James Urban is a landscape architect and urban arborist with over 30 years experience in urban development and planting trees in difficult urban sites. Researching and testing ideas related to the installation of trees in the urban environment since 1982, James has collaborated with many leading arborists, horticulturalists, and researchers, translating and developing applications of their ideas for landscape architects. This includes the testing of new urban tree systems, innovative soil and planting concepts, and developing new approaches to landscape architectural design, detailing and specifications.

The best news is that I am the last speaker of the day. I am hoping to lift you out of your seats during my presentation and hopefully be inspiring. We have heard from many speakers today about how wonderful trees are and how beneficial they can be. The reality is that we will not receive these benefits if we don't allow tree to live in our cities. I have spent the last 25 years trying to figure out how to make trees live.

The good news in my presentation is that I can share the secret of how to reliably grow a tree to mature size in your cities, and how you can do it every time. The bad news is that you don't have enough space in your cities nor do you have enough of a budget in your coffers to pay for my recommendations. Together we need to find the compromises. Ian Lockwood mentioned a paradigm shift which I agree is the critical element. The people in this room are from a variety of areas, involved with highways, public works, planning and more, and I am excited to get this opportunity to speak to this many of you together in one room. Usually we discuss problems in little rooms and shriek "oh my god, what can we do?" This is a wonderful opportunity.

I would like to start by saying that this conference is incredibly unique and is happening because of two incredible individuals, Richard Ubbens and Peter Simon, with whom I have spent the last day. Frankly, either one of them could have gotten up here and given this address today, but maybe it's easier to listen to the outside expert with a plane ticket, though these two guys know what they are doing. If you listen to them they will guide you to the answer.

Put simply, now that we have established trees as part of the infrastructure of the city, we have to get trees and their requirements to the same level of water meters, electric lines, curb widths, and the road widths, instead of being the least important piece of the infrastructure. To do this we have to look below the ground. Clearly, below the ground is where it's at.

I recall one day I was getting ready to go to a lecture with terrible bronchitis. I was in bed with a fever for about four days before I was supposed to leave and I didn't think I would be able to attend. I was about to call them and tell them I'm not coming. My lovely wife Bonnie, who has stood by me for all these years in my journeys through the wilderness, says "we don't have to call them, I'll go. I'll give the lecture. I've seen your lecture many times—I'll just go and do it." She continued "In fact, you know when you get up there you talk way too long, your lectures are way longer than

they need to be. You know, I could give your entire lecture in just 3 words." So I say, "Oh really, well what are those three words?" And she simply replied, "Trees need dirt. Simple as that. Trees need dirt, I would say it a few times for repetition—trees need dirt. 'Thank you very much', pick up on honorarium cheque and I'm out of there. I mean what else do you need to know?" And that is honestly where we started about 20 years ago with "trees need dirt." Now we have to figure out how to do it.

So we have to understand trees. Tom Perry, my mentor and a good Harvard microbiologist taught me everything I know about soils and trees. He also taught me that a tree is really a wineglass on a dinner plate.

I always went one better than Tom by explaining that this is actually a crystal wineglass and a piece of china [holds up glass and plate to represent a tree and its root system]—they are both very valuable and very fragile. The problem is that if you want a bigger tree, you need a bigger plate. There is no way around this. You need a bigger plate.

So, how are we going to cram this plate into a sidewalk that is a third the width of this plate or maybe even a quarter of the width of this plate? This is what I have spent the last few years doing.

We need to get more science into our understanding, and I say this even though I come from a design background (I have worked for urban design firms, drawing nice little painting details around the base of the tree). We need to get the science in balance with the design. Until you have achieved the goal of "trees need dirt", all those fancy little details up on the surface don't mean a hill of beans.

I have walked around Toronto for the last day looking at beautifully designed painting patterns and lights but also saw the largest collection of dead trees I have seen anywhere in any city in the United States or Canada.

So, we are going to have a little science experiment here. I want everyone to stand up. Now, I want everybody to stand with your feet apart as if you had to spend the rest of the day without moving your feet. Where would you put your feet?

You spread your feet fairly far apart in what generally we call a military at ease position. You will find that you can sway a little bit without moving your feet. You've got a lot of structural stability with this position. You will also notice that your feet are spread about as far apart as your girth and your shoulders—because your rooting system is about the same size as your drip line.

The physics of a human being are actually very close to the physics of a tree.

Next we are going to compact the soil around you a little bit. I want everybody to put your feet together so they are touching. Now you are a tree on a lawn in a suburban environment where they compacted the soil of the hole they dug out. Six inches of soil was spread around for the lawn but you just have the soil around your feet. Now you'll see that your ability to sway—your structural stability—is dramatically reduced. If I told you to stand this way

for the rest of the day you probably could, but you wouldn't like it.

Now stand with one foot up. You are the tree at the end of a parking lot island at a shopping centre. You can see that this is quite a bit more difficult, but you can still do it.

Now we are going to move you onto Queen Street. Everybody go up on your toes. You are now a street tree on the edge of the city, and see how you like that!

Now the physics and the science of that experiment are incredibly close to the reality. You can see that you had to move really far into the city before you really got into trouble.

Your structural stability is in trouble when you are on one foot and you are uncomfortable. Soon enough everybody will fall over from the experiment, trying to support themselves on their toes. Clearly, being a street tree in the city you were in trouble, and we have to figure out how to make those dynamics work.

