Stephen Enloe is our presenter today. And Stephen is an associate professor in the Department of Crops, Soil, and Environmental Sciences at Auburn University. He is their invasive plant extension specialist. Stephen has a Bachelor of Science in Agronomy from North Carolina State-- go Wolfpack-- a Master's of Science in Bio-Agricultural Sciences and Pest Management from Colorado State, and a PhD in Plant Biology from the University of California at Davis.

Stephen has 17 years of experience in research and extension with noxious and invasive weeds across the US. And he currently is focused on invasive plants in the southeast US. It's my pleasure to introduce Stephen Enloe.

OK, well thank you very much, Tom and Holli. It is very good to be here today. I see we're up to 181, 182 participants and the list is still growing. It's wonderful to see so much interest in the topic. When Tom asked me to do this webinar, I decided in terms of herbaceous, troublesome invasives, I saw the topic was probably a little too much and decided to try to break it down and focus this webinar on invasive grasses. And so we may not cover every single invasive grass that you're interested in, but what I've put together I hope will be very useful.

We will be taking questions. And so you can type your questions into the Q&A box. Tom will be in charge of those and we'll come to some specific breaks within the webinar and we'll do our best to answer questions. I can't promise that I will absolutely get everything, but we'll do the best we can here. So let's move forward.

So I would like to give a special thanks to Dr. Nancy Lowenstein, one of my colleagues here at Auburn who worked with me on putting this together. And I want to give her a lot of props for this. OK, so what we're going to do today in terms of a discussion outline- and I do want to answer questions and I'm very interested to hear some of the discussion points that many of you will indeed have.

But to break down the overall concepts of the actual problem in and around the eastern US forests of invasive grasses, we'll follow that in with the biology and comparing key reproductive characteristics of several species. And then we'll try to link those up with management so that we can get maximum effectiveness in terms of things we are doing in the field. And then we'll try to tie it all together and answer questions and go from there. OK.

Now I'm a speaker who loves feedback from the audience. And sometimes these webinars are a little difficult to get that. But we'll do the best we can here. OK, so some specific species I want to cover today. Cogongrass. Common reed, also known as phragmites. Golden bamboo. Giant reed, also known as arundo. Japanese stiltgrass. And miscanthus, also known as Chinese silvergrass.

OK I'll speak up just a little bit. I hear there's a-- I'm seeing that come in there. So if you look at the eastern United States, we got a pretty big area here with a tremendous number of eco-regions. This does not completely cover them all. I've listed several there on the right side of the slide. You know them as well as I do on where you're located and within each eco-region. And given the diversity of folks we have on the webinar here today, your land management goals vary very widely, especially across eco-regions in terms of what you're doing.

And so and basically, that's going to come into play here. But again, it's indicative that we can't cover absolutely everything. But we will do what we can. OK, if we think about origins, history, and introductions of invasive grasses here in the east. And especially these species that I plan to cover. Primarily, we're dealing with several species of Asian origin. Many of them from Eastern, Southeast Asia. Arundo from a little bit broader area, all the way to west Asia.

But a lot of these grasses have been both unintentionally and intentionally introduced. And so we have lots of accidental contaminants, such as cogongrass and Japanese stiltgrass, which have come in with packing materials historically. Forages have been a big introduction point for a number of invasive grasses across the US. Here in the southeast, cogongrass was tested as a potential forage. Turned out to be terrible. Soil stabilization is also another one widely utilized for introduced grasses. And then horticultural purposes have been very important for things like giant reed, a number of bamboo species, including golden bamboo, and miscanthus.

And then finally, sometimes we just don't know exactly how things got here. Common reed, phragmites, has a very complicated history here in the US with native common reed and introduced European common reed. Telling these apart has been very difficult. I'm not going to get into the details of that today, but I do want to cover really what we're doing, what we can do about common reed. OK?

All right, so hitch hikers. A major, major issue. We like to say, be careful who you pick up. In the history of this country and with the settlement of the United States, we did have a lot of hitch hikers in the form

of invasive grasses that came along. And a lot of them were introduced inadvertently, unknowingly. And so it is a fundamental reality we still deal with today as USDA APHIS attempts to inspect as much as they can to prevent new hitch hikers from coming into the country. But it is a reality.

Again, forage and soil stabilization is a major historical problem associated with many grasses that were introduced. And then finally, horticulturally, grasses play a key role within a lot of horticultural landscapes. And they are a key element in a lot of landscape designs. And let's face it, bamboo is downright attractive to a lot of folks, as are grasses like miscanthus and arundo. And so that exotic look that has often been desirable within horticultural landscapes has been a big player. And although a lot of horticultural species cause zero problems as an invasive, unfortunately these have escaped and are causing major problems now.

This one slide really says it all. When you set up a situation where you've introduced a lot of non-native species-- land use change, we know, greatly enhances opportunities for invasion. And so any types of habitat fragmentation. In this one aerial photograph from western North Carolina, we have a major highway system going through. We know that highways are fantastic dispersal corridors, especially for invasive grasses.

We have power line rights of ways, you can see, running up-- I put the arrow on it right there-- running up and down the mountains. We have logging roads and trails here on the top. We have urban development or ex-urban development where we're breaking up the forest and bringing in lots of, again, non-native species and creating tons of opportunities. And then trails that often run that we're dealing with within a number of situations throughout the east.

So it's reality we face. That all of these things can indeed promote in favor the spread of a lot of invasive species, including invasive grasses. And so it's just something that we have to fundamentally recognize that this is the way the landscape looks today.

In terms of silvocultural practices, Chris Evans and his co-authors several years ago published a fantastic guide in terms of invasive plant responses to silvocultural practices across the South. The information in here is very good at detailing exactly what forest managers can do, recognizing how these practices can promote invasives, and exactly what they can do to prevent encouraging invasives in a number of different situations. This is available online at invasive.org, and I strongly recommend you go there and take a look at it. And you can download this thing for free.

So we've talked about origins, introductions, and why. Why we have the problem. The impacts are widespread. And within the audience here of now 211 people, you will-- many of you will have seen and experienced everything from minor alterations locally to literally complete ecosystem transformation from different invasive grasses. And all along the spectrum.

What we tend to see across the literature, as we review it for invasive grasses, as they invade a system from the initial patches to complete ecosystem expansion, they tend to form typically monotypic stands where not much else grows in them. They tend to be very aggressive, very competitive. And this rapidly results in reductions in plant species richness. So the number of native species especially, and diversity across landscapes.

Invasive grasses tend to strongly change disturbance regimes. OK? So they often create very continuous fine fuel layers. We get buildup of litter and thatch, each and every winter typically, as they tend to dry down. And, of course, when you have such a continuous fine fuel layer, the inevitability is frequently increased fire frequency, with very hot fires for some species. So we see that linked in as they, for monotypic stands and, change that disturbance regime and tend to burn very hot.

It's inevitable also that they're going to alter the nutrient cycling and alter microbial communities. We often see changes in nitrogen cycling and carbon cycling when we have invasive grasses come in. And so all these things kind of tie together and we have lots of feedback mechanisms that really drive the establishment and dominance of invasive grasses within a number of our forest systems.

Some big things especially that are being more and more recognized is not just inhibition of the herbaceous understory layer that we have in forests. But it's also overstory regeneration is lacking. And we have documented the losses of both conifer and hardwood establishment and growth for specific invasive grasses once they get established. We've seen this with cogongrass. We've seen this with microstegium, and it is a real problem. It's hard to really fathom, sometimes, how a little tiny grass can actually limit our tree recruitment. But it does happen.

And after you get a lot of invasive grasses established, they do begin to alter your management options. And prescribed fire being an extremely useful tool across a number of forest systems, especially in the southeast. But when things like cogongrass come in, it really changes your ability to effectively use fire.

So there are many more impacts beyond these, but this is just an overview of really what you're dealing with them and some of the bigger picture things that tend to happen with invasive grasses. Cogongrass, again, is a fantastic example of just about all of these coming into play. Imperata cylindrica, southeast Asian grass introduced about 100 years ago forming very dense monotypic stands. Located primarily in the deep South, with the epicenters being in Florida, Mississippi, and Alabama, with patches and populations expanding to the north, all the way west into Texas, and into Georgia and South Carolina now.

