John Oyler
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Mr. Oyler spoke on the practice and principles of restoring damaged landscapes. Mr. Oyler has been a plant materials specialist on a number of damaged sites, including the Palmerton, PA Zinc Superfund Site and the remediation of the area around Mt. St. Helens. He has also developed plants and technologies to solve many environmental problems.

The following is a transcription of Mr. Oyler's keynote address.

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Good afternoon everybody. It's good to be here. I think what I'm going to do, the best thing I could do, would be to try to put the Nine Mile Run slag project into a bit of perspective. It's a large project, but it's not the largest. And it's an ugly place to some people's eyes, but not necessarily the ugliest. I'd like to go through some slides real quickly. I've got a lot of them and very little time. But I'll show you some other projects I've worked on and what we have done on those. I'll start off with a real interesting little project a few years ago at Mt. St. Helens.

This is looking at it prior to the 1980 eruption, of course, across Spirit Lake. It's about 9,600 feet at that point. In early 1980 you start to see some bulges on the northwest face of the mountain. Some fumaroles are opening and there are early steam vents. Unlike what we think of as a "typical" volcano which is a nearly vertical movement of molten material, we had a lateral blast. The north and northwest quadrants just collapsed and about a cubic kilometer of material erupted on May 18th, 1980, blowing out that whole corner. It was real quick when it happened. Earthquakes triggered the north face to collapse and it blew out. There was about 150 square miles of land that was devastated within just a few seconds. The air temperature as far as 15 to 18 miles northwest of the mountain was over 700° F. Lots of numbers. It was very impressive. I've heard that over 500 Hiroshima blasts—I've heard over 3,000 Hiroshima type blasts as far as amounts of energy that were released.

Now, on that mountain was about 120,000 acre feet of water tied up in snow and ice, and that melted within—I've heard about a millisecond or two milliseconds. A lot of that went up in steam, but most of it just melted and mixed with that cubic kilometer of material. So you had incredible amounts of water and hot mud coming down the mountainside. The mud at the base of the mountain was over 700 to 800 feet deep, and it was boiling when it was placed. Many months later, you still couldn't walk on that yet. As the blast proceeded down the valleys it carried solid material, built an instantaneous dam, and created lakes. So Blackwater Creek became Blackwater Lake with a very unstable dam that could go at anytime.

It is really interesting what happened after the blast. Little water holes appeared throughout the first four to five miles from the mountain, and different microbes appeared in different ones. We called them the primordial soup. There were green bacteria in some, red bacteria in others. Yellow, even black water. Very interesting. There were human health problems. The trees were blown down. Well, all the trees from four to five miles from the mountain literally evaporated. They were just—gone! You had a falling dead zone then that began around five miles from the crater and that proceeded out as far as 10 to 15 miles, and then you had a standing dead area. The trees that you're looking at here, those are old growth and virgin Douglas Fir. They're anywhere from 200 to 300 feet in height. Each one of those just lying like toothpicks. The amount of energy is just awe inspiring—to see how much damage in just a few seconds.

Probably about eight miles from the mountain there are some remnant dead trees. Lots of ash. Lots and lots of ash. The ash cloud carried primarily to the east and northeast. Luckily, the eruption

Mt. St. Helens in Washington

occurred on a Sunday morning and there weren't that many people in the blast zone. Normally, there would have been several hundred loggers and other people that would have just been wiped out instantly. The tally was actually 59 people, campers and hikers that were in there. These people didn't get out. They said that the people died probably pretty quick. Air temperatures of 700 or more degrees Fahrenheit—one breath of that superheated air took them out. So, people just didn't get out at all. This area was an old clear-cut. Deposition of ash in the area. We actually had five separate depositional eruptions in 1980 between May and October and you can see different layers of the ash. They each have their own character. Very, very erosive material. Just like a pile of sugar.