If we are able to get trees to have more dirt, we really accomplish sustainability. I have heard the word 'sustainable' so many times. And it really makes me angry that the level of maintenance and the designs that I see in our public spaces are not sustainable.

They may be green. The building we are in today is an absolute textbook case of unsustainability. When you look at the trees around this building as you leave tonight, look at the relationship of the quality of the tree and the size of the soil volume that is open to the sky.

It is a direct linear relationship to tree health. All of those trees I believe were probably all planted about the same size, at the same time and there's a huge difference between trees that should be removed or have been removed to trees that are looking fairly healthy.

By increasing the soil we will eliminate the need in the long term for additional water because the soil should be balanced to the water needs of the tree.

We will dramatically increase the species diversity that we can attain, because we can now build soil systems that are made for the tree. We no longer have to be confined to that list of ten species that are the only ten that will survive in these horrible conditions. We can start using more native trees and can start with some high degree of variability, planting a whole block of trees in one species and fully expect that in twenty or thirty years they will still be there.

We have to act because we are losing species. If you take the species of trees that are killed by the long-horned beetle and those by the Asian emerald-ash-borer out of your city, what have you got left?

How many species are left? One, two, maybe three. It is frightening, and we haven't seen the end of this yet. We must dramatically broaden the number of species that we plant, and the only way we're going to do that is by dramatically broadening the amount of soil and broadening our attention to soil details.

So, I have this misguided notion that if you draw an oak tree on your plan this is what you thought you created.

If you didn't think that you better tell somebody. If you are a designer that said, "oh, I put an oak tree there but it's never going to look like that", tell somebody. How many people have actually said that to clients? [No hands]. Now the problem is that we all know this is more likely what we end up with.

You can see that all the black arrows in this streetscape are either dead trees or trees that have died and have been replaced. This was a wonderful urban design project.

The orange arrows are trees that are in deep trouble. The photo is of early August. We have had huge amounts of rain, so these trees should be looking great.

The green arrows are the trees that are actually looking good. Not a single one of them is growing in a little hole in the side of the pavement. How can we make our cities green without actually having only the trees growing in big spaces?

Let's look at these trees on University Avenue here in Toronto. You should all recognize these trees.

This is Toronto's only good set of trees in all of downtown. This set of trees is what I would define as a functional set of trees.

They have finally grown big enough that they are actually creating urban heat island reduction. They are actually contributing something to stormwater management.

They are reducing temperatures and are beginning to make you feel secure. They make you feel like you are in a place that calms you, soothes you. These trees do all the things we've been describing today. Unfortunately, it is the only set that you have in this city.

Is it the planting detail that causes these to live? Somebody says, "well maybe

because they're up on these little platforms they're doing fine."

I think these trees are doing well because they are growing in a soil type that under the ground is actually fairly good for growing trees even though it's compacted to hold up the sidewalk.
It is possible to have fine soils like this in some cities. When we look at the examples, as Paul Ostergaard showed us, many really great cities have trees that are growing well.

I tick off in my mind where those sites are, and they're always in areas where I know the ambient background soil is of a very gritty nature or one where I have a lot of rock under the ground.
Some of these areas have a certain kind of structure to the ambient regional soil conditions that allow one to develop that soil, compact it, do whatever it is they need to do, and still leave some space for trees.

I have bad news for you Torontonians. Your very fine, silt-filled, sandy soils here are not one of those soils.
I really don't think that you have very many soils in this kind of geology that qualify for growing trees easily in cities.

So, it's going to be extremely difficult for you to create the kinds of physical environments that you saw earlier today in this city without actually engineering, and thinking about every square inch of soil, every cubic inch of soil that those trees are going to need.

When we look at trees in this city in that exact same planting detail, they do not do very well. So it's clearly not the planting detail.

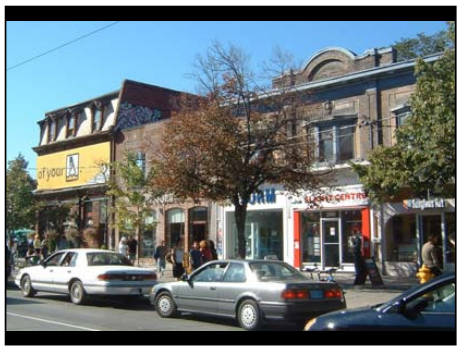
It's just something about that ambient soil in that one place. If Toronto planners could replicate that they would be home free.

But you need to replicate it a lot.

And you tried replicating it, or tried to do something different on the other side of the street where we have these raised little boxes, which are open at the bottom.

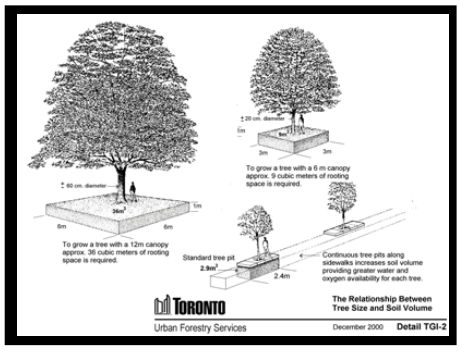
They are now interconnected from tree to tree with one point four metres width of soil to support a huge tree in the future.

The problem is it's a huge improvement over the standard detail. Is it enough? Not really. There are other places where you actually are growing good trees here in Toronto.