As I mentioned before, cogongrass definitely changes the business of fire. And within many of our conifer forests, cogongrass can create fire conditions that are very detrimental. But yet it is pyrogenic in nature with positive feedback mechanisms. And so that a month after burning, we have severe tree injury and we have 100% ground cover of cogongrass after that fire.

When you take an aerial view of cogongrass in the southeast-- this is from Baldwin County, Alabama-- and you can see all those circular colonal patches that are expanding and coalescing to form literally what we call large imperata sheets. And in Southeast Asia where cogongrass is native to, these things can cover 15,000 to 20,000 acres at a time.

We don't see that type of coverage here in the US yet, but cogongrass is a picture that's reminiscent of what we see out west with downy brome cheatgrass, bromus tectorum. Where everything you see from this aerial photo in that golden color is all cheatgrass. It has invaded the Great Basin and changed the fire frequencies and fire return intervals, resulting in the complete devastation of sagebrush communities across the west. So cogongrass is our version here in the east and southeast of what cheatgrass has done out west and it is very concerning.

Now, a second species to cover, miscanthus, Chinese silvergrass. Latin name miscanthus sinensis. Horticultural species that has clearly-- did not stay where it was put. And it has escaped, especially along road sides in several areas. This is from EDDMapS on the southeast [INAUDIBLE] website. This is voluntary data that's been reported for Chinese silvergrass escapes.

These are not from ornamental plantings, but these are out in the wild in natural areas. And you can see a tremendous number of reports of Chinese silvergrass across-- especially North Carolina, Virginia, eastern Tennessee, West Virginia. Right on up the east coast there and then all the way southwest into Louisiana. So this is a species with considerable distribution already, but a lot of potential ground to

catch up.

Miscanthus tends to really proliferate along forest edges and in open grasslands. And tends to form very dense canopies. Very, very tall grass right down the forest edge. In addition, miscanthus is being studied extensively in terms of bio-energy production. So along with species like switch grass, the native, but also things like arundo donax, elephant grass in Florida and Georgia, and miscanthus.

And you can see here a picture of a test site evaluating a number of different collections of miscanthus sinensis. So you can see, there is tremendous diversity within the miscanthus sinensis that we have here in the US. And this has caused some concern among a lot of folks regarding the potential for escape from bio-energy plantings. And it's an issue that continues to develop and be studied.

Golden bamboo and other invasive bamboos. Golden bamboo's probably one of the most common phyllostachys orio. And classically associated with all homestead plantings for many-- oftentimes, many, many years ago, a very novel species that folks have planted among a lot of horticultural plantings as running bamboo with creeping rhizomes.

It has readily escaped and creeps out from established plantings. Or where old homesteads were abandoned, we now have populations out in the middle of nowhere and you often see these things all over the southeast, especially the deep south, from Texas to Florida. But then all the way north up into Connecticut, it's sure there. And so it's out there and you'll find it's one of our more difficult species to get rid of.

You often see large, dense roadside stands. A lot of these may have originated from old homestead plantings. But when you dig back into these types of stands, you won't see a lot growing underneath a very dense stand of bamboo. Now some folks have made the argument that bamboo really doesn't get into the woods. That's not the case and you can see here a very clear example of how golden bamboo has invaded and infested mixed hardwoods.

Japanese stiltgrass, microstegium vimineum, a unique, typically short statured annual grass species. You look at a wimpy little grass like this and wonder how in the world it could ever be a problem, and then you actually get out there within the entire eastern US and realize is capable of completely taking over the understory of a tremendous number of different hardwood systems. If you look at EDDMapS reporting data for microstegium, just gasp and take a deep breath there as you can see that it utterly

dominates and has been reported literally all across the eastern US. Heaviest in the mid-Atlantic region there.

And giant reed or arundo donax. Again, a horticultural species that is really popping up on a lot of folk's radar across the east these days. If you look at EDDMapS reporting data, you can see it has been reported all over the southeast. Really the big concerns with arundo donax or giant reed is what we know it has done in the western United States. In California, Arizona, Nevada, New Mexico, and Texas especially, where is has caused immense, immense problems. And has been very devastating out there.

But we have it all over the east. And so guilt by association, if it's invasive elsewhere, is often a good predictor of its invasiveness here. And so then we see this stuff all over the place. We're worried about it establishing near water. I understand that river systems and stream systems are exceedingly different here in the east and south than they are in the western US. And we also see it on road sides and invading forest edges.

But really, go out to Texas. Go to California and you see things like this. This is giant reed or arundo on the Rio Grande River in Texas, where you literally have thousands and thousands of acres of solid monocultures of arundo. Now I'm not absolutely predicting that's going to happen across the eastern US, but it certainly does make us pause as we see what the species is capable of.

And finally, common reed or phragmites australis. Again, having a very complicated history here in the United States. Uncertainty as to its native and non-native status, now recognized as having both native and non-native types established across the US. Very, very broad in its ability to invade everywhere from road sides all the way to wetlands, where you can see it has aggressively formed very dense monocultures. And a very tough species to deal with.

If you look as EDDMapS data for this species, it's lacking. A lot of that may be due to confusion over native and non-native statuses. But along the East Coast, the common reed is exceedingly problematic. But we also do see it all the way to the west coast in California and up into Washington.

OK. Right here's a very good stopping point to answer a few questions. What do we have?

The only question I see so far is a request to please discuss specific grass--

OK.

Herbicides.

OK. Excellent-- Fred Huber, excellent question and we will get to that. I've got some definite things I want to say about the fops and the dims. And so we will come back to that question. I will address that very specifically. OK? All right, any other questions at this time?

And feel free to type those questions into the chat box and we'll pass those along.

All right. OK, folks. Let's keep it rolling then. So we're on time, doing well. And here we go. OK, the fundamental reality with all of these invasive grasses-- and you all will know this from a lot of frustrating experiences in management-- the reproductive biology and ecology are the things that continually thwart us from finding that silver bullet for invasive plant eradication.

We all want eradication. The complete elimination of all living propagules of a species. We want eradication on our properties that we manage. We want them eradicated from entire forest areas, from states, from the entire region, or even from North America. The larger the infestation, the more difficult eradication is. So in most cases, the cat well, cat's out of the bag. A Pandora's box has been opened. And there's no getting a lot of these out of the US.

However, we can very effectively manage. We can locally eradicate incipient infestations. And so there's lots of encouragement in the fact that it's not an absolute hopeless cause. But a lot of times when I talk to people and give advice on invasive plant management, I find there are some basic biology information that folks often just are not familiar with and have not paid attention to. So I really want to cover several different aspects in terms of sexual reproduction, and asexual reproduction for these invasive grasses specifically.

I put some tables together here. Now I think you might go blind and run away screaming if I were to read through these entire tables, but I've provided this information as a reference for you. When we talk about this specific set of species, Japanese stiltgrass is an annual. The rest of these are perennials, meaning that-- the annuals reproduce by seed only. Perennials can often reproduce by both sexual and asexual means.

In terms of pollination and breeding systems, Japanese stilgrass is both self-pollinated with

clastogomous flowers that never actually open, and cross-pollinated through typical open flower pollination or chasmogomy. Common reed is crosd-pollinated actually with some self-pollination and possibly even apomictic, meaning it is a form of sort of colonal seed production, where gametes are not fused.

Miscanthus we do know it is cross-pollinated and generlaly self-incompatible. And even possibly some horticultural cultivars have been reported to be a apomictic. Cogongrass, completely self-incompatible requiring cross-pollination. And finally arundo, which has no known seed production here in North America. And bamboo's a very interesting case. We know so little about bamboo flowering, because it happens so rarely. Many bamboo species may flower every 70 years on decadal scales. There are populations of bamboo that have been planted in test gardens here in the US since the 1920s that might have flowered once in that time period.

