03. Monoculture:

J. F. Kelsey - - - 2025 Feb - - - Rev 15

If you have read this far, we can assume that your intention is to grow black walnut trees as an agricultural crop with an eventual harvest. Chapter 1 explained **WHY** grow veneer quality black walnut. Chapter 2 explained **WHERE** black walnut likes to grow. This chapter will explain **HOW MANY** to grow. If a good site is available and a black walnut project is going to proceed, then to maximize the returns the plan should be intense. If black walnut is a good idea, then lots of black walnuts (a monoculture) seems like a better idea.

SPECIES	REGION 1	
	$/MBF	(# RPT
Walnut	$928.41	9
White Oak	$407.12	11
Red Oak	$296.83	11
Other Oak	$310.23	8
Cherry	$375.49	9
Hard Maple	$258.81	11
Soft Maple	$228.84	10
Ash	$188.34	8
Yellow Poplar	$133.31	11
Basswood	$75.97	4
Hickory	$151.21	7
White Pine	$67.86	2
Other Pine	$70.00	1
Other Hardwood	$44.56	2

If your available black walnut site is abandoned, it will become populated with explorer tree species like box elder and sycamore - mostly "Other Hardwoods" in the stumpage price report at the left. Forest surveys show about 2% black walnut in states within its natural range. So, a rough price for the timber mixes on an abandoned site is:

2% * $928 + 98% * $45 = $62/mbf

In contrast, the standing timber price for a black walnut monoculture is:

100% * $928 = $928/mbf

The advantage of a black walnut monoculture is a factor of 15 over the results of doing nothing.

Figure 1. West Virginia Stumpage Price Report, March 2018 for standing timber.

Figure 2. The author's 1995 black walnut monoculture planting after trainers have been removed

Our agricultural objective is to convert sunshine into beautiful brown veneer. If we up the percentage of black walnut from 2% to 100%, we'll get 50 times more of the valuable product. Do you know a farmer whose corn field is only 2% corn plants? Black walnut monocultural plantings have been demonstrated as a workable approach on hundreds of plantings for hundreds of years. You might think of your property, not as acres of dirt, but square feet for solar capture. To optimize this crop, all your square feet of solar energy should be captured by black walnut foliage.

The advantage of growing a monoculture sounds too good to be true. It is probably a little short of true. Growing a monoculture opens the door for some problems. Read on.

REASONS FOR A MIXED SPECIES PLANTING

1. Mixed species is nature's way. A mix takes less effort than a monoculture. That's what you'll get if you do nothing. There must be a synergy advantage between species, even if we don't understand it. A longtime proponent of dense mixed direct seeding is Larry Krotz from northern Iowa. You can read the story of his experience at: thescalepit.com/ContentBW/MLF.htm

2. Some species out-perform others on various sites. One approach on a complex varied soil site is to plant a dense species mix and let them duke it out. Let each species find its niche. A good hickory is worth more than a stunted black walnut. This mixed approach will be slow, but more accurate than soil test or a soils map. Trees are geniuses at analyzing soil and climate.

3. Trainer species might he chosen as valuable backups, anticipating failure with black walnut.

4. One risk for a monoculture is that an invasive pathogen comes along and wipes out black walnut, as has happened with chestnut, elm, and ash. This would be a total disaster. If the black walnuts were part of a species mix, it would only be a partial disaster. We have used several species of trainers, but in each case plan to end up with a black walnut monoculture. No alternative is completely safe. We are taking the risk. Farming never has been a sure thing.

Figure 3. A natural mix of hardwood and conifer species

THE PROBLEMS WITH MONOCULTURES?

Why is a Monoculture Hard to Maintain? How come nature wants so many different species?

To understand why natural forests, look like figure 3, it might help to go back to the basics – way back and very basic (stay calm, there's no math and this relapse will eventually bring us back to black walnut monocultures).

A 1950 Princeton University department of mathematics grad student, John Nash, in his PhD thesis, gave a proof that for an N-player game there exists at least one equilibrium of strategies. This area of mathematics is known as game theory, and this situation has become known as the Nash Equilibrium.

In my barnyard language: When a game has reached a Nash Equilibrium, any player changing strategy will make things worse in total for all the players. Put another way, a Nash Equilibrium is a mix of strategies that maximizes total rewards. I'm sure my definitions are not rigorous, but it captures the essence. Nash's thesis is 27 pages long, and I only made it to page 3.

