02. Site Issues:

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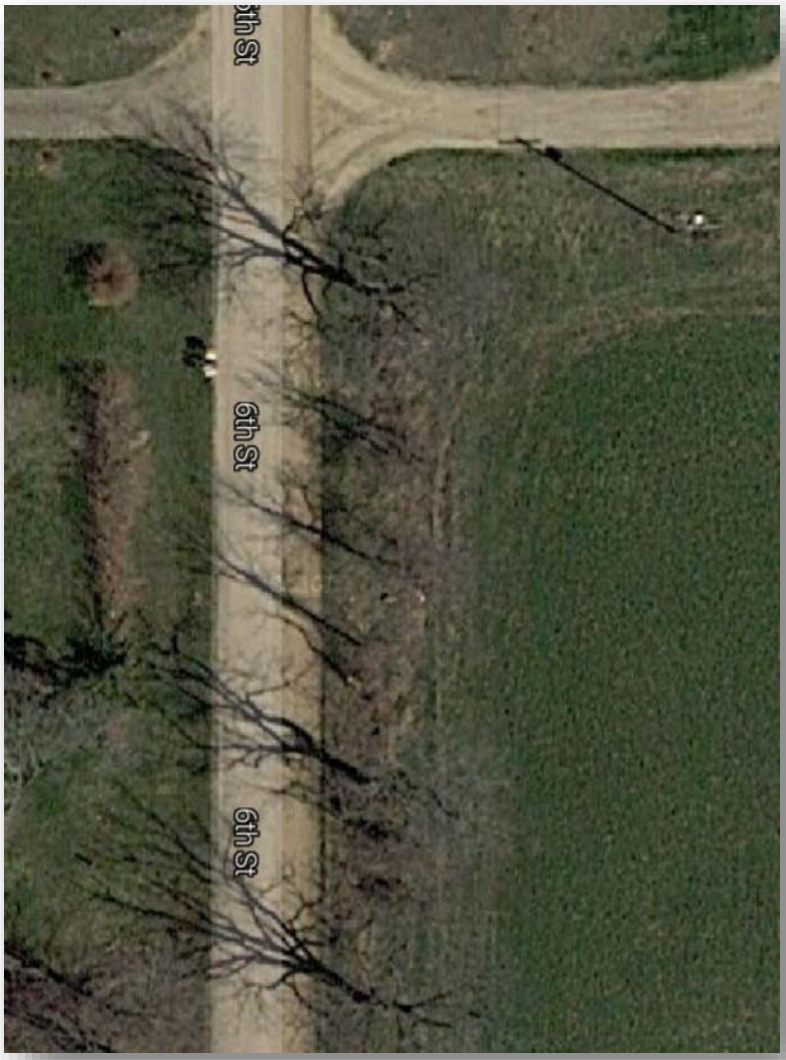
We didn't promise that we would explain how to grow veneer black walnut just anywhere. There are great sites, impossible sites, and everything in between. The good news is that there is help available to analyze a proposed black walnut site. There is no point in starting out blindly. A poor site guarantees failure. A good site allows (but doesn't guarantee) success. The site sets the high limit of possibility.

Black walnut trees are outstanding mechanical engineers. Their main businesses are collecting sunlight and reproduction. They waste no extra structural material (wood) than is necessary to withstand wind and ice storms. They hold onto the planet by a large gravity root-ball. If they can't amass a large root-ball, they refuse to grow tall and vulnerable to upset.



Foresters have observed the ratio between the limited tree height and usable soil depth. The limited tree height (in feet) at age 50 is called "Site Index 50", or just "site index". It can be measured by a soil expert before any tree is even planted – amazing! You may have heard of Site Index, but need some convincing, so here is a short story:

When my father came home from World War I in 1919, he planted a row of black walnuts along the road. I well know from digging fencepost holes that we had a hardpan just below plow depth. Now after 100 years, these trees are completely successful, reproductively (their business), but only 35 feet tall – fat and ugly – unnoticed by a passing logger.