And so these pollination and breeding systems will often come into play in regards to management. Seed production, we know stiltgrass is very widespread, making lots of seed. Common reed, not so much. Very variable for miscanthus due to that self-incompatibility. And cogongrass too. One thing I will say is, even with self-incompatible species, though, the more establishment you get of individuals, the higher the seed production is typically going to be as those opportunities for outcrossing increase. And that is definitely what we're seeing with cogongrass across the southeast. Arundo, again, nothing. And golden bamboo is so extremely rare in terms of flowering. It's even hard to study.

Wind and water are the two primary dispersal agents for a lot of these grasses. And this flooding is just a nightmare, especially for things like siltgrass, because you do your best to manage it. And the next time the flood waters rise, you get an entirely new crop of seed coming in. And so it's hard to stop. Wind dispersal, some folks have advocated planting very dense shrub layers on the edge of forests as a means of deterring wind-dispersed seed, to some success. But it's not a perfect solution and it may not fit your management goals.

But the wind and water dispersal from natural means are really headaches for a lot of these species. And that is beyond all the anthropogenic type methods of dispersal. Seed bank longevity with grasses in general is often relatively short, so we're not dealing with leguminous seed banks that last 50, 75 years.

And a lot of these grasses are extremely short-lived in their seed banks of a year or so. Some reports of stiltgrass being three to five years. But this is a good thing. And it is encouraging for local management

that we're not dealing with a long lived seed bank. And that we can get on top of these things.

So as I mentioned with cogongrass, most of these annual grasses-- or most of these invasive grasses have very small seeds. And I just wanted to show you a few pictures here of-- this is cogongrass. And you can see that the individual spikelet there is tiny. And the fruit itself is about a little bit over two millimeters. You can see three flower heads there in the Petri dish, with literally hundreds and hundreds of germinating cogongrass seedlings. Here we have common reed, Japanese stiltgrass, and miscanthus fruits. And you can again see-- we're on the millimeter scale here. And these things are absolutely tiny, which is why wind dispersal is often so effective.

Now if we then move to really, the thing that is the driver for a lot of these, and that's asexual reproduction. And that is often from rhizomes, underground creeping stems, or stolons a first growth above ground lateral systems. And you could see, as an annual, stiltgrass has no rhizomes. It has been described as having stolons. But really, I think, rooting at the nodes is probably a better descriptor of what stiltgrass is capable of doing.

But you can see that common reed, cogon, arundo, and golden bamboo have very extensive creeping rhizome systems. Miscanthus has more of a-- sinensis has more of a compact branching rhizome system that actually creates more of a bunchy or bunch grass type growth form. So individual clumps as opposed to a sod forming type species.

Now rhizome depth is one of those things that you get in the literature and you will find wild estimates all over the place for some of these species. In general, most rhizome growth is typically within the top 12 inches for most of these. However, anywhere you have sediment that comes along and buries rhizomes. Common reed has been reported to regenerate from rhizomes buried as deep as 30 feet under alluvium. Arundo has been reported to generate from rhizome fragments buried three to 10 feet.

And so it's something that you really need to pay attention to within management. Because I get a lot reports of folks saying, I've been spraying that every year for the last 20 years and can't kill it. But they've never taken a shovel and dug down to find out exactly what kind of rhizome mass you're dealing with. We often say that roots and rhizomes are the hidden half. With these species, they're often way more than half. Oftentimes occupying 70% of the total biomass. And so when you have 70% below ground and only 30% above ground, you've got a much greater problem to deal with.

The data on older, established infestations having deeper rhizomes for these species is very unclear and very uncertain. It has not been reported for most species. So we can't always clearly say that the oldest patches will have the deepest, thickest rhizomes, because that hasn't always been the case. But we do often make the argument that older patches are indeed more difficult to control.

Again, when you look at data for rhizome spread for some of these, it's all over the place. Reports for common reed of about one and a third to six feet a year. Since miscanthus is very compact, a very short rhizome spread. Cogongrass six to nine feet. Arundo, unknown. I did not see a good estimate. But oftentimes you see arundo stands slowly creeping out. Golden bamboo or running bamboos, 10 feet a year reported. Sometimes tend to-- people have even claimed up to 20 feet a year that those rhizomes are capable of running out. And I can't disagree with that. If you've had that experience, then I will believe you.

Stoloniferously, most of these don't have stolons except for common reed, which can have extensive stolon production. And in terms of routing at the nodes, this is another one that comes into play. Arundo donax, very, very effective if you lay a cut stem down on wet soil, you can see rooting. Or if you put it in water, you can see rooting and establishment of new plants. That doesn't happen with miscanthus, golden bamboo, and again, I think it's uncertain-- and I may have left it out there for common reed.

OK, so really, it is often below ground what we are truly struggling with. I want to show you some pictures of this. This is common reed rhizomes. You can see that very dense mat going down probably about 18 inches in this case and extremely thick, heavy mat of rhizomes. All of these rhizomes are capable of regenerating new plant material, so it's real easy to see why even 95% control, or 95% kill, still leaves a tremendous amount of living rhizomes that regeneration can occur from. This is really why a single herbicide treatment almost never works completely, and you often are required to go at it for several years.

Here's the stoloniferous growth from phragmites, or common reed, and you can see these stolons running across the soil surface, rooting and establishing new plants that way too. So you can literally have a network of common reed occupying the soil through rhizomes and running across the top of the ground with stolons, resulting in those very dense [INAUDIBLE] mats of reed.

Right here is miscanthus. Rhizomes are typically-- with these perennial grasses-- are produced very quickly, and they form a very dense rhizome mass, even within one to two years. This is first-year

miscanthus rhizome production. And you can see that [? bungee ?] type, tight clustered short rhizome that you typically see with miscanthus. And within a year, this thing has already established a rhizome mat about eight inches deep, and very, very thick.

And again, cogongrass-- a much smaller rhizome, very tiny in terms of small, cylindrical, white-- covered in a leaf-like sheath, typically going down about four to eight inches when you start digging and measuring, and I strongly recommend doing this. Get a shovel out there in and of these perennial patches. Find out the rhizome depths you're dealing with and the biomass below ground. And it'll really begin to help you understand the depth of the problem you're dealing with.

Take a look at that bottom left-hand picture, and you can see, literally, that every single one of those nodes is capable of producing a new plant. And so you don't often see this because many of those are maintained dormant through atypical dominance until some type of disturbance begins to release them. But it goes to show that if you get rid of, again, 95% to 99%, there's still adequate rhizome for reinfestation if you don't follow up.

Now, in contrast from very tiny cogon rhizomes, here we have giant reed, or arundo, rhizomes. And if you've ever dealt with these, they can be absolutely enormous. You can see that somebody's holding those in their hand there.

And that picture on the right, you can see the sheer size of these rhizomes. And they form a very thick, dense mat. They're often very sort of abnormal looking. They don't have that very uniform, rhizomatous growth that cogon has. They're often thick, swollen. And these are absolutely loaded with energy, and they have tremendous energy reserves. All of these creeping perennials do. And so they have a lot of fuel in the tank to tolerate a whole lot of disturbance.

Here's a great picture-- a great example of leaving small pieces of rhizomes behind after management on the left there. And you can see very short pieces of Arundo donax rhizomes that are resprouting. So in some sort of mechanical removal, these were left, and very clearly can resprout and produce several new shoots from relatively small rhizome pieces.

Here, you see on the right the arundo is one capable of strongly rooting at the nodes. And this floating stem actually got hung up, and you begin to see new sprouts coming from essentially all of those nodes.

And also bamboo-- the nightmare that it is-- running bamboos have very strong rhizomatous growth. In the spring, they form buds on the ribosomes. These buds then shoot, and bamboo goes through the shooting process, whereas those new shoots attain their maximum growth within about four to eight weeks for most bamboo species, before they generally form many new leaves.

And so, you have a situation where, in the spring, massive reallocation of energy reserves from the rhizomes up into that new shoot growth before they leaf out and begin to photosynthesize-- and following that, we get tremendous running growth of the rhizomes as they continue to expand out from the main patch.