Prior to Nash, game theory focused on two player win/lose scenarios, where one player's gain equaled the other's loss—a "zero-sum" game. Nash expanded the field by proving that compromise and cooperation could yield a "win-win" scenario - - - a "positive-sum" game.

Figure 4. John Nash

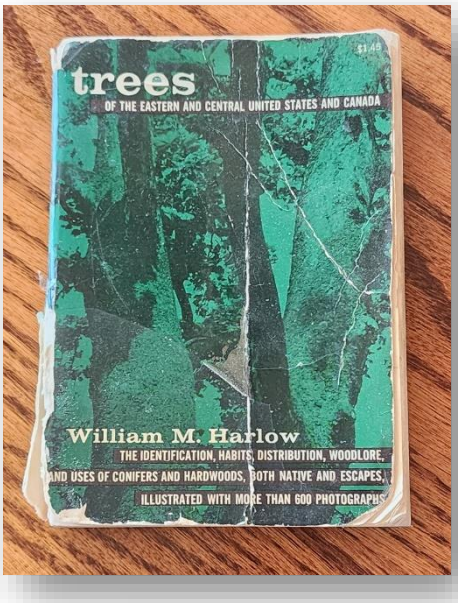
His proof is rigorous and purely mathematical, just a bunch of letters, so it should apply universally, not just in poker and other games. It is true for bacteria, and true on exoplanets. Since 1950, the Nash Equilibrium has led to advances in understanding in many fields of study. I won't bother you with a list, but his 1950 proof did eventually win Nash the 1994 Nobel Prize in Economics. (The reason for the 44-year delay is worth a book in itself. (*A Beautiful Mind* by Sylvia Nasar)

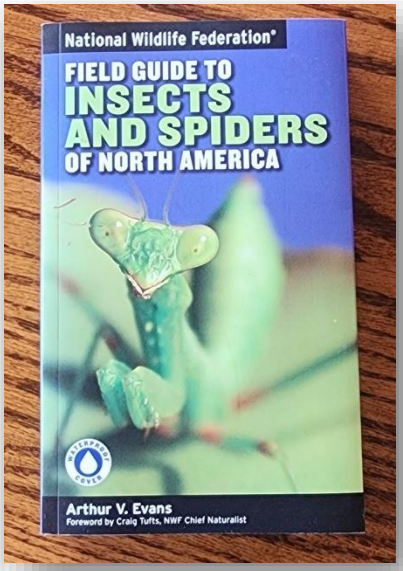
Figure 5. A natural mix of forest species

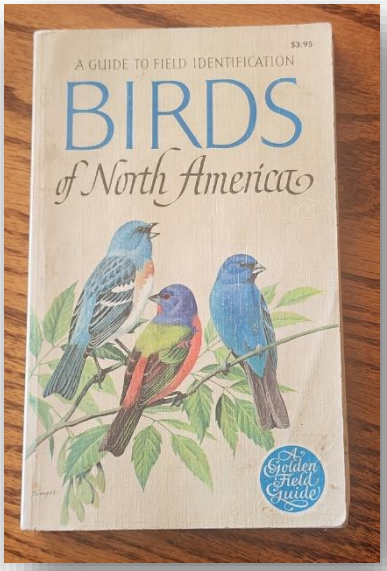
Ecological Implications of Nash Equilibrium

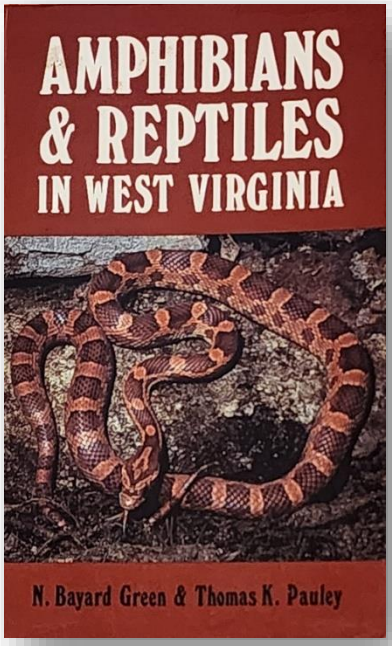
Everywhere we look, we see mixtures, governments, religions, birds, fungi – the list goes on. In the ecology game, the reward is reproduction. Why doesn't one species wipe out all its competition, because compromise and cooperation generally outperform zero-sum thinking? Consider a Michigan pond or the Serengeti Plain, if the species mix is stable, then that ecosystem is in a Nash Equilibrium - a cooperative species mix. In equilibrium, if any one species unilaterally changes its competitive strategy, things get worse in total for all players. The rewards for the single changing species may increase, but the total rewards for the other players will be bigger and negative. Nash's proof doesn't say what connections and forces keep things in balance. It doesn't specify how fragile the equilibrium is, or who the key players might be. Mathematically, it doesn't matter, but we know connections and forces exist, whether we understand them or not.

