INFORMATION ON INCREASE, LOSS, AND GROWTH OF TREES OVER 30 YEARS ON A FORTY ACRE TRACT OF WOODS IN CLAY COUNTY INDIANA

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ABSTRACT

KEY WORDS. Trees, Tree growth, Indiana

METHODS

In 1975, I purchased 40 acres of land mostly wooded, in Clay County, Indiana. It was then divided into 100 x 100 foot plots. All the trees over 12 inches dbh were then identified, marked with writable aluminum tree tags and measured in 1977-78. The tree tags were marked with the numbers of the plots and the trees within the plots. Plot number 1-1 was in the NE corner of the property. And 1-1, 2-1,3-1 etc. through 1-1 to 1-13 were to the west along the north edge the of property The next row of plots was just to the south with 1-2 to 13 2, and the other rows south of those, to 13-1 to 13-13 in the SW corner of the property, pipes were placed in the corners of the plots with the plot numbers included on them. ,The trees were all measured again at 15 year intervals, with trees newly that had entered into the 12" class; also trees that had disappeared were noted Many of the tags were removed by squirrels thus were replaced by quarter inch thick round aluminum markers., The trees were tagged with the markers placed on the trees with aluminum nails The tree tags were marked with the plot numbers and the tree numbers, for example plot 1-2, tree 3 would be for the third tree measured in plot 1-2. A 5x8 card with a map was made for each plot, with each tree entered in on the map and a table indicating each of the measurements for each of the trees for each year, and also any trees that had grown into the plot or that had disappeared in each year.

There had not been much cutting on the study area in a number of years. Only one cut stump could be found on the study area in 1975. There were several habitats on the property, big ravine, small ravine, upland woods, young woods, brush and field. The three habitats, young woods brush and field had harbored livestock not too long before the project began. About six of the plots were primarily in young woods, six in brush, and two in field when the project began Most of the remainder of the study area, 111 plots was in older woods. The remaining 13 plots were in driveway, buildings, a lake and cultivated field, .

The 12" dbh and larger trees in 131 plots in flat woods, wooded ravines, a big ravine wooded, young woods, brush and field measured in 1976-77, 1993 -1994 and 2009-2010 periods. This gave us two sets of plots at 15 year intervals.

RESULTS

Thirty four species of trees 12" dbh or above were found in the study area, but the white ash and green ash were considered together because of difficulty in separating them totalling 33 species listed in the tables. . Table 1 indicates these trees along with the number in each of the 15 year periods. Over 1700 trees were found during each of the 15 year sampling periods. When trees had more than one stem over 12" inches dbh, each stem was measured and counted as a separate tree.

The most abundant tree on the study area was the tulip tree, *Liriodendron tulipifera* (n=294 trunks).followed by Red hickory, *Carya ovalis* , Red oak, *Quercus borealis ,Shagbark hickory,* Carya ovata, White oak, , *al*, Red maple, *Acer rubrum*, American Sycamore, *Platanus occidentalis ,and Sassafras albidum, all totaling over 100 individuals* There were six species totaling only one individual each Apple, *Pyrus malus* Cottonwood, *Populus deltoids*, Shellbark Hickory, *Carya laciniosa* , Honey locust, *Gleditsia triacanthos*, Hop hornbeam, *Ostrya virginiana*, Shellbark Hickory, *Carya laciniosa, and willow. , Salix sp.*

THE TREES (listed in order of decreasing abundance)

1. TULIP TREE, *Liriodendron tulipifera* (n=294)

Flat woods 126, Wooded ravine 52, Big ravine 47, Brush 31, young woods 25, open 13

The tulip tree is the most abundant tree in; the Brazil study area, including 294 trees in all. In the first year of the study, (sample # 1) there were 150 tulip trees, followed by 253 in the second and 278 in the third sampling period.

This was one of the most successful trees in the study area, with an increase every sampling period and , with only 16 trees dying during the 30 years. Eleven died 11 entering the population after the second sampling period, one after being present in the second period only, four after being present in the first two periods only.