Figure 1. The shadow of a 35' power pole (upper right) and my Dad's 100-year-old black walnut shadows –about the same height.

Bedrock, water-table, and hardpan are examples of root impenetrable soil layers. If you can't grow tall trees, it is clearly better to grow something else with shallow roots. One exception might be to break up a hardpan before planting. Experiments are underway using a backhoe near Purdue University, and with a sub-soiler by Casey Calvert in Illinois. Results are several years away. Beware; some trusted advisors say that it won't work. You're on your own here, and the problem doesn't show itself during the early years of growth.

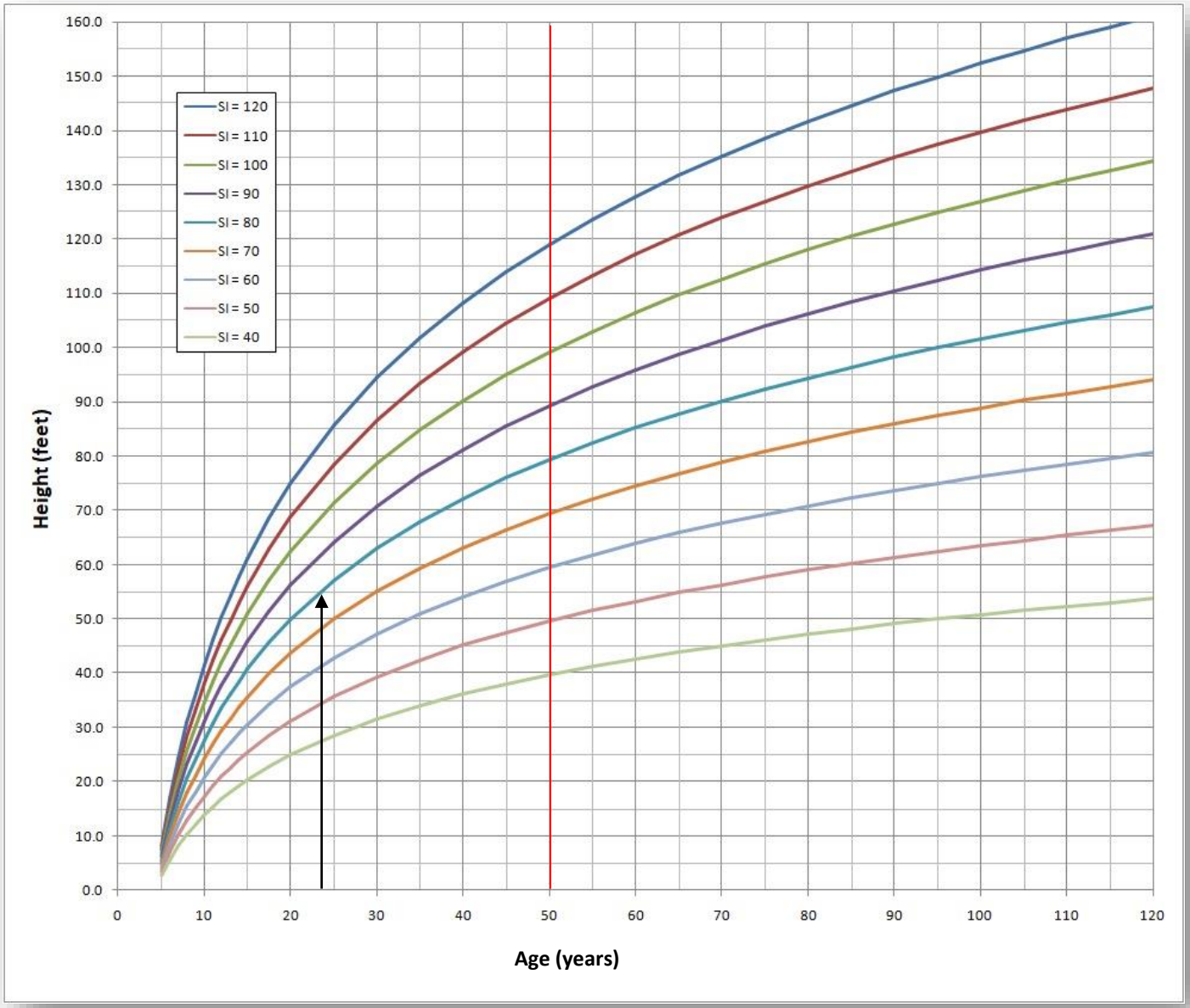


Figure 2. Black walnut growth curves for various site indexes (SI)