As we get further away from the blast, probably about 20 miles away, you had this tremendous amount of mud and water that had been the snow pack and the mountain itself. This was boiling as it proceeded down. Very, very sandy and very erosive. It cooked a lot of the trees—just from the high temperatures—boiled water inside the trees. As it went around the outside of curves (where the water has to speed up along a stream), because it was so sandy and grainy, it just ate the riverbanks back taking roads that had been probably 150 feet away from the river at that time, and just ate the banks back rapidly. Took a lot of bridges out. Filled up a lot of floodplain. Just lots of problems. Major problems.

We had to put cinch straps on lots of cattle and lift them out with helicopters. It was just—you know—what DO you do? People as far away as Spokane (which is over on the eastern side of Washington about 300 miles away) tell me that it was a sunny afternoon and the sky absolutely went black. That you, literally, could not see your hand in front of your face. It just came up on the horizon and dropped. You could see the pre-eruption soils out on the range land. So, this effected the entire state in different ways, and ash on top of it. Decimated standing crops or existing crops. On the crop land, it wasn't a big problem because farmers could plow it in. It actually helps the soil when it's mixed in. On the range land, which covers most of eastern Washington, though, you can't afford to do anything like that. The land has such low productivity that you can't afford to even fence it much less plow it or anything else. So there's lots of problems across that area. The white fields haven't yet been turned under. The farmers are out plowing it in now. Very abrasive material—it ate all this mechanical equipment that farmers tried to use. If the lentil crop tasted grainy for a couple of years, you know why now.

Back in the blast zone and nearby, we had to do something. We had to do it fairly quick. The climate out there, basically, from September or October it rains and rains all winter. This eruption occurred on May 18th, which is perfect. The rains were just stopping, so we had a whole summer to do something. We wanted to do it quickly. There's about 100,000 people who live immediately downstream along the Toutle and Cowlitz Rivers and we needed to get this material out of it so, we had to fly on grass seed as quickly as possible. Nothing toxic about the material; pH was near neutral. It was just a logistics and fertility problem. All the roads had been taken out; we had to do it all by air. So we got started as close as we could, as I said, there were eruptions throughout the year. Every once in awhile we had to turn around and head back—the mountain spooked up on us. We got about 25,000 acres seeded in the first two seasons and what we were trying to do was stabilize the areas closest to the streams, get the streams dug out, so that they had room for the water when the rains resumed in the fall.

Just a fertility problem. Very sterile soil. This is similar to the slag pile here at Nine Mile Run. We lost the microbes, okay? We had sterile material

"The eruption cooked a lot of trees—just from the high temperatures—actually boiled the moisture inside the trees."

placed on top (anywhere from a few inches to hundreds of feet deep) and we had no microbial activity. We had very few macronutrients. We had a real nice seed distribution here from the helicopters. Everything came up and started looking pretty good. We had a grass/legume mixture. We had several different mixtures, depending on elevation. Fireweed came in in a lot of areas. It's a natural invader in the Northwest. Suddenly, about 45 days after planting, the whole mountain turned red! What are we gonna do? We couldn't afford to keep going up and re-fertilizing. This material was so porous, nitrogen was just leaching right through the profile. Everything that we put on was deeper than the roots.

Each eruption had a different character and you could see the different layers from the different eruptions. They each have their own character; some were black, sandy material, some were gray or whitish popcorn-like material. We had a few thousand acres of new grass cover that was just sitting there looking like it was about to die and we needed to do something to get longer lasting sources of nitrogen up there. There are several slow-release nitrogen forms up there, including dead elk. You know, we'd find a green spot suddenly in this red field and we'd walk over and there'd be a dead animal. So that was the nitrogen source there. Most of the main types of slow release nitrogen are all dependent upon bacteria. Generally, it's a sulfur-coated pellet with soluble nitrogen inside. You have to have bacteria that can eat that sulfur away. Here, we had none. So what we ended up doing, was that we found a slow-release material called IBDU, Isobutyl Idene Diurea. It's a long chain of nitrogen and you only need moisture in the soil. Luckily, in the Pacific Northwest, you've got moisture. We put that on and the grass took off. You can get that in eight to nine month release form. So, beyond that point, we used IBDU.