This picture on the left is one of those that's very common when we get complaints about bamboo coming under somebody's fence or onto somebody else's property. And even when you use barriers, you can see that tremendous rhizome growth that is pushing against those barriers.

And these running bamboos, they just never stop. And so you can hope to contain them, but it is often exceedingly difficult. And this is just a good example of the sheer rhizome mass that is constantly pushing. It's trying to expand, trying to increase that stand.

Here, you see that happening out from large bamboo circular [? colognes ?], and you can see all these new shoots about 10, 15 feet from the patch edge, and these new shoots have yet to leaf out. But these are all literally from rhizomes that have expanded out from the patch itself. And this occurs each and every year, and in the spring, you see this type of new shooting occurring.

OK. Let's see. Was that-- Tom, was that the point I wanted to stop at next to take any questions at this point?

Yes, I think so. And--

[INTERPOSING VOICES]

You have one from [? Marsh ?] Hughes. What is the germination temperature for stiltgrass?

Oh boy. OK, you caught me with that. Season-wise, stiltgrass is reported to germinate often as early as March. So typically, those are pretty cool temperatures. I think maximum germination is going to occur later into the spring and early summer. And so it will germinate over a wide range of temperatures

because we do see stiltgrass continue to come on.

But in March, oftentimes temperatures are going to be in a lot of places either in the 50s-- and so I don't know what that base germination temperature is right off the top of my head. I could look that up for you later and get back to you on that for sure. But it can happen quite early in some parts of the country. In the colder parts of the country, I think that's going to be a little bit later in the spring.

Next question from Kelly Cairns in Wisconsin. Our most common invasive grass in forests, especially in flood plains, is reed canarygrass. Any advice on getting trees regenerated after reed canarygrass has exploded after a timber harvest?

Oh boy. OK, I did not incorporate reed canarygrass into this talk. And Kelly, let me think about that one and get back to you at the end of the seminar because reed canarygrass is yet another very aggressive beast that we are dealing with. And so I will come back to that at the very end, OK?

Dee Price asks, how do these invasive grasses relate to Johnson grass-- and dealt with as a noxious weed in the Northeast.

OK, well, Johnson grass is another warm season grass that was introduced purposefully. And unfortunately, it did not stay where it was put. It turned out not to be desirable, but escaped and became one of the worst invasive plants we have across a lot of the country now, and has definitely spread northwards.

Johnson grass is another rhizomatous grass species with a pretty thick rhizome system-- nothing comparable to phragmites, but it also flowers and produces a lot of viable seed. And so we often see it moving up and down the road sides. It typically does not like shade, so it doesn't get into the forest so much. But within agricultural systems, hay fields, and road sides and rights of ways, is a very tall statured, perennial grass-- can cause tremendous problems.

Rod had a question. Are your distribution maps current? We have common reed in New York, but it does not show on the map.

Yeah, Rod, excellent question. And I mentioned this before that those EDS maps are voluntarily reported data, and anyone can register on EDSmaps and report distributions of a tremendous number of invasive plants. My purpose in showing those EDS maps was to sort of show a general distribution.

And you're exactly right. There is tons and tons of phragmites where you are, no question about it. And I'll mention again, this is an opportunity for folks to volunteer and contribute to the better mapping of species like phragmites, where clearly we are deficient in that area. So yes, I agree 100%.

Those are all the questions now.

All right. OK. Good deal. I see one there from Tom [? Vorek. ?] Are any of these roots rhizomes edible? OK, does anybody a fan of bamboo shoots?

Apologies to Tom.

[LAUGHTER] That's OK. So there are some species of bamboo that are definitely edible, moso bamboo for sure. The newest is the rhizome tips emerge and turn into shoots. Those things are edible. And so yes, they are. In terms of other rhizomes being edible, I would love for anyone to contribute who's ever eaten any of these roots or rhizomes and tell me how they taste, but I don't see a lot of interest in consuming most of these things.

I do see more question from Robert Piper. I'm in Western Pennsylvania. Can stiltgrass freeze out at any time?

Western Pennsylvania. Can stiltgrass freeze out? Say, with an early frost-- I guess if you had an early germination with a severe, late, hard frost, I think you might get some mortality there, but it would have enough of a seed bank to recover from that. It typically will have produced seed in the late summer, early fall, so before the fall frosts begin, it will have already produced viable seed which will tolerate winters, no problem at all. All right.

Think we could move on now.

Yeah, absolutely. OK, management options. Cultural, physical, biological, and chemical options-- again, there's no silver bullets. When we talk about cultural, you wouldn't be here if you didn't already have the problem. We say an ounce of prevention is worth about a $1 million of weed control. That is indeed the case, and we really do push the idea of early detection, rapid response. Stopping new infestations and implementing best management practices are going to minimize weed spread.

Fire plows-- don't plow through cogongrass on your road sides. Recognize, if you're not managing on

your road sides, you're spreading a lot of seed that way. Microstegium is a bad one for that. Just a number of different ways-- they're common sense, but they're often very frustrating in terms of management to do.

Washing equipment off, making sure you're not planting contaminated seed, and making sure you're not planting or encouraging the growth of invasives that are actually known to be invasive-- so lots of cultural things. A lot of you are already doing the best you can there.

Education of neighbors and adjoining landowners-- you'd be surprised at the lack of knowledge and understanding a lot of folks have. They don't recognize the problems invasives cause, and so it's a good opportunity for you to reach out and educate them. And we've always found that it's a whole lot better-- education is better than confrontation. And so get them on the same page before you jump down their throats.

OK, so if we think about different physical types of control strategies-- and many of you have implemented lots of these. What I've tried to do here is summarize a lot of the literature regarding mowing, burning, grazing, hand pulling, digging, all these physical types of control.

Mowing is effective within pre-flower timings for Japanese stiltgrass control. I know there is some cleistogamous seed that's produced earlier. But in general, as a late summer flower, you've got a pretty good window to get pretty good suppression of stiltgrass with mowing. For common reed, some folks have reported mowing for three years in a row did it, other folks two-- two times a growing season for two years for miscanthus.

But for everybody who's reported this is effective, I've had people who say that they mow nonstop and don't get rid of it. Cogongrass-- really, arundo and bamboo-- I don't think you can mow enough. I don't think you have enough gas or diesel to actually completely eliminate these things with repeated cutting. You'd be at it every single week for many, many years, in many cases. They have such tremendous energy reserves.

Burning in general-- burning has not been effective for literally any of these species as a standalone tool, OK? Grazing is all over the place. Stiltgrass-- highly undesirable to most grazing animals and wildlife. Common reed-- cattle will readily graze it, but to get effective control, the heavy grazing that you need often results in a lot of non-target damage.

Miscanthus is grazed readily in Japan, and they actually graze it in agroforestry situations and do a pretty good job there. We haven't really done as much of that type of work here in the US. Cogongrass-- very high in silica with very sharp leaves that are very undesirable to grazers. You can force cattle on young, new growth, but if you are forcing them to eat it, they're certainly not doing very well.

Arundo-- there's almost no information out there. There's a lot of anecdotal reports that goats and sheep will really go after it when it's small. And so in terms of management, if you are able to use goats and can get it within their range, they will go after it. Golden bamboo, again, is grazed by all classes of livestock if they can reach it. So once it gets above, they'll create a browse line around bamboo patches, but they are not going to be able to climb it very well.

Hand pulling for microstegium-- very effective before seed production. It is nearly impossible to hand pull any of these perennials unless it is a brand new infestation from a single rhizome piece that's been cut. For the most time, when you hand pull any of these perennials from established stands, if you can even do it, you break off the shoot from the rhizome and often get very little of the rhizome mat to come up-- very difficult.

Digging-- not needed for stiltgrass. And literally, we're talking about major excavations of rhizome removal for maximal effectiveness, and heavy machinery is often going to be required. I challenge anybody just to take and go measure out a one square meter area-- a meter by a meter-- and hand-dig all of the rhizomes of any of these species out of that area, and then determine the feasibility of expanding that to larger patches of hand labor.