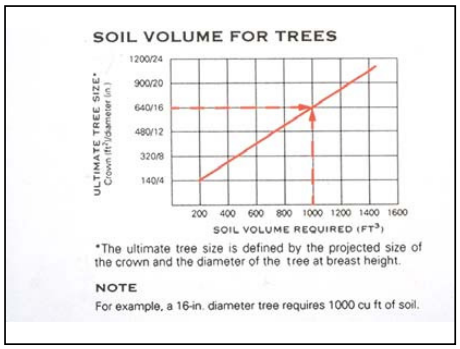
This is Queen Street West. Apparently these lindens were actually looking pretty good until we decided to make beautiful little paving patterns around them. We ended up killing most of them. Even the new trees that are coming along, the replacement trees, are not doing very well.

We have to be very careful with this commodity of soil, this living material, that when we have it and the tree is doing well, we can't mess with it.



Above is a nice drawing that Peter Simon created which shows the relationship of the amount of soil that one needs to grow trees of different sizes. You can see that to achieve the full, mature tree on the left, you need a lot of soil, and a one point six or one point four metre wide trench is not going to do it for you. It's just not going to do it.

So what, what are you going to do? How are you going to solve this problem?



This is a chart that I have prepared and is available as a handout. It is an article I wrote called Room to Grow. I developed the chart by observing the work of many researchers.

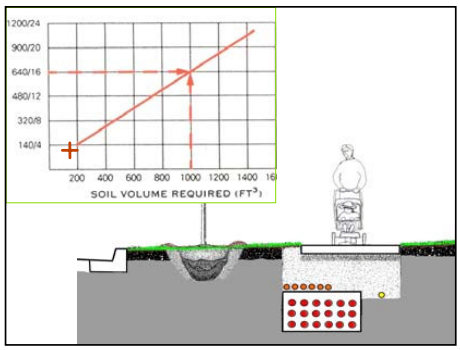
While many of the people who have spoken today are great researchers and are very careful to credit all the people that helped them and do all their work, I don't even have a Master's degree. I just go out and borrow from people and try to give it to you.

But this is not my work, it is an amalgamation of five researchers' work. The red line sloping up shows the relationship of the tree size, either looking at its diameter, its DBH or its crown diameter to the soil volume required.

The red dotted line example, which is the beginning of a functional tree, a sixteen inch DBH tree, is a very functional tree.

You need one thousand cubic feet of soil, and Gerald Lajueneese, the last speaker, was talking about maybe five hundred or six hundred cubic feet of soil to make a tree thrive.

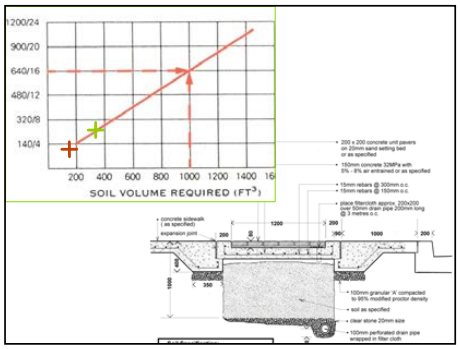
I don't think that is accurate. You need dramatically larger volumes of soil or you need to adjust your expectations.



So when we look at your typical tree planting detail, and everybody says, "just give me the damn standard detail," this little detail is down in that little red X in that box.

It doesn't give the tree much soil at all, but that detail is designed to get the tree through the guarantee period and it works really well at doing that. The tree survives through the guarantee period. Everyone is happy.

If you're in a lawn area, even if it's a compacted lawn, it might actually get the tree through the political cycle of the term of the mayor. I think we want to go beyond that. If you're in an urban area and if you're on a two year aldermanic cycle, you might just get through the term of your alderman.

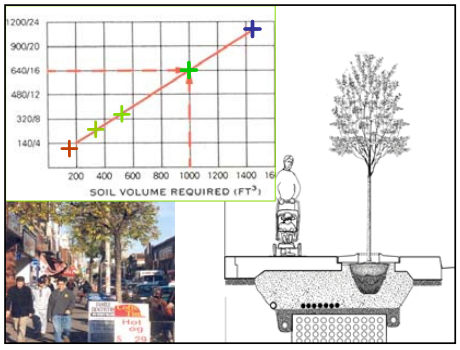


Now, here is the current detail that you are talking about. You can see by the little green X on that arrow that we've moved up this line a little bit.

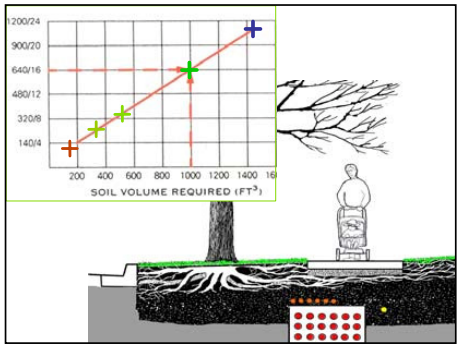
That is about the amount of soil that this detail gets. This is a huge advancement for you.

The soil trench is pretty wide. We started building these things in 1982 and I'll show you what happens to this trench over fifteen years.

It is still clearly not enough. This is another example of making the trench a little bit wider and we move a little further up the scale, but we're still not getting there with a long way to go.



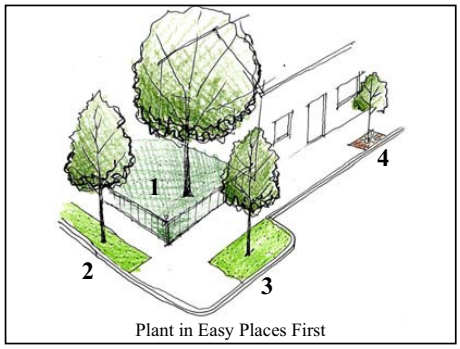
What we need to do is to get up to something like this. And how do we do this in an urban environment?