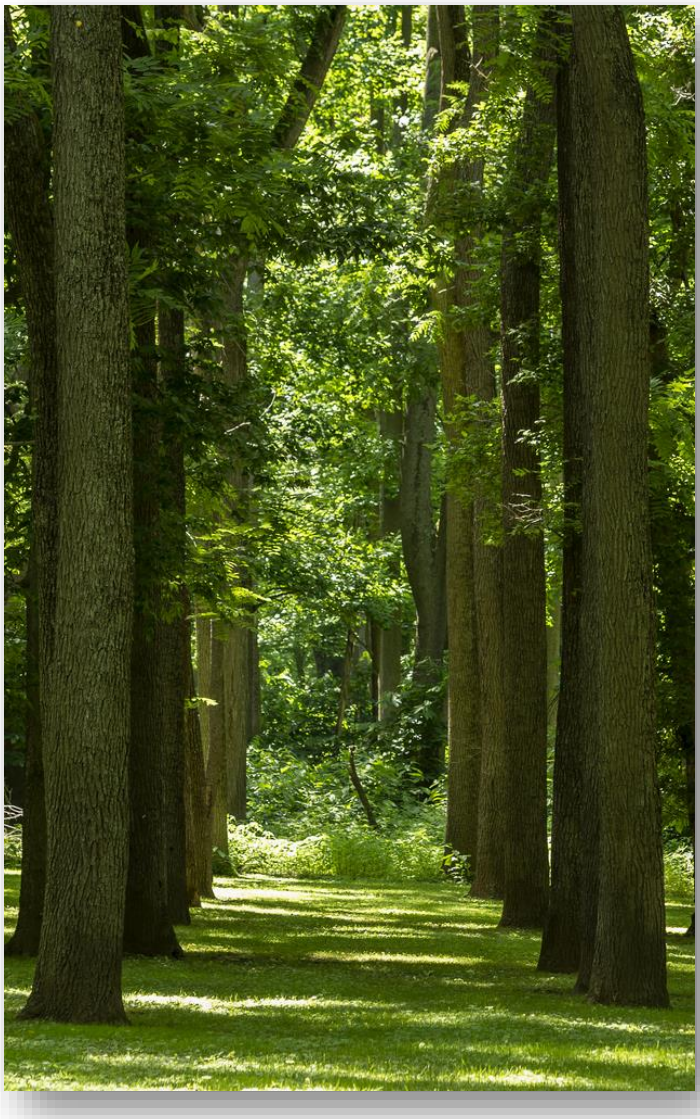
If you have black walnut trees over 10 years old you can measure their height and use the chart above to determine the site index. This is an expensive but accurate way to find the site index – and completely too late. For an example, our 23 year old monoculture plot is 54 feet tall (black arrow), so

that site index (50) is right on the 80 line. Those trees should grow about a foot a year up the blue line to 80 feet tall at age 50. For more details on black walnut site index, see Appendix B of this chapter.

Before we get down to possible sites, let's dispense with some unsuitable topologies. Black walnut is a lowland species, and wants the same ground that farmers want. Farming your good land and growing black walnut on your bad land is a clever idea, but alas it won't work! Highland sites are oak/hickory environments. Our loggers, whose family has been in the logging business for at least two generations, informed us that they have never cut a decent black walnut from a highland site. A black walnut tree may manage to stay alive on an upland site. It will grow feebly, with poor resistance to a multitude of enemies.

Figure 3. Our beautiful highland black walnut planting – 2006 - A perfect failure!

