Urban Forestry

David Nowak*

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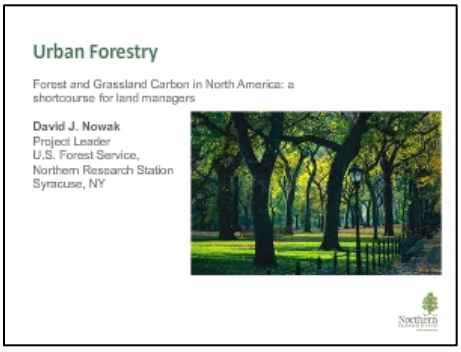
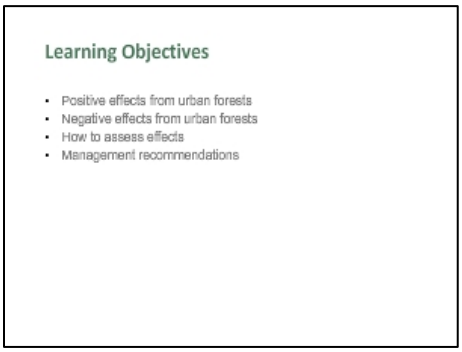
Slide 1. Urban Forestry



Hi, my name's David Nowak. I'm a project leader of the U.S. Forest Service out of Syracuse, New York, Northern Research Station. And my research unit researches the ecosystem services provided by urban trees, and today we're going to focus on the service related to carbon.

Slide 2. Learning Objectives



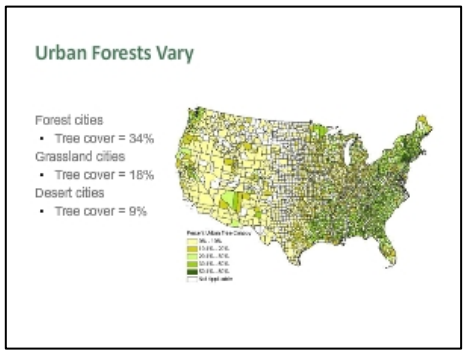
What I'd like to talk about today is the positive and negative benefits related to carbon, how you can assess carbon in your own forest, and then some of the management implications related to carbon. So to start we have to know what are urban forests.

Slide 3. Urban Forests

Urban is defined by the U.S. Census pretty much as any urban area that has a population density of about 500 people per square mile. So these are places where people are concentrated, also with cars, buildings, and all sorts of associated emissions. They currently occupy about 3.1 percent of the lower 48 states and have over 80 percent of the U.S. population within these areas, and it includes all of the trees associated within those lands populated by people.

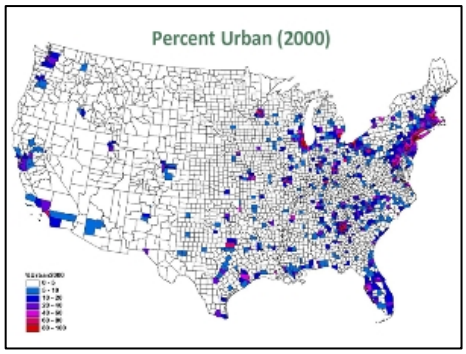
** This document transcribes the presentation given by Dr. Nowak. The presentation is part of General Technical Report NRS-93, "Forest and grassland carbon in North America: A short course for land managers." The full report, comprised of 15 presentations, is in DVD format and can be obtained at http://nrs.fs.fed.us/pubs/order/40110. The presentations and related materials can also be accessed at http://www.fs.fed.us/ccrc/carboncourse/*

Slide 4. Urban Forests Vary



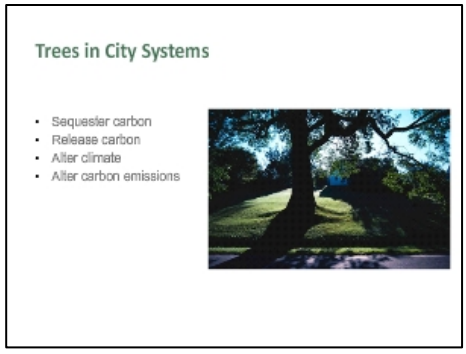
These forests vary across the United State depending on where you are. Cities developed in forested regions tend to have about 34 percent canopy cover within their cities, cities in grasslands about 18 percent, and cities in deserts are around 9 percent. So what that means is that forests differ across the country. If you're in a desert landscape, enhancing tree cover is much more difficult due to the lack of water. Living in forested regions, enhancing tree cover is relatively easy, and we often prohibit trees from coming in by putting down impervious surfaces or by mowing landscapes. So if we want more plants in those areas, stop mowing.