It is one thing to think about how we're going do that with all the utilities in a suburban environment.

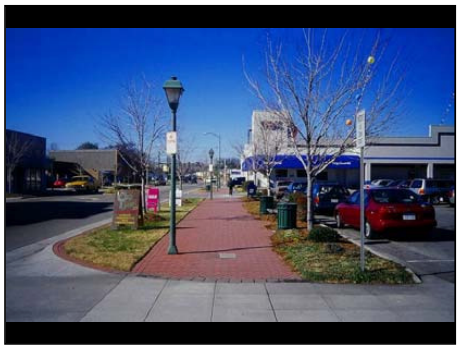
When we get to an urban environment it's really tough as there is a huge variety in planting conditions within the urban environment.

I have a set of twelve principles, but I don't have time to present them all, so I will just cover the most important ones.



Plant in Easy Places First

The first one is plant in the easy places first. It's this idea that every tree has to be planted in exactly identical holes, in exactly the same way, along the street. That is just not going to work. If we can create a tree, as in example number three (above) and dig some soil out of a place where cars aren't going to drive anyway putting the tree behind the curb, we can also make the tree in a tree lawn. Anything but item number four in the picture above.



Here is a project that we worked on in Norfolk where the street was the edge of the curb.

The left side of the sidewalk in the picture was the curb line. We didn't plant trees in little holes surrounded by pavement in this entire twelve block long commercial district.

Every tree was planted in different locations all across the district. We made the most out of whatever we could, taking advantage of every opportunity to improve the soil as this was a very low budget project. Did we achieve our thousand cubic feet of soil here? No.

Did we spend the money that we had to spend wisely? We think we did.

We ran across this street here in Toronto yesterday when we were walking around.

While I understand fully the urban design principle of putting the tree on the curb, just don't forget that you need the money and the control to get the roots to do what you need them to do.

This should be your starting position and then argue it. See what is in your budget. You can't do these urban design plans in a vacuum without actually drawing the soils that you want to get.

How much are you spending now for just one of the trees in the side here? These are five hundred to eight hundred dollar trees if you're planting them in just regular soil?

I think Richard told me when he is doing his trench idea. Peter, you said that trench idea was around two or three thousand dollars Canadian.The trench idea gets him only a little bit up the chart I mentioned earlier. To really achieve some of the ideas that we've seen presented here in terms of urban design, it could cost upwards of five or six thousand dollar a tree.

The Dutch, who are way ahead of us on this score, are spending around ten to thirteen thousand Euros per tree in a tiny town of 150,000 people in the middle of Holland called Appledorn.

They spend this because they understand what they need to do. In the Hague, where they really care about these things, they installed a trolley line and spent 80,000 Euros per tree to get the right amount of soil in the ground that they needed. I must admit that even after two kilometres of that they backed off on the rest of them, building at a mere 30,000 Euros per tree.

These are very expensive objects to put into the urban environment.

Now the question is, is it worth it? How much does Toronto pay for these really beautiful painted streetlights Paul, and some of your nice projects, how much did those cost apiece?

About 15,000 to 20,000 dollars for a streetlight. The question is do streetlights and trees offer the same value to the urban environment?

Which gives more value to the urban environment? We know they cost about the same if you do it right. Right now you're not spending nearly enough on trees and maybe too much on street lights. So, I proposed an experiment.

Go to this street right here, which is a good example, and have public works take-out that streetlight on the left side of the street.

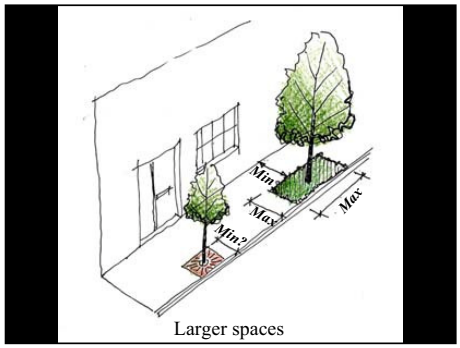
On the same day have the parks people come in and cut down one of the mature trees. Which event is going to cause greater angst at city hall?

I don't think it would even be close. I bet you as soon as the chainsaws start humming, somebody would ask "what are you doing!"

Sometime later, someone might ask, "didn't there used to be a streetlight on that street?" even though it has been out for two weeks.

I personally believe that a good, functional tree has a lot more value to our urban environment than a streetlight.

We need both of them. They have about the same parody in what it takes to put them in the ground and make it all happen.



Larger spaces

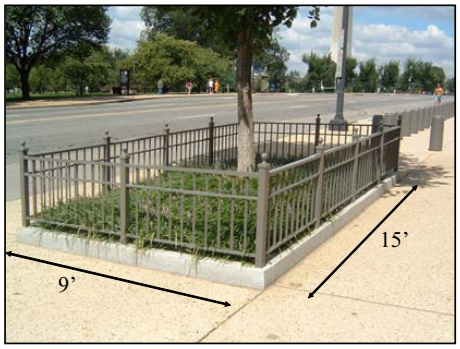
The first thing that we need to do is make the spaces bigger. If you do nothing else, that extra little bit of soil that is open to the sky is the cheapest thing you can do to get more rooting space in the urban environment.