Exceedingly difficult-- we have dug hundreds and hundreds and hundreds of cogongrass rhizomes, and it is incredibly difficult. Arundo rhizomes are very woody, golden bamboo very woody, miscanthus very woody-- common reed, not quite as woody, but just exceedingly difficult to even get a shovel or a pick into a rhizome mat of any of those species.

In terms of the promises of biological control, this is really a frustrating thing for grasses. We have very few bio control agents. I'm talking about classical biological control going back to the native range, searching for insects or disease that are host-specific to the target weed, testing them excruciatingly before bringing them over, releasing them here in the US, and hoping that they have some negative impacts.

For stiltgrass, there's none available. There has been observed reports, and you'll often see these for bipolaris, a pathogen, or some different insects. None available for common reed, miscanthus, or cogongrass. For arundo donax, Tetramesa romana, a stem-boring wasp, was released back in 2009. And so golden bamboo-- really none available-- very few reports.

One interesting thing for miscanthus and arundo, the probability of bio controls will go down even further if they become widely utilized as bio energy crops because that would be in direct conflict with the goals of a good bio control program because it would require-- it would be like introducing a new pet into a new cropping system here in the US, so not likely.

So the problem with bio control-- it's often been focused on broad-leaf species. So many grasses are closely related to some of our most important agricultural grass commodities, and that has made finding very host-specific pests-- or host-specific insects and disease for these weeds extremely difficult.

So it's a difficult thing. The concerns of non-target damage and escape and movement is a concern. We've had some fantastic examples of success, and some very big mistakes we've made in the past with bio control. I don't have a lot of hope for bio controls for most of these species.

OK, let's stop right there in terms of [? these ?] management before I get into herbicides. And I know we got started a few minutes late, Tom, but we're definitely going to get our hour in here for your credits. So do we have any questions at this point on non-chemical control or management of any of these species? And I will get into integrated strategies they utilize both physical controls and herbicides.

The only other response we've gotten is from Peter [INAUDIBLE], who commented that knotweed is reported to have vitamin C, but not questions.

OK, knotweed-- yeah. So the [? polygonaceae ?] species-- not grass. They're not grasses in general. But yes, I've heard that before too. OK, so folks are itching to get to herbicide questions here. OK, here we go. So the reality is, after many, many efforts of implementing a lot of different physical controls, we do often use herbicides in a lot of situations.

The lack of selectivity is really a big problem in many areas because we're trying to manage them in invasive and highly diverse areas, and we want to minimize non-target damage, and we want to do the best we can with that. I always have to say this, but herbicide label is the law. You must read and follow it because it is a legally binding document.

If you're looking from technical support from companies, you're going to find it varies widely from company to company. In the 1990s and the first decade of the 2000s, we had companies that were much more heavily invested in basic plant control that have now kind of backed off from that some. And a lot of companies are heavily focused on agronomic production. And so you're just going to find widely varying technical support in terms of products.

OK. Herbicides widely used for invasive grass control-- I've put together a table here, and I've got a couple of tables. This is not all of it. Far and away, the number one active ingredient utilized for a lot of invasive grasses is glyphosate. You may know it as Roundup Pro Core Concentrate, Rodeo, Aquamaster from Aquatic Habitats, and about 300 generics out there-- tremendous number of glyphosate species.

Some of the key points that I'm going to bring up here in terms of recommendations is depending on where you're at in the country, and you will find different recommendations in terms of herbicide rates and application volumes for spot treatment and foilar broadcast. For example, you can find PA-- and these are the Latin names-- the abbreviations of Latin names. So PA is Phragmites australis. AD is Arundo donax.

You can see Roundup Pro and some glyphosate formulations recommended at 1.5% volume to volume for spot treatment, miscanthus, or Microstegium vimineum at 2% volume to volume being very effective. Other folks suggest Arundo donax needing about a 4% volume to volume solution of a Roundup or glyphosate product, and Imperata cylindrica, or cogongrass, about a 4% solution too.

Golden bamboo is much higher, typically in that 5% to 10% volume to volume range. And I will say that even with those high concentrations, golden bamboo is unbelievably difficult to kill with glyphosate, so it is going to take many, many applications to do it.

Foliar broadcasts are often for glyphosate products-- for microstegium-- in about 1.5 to 2.5 pints per acre. For the rest of these perennials, you're literally going to be up in the range of close to a gallon per acre for a lot of products. Between two quarts is on the low, and I never have a lot of faith in two courts of any of the glyphosate formulations for creeping perennials. At best, I think you're going to get a lot of suppression, but you don't kill as many rhizomes with the lower rates.

So most of the time, you are up around literally 3.5 to 4 quarts, or up to 5 quarts per acre, depending

on the species. And that alone does not completely kill the entire rhizomes mat with glyphosate. Historically, you may have heard Roundup kills the root. Well, yeah, it does that very well for annuals, but it does not completely kill rhizomes-- those creeping underground stems.

You can watch them die. It takes a long time, oftentimes. You can watch ribosomes die for two to six months following a glyphosate application. But in general, as a rule of thumb, for spot treatments, you're often somewhere between about 2% and 5% volume to volume applications for a lot of these troublesome, invasive grasses.

And now, glyphosate is non-selective, has no soil activity. One of the most important things is the formulation you're using in relation to being labeled or not labeled for aquatic use. Many glyphosate formulations that have a surfactant package built in are not registered for use in aquatic environments. It is the surfactant package that has aquatic toxicity issues with regards to fish and other aquatic invertebrates.

And so any time you are working around water with glyphosate, make sure you're using aquatic formulation, and always add an aquatically-approved surfactant that will help improve absorption into the leaves because without it, aquatic glyphosate alone does not absorb very well-- the plain molecule. Noticeable activity with glyphosate, especially within natural areas-- you're not getting any residual control from it. And it's only effective on what you foliage-wise spray it on.

The other-- probably the 800-pound gorilla, the most powerful grass herbicide that I think we have, is imazapyr. And this is a compound that you have to be very careful with. If you're in forestry, you're going to use this widely in terms of site prep and at lower rates for herbaceous release or treatments like that.

Two-pound-per-gallon formulations of imazapyr would include Arsenal, Chopper, Polaris, Habitat-- Habitat being the aquatic formulation. And oftentimes for foliar spot treatments, you're going to see-- you're going to come in around 2% volume to volume for those two-pound-per-gallon materials. Some folks recommend less, but for the deep rhizome systems, again, imazapyr-- I still like to be at about 2%. For foliar broadcast applications, at 3 to 4 or 4 to 6 pints per acre is where you're going to need to be for foliar applications.

Imazapyr-- tremendous soil activity. This is not something to play around with under desirable

hardwoods or literally around any desirable species, as that soil activity can be taken up, and you can get significant non-target damage. So you have to be very careful in using imazapyr products within forest systems. Within the conifer systems, things like [INAUDIBLE] pine, of course, very effective. You have to be very careful in longleaf pine and slash pine, especially.

[INAUDIBLE] excuse me, I want to go back. Arsenal AC, the forestry product specifically, is a four-pound-per-gallon formulation, and so you can literally typically cut the rates in half for most of these perennial weeds because it's double strength.

[INAUDIBLE], typically another forestry product-- it has been utilized for bamboo as a soil treatment, not necessarily a foliar application, but a spot treatment applied in a grid pattern within the stands. And that is a very slow treatment to work, as the bamboo takes up from the soil, it repeatedly defoliates.

Imazapic is an active ingredient found in Plateau and generics like Impose and Panoramic. For microstegium, for foliar treatments, four ounces per acre has worked very well. It's also worked as a pre-emergent material, getting it out before microstegium starts germinating, or the combination of imazapic glysophate, which is Journey, and you want to be in that 10.7 to 16 ounce per acre range for microstegium.

So these are some of the key herbicides that are utilized for grass control. The graminicides-- these come up a lot in terms of how effective are they. Is it worth my time to use them? And you'll often hear them called the FOPS and the DIMS, and that has to do with their base chemistry name, like fenoxaprop, fluazifop-p, clethodim, sethoxydim.