This species was significantly more abundant in woods than expected (83 expected, 126 present), brush (13 expected, 31 present), open areas (9, 13) open areas and young woods 9 expected, 25 present). They were less than expected in the big ravine (93 expected, 47 present) and in the wooded or smaller ravines (87 expected, 52 present) (Chi-square + 112.3

The tulip tree was most abundant in the eastern part of the study area, with much lower abundance in the west, particularly on the west side of the stream flowing through the big ravine. There were 43 tulip trees in the big ravine itself, .36 in the east side of the stream flowing through it, 7 on the west side.) _This species was an obvious invader with 31 in brush, 25 in young woods, and 13 in open area, in what were originally without trees. .

Growth rate.

2, RED HICKORY, *Carya ovalis* (n =286)

Wooded ravines 16, flat wood 94, Big ravine 76

The red hickory was the second most abundant of the 12" dbh trees in the study area. It was significantly more abundant in the in the wooded ravines (5 expected, 116 observed), about as expected in woods (81 expected, 94 present), and less than expected in the big ravine (90 expected, 37 present) Tulip trees were not present in any of the open areas (brush, young woods, open areas), indicating it was not a good invader. .Jackson (2003) stated that this tree was found throughout Indiana, but was "often not numerous or dominant in a stand."

The red hickory was clearly an upland woods species, with few individuals in the riparian area (big ravine), none in the southeastern area, originally open, and there were only 3 in the NE two moist woods area (columns 1 and 2), where pin oaks were common.

Red hickories were very successful in the study area. They continued to increase throughout the time of the study, with 203 in the first sampling period, 240 in the second, and 263 in the third. (X2 = , 2 df). Of the 286 red hickories, 183 were present in all three sampling periods, 41 were new starting with sample 2, and 37 more were new starting with sampling period 3. On the other hand, only 24 of these trees were lost, 9 by the beginning of the second sampling period, five from sample 2, and ten from sample 3 (check this- 15 more by the beginning of the third??.

Growth rate

3. RED OAK, *Quercus borealis*. (n =221)

Wooded ravine 98, big ravine 74, flat woods 49, but none in brush, young woods and open area.

The red oak was the third most abundant tree of the study area. It was significantly more abundant in wooded ravine with 98 trees (65 expected), as expected in the big ravine with 74 (70 expected) It was less than expected in woods (49 observed ;62 expected). There were none in the three more open areas.

The red oak was clearly a woodland species. It occurred over much of the study area, north, east and west, but not in the southeastern area, which had been pretty much open at the beginning of the study.

It was a successful species in the study area. There were 159 trees present in the first sample, 193 in the second, and 199 in the third. There were 145 trees present in all three sampling periods. There were 7 trees present in only the first year, 4 in only the second year, and 20 only in the third year. There were 10 occurring in only the first and second sample only and 35 in the second and third sample only.

Growth rate

4. SHAGBARK HICKORY. *Carya ovata* (n=206)

Flat woods 93, wooded ravine 77, Big ravine 33, young woods 2, open 1.

The shagbark hickory was the fourth most abundant tree of the area. Like the red oak, it was primarily a tree of the mature woods, although 3 occurred in the more open areas. It was significantly more abundant than expected in woods (59 expected, 93 present), and in wooded ravines (61 expected, 77 observed), and significantly less abundant than expected in the big ravine (65 expected, 33 observed). There were only 3 in the open areas

Shagbarks were spread pretty much throughout the wooded parts of the area, except they were few in the big ravine and few in the SW and SE portions of the area.

_____ trees were gone at the beginning of the second sampling that had been present in the first sampling, and ____ were missing in the third sampling that had been present in the second.

Growth rate

5. WHITE OAK. (n=187)

Wooded ravine 84, flat woods 53, big ravine 44, open 3, young woods 3.

White oak was the fifth most abundant species of tree in this study. It was a species of the mature woods, although 3 were found in in young woods, and 3 in the open area.