We really emphasized the legumes for natural nitrogen fixation and we didn't have any further troubles. Up, higher up on the watershed, Weyerhauser Company in particular was interested in replanting a lot of this area as soon as possible. They came up with a "rhino", it looks like a cow catcher, placed on these dozers. These dozers were running back and forth across the slopes on the contour mixing the ash in with some of the soil, and they were planting in the furrows. So, a lot of people were trying different things. Digging holes didn't really work. The trees drowned. Further downstream, we had several rivers. The Green River and the north and south forks of the Toutle River dumping into the Cowlitz River, which flows down to the Columbia and out to the Pacific. All the side streams along those rivers just filled up with dead trees. Water couldn't get out. We had several hundred of these little tributaries that we had to dig out. The material that backed up into the streams was almost like quicksand—you could walk across it at times and if you stopped and wiggled your feet, you went down to your knees. (Or down to your dozer.) So we had to work from the sides, but we were able to get them cleared out.

We used drag lines that had 15 to 20 buckets on them and generally you could stand anywhere along the river and see at least three of them in your view wherever you were. These were working about 24 hours a day for about 18 months digging the Cowlitz, and particularly, the Columbia River. The Columbia River from Portland, Oregon to the Pacific is 110 river miles. Normally, it has a 45 foot deep, 65 foot wide channel for ocean going ships, the ships just shoaled out and lifted ocean going freighters up—tipped them on their sides. It all had to be dug back out. It was just incredible—the scale of the project. They say that it was second only to the Panama Canal in the amount of material that was moved out. Lots of problems elsewhere down the rivers.

Homes that were, for example, about 200 feet back from the water were affected. Again, as I mentioned, on the outside of the turns the highly erosive material just ate it away. Unfortunately, homeowners insurance wouldn't even touch these places. They couldn't do anything until the house fell in. So people just had to sit there until the house just physically fell for the insurance to give them some money. Lots of houses like that.

About a year later, the lava dome started forming again. There was a real strong smell of sulfur. The dome was growing at about an inch per hour. You could just stay out for a couple weeks and go back and physically see how the earth had grown since

The Blue Mountain site was contaminated by heavy metals.

you'd been gone. Real eerie. No place to park up there, either.

This second site I want to mention is a little closer to home. It is Blue Mountain. It's about 15 miles north of Allentown over on the eastern side of the state, in Southern Carbon County. It's an EPA Superfund Site, currently. We have four operable units: the Blue Mountain; the cinder bank (which is a slag pile that's about two and a half miles long and about 33,000,000 tons of material); offsite soils (which are all the soils in every direction from the zinc smelters that are above background in heavy metals, that's still to be determined in area—looks like it's going to be in the area of 30 to 35,000 acres of land, though); and then, area surface and ground water. We do have a contaminated aquifer at that site and we are beginning to work on that.

I'm going to limit myself today to the Blue Mountain unit. That unit has moved along a little bit faster and we have more to report. In 1898, the first smelter opened there and a second in 1911. The early ores they were working were a smithsonite mineral which is a zinc silicate and there weren't a whole lot of pollution problems associated with it. That played out in their mines, and they had to switch to sphalerite minerals in 1915, zinc sulfide. So you had lots of sulfur that needed to come off these ores as they were being processed. Estimates that we have today, suggest that between 1918 and 1970 when the first scrubbers were installed, we averaged about 3,300 to 3,600 pounds of sulfur per hour coming out of the stacks. It was 24 hours a day from 1918 to 1970. Steep valley—the air tends to hang there. You get inversions in the summer. The first scrubbers went on in 1970. Sulfur emissions dropped to about 1,400 pounds per hour until 1980 and all smelting ceased at that point.