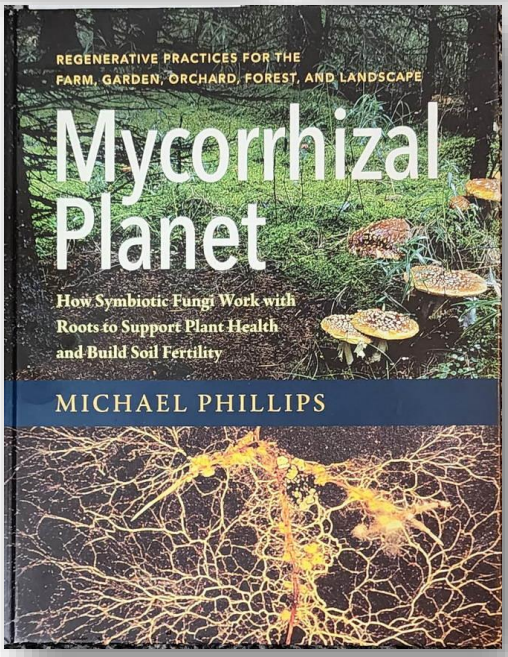
The zeroth law of ecology says “Everything is connected to everything” - fully connected – that’s a safe guess. We can identify some of these balancing forces. For example, one species’ excessive reproductive success can lead to its starvation or drowning in its own waste.











Nash vs. Monoculture

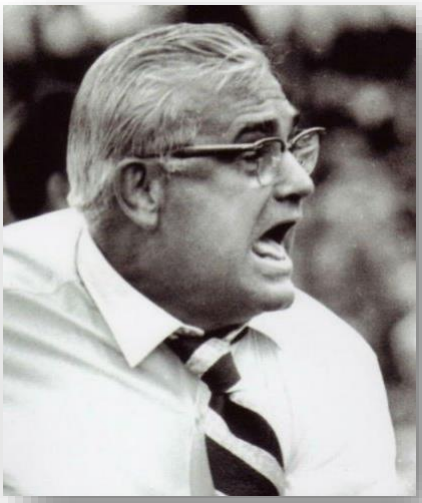
Before European colonization, North American temperate forest species mix was in Nash Equilibrium. Get out your tree book, your insect book, your bird book, your amphibian book, and your mushroom book. Count up how many players there are in the forest game. How many food chains? How many niches? How many connections? What is the effect of a disturbance? As forester, Jim McKenna, says: “You think rocket science is tough?”

Forest surveys find black walnut at just 2% of the forest species mix. Now we are proposing to grow a 100% black walnut monoculture. We are going up against Nash's invisible forces. We will tear up everything and make a pure black walnut planting. By eliminating the diverse ecosystem, we are unknowingly creating a multitude of empty niches. Everything except black walnut will be against us. Every time we turn our back; the old gang will charge back to claim their old empty niches. The ecosystem will try to get slowly back to the 1492 species mix. A black walnut monoculture can be made to work, but be aware; it will demand attention, with human and petro-energy input.
By introducing a trainer species, we are making a "biculture" rather than a monoculture. The addition of another species should make our battle with Nash forces a little easier. Actually, the addition of another species has a surprisingly large effect. Though the precise reason for this may not be clear, the practical benefits are welcome and undeniable.

The Forest Game

Before returning to black walnut, let's ponder a bit more about the implications of the Nash Equilibrium. Several conditions underpin the proof, which I'll cover in my usual courageous style.