Some suggest that it takes up too much space.

Above is 5th Avenue in New York City, right down the street from Rockefeller Centre—a pretty dense urban environment. How many places in Toronto are more dense than 5th Avenue in terms of pedestrian traffic?

Is there any place? No. The hot dog guy gets twice the space that the trees get!

Now if a hotdog vendor can get a four foot six by ten foot space, than isn't a tree worth that much space? Can we take and dedicate that much space and maybe put a little fence around it or do whatever we need to do to make that space a dedicated tree space?

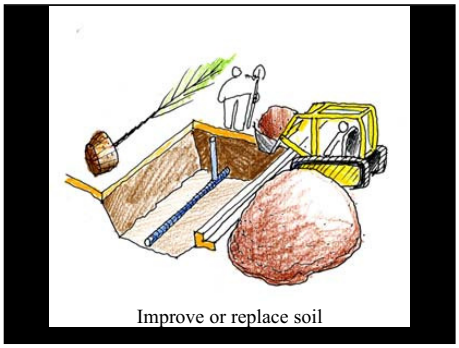


This is my tree grid. This happens to be at the Bureau of printing and engraving,

which is where we make our money in the US, and it is the second most visited site after the White House in Washington.

Buses will stand eight lengths, up and down and then two deep on this street with thousands and thousands of high school kids and people wanting to see their money being made.

This place is very intense. I was still able to talk the people into a nine by fifteen foot opening for each tree in a very intense urban environment.



Improve or replace soil

Now, once we make that hole as big as we can, we have got to improve the soil. We need to improve the drainage as most trees drown. There are many more problems of too much water than of not enough water, even here in Toronto probably.

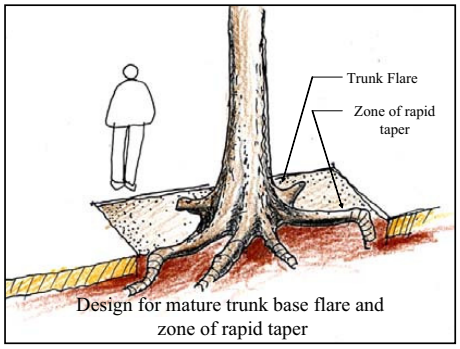
Making the soil volume larger allows more water to absorb into the soil and hold more water.

Somebody mentioned that we have to have an irrigation system for every tree. Forget it! Take that money and put it into soil. I really don't think you should be irrigating any trees. If you've got more than thirty inches of rainfall a year you probably don't need irrigation.

We all know that the construction leaves our soil absolutely lifeless (above is a residential site in Toronto).

The whole soil issue takes me a couple of hours to talk about.

Now the other problem that we have is that at the base of the tree there are some really remarkable things that happen. This is what we call the trunk flare and the zone of rapid taper. The trunk comes down into the soil and has to divide into six or eight large roots that anchor the tree and provide its stability.



Design for mature trunk base flare and zone of rapid taper

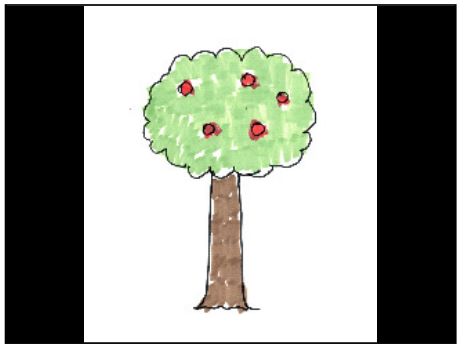
A very pronounced flaring happens right at the base of the tree, and then continues in the soil for approximately another two metres. We call that the zone of rapid taper.

The area between the trunk flare and the zone of rapid taper can destroy almost any sidewalk you can design when and if the tree grows large enough.

So, we have to design for the base flare and for the zone of rapid taper. I challenge anyone who is drawing a planting detail to draw the tree anatomically correct in the space that you've designed at the size you think it will be at its largest time. Then show the drawing to your client saying, "this is the biggest tree we think we can get in here." I think if you really are honest you would say, "well, first of all, I am not providing any soil. So it is not going to get very big."

So, this is why we should have this little collar around it. I think your client is going say, "that is as big as it will get?"

If you are honest and you provide soil and the tree really is going to get big, you'll quickly find your detail doesn't work.



Paul's daughter drew this wonderful picture of a tree. She even got the trunk flare correct.

How many landscape architects get the trunk flare correct on their own drawing? From the mouth of babes! Maybe it is because she is so small that she can see the flare—it is at her level. We are looking up and she's looking down. Now just take this drawing, Xerox it, and try plugging it into your tree planning details because this is what is going to happen.

This will happen. It is beginning to gobble up bricks, and you might think that looks quaint. But this is actually injuring the tree, and causes problems. We can't afford problems!

So, we need to design our urban environment to avoid these kinds of things. We also need to design our urban environment to grow really great trees.

Looking at this detail, how many of these tree holes are in the city? Ten

thousand maybe? Get rid of them. Just lift them up and take them away!

Put a little fence around here right out to the edge and fill it full of gravel or plant some nice little ground coverage in it.

Or you could get your neighbour and start an adopt a tree program. You go and rip up tree grates like the one above, fill it full of nice topsoil, and the shop owner will go out and plant annuals in their soil and water them.