Slide 5. Percent Urban (2000 - 2050)



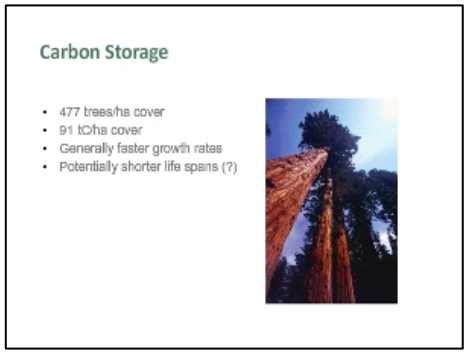
Also the landscape is changing. Urban land in 1990 occupied about 2.5 percent of the lower 48 states. In 2000 it went up to 3.1 percent. That increase was about the size of Vermont and New Hampshire combined over that 10-year period. Taking that projection, those type of patterns from 1990 to 2000 projecting forward, we'll show you in a second what's going to happen to the United States if those projections hold true. This graphic here shows the current percent of the urban area by county, so white counties are counties less than 5 percent of the land area classified as urban and the counties in bright red are greater than 80 percent. If you take the patterns form 1990 to 2000 and project them forward in 10-year increments this is what you see. This is the 3.1percent in the year 2000. This is what happens in 2010, 2020, 2030, 2040, and 2050. And what you note is most of the urban development occurs in the areas that already have the urban development because we have a base upon which urban land can expand. Between 2000 and 2050, urban land is projected to go from 3.1 percent to 8.1 percent. That's an area larger than the state of Montana. One third of the development is projected to occur within forest lands, which means about the size of the state of Pennsylvania will be existing forest land that's rural that's going to convert to urban land. Not that all the trees are going to go away. We're going to have a lot of people living within those forest stands within that area the size of Pennsylvania. So the issue of urbanization is not going to go away. It's going to increase in the future, so how does this affect carbon cycling?

Slide 6. Trees in City Systems



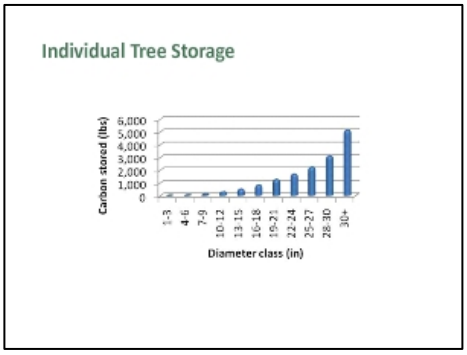
Well, trees in cities, like natural forests, they sequester carbon, they release carbon, but also trees in cities alter climate and they alter emissions that come from urban centers, and that's what we're going to talk about right now.

Slide 7. Carbon Storage



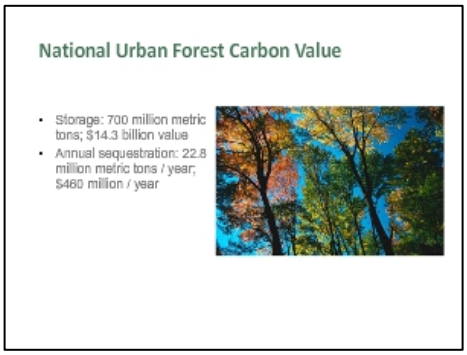
Storage, the amount of carbon currently in the trees, so about half of the dry weight of a tree is carbon stored from the atmosphere, is about 91 tons per hectare of canopy cover within urban areas with about 477 trees per hectare of canopy cover, which is lower than natural forested stands because of the density of trees is much less. But the potential for sequestration might be higher on a per tree basis in urban areas because urban trees tend to more open grown, have less competition for light and water, and likely have faster growth rate for many of the trees. However, we don't know the effect on life span. Are trees in urban areas living longer or shorter than trees in forested stands, because there's attributes that would say that trees might live longer if they're healthier, but also there's a lot of land use change and human interactions that go on that tend to kill the trees off maybe in a shorter fashion.