1. The T-Ball Law: **All the players want to play.** Named after the sand-lot game for 4-year-olds, this principle asserts that every player in the game wants to participate. In the forest game the reward is reproduction and all species must strive to stay alive and reproduce. Can you think of a living organism indifferent to survival or reproduction? Not wanting to play in ecology quickly leads to extinction. Sexual indifference is seldom passed on more than one or two generations.

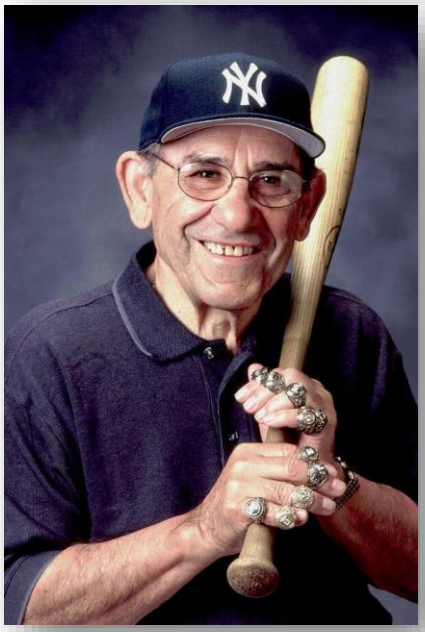


Woody's Corollary: **Winning is folly**

Originally, I phrased the first law as "All the players want to win," but over-competitiveness can ruin the game. A species that cares too much, seeks to dominate, disrupts the equilibrium, worsening the total conditions for all. There is a tricky line between wanting to play, and wanting to win. This principle is named after Ohio State football coach Woody Hayes. He had had a very successful career, but remember Woody's infamous punch? The university fired him. He wanted to win too much and went over the line. The act overshadowed his accomplishments.

2. von Neumann's Law: **Everybody matters.**

Named after mathematician John von Neumann, this principle emphasizes that all players' rewards matter. If only one of the players is considered, it is something else, not game theory. This often happens. The one player simply tries to destroy all the competition. It's a way to make enemies fast. The situation is unstable unless that player completely succeeds in making a monoculture. How rare is that? It is not rare to try, but it is rare to succeed.



3. **Yogi's Law: It's never over.**

What is an equilibrium anyway? An equilibrium is something that goes on and on and on forever. New York Yankee catcher, Yogi Berra's, famous quip is, "It ain't over 'til it's over." Real-life games are nothing like sport games. In real-life games there is no referee, and no end-of-game buzzer. When we realize the forest reproduction game goes on forever, some things become obvious.

a. We can show that in equilibrium, every player is a winner. No player can be a loser, simply because the game goes on forever. No bankroll can be big enough to support losing forever. In ecology, the reward is reproduction. All players have to reproduce (win) to stay in the game forever. All loser species are no longer in the game, extinct long ago.

b. Who are the actual players in the forest's reproduction game? A tree can't be a player, simply because it only lives a couple of hundred years, not forever. The tree's species is the player, but a species is just a concept. The only physical part of a species that endures over generations is the species' genetic package. Within a species' genome is its set of thousands of genes that define the species. Each gene can have different flavors, alleles, like the human gene for eye color which has blue and brown alleles. So, the actual player in the forest reproduction game is a species' gene set with all its alleles. You think rocket science is tough?

Aggregate Players:

The zeroth law of ecology says "Everything is connected to everything", but some connections are stronger than others. Black walnut teams up with squirrels. They help each other. Black walnut also teams up under ground with Mycorrhizal, trading sugar for minerals.

Sometimes the connections are so tight that species "a" can only survive symbiotically with species "b". In these cases the joined species compete together in the forest game as a player.

Figure 6. The countries of Africa

Examples of Nash Equilibrium:

I know I'm drifting afar from growing black walnut trees, but I want to give a couple of examples in case you are not convinced of the universality of the Nash Equilibrium.