The annuals may cut the roots a little, but when the shop owner waters the annuals, they are also watering the tree. The tree is being watered at precisely the moment it needs water. The annuals are the little canaries that are sitting out on the sidewalk and telling us the tree needs water. It is amazing how people will latch onto this type of program, both businesses and residents. People will adopt it and take ownership. If they're taking care of the flowers, they'll do it.

Georgetown in Washington DC has an adopt a tree program and almost every tree is being taken care of by the public. It is amazing what happens.

You've got to stop this detail of planting a tree in a tiny hole. You just stop it. I mean trees need dirt, not little collars put around them in the urban environment.

I would contend that in most of the streets that we walked on, if a two foot fence was erected around the tree, it would just be high enough to keep people from walking in the space.

The Dutch use a beautiful little hairpin galvanized steel rail. It's just a little 'U', a very simple little galvanized rail.

And it just goes up and back down on both ends of the tree pit, not connecting in the middle. People can even chain their bicycles to it.

I bet you that there is not a street in your city that where there is not enough room to do this type of thing.

Someone mentioned chance encounters earlier today. People may need to change their cadence, perhaps brushing shoulders with someone as they walk down the street, maybe even say hello to them.

There are all kinds of wonderful things that could happen by changing this detail.

In the US we are using iron tree grates much more than you're using them up here.

This particular tree grate costs eight thousand dollars. Now don't tell me you don't have any money. This tree walked into that tree grate—it actually did. The tree slides in the hole soil mass which is why those trees are not in the centre of the hole after a year or so.
The tree grate is not only killing the tree, but it cost $8,000. If the tree grate had not been there in the first place, the tree

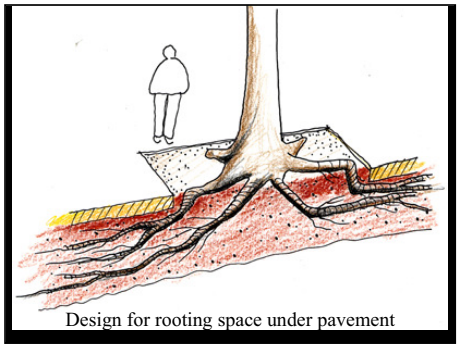
would have been fine. Don't tell me, "my city will come by and fix this."

The national park service on Pennsylvania Avenue, one block from the White House, could not get all of the tree grates cut in time losing a few trees recently.

Now you see how there's a little mound there? It was not built that way. This is eleven years after planting and that tree's trunk flare is beginning to emerge. If the bricks were twelve to eighteen inches away from the tree, there would be less damage.

The tree is solving the problem for itself. Maybe once every four or five years somebody comes around and picks up a few of the bricks, or the homeless people throw them through the windshields of a car!

But it is a solvable problem. It doesn't kill the tree. Of course, if Andrea is correct, the crime rates will go down so much that we won't have to worry about people throwing bricks on cars.

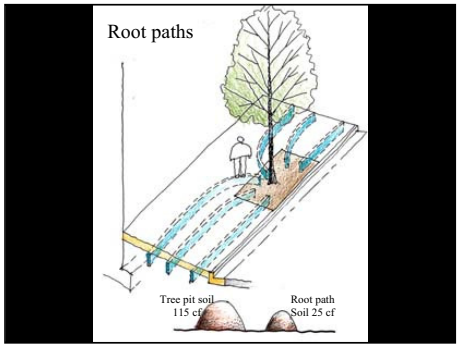


Design for rooting space under pavement

At some point you are going to have to get the roots under the ground, under the pavement.

You can't build urban environments and not have this happen. Fortunately, I have set the minimum size planting hole, so that you don't have to worry about this. It is twenty by twenty feet, so the roots won't damage the sidewalk. But who has that much space? So I have been thinking about alternative ways of getting roots under the pavement.

One of the principles that I have is that urban soils are dramatically different from site to site.



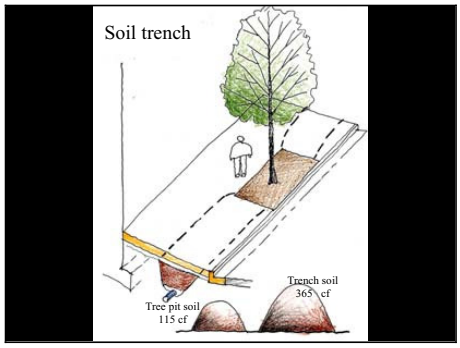
If you have a standard detail where all trees in the city are planted in a certain way, you'd better have that detail be for the worst site. This means you are going

to spend five to twenty thousand dollars a tree for every tree in the city.

Unfortunately, you can't afford that. What you need is a sliding scale with multiple set of details that forces the designer to discover what the soil type is.

In other areas, most of the trees grow well, but some of them don't and they are locked in their little boxes and they can't get out. Is there a way in which we could give some guidance to the roots—a pathway out of this little hole we've left.

I call these root paths. You take a Vermeer trencher and you trench out these one foot long trenches and they snake down the sidewalk from tree to tree. We then install a drain board and fill it with top soil building the sidewalk over the top.



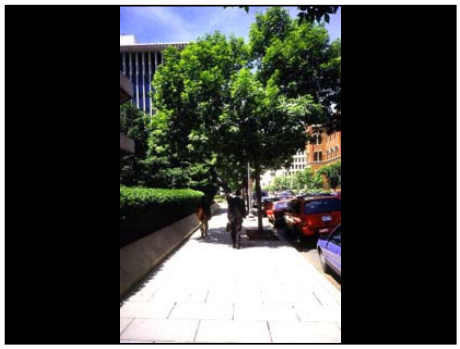
You won't be able to do this in places where the soil is very fine grain or heavily compacted soil.