This species was significantly more abundant than expected in, wooded ravines (55 expected, 84 present) and significantly less abundant (59 expected, 44 present) in the big ravine. In woods they were as expected 53 trees. (Chi-square =29.7)

___ trees were missing at the beginning of the second sampling period, and ___ at the beginning of the third sampling period. Of the latter, ___ had been present for the first and second sampling, whereas ___ had been present for just the second sample.

Growth rate

6. RED MAPLE, *Acer rubrum* (n=149)

Flat woods 80, brush 42, young woods 10, wooded ravine 9, Big ravine 7, open area 1.

Red maple was the fifth most abundant tree on the study area. The trees discussed to date OR most of the other trees in the study differed in having relatively few trees in the SE part of the study area which had been cultivated or at least managed earlier. However, there were many more red maples in this area (42+10+1= 53 or 2,3% of the trees studied). The red maple apparently was more adaptable to germinating in this basically open area than most of the other species. Presumably it was able to do this because of faster germination and or growth, but also it was fairly moist which favors this species (Jackson, 20040 None of this is surprising as the red maple is considered an early succession species.

The red maple was significantly more abundant in the flat wooded, brushy areas and young woods, than expected, and significantly less abundant in the big ravine, and in the woody ravines than expected (Chi-square = 295.6)

On the map, the red maple showed two distinct clusters, one in the SE area in the area of the previously open areas, where this species seemed adaptively favored. The other cluster (containing was in the SW flat forest west of the big ravine. I would suppose that might have been open ground at an earlier period. a

_____ of the red maples found in the first sample were dead or gone at the beginning at the second sample, _____ of the trees present in the first and second samples were dead or gone, and also _____ trees were dead or gone that had been present only in the second sampling period. F

Growth rates. Were the growth rates much greater in red maples, fitting in with the idea of fast growth adaptation expressed above.

7. American Sycamore, *Platanus occidentalis* (n=148)

Big ravine 116, wooded ravine 16, open 7, woods, brush and young woods 3 each.

Sycamores are often found in riparian areas, thus it is not surprising that they would be most abundant in the big ravine where there was a small stream throughout its length.

There were 106 sycamores in the first sample, increased to 129 in the second sample and decreased to 120 in the third sample. The sycamores were doing fine except that a minor tornado went up the large ravine and took out 18 sycamores prior to the third sampling period.

Sycamores were significantly more abundant than expected in the big ravine (47 expected 116 present), and in the open area (4.6 expected, 7 observed) and significantly less abundant in the wooded ravine ((45 expected, 16 observed), flat woods (42 expected, 3 observed), and brush (6.5 expected, 3 observed). They were especially abundant in the big ravine (riparian area) as the low areas are a favored habitat for this species. The sycamores were greatly associated big and smaller ravines. Only about five were in the flat woods. Sycamores were also one of the invaders of the open areas in the southeastern part of study area.

A total of 83 sycamores were present in all of the sampling periods, 23 more for the second and third sampling periods and 14 new ones were in the final sampling period. Twenty eight trees died out during the study, 5 by the beginning of sample 2, and 23 by the beginning of sample 3, including the 18 trees taken out by the tornado, all in the big ravine. (Were trees taken out during the tornado except besides sycamores)>

Growth rates

8. Sweet gum. *Liquidambar styraciflua* (n=124)

Brush 48, young woods 31, Big ravine 21, flat woods 18, wooded ravine 3, open area 3.

The sweet gum significantly differed in number between habitats (chi-square = 567.0) with 48 trees in the brushy area whereas only 6 were expected. In young woods 31 were expected, whereas 4 were expected. Three were expected in the open area and three were present. In all of the major wooded areas, sweet gum was significantly less abundant than expected; big ravine (39 expected, 21 observed), wooded ravine, 37, 3), and woods, (35, 18).

This species was centered primarily in the SE part of the study area which had been cultivated earlier, with a less prominent area in the southern part of the big ravine. Jackson (2004) indicated that this species is found in wet bottomlands and flatwoods, and these ae the wetter areas in the study area. This species and Red maple were the major species invading the previous open area during this study.

Of the 124 red maples, 21 were present for all 3 sampling periods. Twenty-three were present the first sampling period, 84 the second, and 120 (96 %) were present in the final sampling period. Sweet gum is doing very well in this study area, with only four (3.2%) dying during the course of this study.