In another case we had many older black walnuts on a terrace pasture. They were in poor health, suffering from a host of defects. I called our regional forester and asked him what's wrong with them? He said "There're off site." - - - short answer.



The actual problem is underground – mainly shallow usable soil depth, which only a soil scientist with their x-ray vision can see. So highlands, terraces, and probably steeper slopes are unsuitable. That leaves bottom land, but not even all bottom land is suitable.

We want to grow big veneer trees and we want them to stay upright. Big trees need big root balls to support them mechanically and biologically. Black walnut is a deep rooted species, and it will not get tall with a shallow root system no matter how wide it might get. Shallow rooted black walnut trees may stay alive and happily cover the ground with nuts, but their overall size will be suppressed.

Soil scientist us the term "Depth to Restrictive Layer" (DRL). All sorts of things can form a restrictive layer: hardpan, bedrock, water table, pure sand, dense clay, and compaction. It is not just a penetration issue; new root growth needs moisture, aeration, and nutrition every inch along the way. That's why pure sand is a barrier.

Figure 4. Imagine what it takes to hold these giants upright!

Now let's back up to site index. Many factors determine tree's height, but soil depth is the main influence. From our brief experience, I have a low quality equation in my mind that says:

Site Index$_{50}$ (feet) = 27 feet + DRL(inches)

So a site with 30 inches of usable soil depth has a site index of 27 + 30 = 57 and should grow black walnut to 57 feet height in 50 years. A site with 60 inches of usable soil depth will grow black walnut to 87 feet at age 50. My dad's hardpan at 10 inches gives a site index of 37 feet. Incidentally, my dad's soil grew good agricultural crops. Those crops did not need the soil depth that big trees need. It is hard to judge black walnut site suitability from weeds or even young black walnut trees. The trouble hits, when the trees want to get big. If you can't find a soils expert, dig a hole.

We have planted and replanted a heavy grey clay area in a river bottom site many times, and finally gave up. Looking over the fence from our plot of crooked walnut dwarfs, we could see our neighbor's beautiful soybean crop on the extension of the same soil type. We wasted 20 years of good agricultural crop income while this lesson was slowly sinking in. Clay soils can be good walnut sites, but not if the clay content percentage is so high the soil stays saturated (no percolation).

Another site issue is "hydric" (saturated, anaerobic, swampy) soils. These conditions are fatal to black walnut, but might be corrected. First the source of the water must be determined. Is the water source from underground (springy), or run-off ponding (poor surface water drainage)? The first is attack by tiling, and the second by ditching, diking, and berming. If the correction doesn't match the cause, it will not work - an expensive and unnecessary lesson – exactly what we want to avoid. Tiling for trees is not like tiling for corn. The tile would need to be deep and closely spaced – most likely a bad economic idea.

Figure 5. A bermed and ditched planting on a soil site that was hydric from surface ponding – 2014. Trees have started out well, but vigor problems started showing after 7 years. Now I dug holes and the water table is around 2 to 3 feet – Duh!

Figure 6. A damp black walnut site

There are not many agricultural crops I can think of that would be happy growing on the above site. This site was planted in 1970 and replanted 4 times because of weeds. We finally got the black walnut planting to survive in 1980. We have exactly one tree from the 1970 planting. All the others are from the 1980 planting. The problem was not the annual flood water, but the weed seed that the flood water brought in and nourished to giant heights. We have smoking-gun proof that black walnut seedlings cannot survive enclosed with 16 foot giant ragweed (a West Virginia Big Weed champion) and 3 inch DBH pokeweeds (also a West Virginia Liar's Club entry). It is easy to plant seedlings in March – not so easy to crawl in on your hands-and-knees in 90 degree July and (first find your little babies) then give them some daylight with a hand sickle. Anyway, that is how we finally got them started in 1980. There must be a better way. Once they are as tall as annual weeds can grow, they have won the battle!

The area floods once or twice a year and is submerged for 4 days each time. Each flooding leaves behind a half inch of new rich soil (mud). These trees have no visible buttress. Their buttresses, if any, are long buried.