You'll see products like Acclaim, Extra, Fusilade, Select, Vantage, or Poast, and there are other others out there too. These are very specific to grasses. They affect an enzyme that is insensitive in broadleafs, and so you can kill grasses with them without hurting broadleafs, which is really nice to have that selectivity.

The labels with non-crop areas vary among these products. So if they have a non-crop label, then they're going to have frequent utility, primarily for microstegium control. And so they vary in their effectiveness. All or most will be effective at seedling stage. Some of them are effective up to pre-flowering. So you also often have a pretty good window over the summer to use some of these products.

They do vary. They are generally weak on large, rhizomatous perennials. Now, some of these are effective on Johnson grass, but when you get into things like cogongrass, phragmites, or bamboo, typically, they just don't effectively translocate throughout the rhizome system and kill it. So they translocate to the growing points within the [INAUDIBLE] and kill those shoots. But you get shoot burn down, but then you typically get pretty rapid resprouting. And they just fail to completely kill the rhizomes.

So for annual grasses-- for microstegium especially-- they can have a really good fit and increase your selectivity. And there's been some data out there to suggest that they actually can result in a little bit better control and release of native species than glyphosate treatments. So these things are definitely something to look at. Sometimes, they're pretty expensive, though, and that can be a limiting factor in their usefulness, especially within natural areas.

Now spray additives are always a big question. These are additional products added to the spray tank to improve absorption and other things, and are generally required. NIS is one you'll often hear of-- non-ionic surfactants. You never need to go above 0.5% volume to volume. But NIS is often a very good choice to add, and the labels will specify them in terms of adding about a 0.25% volume to volume of good, non-ionic surfactant.

MSO or methylated seed oil-- very effective and very useful for certain formulations of imazapyr like Chopper Gen2, and can also be useful with Plateau. Crop oil concentrates are another one often utilized with some of those fops and dims, in terms of selective annual grass control at about a 1% volume to volume. Herbicide labels are going to dictate the best additive to use.

You may need other additives depending on your situation with glyphosate. Ammonium sulfate can be used if you have very hard water. We have about 200 parts per million, especially calcium. Some pH stabilizers-- colorants or spray dyes are very easy for spot applications. Emulsifiers and drift control agents-- not so much in terms of spot applications, but in terms of broadcast applications, these things are also useful. And there are several others out there. But the label will typically recommend what you need. Now, what about optimal timings for herbicide treatments? And I want to focus on the perennials here. We often talk about late summer, into the fall-- has been widely shown to be the most effective window for herbicide treatment of a lot of our aggressive perennial grasses.

Oftentimes, we talk about treating phragmites at flowering, arundo at flowering. Golden bamboo is not

going to flower, but cogongrass flowers. It's kind of bizarre and flowers extremely early in the spring. It's one that does not link up with flowering, but it does link up with late summer and fall treatments being most effective.

Here are the problems of waiting. Some things just get too big to treat with ground equipment, and especially for backpack spray crews. Phragmites can get very tall. Arundo can get overhead. Golden bamboo is going to shoot up fast. And waiting until late summer or fall, you're just unable to get over the top of it at that point, so you got to start spraying earlier.

Too much acres to treat within a short summer/fall window is a problem for a lot of folks, and you've got to spread out your applications over a longer season. You need your crews working for a longer spray season than just the late summer and fall. And of course, weather, weather, weather always throws a monkey wrench into the best laid plans that we have with regards to whether it's drought, whether it's excessive rainfall, whether it's inclement cold weather coming in, especially in the fall. These things can always frustrate.

So one thing this will tell you, though, is if the standard is late summer/fall treatments, when you start to deviate from that, you may begin to see less effectiveness, the earlier the applications. I'd never recommend treating perennials in the early spring because that is when they are pushing growth upwards, and you just don't get very good control with most of our herbicide glyphosate with imazapyr treatments treating that brand new growth of perennials in early, early spring. Oftentimes, we want to wait until there's a couple of feet of regrowth minimum-- so things like phragmites, maybe waiting until it's four to five feet tall.

Times to avoid spraying-- clearly, if the grass leaves are rolled up, that's drought conditions. Do not spray. If rainfall is upon you and you know it's coming-- and the rain fast period is going to vary by herbicide, but it's nice to have several hours before rain. We used to say we'd love to have 24 hours. Labels will often now specify rain fast within sometimes 48 hours. For glyphosate, they have surfactant packages built in now. They're pretty good at having a relatively short rain fast period.

If you have lots of soil activity-- so you're using imazapyr-- a little bit less important, but imazapyr is still largely foliar active. For heavy frost-- and we talk about applying in the fall-- I love to see about two to four weeks ahead of first frost, if possible, when you're treating perennials like this because oftentimes a heavy or killing frost can really shut down herbicide translocation downwards.

And the closer you get to that, especially further south you get, where plants are more susceptible to frost, the better it is to have about a four-week period, if possible. If a label says do not spray and this is in heavy winds and things like that, then you've got to follow that label.

Now, let's wrap this up pretty quickly here. We're a little bit over, but we're about at an hour. Integrated strategies-- so why do them? I talked about cutting, burning, and mowing, how they're typically never standalone. We do often integrate them in with herbicide treatments. What are we doing here? Number one, trying to get it to a manageable size. Number two, dealing with that thatch litter layer, that decadent growth that can often inhibit herbicide treatments.

Number three, stimulating new uniform growth that's going to be easier to get through, easier to recognize and uniformly spray. Number four, those things can help you access very dense infestations so you can work your way into an area you just couldn't even get into before. And number five, reducing below ground energy reserves and then following that up with a treatment when photosynthates are moving downward.

Ideally, theoretically, doing any of these cutting, burning, or mowing operations to allow treatable regrowth in the late summer and fall, when plants are storing energy below ground, that's probably about the optimal way to integrate these things. Now, I know that's often difficult to do, and we're limited within the seasons, which we may be cutting, burning, or mowing for many reasons.

And it doesn't always work out perfectly. If you're doing winter burns, you'll often find that your regrowth comes back much more vigorous, and you cannot wait until fall to treat. If you can implement early summer type cutting, burning, or mowing regimes, a lot of times, it's really good in terms of getting a good size regrowth towards the late summer for application.

It varies by species tremendously. It's not something that is very simple, and it varies within the conditions you're working in. But this is really why we would recommend integrated strategies.

After herbicide treatment, do not be too hasty to mow, cut, or burn, OK? So what you want to do-- you've invested in a very expensive herbicide in a lot of cases. If possible, you want to wait for your shoots to be crispy all the way to the ground. If you cut or mow those things off prior to that happening, you are reducing the potential for some downward translocation.

And so, as a lot of these perennials die from the top down, especially with imazapyr type treatments, you really do not want to sever-- cut them off-- as that herbicide often translocates very slowly over a month or more. And you see kill expressed over a couple of months, even. So don't be hasty in terms of following up just to clean up a site. Let the herbicides work.

Finally, why doesn't a single treatment normally eradicate anything? This is what we face and why. We often push programs, adaptive management, and following up with additional treatments because even short-lived seed banks will have some seed that delay emergence and escape.

Leaf area and shoot growth, as I mentioned before-- and I hope you've sort of gained a picture of the massive amounts of underground growth. Oftentimes, our leaf area is just not adequate to get enough herbicide to below-ground parts. And then, when your below-ground parts are filled with dormant buds, they're not active transport sinks, and they often do escape treatment.

And finally, environmental conditions at the time of treatment can greatly locally influence outcomes, whereas you see very good control in specific patches and very close by. A couple of days later, you don't see as good of control. That can come down to applicators in some cases. In other cases, there's just random environmental variation out there that results that we can't even explain to date.

So to tie it all together, the reality is effective management-- we've come up with effective management for most of these species. Bamboo is probably the hardest of all of these to get rid of. But under-- [INAUDIBLE] and ecology in terms of reproduction, and really, what you're dealing with below ground for these perennials can really help in terms of beginning to address them better.