Growth rates

9. Sassafras. *Sassafras albidum*. (n=115)

Wooded ravine 52, Flat woods 50, Big ravine 12. Young woods 1.

Of the 115 trees of this species of this species, surprisingly only one was not in mature woods, but was in young woods. This was a species of the dry woods with 102 individuals in wooded ravine and woods. Only 12 were in the big ravine. Sassafras trees were significantly more abundant in the drier, upland habitats woods: (32.5 expected, 50 observed), wooded ravines (34 expected, 50 present). It was significantly less abundant in the big ravine (36 expected, 12 observed) and the previously open habitats, brush, open, and young woods (collectively about 12 expected, but only 1 present). The small number of sassafras in the previously open SE areas

Of the 115 trees of this species,42 (36%) were present in all three of the samples. Forty-two of the trees were present in all of the sampling periods 26 were present in the second and third periods, and 15 were present in the third sampling period only. Thus 83 sassafras were present at the end of the project, whereas there were 68 in the first sample, and 95 in the second sample. Five had died by the time of the second sample, and only seven were present for the second sample. And 21 were present for the third sample. Sassafras increased in the early part of the study, but decreased in the latter Thirty-two died during the study leaving a net gain of 15 trees.

Sassafras trees were pretty well distributed in the study area except in the big ravine and in the open areas. This was surprising as sassafras are quite often abundant in early areas. This lack was probably because this area was fairly moist.

Growth rates.

10. Ash. *Fraxinus americana* (white ash) and *F. pennsylvanica* (Green ash) (n=86

Big ravine 37; wooded ravine 29, flat woods 17, Open 2, brush 1)

Two species of ash were included< white and green, but they were combined here because I was often unable to distinguish them. I suspect that most of those in the big ravine were green ash and those in the drier areas were white ash. Ashes were significantly more than expected in the big ravine (37 observed, 26.5 expected, and in the wooded ravines (29 observed, 26 expected) , and significantly less in the drier woods (24.3 expected, 17 observed), brush 3.8 expected, 1 observed), open area (2.7, 2), and young woods (2.7, 0). The map shows them to be fairly well distributed throughout the area except fo. r the SE corner (young woods, brush and field,, and to the west of the big ravine.

Of the ash trees, 24 were present in all three samples, 13 were present in the last two samples, and 8 were present in the last sample. Nineteen were present in the first sample, 17 in the first and second and 5 were found only in the second sample only.

As everywhere throughout the Midwest, the ash is not doing very well. There were 60 trees in the first sample, followed by 59 in the second sample, and 45 in the third . This was a significant drop) xbar = _____. Forty five trees were present or entered the population during the study (52%) On the other hand, 41 (48%) of the trees died during the study. This was the highest loss of any of the species during this work (check)

Growth rates.

11. Bitternut hickory. *Carya cordiformis*. (n=72)

Wooded ravine 27, big ravine 23, Flat woods 22)

The bitternut hickory is pretty much randomly distributed in the woodlands of the study area(Chi-square =9.6), but it is not present in the three more open areas. It was about as expected in the big ravine. It was most abundant, but only slightly more than expected in wooded ravines (27 vs. 21.)The wooded ravines had slightly more bitternut trees than expected.

Bitternut hickories were pretty much distributed around the study area, except in the open areas, and in the southern most portion of the area *west of the big ravine.*_The bitternut hickory a woodland tree.

Growth rates.

12. American Beech, *Fagus grandifolia* (n=64).

Wooded ravine, 40, big ravine 16, flat woods 8.

Beech was the 12th most abundant tree in the study area, with 50, 51 and 45 trees during the three samplings. Beech trees declined somewhat over the course of the study.

Beeches were significantly different by habitat (chi-square =36.8) Significantly more were present in the wooded ravines (40 observed, 18.9 expected)and significantly less in all other habitats, big ravine (20.1 expected, 16 observed), woods 18.1 expected, 8 observed), including in the three open area habitats in the SE portion of the study area.

