's area covered by forest canopy, versus time since the field was left fallow. The canopy began to close along the western edge of the field in Year 6, and rapidly expanded to cover most of the field between Years 10 to 15.

As the canopy of the new forest grew, it slowly began to shade out the grasses, goldenrods and brambles below it. At the same time, herb species typical of forest understories began to appear, including buttercups and orchids (Figure 9).

Figure 9. A ladies-tresses orchid (*Spiranthes* sp.) in the understory of the new forest, Year 14.

During the growth of seedlings into trees, the relative abundance of different species changed due to differences in their survival and growth rates. Overall, about 50% of the seedlings found in the field in the first few years had died by Year 15. Tuliptree continues to dominate – actually, even more so than initially (93.3% in Year 15, versus about 74% in Year 3; Figure 6). White ash and box elder remain present in the 15-year-old forest, but almost all of them are in the understory rather than the canopy. On the other hand, sycamores, junipers (red cedar) and black cherry are now found in the canopy, each representing a few percent of the trees. Other native species present include bitternut hickory, black gum, black locust, American holly and red maple. Oaks and beech, however, are still absent.

Invasive non-native tree species are very rare in the new forest. Some were present initially but quickly died out; for example, seedlings of tree-of-heaven (*Ailanthus altissima*) had a mortality rate of 69% from Year 1 to Year 2, versus an average of 7.6% for the native species. In Years 7-15, other non-native invasives such as autumn olive and Callery pear have shown up, but not in large numbers. Currently, fewer than 0.2% of the trees in the new forest are non-native invasive species (autumn olive, Callery pear, tree-of-heaven, empress-tree, bush honeysuckle and mimosa).

Vines have grown up the trunks of some of the trees and now are found on about 10% of them. The most common vine species is Japanese honeysuckle, followed by oriental bittersweet. Native vine species (Virginia creeper, wild grape and poison ivy) colonized the field in the first few years but mostly have died out.

Comparison of the 2 x 2 m plots that were fenced to prevent deer-browsing, with those that were left open, showed that deer browsing has slowed growth. This was particularly the case up to Year 10 when most of the seedlings were still less than five feet high. Similarly, a lower rate of deer browsing may be responsible for the faster growth of the new forest along the west side. The hypothesis here is that the high density of seedlings close to the old forest (Figure 7, top graph) was so great that it overwhelmed the ability of the deer herd to browse them all, so that more of them were able to grow up to tree size.

The 15-year-old and the 75-year-old Forest

In broad terms, the new forest is similar to the old one to its west. Both have tuliptree, and to a much lesser extent black cherry, as the dominant trees in their canopies. White ash and box elder are common in both, but mostly below the canopy. They share other, less common species (e.g. bitternut hickory, sycamore), and both have very low abundances of non-native invasive trees.

On the other hand, the new forest's trees are obviously still much smaller than the old ones, averaging 24 feet versus 105 feet tall. Although 50.3% of the seedlings initially found in the field have died, the tree density of the new forest is still nearly 20 times greater than the old forest (Figure 10).

Figure 10. The interior of the 15-year-old forest, showing the high density and dominance of tuliptrees.

We can combine the size and density data to estimate the relative amounts of carbon in the two forests. The first step is to calculate what foresters call the basal area (BA) of the two forests -- a way to represent the proportion of the ground covered by tree trunks. One way to think of it is that if we cut down all the trees, hypothetically, the BA would be equal to the total area of their stumps. The BA of the new forest is now about 57 square feet/acre; this is about a third of the old forest, which has 161 square feet/acre.

As a second step, combining the BA measurements with the limited data we have on tree heights, we estimate that the 15-year-old forest contains only about 10% as much carbon as the 75-year-old forest. However, the new forest trees have now reached a size at which they have begun to accumulate carbon rapidly.

In conclusion, the 15-year-old forest is different from the 75-year-old one, but in important respects – e.g. dominant species, tree diversity, understory composition, and amount of carbon – it is moving rapidly in the same direction.

Figure 11. Satellite photo of the study area in Year 12, showing the old forest (left), the new forest (upper right) and fields still being cropped (lower right). Source: Google Earth, 9 September 2015

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