Slide 8. Individual Tree Storage



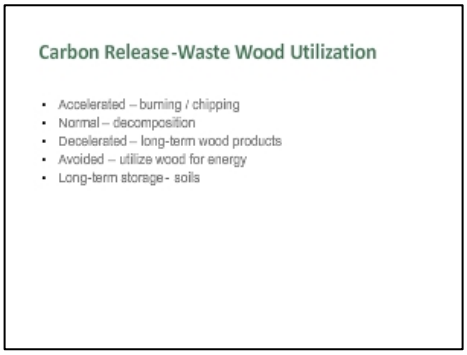
Urban trees are often managed on an individual tree basis. So what that means is larger trees store a lot more carbon than small trees. So the question is, when we remove carbon from the system, what do we do with that carbon, but also the managers need to understand that that storage is the potential that we can lose. That's already carbon that's locked away from the landscape, and these decisions we make about trees are very important. And if we replant trees, take out a large tree and plant it with a small tree, we have made a huge shift in carbon in terms of storage.

Slide 9. National Urban Forest Carbon Value



Currently the United States, the 3.1 percent of the land base have about 3.8 billion trees in that urban landscape, store about 700 million metric tons of carbon, and about 22.8 million metric tons of carbon are sequestered or taken up each year by that urban forest. The values of that, giving a current rate that we did in a study of 20.3 dollars per metric ton, is about 14.3 billion dollars in storage value at about 460 million dollars in sequestration value per year. So storage is what we can lose, sequestration is what we're going to gain on an annual basis with the forest taking up.

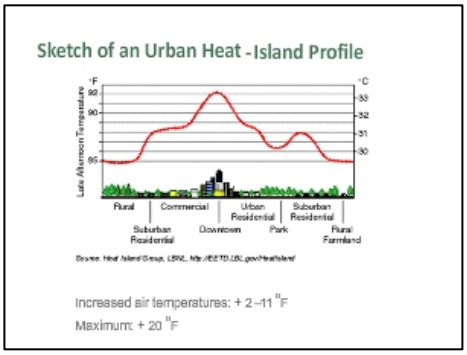
Slide 10. Carbon Release – Waste Wood Utilization



So the question is, now we have this urban landscape, what do we do with the carbon after the trees are removed? Often in urban areas, trees are a waste wood stream. We try to get rid of it as quick as possible, and what do we do with that? So often we chip it or we burn it to get rid of it and get it out of the system. Well, that's accelerating the decomposition of carbon and putting it back to the landscape. Other options in urban areas and more natural landscapes, the trees just fall in the woods and they decompose at a normal rate that you would see in a forested stands. Or you can also have an option of decelerated release of the carbon into the atmosphere. If we take the wood products and use them and put them into long-term storage, you delay the decomposition rate of the forest. One of the biggest aspects related to urban forestry is the avoided emissions. We'll get to that in a second, but one way we can avoid emissions too, is to use the wood and burn it for fuel, cogeneration or burn it in-house so they don't have to use fossil fuels to heat our buildings. We use the wood from the forest itself, therefore we avoid the emissions in the first place.

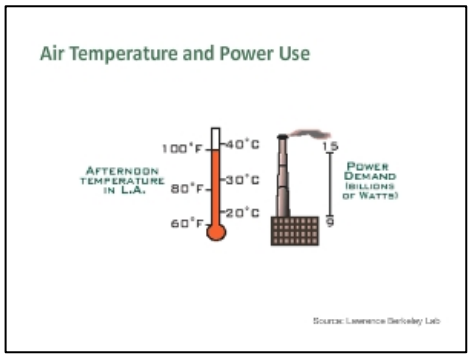
One of the last questions we look at is, it's not well-understood, what's long-term carbon storage within urban areas? How much is actually being retained in the soil systems over what period of time?