The map shows that most of the beeches are in the northwest four columns of the area west through column 7, and to the west of the big ravine I columns 12 and 13, south through row 5. These are in areas that have well developed ravines (including the area we have termed the beech ravine (in rows 3-5). In the northwest area beyond the big ravine.

Beeches are especially interesting in that there are numerous small individuals (especially evident by their leaves in fall and winter after most of the leaves of the other trees are off. These have present and numerous for many years, and grow very little. However Speer and Whitaker, (in prep) found these trees (1 to 5 inches diameter) to be very old (up to about 75 years (check)r

Growth rates.

13. Pin Oak *Quercus palustris* (n=55)

Flat woods 32, wooded ravine 10, Big ravine 8, young woods 4, brush 2, open 1

The pin oak occurred in all habitats, but was most abundant in woods, followed by wooded ravine and big ravine. However, there were seven individuals in the three open areas in the SE portion of the study. Area. This tree was capable of entering open areas. Some of the open area was moist, further favoring this species.

There were 57 trees at least 12"dbh, 38 in the first sample, 49 in the second and 50 in the third. This species has increased over the term of the study. Thirty two trees were present in all sampling periods, 11 in the second and third years, and 3 in the third year. Thus 20 entered the population, and six disappeared.

Pin oaks grew mainly two areas in the study area, mostly in the east (woods and open areas) and the SW, mostly west of the big ravine.

Growth rates.

14. Black Walnut *Juglans cinerea*. (n=44).

Big ravine 31, Wooded ravine 8,Flat woods 5

The walnut was the 14th most abundant tree in the study area, with 44 individuals, most (70.4) of the total in the big ravine. Walnut trees were significantly more abundant than expected (31 vs 13.8) in the big ravine, but less than expected in all other habitats, and with none in the open habitats of the SE part of the study area. Eight were in the wooded ravines, thus 39 of the 44 (88.6%)were in ravines

Twenty of the 44 trees (47.4%) were present in all three samples, 6 were present in samples 2 and 3and 1 was present in only the third. Thus 7 trees entered the population in the second or third sample, Four trees disappeared after sample 1, 4 after entering in sample 2, and 8 afater being present in the first two samples. Thus 16 trees disappeared during the study.

There were 33 walnuts in sample 1, 39 in sample 2, and 28 in sample 3. For an overall loss of 5 over the entire study.

Growth rates

15. Pignut hickory. *Carya glabra* (n=41)

Flat woods 20, Big ravine 13, Wooded ravine 8.

The pignut hickory was the 15th most abundant tree wth 41 individuals.This species continued to increase throughout the study, with 23 in the first sample,. 33 in the second, and 37 in the third. They were significantly more abundant in woodswith 20 trees (11 expected), about as expected in the in the big ravine (12.9 expected, 13 observed)and less than expected in wooded ravines (8 observed with 12.1 expected and none in the open areas.

Twenty pignut hickories were present during all three samples, nine were present during the second and third, and 8 were present in just the third. Thus 37 trees remained once

they had entered the population. Dying during the study were 1 after the first sample, and 3 after the second sample(one was present only during the sample, 1 for the first and second sample)This species did very well during the 30 years 19 entering the population, and only 4 dying.)

The pignut hickory was present in in all three wooded areas, not in any of the open areas. It is part of the oak/hickory forest typical of the climax forest of the area and found most often in the study area in flat woods.

Growth rates

16. Black locust. *Robinia pseudoacacia* (n=29)

Flat woods 20, Young woods 8, Big ravine 1

The black locust was mostly in the flat woods (n=20) but was also found in the young woods (n=8) and one was in the big ravine. Its distribution was very different than in the other species, Except for one Sugar maples Sugar maples Stree in the big ravine (seeds brought in by a squirrel or bird, or blown in?) The distribution of the species was not random (Chi square=19.7). It was significantly more abundant than expected in wooded ravines, less than expected in the big ravine, and about as expected in the other habitats.