In 1982 EPA came in and proposed listing it on the NPL (National Priorities or Superfund List) and in 1983, it was finally listed. That's when I got involved. While the sulfur dioxide was in the air, fumigating the forest, you had particulates of lead, zinc, and cadmium dropping back out of the sky (that had come out of the stacks). Here's what you're left with. We had—the earliest reports we could find were letters to the editor, or notes, as far back as 1922 where amateur naturalists were talking about the understory on Blue Mountain. It didn't look like it had in the past, and the blueberries weren't as good as they had been, etcetera. We found aerial photos from the 1930s to the present and you can see holes in the canopy of the forest appearing in the 1930s. They are getting larger by the 1950s. By the late '60s and early 1970s, the ecosystem had just been stretched like a rubber band and couldn't go any further and just snapped. In just the course of a couple of years, the whole mountain ecosystem collapsed.

What in fact happened, the existing trees were rooted a couple feet deep in that soil. All the metals that were hitting that soil got bound on soil particles and didn't go much below six inches deep. The sulfur dioxide was working on them, but as the sulfur dioxide finally took out the old growth forests, young trees couldn't come in and the whole thing just collapsed. The high zinc levels in the soil took out the soil microbes, bacteria in particular, and so there's no decomposition. There are no nutrients cycling. There's no food. Zinc, of course, is the active ingredient in a lot of your burn creams because it does kill bacteria so well, as you can see here. So what do you do?

We started a remedial investigation. In 1984 (we) began looking at this and found that there are smelter sites just like this all over the world. None of them had ever been vegetated—anywhere. EPA was about ready to order the removal of the top 12 inches of the mountain (assuming that there was a hazardous landfill within 50 miles of Palmerton, which there isn't). The cost in 1985 was about $485,000,000 just for excavation and disposal. So I suggested to them that we consider an in-situ stabilization. If we can get the pH of the soils up near neutral, we can get the metals in the soil to form very low solubility compounds. They won't dissolve and go into solution; they can be held where they are and would be unavailable for vegetation. But again, how do you vegetate?

Well, before I get into that, let me tell you what all the benefits would be assuming we could vegetate. We could increase evapo-transportation. That's the amount of water that has evaporated from the surfaces of the soil and from the vegetation itself. That's about half the rainfall that hits, so that would decrease the amount of water running off that could carry metals. Also, it could decrease the amount of water that could percolate through the soil and contaminate the aquifer. We would stop wind and water erosion which would stop solid materials from going across.

But how do we vegetate? We have a list of problems here. We have very unstable slopes. We have very steep slopes. A lot of slopes on that portion of the mountain are 100 percent to 150 percent or greater slope. Inhibitory water regimes (what I mean by inhibitory is that we lost our moisture holding capacity). It's very dry. You can have a half inch of rain and literally a couple of hours later, dust is blowing from the surface again. Compacted, cemented surface. Inhibitory surface temperature regimes. It's very cold at night and it's very hot in the daytime. That's not conducive to growing tiny seedlings.

Near constant wind turbulence moving the fine materials around on the surfaces that bruises and girdles these seedlings. It doesn't matter if it's a grass or a legume or a tree, when it's short it's very tender and susceptible to agents like that. Very stony, broken, uneven surface—no nutrients, essentially. High levels of the heavy metals and absence of insects or microbes. The column on the left lists the problems broken down into physical, biological, and chemical. Without looking at the magnitude of any one problem, just the sheer numbers....

This was my "eureka!" thing. Wait a minute! All the literature talks about failure of vegetation because of these toxic, heavy metals, but what about the physical problems here? About two-thirds of those problems on that chart are physical problems. So then I said, "Well, I know that there are metals-tolerant ecotypes of vegetation out there, so just for the purpose of argument, here, let's take anything related with toxicity off the table right now. Let's not even talk about it. Let's just assume we can deal with that. What else is going on?" Well, we needed to use some sort of organic amendment. What I chose for this particular site (for a number of reasons) was municipal sewage sludge. Bio-solids it's called now.