Slide 11. Sketch of an Urban Heat-Island Profile



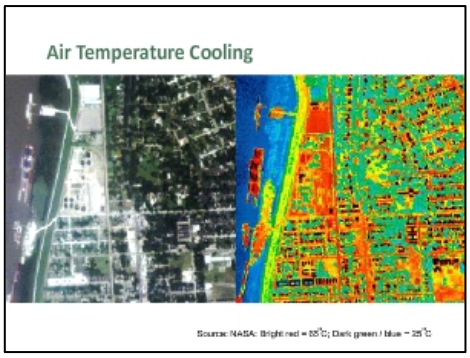
So that's part of the natural cycle with an urban system. The biggest bang for the buck that we get from urban systems is the altering of climate. Many emissions come from urban areas. Having trees in city systems tend to change the climate. If we change the climate, we change the emissions associated from these urban centers. Urban areas have what are called heat islands. They tend to be warmer than rural areas because we put impervious surfaces down to have our buildings and to have our roads. These impervious surfaces absorb sunlight, retain the heat, and radiate the heat back. That in conjunction with the loss of vegetation, because we often clear vegetation to put the impervious surfaces down, which lead to warmer temperatures, typically on an order of 2 to 11 degrees, and it varies by time of day.

Slide 12. Air Temperature and Power Use



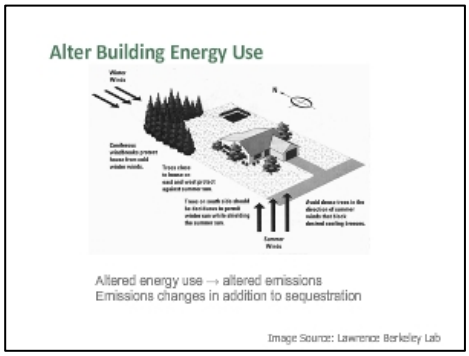
What does that mean? It means if we have warmer city systems, we tend to have more emissions from power plants. We tend to consume more energy. If we consume more energy, we burn more carbon and we put more carbon back to the atmosphere from fossil fuel usage.

Slide 13. Air Temperature Cooling



So what's the role of trees? If we put trees in city systems, they tend to cool the environment. Trees are great evaporators of water. They transpire water. They move water out from the leaf surface into the atmosphere. Evaporation is a cooling process. It leads to cooler air temperature. In this illustration we see a surface temperature map from a satellite that shows the areas of the trees tending to be cooler than the impervious surfaces because of this evaporation of water reducing surface temperatures. The same type of relation occurs with air temperatures. The air moves across these cooler surfaces and evaporates the water. As the air moves away from say, aggregates of trees, it cools the environment around that which then effects human comfort, human health, and energy use in the city system.

Slide 14. Alter Building Energy Use



The other way the trees affect energy use within the cities is through energy conservation. How do we design landscapes around buildings to affect energy use? There's the evaporative cooling effect that you see from the forest across the whole forest regions, but how do we design specifically to shade buildings and to block winter winds? In the summer time, shading of buildings is a good thing because buildings don't absorb the heat from the sunlight. Therefore they become cooler, we don't run our air conditioners as much. The problem is many of our cities are in winter-dominated climate systems, so what happens in the wintertime? Deciduous trees will block about 30 or 40 percent of sunlight, coniferous trees about 80 to 90 percent, so therefore, even trees that drop their leaves, if they're on the south side of the building can shade the building and increase energy use within the city system. So we have to be careful on the design of planting trees around buildings not to shade the building in the wintertime, but to try to shade the building in the summertime. It depends on where you are in the United States in terms of that effect.

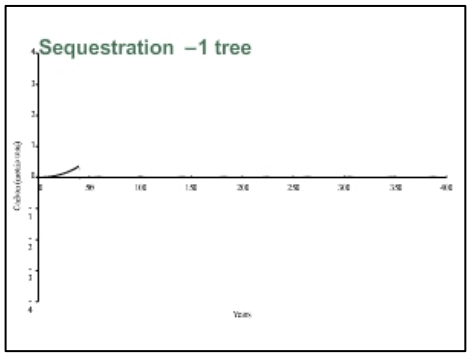
The other factor that trees have, particularly for conifers, is blocking winter winds. You want to plant windrows in the direction of the leading winter winds to avoid that cold air blowing through your building. These also affect energy use. So the question is, how do you design the landscapes to reduce building energy use which then effects the emissions, and this is a supplement on top of what trees are already sequestering? So we can design landscapes, the trees will take the carbon out as they grow, but in addition, avoid emissions from the power plants in urban landscapes where most of the urban emissions come from.