Only 6 individuals were present in all three samples, 8 were present in samples 2 and 3, and one was present in sample 3 only. Four died after sample 1 and 10 after sample 2. 1 and 14. Thus 9 entered the population after sample 1 and 14 died after sample 1. The number of individuals present was 15, 24 and 15 This species tended to be dying out over the course of the study.

Except for the tree in the big ravine, all trees occurred in plots 2-10 and 311 and west to plots 8-11 and 6-12. This distribution suggests that these trees were planted at the edge of where the buildings are the for fence posts or for windbreaks.

Growth rate.

17. Sugar maple. *Acer saccharum* (n=25)

Big ravine 12, Wooded ravine 11, Flat Woods 1.

There were 17 sugar maples in sample 1, 16 in sample 2, and 17 in sample 3, averaging 17.3 in the 3 samples .There were 10 trees in all 3 samples, 3 in samples 2 and 3, and 5 in 3 only, Three trees died out prior to sample 2,and 4 prior to sample 3. Sugar maples held their own throughout the study. Eight trees appeared during the period of the study and 5 died. .Sugar maples held their own during the study

Habitats occupied by this species were big ravine (17), wooded ravine (50), and 2 in woods. There were none in the 3 wooded habitats. There were none in the 3 open habitats in the southeast corner of the property. Big ravine had significantly more trees than expected (17 present. 7.5 expected), and contained 68% of the trees in that habitat than expected.

Sugar maples were spread out in the area, so far apart that it was difficult to gather sap when we wished to demonstrate maple syrup production to our children. I

Growth rate.

18. Chinkapin oak. *Quercus muhlenbergii* (n=24)

Big ravine 17, Wooded ravine 5, Flat woods 2.

There were 24 chinkapin oaks in the study area. 16. 23. And 24 in the three sampling sessions. Thus this species slowly increased over the period of the study. Eight new trees were added over the original 16, making 24, all of them in the last sample. None died over the period of the study.

Distribution of the trees was significantly different from the expected (Chi-square =18.8), with significantly more than expected in the big ravine (17 versus 7.5 expected), less than expected in woods. None were in the open areas in the southeast corner. Nearly all of the chinkapins were in the northwest part of the study area, east to column 8 and south to row 9. One was in column 2 in woods, and one was in the most southern plot of column 11.

Growth rate.

19 . American Elm. *Elmus americanus* (n=21)

Big ravine 12. Flat woods 4, Young woods 3, Wooded ravine 1, Brush 1,

Four of these trees were in the previously cultivated area in the SE portion of the study area.

There were only 19 American elm trees in the study area. They were significantly more abundant in the big ravine than elsewhere with 12 of 21 trees (57.1 %). There were nine the first sampling Ten new stems were present in the second sampling, and one in the last sampling. This was an increase of 18 during this study. By the final sampling, two new trees occurred but 8 were lost leaving 8 trees at the end of the study. There was a major loss over the course of the study, with only 8 (38%) remaining at the end of the study; 13 (62%) had died. In the first sample there were 3 trees in the big ravine, with 10 in sample 2, and 4 in sample 3. In the second sample, there was a large increase in the number of American elms, doubling to 18. But by the third sample only 8 were left.

The largest American elm measured during the study was 19 inches dbh at the beginning of the study, but was already doing poorly, as it was only 28 dbh in the second sampling and was gone by the third. The greatest growth in any trees of this species were 3.5 and 3.4, and one these in of these in the previously cultivated area in the SE corner, one in flat woods. Average growth in the five trees in the second sampling was 2.6" dbh, and in the final sample was 1.1". Only 1 American elm was present in all three samples. It was in the flat woods and measured 12.4, 15.8, and 17.6 thus gaining only 5.2 inches in the 30 years (Ave = 0.17 " per year.

20. Black cherry, *Prunus serotina*. (n=18)

Flat woods 10, Wooded ravine 4, Big ravine 2, previously open 2.

This was a tree of the wooded habitats, only 2 being found in open habitat.

There were 18 Black cherry trees on site over the course of the study, 9 in sample 1, and 11each in samples 2 and three. Four trees were gained and 3 were lost in the second sample, and 5 were gained and 5 were lost in sample 3, giving a net gain of 2 over the course of the study.