Do not ever expect silver bullets. If anyone promises you silver bullets with a specific treatment, don't believe them. And finally, invasive plants are a persistent, learn-as-you-go process. We've done-- there's tons of research out there, but there's always more to learn.

And applicators themselves can literally learn as much as the researchers can. Adapt, and modify, and press on. Giving up oftentimes can result in going back to square one. And so single, annual treatment programs, where you spray it one time and walk away from it-- I guarantee you, you will almost always go back to square one within two to three years.

I do recommend a management guide for invasive plants in Southern forests. It's not comprehensive for a lot of the Northeast, but it is a very good guide in regards to detailing a lot of different

management strategies, along with herbicide prescriptions. This thing is free. You can get it from the Forest Service. You can download a high-quality PDF online from the Southern Resource Station-- www.fs.usda.gov-- and go to the Publications section. So with that, I will stop there to answer questions until we're done.

We've got one from Trent Duncan. What is the best way to convert miscanthus fields to forest land, where the grass is already well established-- 8 to 10 feet tall? And then I think he wanted to follow that up with a specific chemical recommendation.

All right, Trent. We've been actually studying this whole business of miscanthus and in situations of trying to farm it out. Direct conversion to a forest can be a little bit tough. We've found tillage that breaks up those clumps and lifts separate-- lifts those clumps up-- has been very effective at killing miscanthus in Memphis. A single tillage typically isn't going to do it, but we've been able to integrate glyphosate treatments to any regrowth following tillage, and that's been very effective at marginalizing miscanthus as a weed problem.

Broadcast applications of glyphosate across the top of big miscanthus like that-- we've gone up to a gallon per acre in a single application. It doesn't always get it. We often see some survival around the periphery of a lot of those clumps of miscanthus. So I think it's often difficult to get really good coverage, and you do see some survival.

The imazapyr treatments as a site prep type treatment are going to work pretty well prior to going back, depending on the conifer you're planting back. And so those are two very good options. If you can get tillage [? enough ?] for miscanthus [INAUDIBLE] to get it below and lift up those clumps, they do not tolerate that very well at all. And that's one of the reasons we don't see miscanthus as a major agricultural weed problem because it can't tolerate tillage.

David [? Demec ?] has what looks like a comment. "Improving tidal flushing of marshes discourages common reed. Common reed will tolerate brackish water, but not salt water." And I guess that's experience from Cape Cod.

Oh, I love to hear things like that. I love to hear those types of folks who are figuring out management strategies where if you are capable of doing tidal flushing, then by all means, absolutely. So I think that's great, and I love to hear that type of stuff coming from land managers, especially up on the east

coast. Thank you for that, David.

Nathan [? Gatlan-Wilks-- ?] "Last year, when we had a lot of rain, microstegium seemed to explode. This year, it has not been raining as much, and the microstegium does not seem to be as much of a problem. Are my perceptions correct? Does microstegium need a good amount of soil moisture to choke out its competition?"

Well, it does germinate with very good soil moisture. If you're in drought conditions, we often see a lot of annuals that occupy moist forest conditions are delayed or reduced in their abundance that year. Don't grow-- don't assume you've gotten on top of the problem just because of that. And you'll often see in these situations that it will come back like gangbusters when moisture comes back.

I think you may have already answered this, but "what about a grass-specific herbicide such as clethodim?"

Absolutely, Harley. The FOPS and the DIMS-- again, they have very good fits, some of them do, for microstegium. Clethodim has activity-- I mean, it's clearly registered for several perennial grasses. Experience has been, in terms of the heavy hitter grasses with the very deep rhizome and abundant rhizome layers, like cogongrass, phragmites, bamboo, and arundo, it tends to burn down shoot tops, but it does not hold them back. It does not fully kill the rhizomes. So selectivity wise, yeah, it's very, very good within forest systems, where it's labeled for microstegium control.

Sierra Ward asks, "Do you recommend cutting bamboo prior to spraying it?"

OK, so this a really good question. I didn't really get into this. One thing to be careful about in terms of hand labor with bamboo is the condition called histoplasmosis. And here in the deep South, where you have blackbirds roosting in bamboo, we have often recommended literally using respirators-- like a class II respirator for any hand labor within bamboo.

In terms of cutting it, number one, if you've got a really tall stand of bamboo, it's going to be very difficult for you to get any type of herbicide application over the top. The bigger the bamboo, the harder it is to do in that case. And so it's often recommended to mechanically cut it all down, whether you're using a mulcher or if you can [? bush ?] over-cross it, which is tough to do, or hand cut it, and then treating the regrowth.

The big problem with doing that-- and it's highly-- it's often recommended. But again, you're trying to spray it when it has very little leaf area because otherwise it over tops you again and gets ahead of you again. And so you're trying to put a bunch of herbicide under a very small amount of leaves to translate down to a massive rhizome system.

And we often say that with glyphosate applications, many applications, maybe up to at least six or seven applications, sometimes, of cutting and spraying. Bamboo is something I'm working on right now. I've got some research projects where we are trying to come up with the absolute most effective way for land managers to get after it. I think there's a really-- it's still a big black box on optimal strategies.

So yeah, I can recommend that. It's very difficult, and we don't have surefire ways to get rid of it with glyphosate. Herbicide-wise, if you can spray Arsenal-- imazapyr-type herbicides-- I think they're a little more effective for it. OK?

Marge Hughes-- are there graminicides formulated and packaged for homeowner use?

OK, there-- oh boy. I want to say that at least a couple of them are. They're oftentimes not going to be easy to find, certainly not at the box stores. You might find some of them at feed and seed stores. I want to say Acclaim Extra is probably one that you might be able to get your hands on relatively easily, I think. And so, I think you can.

But in general, they're not restricted use, per se, so you can go-- you could go to a pesticide distributor and purchase. They would probably want to sell you at least a 2.5 gallon jug, maybe two 2.5 gallon jugs minimum. And some will have smaller container sizes. So you can get them. They're not restricted use. State labeling may require you to have a pesticide applicator license to get that.

Guy asks, "How do you deal with treatments when your neighbor has a problem and does not treat his infestation?"

Yeah, that is a major frustration, Guy, and I think that there are thousands of land managers relate to this all over the US. Attempting communication and education, trying to get them on board in a more cooperative way of addressing things is very important. Going with the approach of spraying across the fence-- sometimes it works, and sometimes you can get a lawsuit on your hands. So you have to be very careful with doing things like that.

If it's bamboo, trenching is something. And dragging your neighbor out there and repeatedly show him that his bamboo is growing across. Some species may be subject to state noxious weed laws that you might be able to get regulatory involved in. Other places, that absolutely is not going to happen, and nobody's going to lift a finger to help you in that direction. I always try open communication before confrontation. That's really about the best I can give you right now.

Patty asks, "What's the best herbicide for eradication of reed canarygrass?"

OK, so back to this reed canarygrass question. I didn't really cover that one specifically, and that has been a really difficult species to deal with. The FOPS and the DIMS have been utilized, and research data has shown they often-- you see quite a bit of regrowth following application of those to reed canarygrass.

Glyphosate as an herbicide is effective at burning it down. You kill some of the rhizomes. It requires repeated treatment, and you can have seed germination, I believe, recovering from. So it's a very frustrating one to get a hold of because the selective options for control and reestablishment of species are much more difficult for that. So that one-- let's get these other questions [INAUDIBLE].

Sure. "Where does Japanese knotweed fit into this outline?"

OK, excellent question. It's not a grass. So it's in the polygonaceae. And I know Japanese knotweed and a few other knotweed species are a nightmare of a problem across the Northeastern US, across the Pacific Northwest, and down into the Mid-Atlantic states, even into western North Carolina. And so this presentation was not specific to Japanese knotweed, even though some people mistakenly called it Japanese knotgrass in the past. And I'm going to have to hold off on answering too many questions about that.