Slide 15. Tree Maintenance

Lastly, we have to look at how humans interact with the system. Tree maintenance is very important. Tree maintenance often, because we use fossil fuels, produces carbon back to the atmosphere. So what is the net effect of managing our forest? We look at the altered emissions, we look at the sequestration rates, but what is the maintenance effect? I'm going to show you a little illustration of what this means.

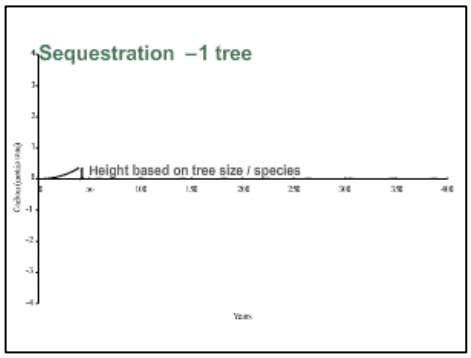
Slide 16. Sequestration – 1 Tree

If you plant a tree, through time that tree will sequester carbon. This is the planting of one street tree in the city through a period of time, so after about 40 years, it sequesters a certain amount of carbon.



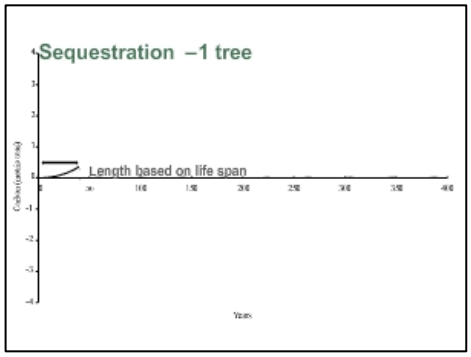
Slide 17. Sequestration – 1 Tree

The height of the graph is determined by the species itself. The bigger the tree the more the tree can sequester carbon over the period of time.



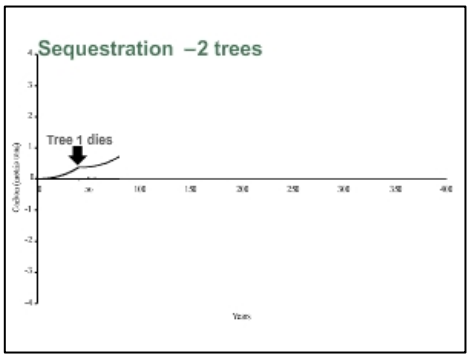
Slide 18. Sequestration – 1 Tree

The length of this period is the life span. These are important because once the tree dies you get a transition. These transition points are very important in terms of maintenance because a lot of carbon is produced at that point because we have to remove the tree and replant. We drive our cars, we bring our chainsaws, the chippers and all these other materials that use fossil fuels to make these points of transition. We also have maintenance occurring during the regular lifespan of the tree.



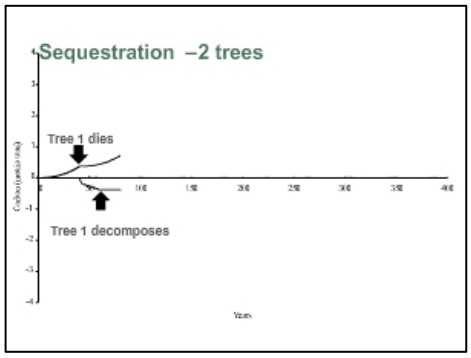
Slide 19. Sequestration – 2 Trees

But looking at without any maintenance, assuming this tree is natural system, you have one tree that dies and the next tree comes in behind it in that location. So in essence we get sequestration accumulating through time.