There were 4 cherry trees in flatwoods in sample 1, 6 in sample 2 and 7 in sample 3. There were 2 in the wooded ravine in samples 1 and 2, and only 1 in sample 3. Cherry trees were in the previously open areas in samples 1 and 2, and only one in the third sample. The black cherry was found significantly more often in the flat woods than in the other habitats (Chi square = 4.7.

The largest trees seen during the study were 28.7, 26.9, 25.9, 25.6, and 24.6. Of these, 2 trees, (25.9 and 26.9) were present in the first sample but dead by the second sample. Tree 24.6 was present in the first sample at 24.5, but grew only 1.6 inches at the time of the second sample, and had lost 1.6 inches at the time of the third sample. Two of the larger trees were doing well; 25.6 entered the 12" class at 20 inches thus grew at least 5 inches in the first 15 years and 5.6 in the last sample.

Tree 28.7 was 14.9 in the first sample, 18.3 in the second (+3.4) and grew 10.4 to 28.7 in the last sample (this must be a mistake as this was about three times the growth, far more for a cherry than in any other sample).

Black cherry was spread thinly over the study area, but five were along the line previously cultivated, and 8 were in the southern part of the big ravine.

21. Big toothed aspen, *Populus grandidentata* (n=12)

Flat woods 7, Wooded ravine 3, Brush 1, Big ravine 1

This species was 21st in abundance with 12 trees present but they showed constant increase with 3, 7 and 10 in the 3 three samples.

Big toothed aspens were significantly more abundant in flat woods than in the other habitats with 7 of the 12 (58%) there, (Chi-square=15.09, 99% level). There were no significant differences between the other habitats, 3 in wooded ravines (25%) and one each (8.3%) in big ravine and brush.

There was some clustering, with 8 0f the 12 along the open area, 3 of the 4 remaining (75 %) were in a plot (13-10) west of the ravine and the one remaining was at the southern edge of the big ravine. That 8 of the trees were along the edge of the previously cultivated area suggests that this species may be an early successional invader of open areas.

22. Basswood, *Tilia Americana* (n=10)

Wooded ravine 6. Big ravine 4.

There were only 10 trees in the study area, 4 in the first sample, and 8 in the second and third samples. Seven new trees entered the population, and two died during the study. Six of the ten trees were in the wooded ravines (3 expected), 4 in the big ravine. There were were significantly more basswoods (Chi-square = _____ in the wooded ravines than in any other habitat. None were in the flat woods or in the

previously cultivated areas. There was little pattern to the distribution of basswoods. They were spread over the wooded portion of the study area, except there was none in the previously cultivated area.

Growth rates. One basswood occurred in all three samples, 16.1, 16.6, and 17.3 inches in the three samples. It thus grew only 1.3 inches in 30 years. It may have been dying. Two other basswoods grew 2.5 and 2.6 inches over a 15 year period. Basswoods were not doing very well in the study area, either in numbers or growth.

23. Black Oak, *Quercus velutina* (n=6).

Wooded ravine 4. Flat woods 2.

This was a relatively uncommon species in the study area, with only 6 individuals being included. One of the six in flat woods was one of the larger trees in the study area at 31.7 inches dbh. However, it was dead by the time of the last sample. (Check the size of the largest black oak- It is listed here as 31.7 on the sheet, but "almost 5 feet in the text.)

There were four black oaks in the first sample, six the second and 3 in the third sample. Thus there was an overall loss of 1 during the study.

Three of the black oaks were west of the Big ravine; the other 3 were in wooded ravines near the previously cultivated area.

Growth rates. The average growth rate in six trees was 4.2 inches dbh, but the largest growth rates over 15 year periods were 5.9 and 5.2 inches dbh. One was in flat woods and the other was in the big ravine.

24. Slippery Elm, Red Elm. *Ulmus rubra* (n=6).

Big Ravine 4, Wooded ravine 1. Flat woods 1.