Sludge alone would not work on this site. We needed to be able to put it on the surface and not incorporate it—not plow it in because of the slopes and because of the amount of rock and dead trees up there. We needed something else. Rather than putting sludge on the site and incorporating it with the soil, why don't we first incorporate it with something similar to soil and then apply it? Just the opposite. Alright, so we're looking for a light colored, alkaline, granular waste. Cement kiln dust came to mind. Power plant fly ash came to mind. We looked at different things; we tried them. Power plant fly ash was selected. Now, what else do we need to do to this thing? So this was becoming a designer soil. If you look at the column on the right, you can see that for each of those problems, we found some component of this that lent a solution. So what we ended up with was a sewage sludge, power plant fly ash, limestone, tweak it with a little supplemental potash. Then, we had to get a delivery system that could get it up on that mountain. Well, we thought we might have some system that could work. So we proposed doing greenhouse studies to EPA at that point. How much sludge? How much fly ash?

What I wanted to do was supply 2,000 pounds per acre of organic nitrogen through the sludge. So that was the driving force. And then, you back calculate how much sludge you need to supply that amount and then, how much fly ash do you need? I wanted to use the minimum amount of fly ash necessary. There's no need to put more than we need, but we didn't know how much that was yet. So we had equal volumes in a one-to-one mix, and then the sludge remained a constant amount with half as much fly ash, and then the same amount of sludge with one-third of that, or one to one, two to one, three to one mix (we called them).

We selected about a dozen herbaceous species. Grasses or legumes that were either known or suspected to be tolerant to metals. We grew them in half gallon milk cartons so we could split them open real easy and see what's happening to the roots. We had Blue Mountain soils on the bottom. There's the equivalent of ten tons per acre of limestone and 80 lbs/acre of potash in there—that little gray stripe—and then the sludge/fly ash mixture on top in the various ratios. Looked like two to one or three to one was the best ratio. On the second from the right, there's three to one plus humus. What you see there, that would be the hottest treatment. What I mean by that is, on the surface of Blue Mountain (probably five to ten percent of the face of the mountain) is a black material on top of the soil. That's undecomposed bark and leaves, and those have the highest metal content of anything on the mountain—maybe, ten times higher than the soil itself. So we put that in just to see if that would be any particular difficulty.

What in fact happened is that in the greenhouse, the humus with the highest metals content actually had the best growth in a lot of pots, and we thought it would fail. Well, okay. The legumes did not perform as well as the grasses. We had both warm season and cool season grasses. Warm season

A truck designed to blow flyash and sludge up to 100 feet up the slope.

grasses are slower to establish. Little blue stem actually took up about 1/100 as much metals as tall fescue (or rye grass) so there's big differences in the amount of uptake. Based on those results, this was May 1986, we proceeded to the mountain and we installed ten, one-acre test plots using three acres of the one to one, two to one, and three to one ratios, and the one acre control (that received the same amounts of limestone, potash, seed, and mulch but no sludge or fly ash).

The truck that you are looking at is the real key to this. It's similar to a salt truck or a cinder truck, but instead of having spinners that throw material out to the side, it has a fan that literally blows the material out. This is critical because you have to be able to apply solid material on slopes like this. We found that we can apply with consistency 100 feet uphill or downhill from the terrace routes. We brought in fly ash and sludge, mixed them up on site transported them up the mountain. Here we are blowing on the sludge and fly ash.

It's about 54 percent, 55 percent solids after it's mixed. We can lay it down. We're putting on about 200 wet tons per acre or product tons per acre. That's about two inches deep on completion. It would lay down five foot, 30 foot, 70 foot, 90 foot—two inches deep all the way back. It was like a lawn sprinkler.

After the application we had a nice neutral color. We wanted something to lighten the black color of the sewage sludge. The black on the surface would absorb excess amounts of heat and it would crust and it would dry, and it wouldn't re-water well. The fly ash neutralized that, and this light gray color that we have does not absorb large amounts of heat, and also, the sandy texture of the fly ash keeps the mixture open.