A beautiful black walnut tree here suddenly died, and here is why. This is a long narrow 1.3 acre plot, and I brush hog the big weeds at least once a year. The plot comes to a point on one end and I always made my tractor turns around that nice tree. All that traffic compacted the soft soil and suffocated the roots of our beautiful tree. Normally, the cracks in this drying mud allow the roots to aspirate. The tractor and I packed it air tight.

Figure 7. Dried mud shrinks developing cracks that would otherwise suffocate the tree roots

We have now crossed off many potential sites as suitable for reasonable black walnut growing. We are down to deep well-drained bottom land soils, which is often written and often naively ignored. One piece of good news is that soil chemistry is usually an insignificant issue. This is very good news, because texture, chemistry and pH are almost impossible to artificially change down to a tree's usable soil depth. If trees can survive early conditions, they will slowly improve their underground environment, textural, chemical, and microbial.

Summary:

1. Prime farmland –no problem if deep and well drained
2. Less then 4 feet of usable soil depth – better try something besides black walnut
3. Hydric saturated site – might be corrected – but very doubtful
4. Highland site – better try something besides black walnut
5. Occasionally flooded site – ideal, but difficult to get plants started.
6. Black Walnut Site Index below 70 – consider other species

I have noticed that the more experienced a forester is, the stronger the sermon on site issues. Their warnings cannot be strong enough. I poor site will eventually defeat your grand plans, no matter how much personal energy you are willing to invest. Growing these trees is a life-long investment, maybe 2 or 3. Soil science is a complex and mature science and help is a phone call away. The Natural Resources Conservation Service has employees in every county. Engaging a soils expert is step 1.

Breaking News! The NRCS soils site https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx has black walnut site index$_{50}$ and/or a black walnut suitability rating for some states – MO and WV for sure. For technical details on how the suitability ratings are developed, see Appendix A. (I would still ask for "boots-on-the-ground" advice.