There were only six red elms in the study area, but all were in woods, and all were present in the first sample. Two disappeared prior to the second sample, and three prior to the third sample, leaving only one in the final sample, but even this one was dying. This species seems clearly in trouble in the study area.

The six trees were pretty well distributed over the study area.

Growth rates. All the slippery elms were in relatively poor shape. The only two trees for which we had any growth data over 15 year periods measured 1.9 and 1.6, both probably because the trees were in relatively poor condition.

25. Black Gum. *Nyssa sylvatica*, (n=5).

Big ravine 2, Wooded ravine 2, Flat woods 1.

There were only 5 black gums in the study area. Four were present in the 1st., second, and third samples. One dropped out, and one entered the population prior to the third sample. All were in the wooded areas, none in the previously cultivated areas.[1]

All five Back gum trees were in the north central part of the study area, in rows 3 to 6 and in columns 3 to 10.

Growth rate. Only 2 of the trees had somewhat usable measurements. One had measurements of 16.5, 18.5 and 20.1, the other 19.5, 20.3, and 21. 4. Thus the two had growth rates of 3.6, and the other 1.9 over 30 years, which indicates this species is not doing well in the study area.

26. River birch. *Betula nigra*. (n=4).

Big ravine 2. Brush 2.

There were only 4 River Birch in the study area, 2 in the big ravine and two in the brushy field. One was present in the first sample, but had died out by the third, and three entered in the second sample, one of which died out by the third; the other two remained into the third sample.

As for distribution, two of the trees were in one plot in the brushy field, the other two were in column 2.

Growth rate. Only one of the trees had a usable growth rate, 4.9 over 15 years.

27. Cottonwood. *Populus deltoides* (n=1).

Big ravine 1.

The single cottonwood was in the southern end of the big ravine. It was present in the first sample at 2,2 inches dbh, and in the second sample at 17.4, but was dead by the third sample.

Growth rate. The single cottonwood grew 1.9 inches in the first 15 years, but had died by the third sample, thus I suspect that this rate was much less than would be expected.

28. Honey Locust. *Gleditsia triacanthus*. (n=1).

Big Ravine 1.

The single honey locust was in the big ravine and was present in the first sample (15.2) and grew 2.2" to the second sample (17.4). It died prior to the third sample.

29. Hop Hornbean. *Ostrya virginiana* (n =1).

Wooded ravine-1.

The single hop hornbeam was on the upland area just above the big ravine. It was 12.8 in the first sample, and was still 12.8 in the second sample which indicated that it was dying. And it was dead in the third sample.

30. Shellbark Hickory. Carya laciniosa (n=1)

Big ravine-1

The single shellbark hickory was in the big ravine. It was 15.7 in the first sample, grew 1.4 to the second sample (17.1) and another 1.7 (18.8) in the third sample. The total growth was 3.1 in the 30 years.

31. Black Willow, *Salix nigra.* (n=1)

Big ravine – 1

The single black willow was in the big ravine. It entered the population in the second sample (12.4) and grew only1.7 and was 14.1 dbh in the third sample. The slow growth rate was probably because of competition from the larger trees around it.

32. Apple. *Pyrus malus*. (n=1).

Flat woods-1

The single apple tree was in the flatwoods right next to the road. I suspect that somebody had thrown an apple core out the window there. It entered the population of trees in sample 2 but grew only 1.9 inches dbh (12.4 to 14.6) to the third sample. The low growth was probably from competition from the larger trees around it.

DISCUSSION

The study area is in an oak Hickory forest. The most abundant tree is the tulip tree, but the area includes 5 species of Oak as follows, Red oak (n=221) , white oak (n=187), pin oak (n=56), chinkapin oak (n=24),and black oak(n=6) total 494 individuals The hickory species also total 5,as follows:, Red hickory (286), Shagbark hickory (206), Bitternut hickory (72) pignut hickory (41), and shellbark hickory (1). The number of individual hickories total 606. Thus the oaks and hickories total 10 or about 1/3 of the species of the species, and 1100, or about 20.5 or 1,5th of the individuals (Check total number of species studied, (32 or 33???)

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[1] cpn