We started these trenches in 1982. You will notice on these drawings that there are little piles of dirt—the amount of dirt you actually get under the sidewalk. The tree pits above were large 6 by 8 foot pits. There is about 115 cubic feet of soil in the tree pit and then another 365 cubic feet of soil if you excavate a six foot wide pit (going down 3 feet). I don't think you're going down that deep here in Toronto. So if my trees are spaced out 35 feet on centre, I have got 365 cubic feet of soil under the ground and another 100 cubic feet in the trench—that is close to 500 cubic feet of soil

This is the prototype that we built at National Geographic in 1982.

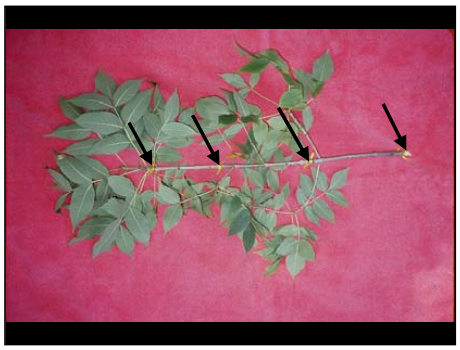
Drainage is absolutely critical. Literally, just connect all the tree pits and install drainage, as it is so important.

That little box on the sidewalk is my tree watering box. It connects to pipes under the sidewalk that are empty perforated lines. I can put water, liquid fertilizers, or compost heap in that box and energize the soil. We fill the trench up with soil and it is compacted lightly and we use the soil as the form for the bottom of the concrete.



This is about four years after planting, and these ash trees are starting to take off. I'm getting pretty jazzed about what we're doing and I'm starting to lecture about it, how wonderful this system is. I'm watching the trees—this is year sixteen.

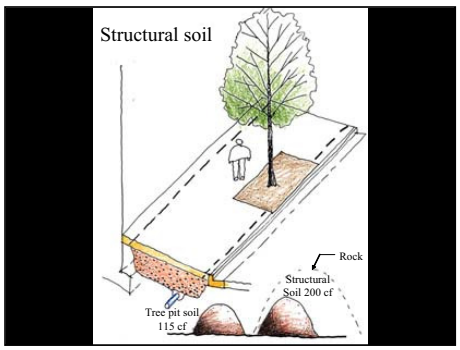
This slide is not a yellowed slide, that is the real colour. The average person would say the tree looks pretty nice but those of us who know about trees look at this tree and know something is wrong. The trunk grew to about 8 inches in caliper and stopped growing, and all of a sudden the crown starts spinning out.



Here is a branch off of the tree and you can see that each of those little arrows is pointing to the internode, the point at which the branch stopped growing that year and then grew another year. And you'll see that the internode distance is starting in years 12, 13, 14, and 15. You can see this tree is just slowing down its growth rate. It's starting to decline in the crown, and is not putting on as much caliper.

This is year 16 again and you can see that it still looks like a very functional set of trees. Now if you look at the trees on the other side of the street they're the same species of trees planted the same year, only in the standard city of Washington tree planting hole. There is an amazing difference, so we got a lot out of these trees. We spent about $3000 a tree in 1982 dollars, though I don't know what that would work out to today. This included the reinforcing, the drainage, and the soil, but they're beginning to slow down.

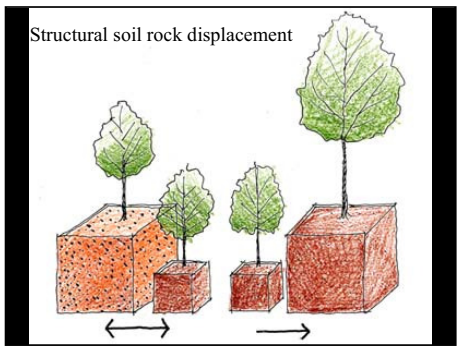
Now remember I said that the trees were 8 inches in caliper if you have approximately 425 cubic feet of soil in that detail? Guess what the chart shows. It shows that the tree runs out of gas at 8 inches in caliper. This chart is really quite dead on and I'm quite pleased with it. I'm quite pleased with this whole experiment because it shows a lot of information. You probably should expect about the same performance out of a 400 cubic foot tree pit.



Now we came up with this solution in the meantime called structural soils. There has been a lot of talk about structural soils and I was actually part of the team that wrote the specifications for it. I still use structural soils today on my projects. But look at the pile of dirt in the picture above. You'll see that the dotted line is the pile of rock that you're putting in the soil. The other little pile is the amount of soil that you get.

In all of that effort of digging out the entire sidewalk, 15 feet wide all the way from curb to face of building (35 feet long), I ended up with 200 cubic feet of soil under the ground. This is because it's mostly rock (80% structure and 20% soil). And it looks great. Tree roots grow through structural soil wonderfully—the early tests blew us away. We are quite excited about it.

I am always nagged by the fact that structural soil could fit on this chart but does it give you the same answer? I always said it can't because there's not that much soil in it.