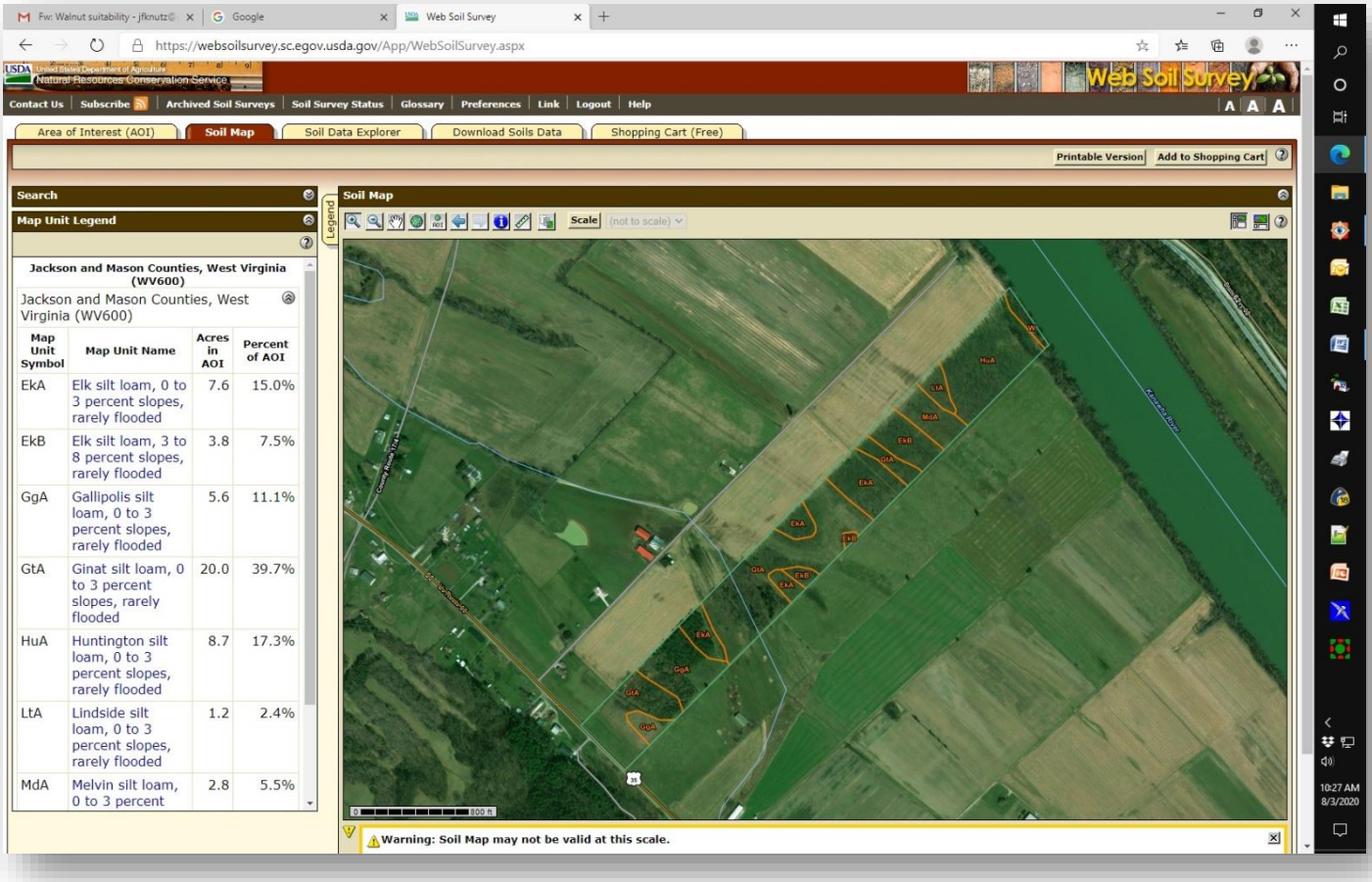


Figure 8. A screen capture of the web oil Survey website.

Appendix A Black Walnut Site Suitability

The black walnut suitability algorithm is described in a technical paper by Douglas C. Wallace and Fred J. Young. https://www.nrs.fs.fed.us/pubs/gtr/gtr-p-24%20papers/64wallace-p-24.pdf The paper does not say suitable for what purpose, but the objective is obviously timber. Black walnut may stay alive on an unsuitable site and fully meet some other objective, like wildlife mast, livestock shade, or aesthetics, but not timber. I'll gloss over some details, but show the main issues using both metric and English units. There are 4 show stoppers anyone of which will not only disqualify the site for black walnut suitability, but assure tree death.

1.	Soil depth to restrictive layer	<50 cm	*<20 inches*
2.	Flood duration	>7 days	
3.	Available water capacity	<7.6 cm	<3 inches
4.	Water table depth in April	<15 cm	<6 inches

If the soil just squeaks by one of these, the prospects are still bleak. There are 3 major and 5 minor soil attributes that add up to a suitability score. The majors are weighted about 3 times more than the minors.

MAJORS:

1.	Soil depth to restrictive layer	smooth curve	50 to 150 cm	20 to 60 in.	0 to 1
2a	Soil texture (clay)	two steps	<35% to >50%		1 to 0
2b	Soil texture (sand)	steps	<60% to >90%		1 to 0
2.	Take the lower of 2a and 2b				
3.	Available water capacity	smooth curve	0 to 35 cm		0 to 1

MINORS:

1.	pH	smooth curve	<4 to 6.5 to 7.4 to >8.5	0 to 1 to 1 to 0
2.	Rock fragments	smooth curve	0 to 35%	1 to 0
3.	Flood probability in May	two step	<5% to >50%	1 to 0
4.	Landform		Ridge/shoulder = 0 Backslope = 0.33 Footslope/terrace = 0.67 Floodplain = 1	
5.	Historic vegetation		Upland prairie = 0 Floodplain/terrace prairie = 0.33 All mixed forest and prairie = 0.67 All forest/woodland = 1	

The 8 scores are weighted and added such that the final suitability score goes from 0 to 1. The final score is then translated to 6 textual ratings from "unsuited" to "very well suited". The WebSoilSurvey website shows the rating for each soil type along with the suitability score and the problem issues.