There are 54 countries in Africa and 44 countries in Europe (I just Googled it). If their borders are stable, they are sort-of in equilibrium. Occasionally some leader comes along, like Alexander, Caesar, Napoleon, Hitler, or Saddam who want to dominate (violate Woody's corollary). They could win a battle or win a war, but that is just an event, like a lion making a kill. Yogi's law says it's never over. It takes energy to maintain a system out of balance - - - maybe infinite energy to maintain it forever. The bad guys just can't keep it up. Nash is like a weak magnet that wants to have lots of players with different strategies – different countries with different cultures. Lately the news networks have been amplifying alarm about our differences with China, but for stability we need differences. We need China to be China. Not many of our leaders understand Nash or even Woody's Corollary, but a few can see the big picture. Bush 41 stopped at Iraq's border, and Harry Truman rebuilt Germany and Japan, making allies out of enemies.

I'll give a second example in the form of a homework problem. This is a hard problem. It might take the rest of your life to work out. Here it is: Contrast the Old and New Testaments, by determining, for each lesson given, if the lesson is in alignment or contrary to the Nash Equilibrium. Hint: Blessed are the peacemakers.

Sorry for the detour. Now back to Walnuts.

The Black Walnut Game, A Game Within a Game

A black walnut tree is a structure the species' gene-set constructs for facilitate and defend the gene's dangerous journey to the next generation. The fact that we like the looks of black walnut lumber is completely accidental. All black walnut trees have the same number of genes in their genome. But all black walnut trees are not alike. There are plenty of differences – another game - a black walnut game within the forest game? Yes, the alleles compete. They want to survive and reproduce. They can go on forever and a single species' allele mix can be in their own Nash Equilibrium. One allele set doesn't dominate. The allele mix is huge and stable.

This does not mean that the gene in a particular individual possesses more than two alleles. An individual can only have a maximum of two alleles, one maternal and one paternal, no matter how many alleles exist in the species population. For instance, Dr. Shawn Mehlenbacher has found 30-some alleles for a hazelnut gene that prevents self-pollination, but hazelnut cultivar Geneva, only has alleles #15 and #23.

I think of a wild species as a many-dimension fuzzy cloud of genes and all their available alleles. Breeders try to reshape the cloud in some direction. They select alleles that produce desirable traits, and try to make a domestic cloud at the edge of the wild cloud. As an example; Auroch are the original wild bovine species (now extinct). By selecting part of the Auroch cloud, early breeders made the dairy cow. By selecting part of the dairy cow cloud, breeders made the Holstein cow. But Holsteins are not all alike by any means, and Holstein's cloud snipping continues. All this effort doesn't change the number of genes in the resulting genome. It's all about isolating a desirable subgroup of alleles from the edge of the allele cloud.

Figure 7. A Holstein

Remember the first law of ecology? "Everything is connected to everything." A wild species, like black walnut, is "chemically aware" of all co-evolutionary species in its ecosystem. Trees have long ago determined which neighbors were foes or friends and evolved defenses or attractants to live with them. It is likely that the wild black walnut cloud has alleles to produce a chemical defense against wooly mammoth browsing. The reason a wild species' allele cloud is so incredibly diverse, is because its ecosystem is incredibly diverse. There is strength in a species' diversity. A forester told me that one weird ash tree in a thousand is resistant to emerald ash borer, and they will come back in 2000 years. Only 20% of humans were susceptible to covid 19. If we were all clones of a 20 %er, it could have wiped us out.

We breeders snip off an edge of the allele cloud, focused on a single trait. In the process we eliminate thousands of alleles without knowing their purpose. The more severe the allele cloud snipping we do, the more natural abilities we toss out. We make a sub-species good at one thing and weakened at everything else.

A Single hand in the Allele game

The ultimate squeezing of the allele cloud is to select just a single individual (a single allele set) from the cloud. This sounds difficult, but it's easy in the plant kingdom. It is grafting or other clonal propagation methods. In agriculture, we often make a planting of clones. In a clonal planting, the whole planting has no more than two alleles for each of the species' genes. It is dangerous for a species to lose its diversity. In a clonal planting, there is little diversity left.

The Challenge of Black Walnut Monoculture

Almost every agricultural crop commercially grown is clonal. Each such crop has its own set of problems coming from the multitude of species trying to claim the empty niches. Most re-invading species are harmless, but a few are aggressive and hostile. Their niche is eating the crop's resources or the crop itself. Commercial growers have developed solutions for each one of their crop's threats. New growers usually fail if they don't learn and implement these solutions.