As another species that is very strongly rhizomatous, it is-- folks have attempted to go after it with Roundup or glyphosate applications. More effectively, imazapyr is very good on Japanese knotweed. But if you're going after it with glyphosate, it's going to require repeated applications. The same type of cut it down, let it regrow, and treat it at flowering has been a strategy a lot of folks have utilized. We do a few different species of knotweed out there, and they don't all die equally, but those are two approaches to go after it.

Anna asks, "What herbicide would you use to treat Japanese stiltgrass on a meadow and prevent native

grass damage?"

OK. Well, so your best options for selectivity-- some of the FOPS and the DIMS, you're going to get some non-target damage on perennials, but they are about as close to selective as you're possibly going to get without spot applications. So read the labels very closely on what grasses will tolerate some of the FOPS and the DIMS in terms of your natives. I know it's not always going to be clear. You might reach out to your local extension folks and university researchers to see if they have any more local expertise with that.

I have not directly gone after Japanese stiltgrass out in open meadows. It's always been in wood situations. But I think in terms of selectivity, that's one of the-- the FOPS and the DIMS may be as close as you can get because glyphosate is certainly not going to be there, and imazapyr wouldn't work, either.

Andrew asks, "Is there a guide to management of invasives in northern forests? Also, how long does reed canarygrass seed last, and is there any good way to treat this species?"

Oh boy. So there comes the reed canarygrass. It sounds like you need to get a reed canarygrass seminar.

Yeah, right [AGREEING].

OK, so again, as I mentioned with Japanese, with reed canarygrass, glyphosate and imazapyr are options. The seed-- I'm going to have to look that one up too because off the top of my head, I'm not exactly sure. So let me-- I'll try to look that up very quickly and then come back to it. OK. Keep going here, and I'll come back to that.

As far as a guide to management invasives in northern forests, I also was going to ask if there's a particular online resource that you recommend for lots of answers on invasive plants.

OK. Anthony DiTomaso at Cornell is doing a tremendous amount of research on a lot of forced invasives up in Northeastern forests. So I'd probably go to the Cornell website first and see what's there. In terms of a specific management guide, though, one is not going right off the top of my head there.

OK. Bob Howe--

OK, here we go. Back to seed banking of reed canarygrass. Well, it definitely can last for more than a year. Yeah, so what I'm reading here is that there can be-- a very small percentage can be maintained for several years, but you're going to have a high degree of turnover in the first couple of years. But there can be some that can hang in there for a few years, for sure.

This is from Bob How. "From a non-botanist on Long Island, is there any thought of using certain invasives along shoreline areas to help minimize storm erosion from storms? I realize it is the opposite of what we're trying to do with controlling these species."

Yeah, absolutely. There's always an engineer out there-- and not to bust on engineers, who view the best species-- that destabilization is more important than the species itself. So you can run into those arguments quite a bit.

One thing that's utilized widely is in the South and the warmer parts is something called vetiver grass, which is kind have been an amazing grass in a lot of third world countries at shutting down soil erosion and resulting in tremendous stabilization. Further up the coast, I'm sure that a lot of different things have been tried, and I don't know specifically that far, but I understand where you're coming from, being in Long Island there and what you guys have experienced.

Anna asks, "Would a complete cover of bamboo with landscape fabric and a thick layer of mulch for an extensive amount of time kill the bamboo ribosomes?"

OK, in terms of covering, typically, running plants with rhizomatous running growth will outrun the edge of your fabric. So they will grow beyond your ability to cover everything, and they will come up right at the outside edges of it. And so, in terms of exhausting its energy reserves by keeping it covered and shoots suppressed, you would literally have to do that for a few years.

Solarization-- covering it with, say, a clear plastic and trying to allow the sun to solarize or kill those rhizomes typically, solarization does not heat the soil deep enough to completely kill the rhizomes of deeply rooted or deeply rhizomatous species because solarization only typically works a few inches down, and there's rhizomes will survive beneath that.

So yeah, if you're going to cover it, boy, it's going to take some time. And oftentimes, if you're using

plastic, that plastic is going to degrade before you've effectively starved out those plants underneath it. So it can be a long process.

John Tate asks, "Are there any costs to your programs to help get rid of invasive species?"

Costs of your programs-- OK, depending on what state you're in, and depending on where you're at-- so NRCS does have a couple of programs that invasives do come up in, which vary from state to state. The Wildlife Habitat Incentive Program, WHIP, or EQuIP, the Environmental Quality Incentive Program-- invasives have come up under that for treatments. They may not-- you have to be enrolled within their programs to qualify, and they have to be supporting the control or spraying of the specific invasives that you have.

Beyond that, weed management areas, which do exist throughout lot of areas of the country, have often-- where you have a group of landowners working together, have been able to compete for pulling together grants, which can provide some financial assistance for management. In terms of an overall, comprehensive, federal program for providing landowner assistance, we don't really have it. And it's one of those things that-- it's not a priority for Congress.

My best suggestion for financial assistance programs is to contact your local USDA service center. They're going to have the most experience and the most up-to-date information.

Absolutely.

From Justin. Bamboo-- "I'm trying to remove a 13,000 square foot patch of bamboo. Back in March/April, we mulched the 10 to 15 foot tall shoots to the ground using a Bobcat with a forestry cutter. I plan to return in the fall for herbicide treatment. This was a bamboo monoculture, but it's near a stream. Do you recommend a certain herbicide treatment, and do you have any experience with mulching bamboo before herbicide treatment?"

Well, mulching would be like cutting. And so what you're doing is, you're getting rid of that top growth. And you did it right at the time that it was shooting up new growth, and so you've probably seen quite a bit of emergence of new shoots from the rhizomes coming up after that.

So when it is fully leafed out, if you can get over the top of it with an herbicide application, if you can safely use imazapyr-- and if you're near water, Habitat would be an option that would be approved for

that. You will probably get the most bang for your buck out of an application of Habitat across the top of that bamboo.

If you can't use that because of the soil residual aspects and the nearby trees, glyphosate is kind of a second option. And for a spot treatment, I would literally be about between 5% and 10% on a volume to volume basis spraying across the top of it.

I tell you what, Justin. If there is any way that you can get a root rank onto that site, which would be, say, getting a heavy equipment, a heavy dozer-- we often say a D9 and a root rake. A root rake that lifts up those ribosomes out of the soil is the most effective way to control bamboo. It's not a perfect solution, but getting those rhizomes up out of the soil, piling them, and burning them is really the best thing you can do, and a root rake is the best way to do that.

Even some types of tractor-mounted tillage implements that can get under those rhizomes and lift them up-- because they're typically relatively shallow. But dig down and see what you're up against. And if you can do that, then by all means, root rake it out.

We're going to take one more question, and it's from Lisa Hough. "Is any federal money going into use of these grasses for bioenergy? If so, why can't it be stopped, given the executive order against this?"

OK. Lisa, you have entered into a very gray area right there, and I'm not-- I don't know. I'm trying to think back if the EPA has finally ruled on whether or not they would allow Arundo donax as a bioenergy. I know they've delayed it several times because that's been very controversial. The miscanthus thing has also been controversial. But there are other forms of miscanthus, like-- let's see-- Miscanthus sacchariflous, I think, that do not produce viable seed that are also actively being utilized in terms of bioenergy.

But that is a great question, and it's something that folks are wrestling with big time. If it's not on the noxious weed list and not a regulated species, then there may not be limitations to using it. Some states have sort of dealt with this, like Florida, by mandating that if you are pointing over a certain acreage-- just a couple of acres of any crop for bioenergy, it has to be approved by the state.

And so, they've been able to regulate planting of some potentially invasive bioenergy species that way. But in terms of a national consensus on the use of some of these for bioenergy versus their invasive potential, it's not out there.

And we have a history in this country of utilizing invasive species for bioenergy. Chinese tallow tree and tung oil tree are two classic examples literally brought in for bioenergy purposes. Where massive plantations were planted, that industry dried up overnight with industrialization, and the southeast was left with massive tallow tree and tung oil plantations.

All right. Well, I really am-- it was just wonderful to see so many people come on board for the presentation, and I hope you were able to--