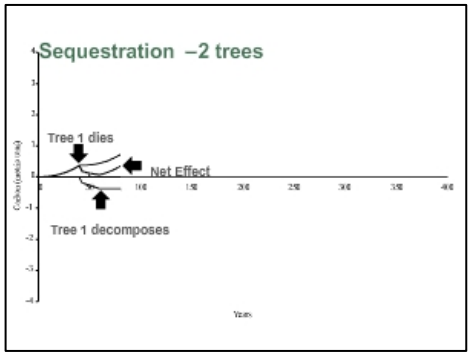
Slide 20. Sequestration – 2 Trees

What happens though is after that first tree dies, it starts to decompose in some rate. In this case in urban areas we tend to burn it or chip it so we have relatively quick decomposition rates…



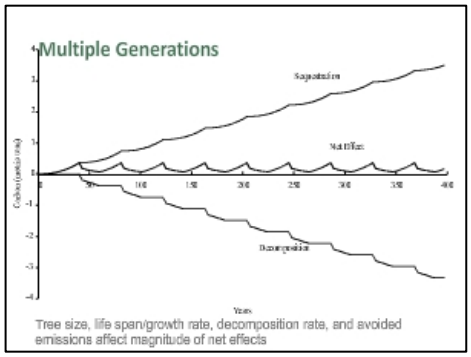
Slide 21. Sequestration – 2 Trees

… and that leads to a net effect. And the net effect is what we're trying to understand. It's what's the net effect of having these trees in the systems along with humans managing these systems.



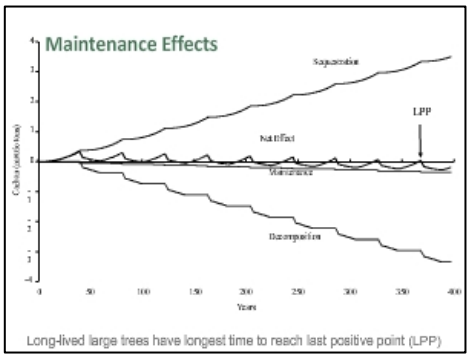
Slide 22. Multiple Generations

So if you take this one tree, two tree scenario and fill it out through time, you get a pattern that looks like this. A wave pattern that changes through time. We tend to have a net positive effect. It depends on species, life span, growth rate. The decomposition rate will affect that and how much avoided emissions. In this case there is no avoided emissions. The tree is not having any energy effects in this simulation. So we're trying to understand is what is the net effect?



Slide 23. Multiple Generations

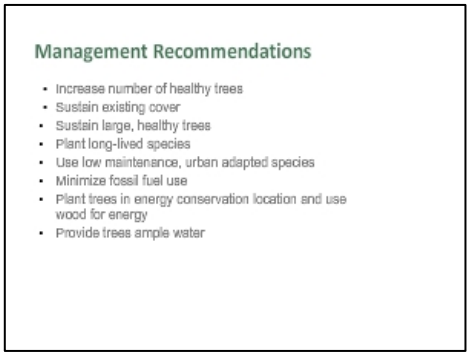
Where do humans come into this is we maintain the trees. So if you maintain the trees you tend to draw back from that net effect, and through time, if we use fossil fuels to maintain trees, we will eventually burn more carbon than a tree at that site can handle, and that slope of maintenance is very important. The more you burn fossil fuels, the steeper the slope, the more it pulls back, and at some point in the future you will burn more carbon than the system can take out from the system and you become negative. You become producing carbon in the long run. Large long-lived trees, the break-even point for typical maintenance is about 800 years approximately. A short-lived small tree, the rotation or the last positive point can occur at about 60 years. So what we do in decisions of managers and the species we pick, the locations we put, the maintenance we provide for the trees all affect this carbon cycle, and we can't decouple the humans from the natural systems, particularly in urban systems where we produce a lot of carbon.



Slide 24. Gathering Your Own Data

How do we collect our own data? There's a free tool out there developed by the Forest Service and many partners. It's called i-Tree at www.itreetool.org, and it encourages people to collect data and assesses the carbon, the energy effects and these things that we've just talked about plus other ecosystem services, and that's available for people to use.

Slide 25. Management Recommendations



Management recommendations, bottom line for not only carbon but many other ecosystem services, we want to sustain the canopy cover we have or enhance the canopy cover, keeping the trees as healthy as possible, as long-lived as possible, using trees to avoid emissions from power plants, finding an energy conserving location, reduce the use of fossil fuels not only from producing carbon point-of-view but producing other air pollutants. And finally, we need to water these trees, make sure there's enough water so that they're transpiring with the gas exchange that's going on because a lot of ecosystem services are derived from the gas exchange in the leaf surface area provided by urban trees. Thank you very much.