Not only are we proposing to grow black walnut trees to an unnatural shape in an unnatural setting, the planting will be a monoculture, maybe a clonal monoculture. We should expect problems. The good news is earlier growers have encountered these problems. Many of the following chapters address the problems and have solutions. If you would rather "wing it" on your own, good luck.

Figure 8. A black walnut monoculture

Black Walnut Genetic Status

Despite our admiration for black walnut lumber, and our many disturbances and plantings, black walnut is still a wild species and around 2% of our forest. Our efforts to increase the black walnut population are up against a very stable Nash Equilibrium. Apparently, Nash has lots of power. You think rocket science is tough? Maintaining an off-equilibrium forest mix might even be tougher.

Black walnut is still a wild species in its native range. Domestication has hardly begun. One select seed orchard has recently been planted. There are hundreds of black walnut named cultivars, mostly nut varieties, and a few named timber selections. There has been some breeding work for timber production, but range-wide black walnut's allele cloud remains wild, diverse, and essentially spherical.

Conclusion

Growing a black walnut monoculture is valuable, possible, relatively easy, but success is not guaranteed. Such monoculture plantings can be made up of wild trees, genetically select trees, or a single clone. The more selective the genetic source of the planting, the more vulnerable to attack and the more grower attention required for success. Many of the challenges have been identified and solutions developed, hopefully covered in the pages ahead. The solutions are not difficult, but also not optional.

It will probably be helpful for understanding the remainder of this book to think of the black walnut species, not as a woody thing with a green top, but as a diverse fuzzy cloud of alleles. In each generation the alleles get shuffled and create a woody thing with a green top to accomplish the cloud's objective. The allele cloud's objective is to make it to the next generation.

Figure 9. A group of the forestry game players. Well protected alleles headed for the next generation, or sidetracked for Kay's cookies.

Comment from Jerry Van Sambeek:

A few thoughts for additions that do not need science to back them up. The forest you picture is a mix of mature overstory trees with an understory of shade tolerant shrubs and unhappy suppressed trees. It is reasonable to assume we can create a mixed species planting of shade-tolerant shrubs under our monoculture of walnut that will have little impact on walnut growth while suppressing the growth of ferns and invasive grasses. If these shrubs have the potential to fix nitrogen all the better – problem is we don't have any natives I am aware of that do a good job of this. Ken Kessler found shrubs that defoliate in the fall after the walnut tend to cover the walnut leaves and accelerate their decomposition or encourage soil organisms to feed on the leaves. You'll have mixed reaction to encouraging earthworms but they can quickly reduce leaf litter. Ken has a list of other organisms we don't think about like springtails. This reduces the number of viable fungal infections that can produce spores in the spring to reinvest the walnut. One of your invasive shrub species is quite effective because initial growth rates are similar to walnut and can provide adequate side shade to limit branch growth. Not sure we can suggest an alternative -- how about hazelnuts or are they considered non-native or shade-intolerant? The bush honeysuckles are not an alternative based on actual mixed plantings. Hopefully there is some food for thought on how to expand on the option for mixed plantings without significant growth reductions that resemble native hardwood forests.

Author's reply:

I planted a long row of European hazels (*Corylus avellana*) and some ended up under the drip line of black walnuts. None of the hazels near the walnuts survived. The rest of the row are okay. I assume the problem is sensitivity to juglone produced by the black walnuts. I suspect American hazels (*Corylus americana*) would have no such problem, based on my unproven theory of co-evolution, i.e., overlapping native ranges, but *C. americana* is slow growing and the size of a lilac, *not much use as a trainer.*

May 24, 2015, 10:17 AM EDT / Updated May 24, 2015, 8:10 PM EDT

John Nash, winner of the Nobel prize in economics and the subject of the movie "A Beautiful Mind," was killed with his wife Saturday in a car crash in New Jersey, according to state police.

Nash and his wife, Alicia, were traveling in a taxi on the New Jersey Turnpike in Middlesex County when it hit a guardrail, killing both at the scene, New Jersey State Police Sgt. Gregory Williams said Sunday morning.

The cab driver and a person in another car involved in the crash were brought to a nearby hospital with non-life threatening injuries, Williams said.

Actor Russell Crowe, who played Nash in the movie based on the 1998 biography, tweeted Sunday morning, "Stunned ... my heart goes out to John & Alicia & family. An amazing partnership. Beautiful minds, beautiful hearts."