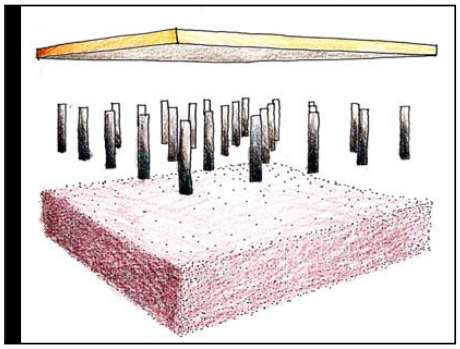
Cornel has finally done a study of structural soil. The orange box on the left is a box of structural soil, the little box next to it is the amount of soil that is actually in that box. They took this experiment and grew trees in it. The box on the far right is a box of the same soil at the same volume as a structural soil box. The two trees on the left grew at exactly the same rate and had the same growth habits. Even though one was in a much larger container, they were growing in the same amount of soil.

There was almost statistically no difference between those two trees. The tree in the big box of regular soil on the right grew like it was going in a big box of soil. So, size matters and you can't use that chart if you're using structural soil. You need to discount it by 20%.

Here are some trees that have been growing in regular and structural soil in Philadelphia. You should note that they were planted at the same time and the ones that are in the structural soil pavement are obviously stressed. We had a huge amount of rain this year, so these trees should just be exploding, yet they have gator bags on them because they're so dry and they can't survive. This is only three years after installation.

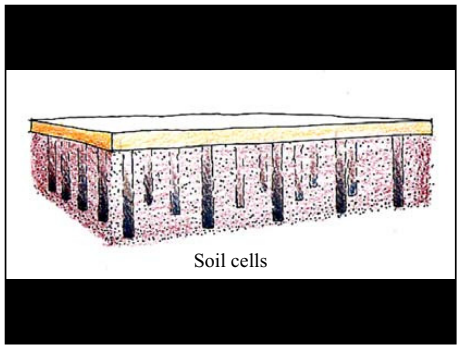
So, there are some serious issues. I get more soil out of my soil trenches for less work than I get out of structural soil. The problem with structural soil is that it's 80% structure and creating a volume for only 20%. That is a lot of work for a little effort. This room is probably about 98% volume and 2% structure—all these columns added up holding this roof up is not taking a lot of space. If this was a big soil trench, we could use all that space for growing roots.

I think if an architect can design a space that's 95% void, why couldn't we design a space under the sidewalk that had a much more efficient structure?

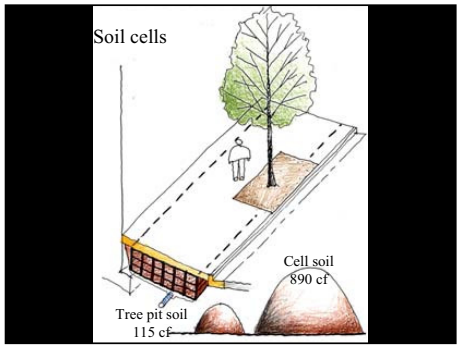


We would get more soil in less space and to do that we have to separate out the structure that holds up the sidewalk, from the soil that is supporting the tree. Could we design some kind of a system

where this could work? To do this you need a product. When you're in the construction business it's hard to create products, and if you're in the academic world, it's hard to get money to do this kind of research. So with my wife's wonderful blessing, I took a big chunk of my retirement savings and gave it to a development company.

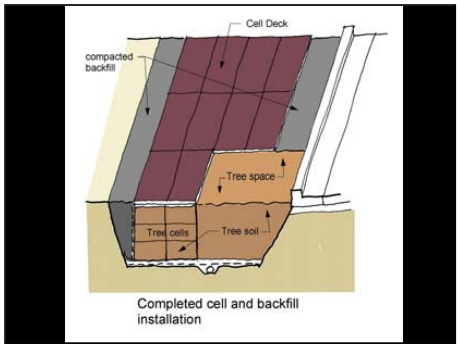


We're actually developing a box that we call a soil cell that will hold up a garbage truck while it's driving over. The pavement will give us 90% void space in the area that we can impact.

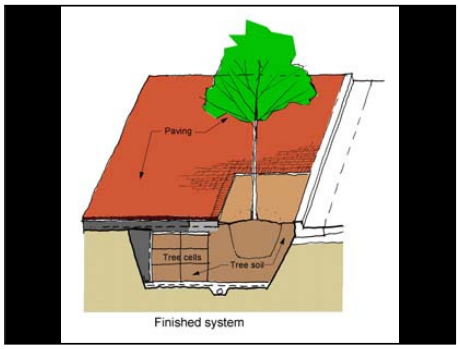


Notice how much soil we get. In this model we get 890 cubic feet of soil and then another 115 in the tree pit. Eureka! We have the 1000 cubic feet of soil that I've been trying to get for the last 20 years!

Am I happy with 1000 cubic feet? No. I want to grow really big trees, but I'm a lot better off than I was.



There is a lot of work to do on this yet, it will be a year before you'll see it. It has been an incredible experience trying to develop these cells and figure out how to actually make them work.



Then you can pave over the deck with any kind of paving you want as the deck is designed to take the water loading. If this was a porous pavement the water would go right down into the soil. Now do you really want to do that?

We have all these different systems and we have to use all of them. We have to think of ourselves as a carpenter and we are building something. We don't use the same hammer and saw to do the whole job; we have little saws for the

little stuff and bigger saws for the bigger cuts. We have many tools in our toolbox and we have to be ready to use them all.

So, a city like Toronto must have at least five or six different standard details that are soil-based. They should require the designer to actually go out and look at the soil and the growing conditions and choose the best tool for the job. Thank you very much.