We narrowed down the list of species based on the earlier greenhouse test. We hydroseeded just because they were small plots—and hydromulched. Even the mulch we are using is shredded newspaper (trying to recycle materials). Within a few weeks following that again, back in 1986, we had decent germination. This photo would have been, probably, October of 1986 after one growing season.

This test plant (little bluestem) grew differently in varying mixtures of existing soil and nutrient additives.

We're outside a couple different Pennsylvania DEP sludge application regulations. They require that the sludge is plowed in or incorporated within 24 hours of application. We could not do that here. They have a slope max of 15 percent for land that receives sludge. That's only about like a beach. It's quite flat. We had much steeper slopes. We found this material is very non-erosive. This is after the third wettest year on record at Palmerton, and we were 13-1/2 inches above the normal 40 inches of precip that they get. You'll see the sludge and fly ash mix clinging to dead trees. Those trees have been sanded in the wind and they're almost as smooth as furniture, but the material stays on them for a couple of years. It did not move. Since then we have been through (up to 2.87') rainstorms in just a couple of years. Even with that intensity, this material did not move, so we're real pleased with it. In 1987, after two growing seasons, EPA said, "Yeah, that's the way to go. We will now do that on the whole mountain."

When I began this project, I was working for the U.S. Department of Agriculture and during that time, I switched over to the company. So we now had to go through lots of legal proceedings and, basically, what we did was we had to negotiate a consent decree or court order with EPA and the company then took the lead for this work away from EPA. Beginning in 1988 then, we took these few original test plots that you can see, and we began doing the design work for the entire project. That began full scale, then, in 1991—lots of legal problems and it took several years to work them all out.

You can only apply sewage sludge in Pennsylvania between April 15 and October 15 of each year, so we're limited to that half year window. We broke roughly 1,000 acres of this unit into five phases to be completed over five years and we ended up having to put in 66 miles of roads on the face of the mountain. There are two types of roads. We have access roads that head up across the slopes, and then we have the working terraces which are spaced 200 lineal feet apart, and from each terrace, we have about 100 feet down and 100 feet up. That was one of the major problems, just building all those roads. The Appalachian National Scenic Trail runs right on the crest here, so there's additional PR problems associated with that. It's the only Superfund site for the whole 2,000 miles of the trail.

It's funny, if I've got a minute here. I was working with the people in Harper's Ferry at the

National Trail Office. We stay in touch and just in my own mind, I had assumed that these folks would want a complete site restoration—everything the way it used to be. They said, "Well, we know you probably have to revegetate it and do all that, but will you do us a favor?" And I said, "What's that?" They said, "Please don't plant any trees up there." I said, "What are you talking about?" They said, "For the whole 2,000 miles, you can never get a good view. There's nothing but trees in the way and this is one of those few areas...." (Audience laughter). Yeah! You never know where people are going to come from! That's something to keep in mind here.

Here's a shot from across the valley, on an area called Stoney Ridge, actually, a terminal moraine from the last glacier, looking at the north face of Blue Mountain. This is May of 1996. You can see that we have greened it up. We are real pleased with it. Because of the regulatory considerations on a Superfund site, we had to plant more grass than I like and now we're paying the price for that. We don't have as many trees as I would like yet, but I suspect that as the grass competition decreases in the future that more trees will be coming out. We closed out our terraced roads on the way out. We just treated them so they're all vegetated again, too. We still have the access roads open, though.

I guess in closing, the one thing I'd like to say is that we all want to think our sites are unique. There's thousands of sites around the world—they are all unique in their own little bit, but they are fixable.

They are fixable. Technology exists out there to do whatever we need to do on the Nine Mile Run site. Just don't think in your own head that we can't do something. Thank you.

The Blue Mountain project began in 1988. This photo shows an area called Stoney Ridge in May of 1996.