Appendix B Black Walnut Site Index Equations

Some soil scientists like site suitability better than site index because tree height can be somewhat influenced by surrounding trees. Other soil scientists like site index more because it is numeric and field measurable (see Appendix C)

There are several candidate formulas to describe the growth of black walnut tree height. The best black walnut height data I could find was in a paper from the Checz Republik. The formula that best fits the Checz data above age ten is logarithmic as reported by Kellogg et al. Regressing and converting to our quaint U.S. units gives

$$H = S_{50} * (0.40435 * \ln(A) - 0.58182), \quad (1)$$

where H is the black walnut tree height in feet, S_{50} is the site index, and A is the tree's age in years. Equation (1) was used to create the chart curves shown earlier in this chapter. The equation rapidly becomes nonsense below age 10 and goes all the way to minus infinity at zero. So, using equation (1) at age 10 and interpolating for lesser age gives

$$H = 0.0349 * S_{50} * A \quad (2)$$

for ages under 10 years. These two formulas (with a breakpoint at 10 years) can be used to make black walnut site index chart curves. To measure site index from age and tree height, the two formulas need to be inverted. The result is shown as a table in Appendix C.

This photo shows a wet area in the center of our planting. The water table approached the surface at the center of the picture, and is a mirror image of the black walnut tree height

Appendix C Black Walnut Site Index Measurement from Tree Height

For ages 1 to 149, the table below gives the multipliers to change the current height to the probable height at age 50, i.e. the Site Index, S_{50} .

Example: In an area, 23-year old trees measure 50 feet tall. From the table below, the multiplier for 23-year old trees is 1.46, so 1.46 times 50 feet is 73 feet at age 50, and so the area has a 73 site index.

Incidentally, we have had very erratic results from measurements before age 10.

Age(years)	0	1	2	3	4	5	6	7	8	9
0		28.63	14.32	9.54	7.16	5.73	4.77	4.09	3.58	3.18
10	2.86	2.58	2.36	2.20	2.06	1.95	1.85	1.77	1.70	1.64
20	1.59	1.54	1.50	1.46	1.42	1.39	1.36	1.33	1.31	1.28
30	1.26	1.24	1.22	1.20	1.18	1.17	1.15	1.14	1.12	1.11
40	1.10	1.09	1.08	1.06	1.05	1.04	1.03	1.03	1.02	1.01
45	1.04	1.03	1.03	1.02	1.01	1.00	0.99	0.98	0.98	0.97
50	1.00	0.99	0.98	0.98	0.97	0.96	0.96	0.95	0.94	0.94
55	0.96	0.96	0.95	0.94	0.94	0.93	0.93	0.92	0.91	0.91
60	0.93	0.93	0.92	0.91	0.91	0.90	0.90	0.89	0.89	0.88
65	0.90	0.90	0.89	0.89	0.88	0.88	0.88	0.87	0.87	0.86
70	0.88	0.88	0.87	0.87	0.86	0.86	0.86	0.85	0.85	0.84
75	0.86	0.86	0.85	0.85	0.84	0.84	0.84	0.83	0.83	0.83
80	0.84	0.84	0.83	0.83	0.83	0.82	0.82	0.82	0.81	0.81
85	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.80	0.80	0.80
90	0.81	0.81	0.80	0.80	0.80	0.79	0.79	0.79	0.79	0.78
95	0.79	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77
100	0.78	0.78	0.78	0.77	0.77	0.77	0.77	0.76	0.76	0.76
105	0.77	0.77	0.76	0.76	0.76	0.76	0.76	0.75	0.75	0.75
110	0.76	0.76	0.75	0.75	0.75	0.75	0.75	0.74	0.74	0.74
115	0.75	0.75	0.74	0.74	0.74	0.74	0.74	0.73	0.73	0.73
120	0.74	0.74	0.73	0.73	0.73	0.73	0.73	0.73	0.72	0.72
130	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
140	0.71	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69