USACE ERDC

Moderator: Courtney Chambers
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Courtney Chambers: Hell everyone. I'm Courtney Chambers from the ERDC Environmental Laboratory. I'd like to welcome you to this Webinar series co-sponsored by the Aquatic Plant Control Research Program and the Army Corps of Engineers Invasive Species Leadership Team.

At this time, I'm going to introduce today's speaker Dr. Christopher Mudge. Dr. Mudge is a research biologist in the Environmental Laboratory at the U.S. Army Engineer Research and Development Center.

Dr. Mudge joined the chemical control and physiological processes team in 2008, and spent five years in Vicksburg, Mississippi before re-assignment to Baton Rouge in 2013. He is stationed at Louisiana State University and is an adjunct professor within the school of plant, environmental and soil sciences.

Dr. Mudge's research focuses on the evaluation of new and experimental aquatic herbicides and development of use patterns to manage invasive, submersed, floating, and emergent aquatic plants, while providing selectivity to non-target and native plants species. Dr. Mudge's recent research efforts have focused on the evaluation of new techniques to control the invasive floating fern, giant salvinia, which is what we'll hear about today.

This is a problematic species to Corps reservoirs, public lakes, and private waterbodies throughout Louisiana, Texas, and the Gulf Coast Region. In addition, he has collaborated with various Corps of Engineer districts, federal and state agencies, and universities to provide innovative, environmentally

compatible technologies through a small-scale laboratory trials, as well as large-scale demonstration projects.

More about Chris can be found in his bio posted on the invasive species Web pages, along with today's presentation and our recorded meeting. We are pleased to have you sharing with us today Chris.

Dr. Christopher Mudge: Good afternoon and thank you Courtney for the introduction. Today, we'll talk about Giant Salvinia and some of the work that has been done, but we're going to start off with a little bit about what the plant is, why it's a problem, and what the US Army Engineer Research & Development Center is doing about this plant throughout the United States.

Giant Salvinia, the free-floating, invasive aquatic fern is native to Brazil and other portions of South America has been in the United States for approximately 15 years. Although it's not the only salvinia species, we also have common salvinia, *Salvinia minima*; giant salvinia is the more aggressive and problematic of the two.

This plant was introduced into the United States through the water garden or the nursery trade that's really pushed its expansion from the Carolinas down into Texas and everywhere in between. It is on the federal noxious prohibited weed list, meaning that this plant cannot be moved across state lines.

Just some general anatomy and plant characteristics. The plant it has a floating, emergent frond. That's what we would commonly, call a leaf, but since it is a fern, it's a frond. It also has a submersed frond. Visually, this resembles a root, but in actuality it does not have roots. The roots resemble what water hyacinth, water lettuce, or any other floating plant would have.

But, in actuality, it's a frond that has a different appearance from the surface frond.

This plant is covered with midribs and trichomes. The trichomes resemble cage or eggbeater-like hairs. If you take your fingers and put them together from your pinky all the way to your thumb and making an eggbeater-like shape, that's what you would see on top of the plant. These stiff hairs are problematic because they repel not only water, but any herbicides that have been applied to the frond surface.

Here are some pictures showing what Giant Salvinia looks like. On the top left with the blue background is a Salvinia plant. Right below, as described earlier, the floating frond, which has a green or lime green appearance or brown color depending on nutrient availability, environmental conditions, or time of the year.

The buds are the new growth, which increase the plant's size. The buds are typically found under the water surface. Here are the submersed fronds, which I described earlier as roots. The stolons are below the surface and connect the fronds.

On the top right hand corner is a picture of Giant Salvinia at Lake Clear Smith Port, which is located in North Louisiana. From an aerial view, you would think that it's land. And from a duck or any other bird species you would also think the same thing because it forms a continuous mat. There's no way to know where the actual water is. Eventually, giant salvinia will take over a lake or other aquatic ecosystem and change the landscape as well as the dynamics of the ecosystem.

Below is a picture from Lake Bistineau from approximately five years ago. The plants are coming off of the damn and piling up. Even though the material is several feet thick, even after an extended period of time, most of the plants survive under these conditions.

Why is giant salvinia a problem in the U.S.? Based on these pictures, plant description, and plant anatomy, you should understand the potential problems this plant presents. But as any traditional, noxious, invasive species that does not have a natural enemy or any other control methods to keep it in check, these plants are introduced into these waterways and cause many problems.

Consequently, you can't navigate a boat through these infestation, irrigation intakes are sopped up or blocked thus preventing water movement. Also, transportation is hindered and recreational activities are impacted. Once a mat of Salvinia form, especially several layers thick, water access is no longer available. These plants also impact everything above and below the water surface. This includes fish, wildlife, and native plants.

Any time you have a native or another invasive plant, such as hydrilla or Eurasian watermilfoil, giant salvinia will form a thick, continuous mat that will shade out submersed vegetation (SAVs). After an extended period of time, these plants will likely die or be significantly reduced in population because of low light conditions.

Giant salvinia also alters the water quality. Overtime, there's a drop in dissolved oxygen, which is bad for fish or any other plants. They also absorb a lot of those nutrients, in particular nitrogen, phosphorus, potassium. Overtime, a significant amount of organic matter is deposited. When the plants form a thick surface mat, the lower plant material at the bottom of the mat will eventually die, especially during the wintertime.

Consequently, a significant amount of dead plant material is decomposing in the water column. Consequently, that creates an oxygen problem. From a standpoint of potential, it is the second most invasive species in the world. Various organizations have tabbed it the second most invasive species from an environmental, economic, and human health problem standpoint.

This plant is a rapid colonizer. It will form several layers of plant material. From the top to the bottom of the mat, it can be up to 2 feet thick in Louisiana and Texas, but in South America, the mat can be up to a meter thick, which is approximately 3.3 feet.

Plants can double in coverage every 36 to 53 hours. In a day and a half to 2-1/2 days, the plants are starting to double their size vertically and horizontally once they've firmly established.

Here are the three growth stages. Initially, when you see the plants coming into the system, it's called the primary stage. The primary stage is when the leaves are flat, which can be seen is this picture. The leaves are flat and will stay that way for a long period of time until it transitions into the secondary stage.

The secondary stage is created when there is one continuous layer and the leaves are rolled or folded. Finally, once they form multiple layers (i.e. plants start to stack on top of each other), this becomes the tertiary stage. In this growth stage, there could two layers, three layers, four layers, etc., however thick. And what's interesting is this plant is not going to be found necessarily everywhere.

It is very problematic in Louisiana and Texas, but it's not widespread as hydrilla, water hyacinth, Eurasian watermilfoil, etc. There are invasive plants we've had for a little bit longer. Some of them since the late 1800s or the 1970s.

This plant was introduced in 1995 in South Carolina in a small pond, but was quickly eradicated. But in 1998, the Toledo Bend Reservoir on the Texas/Louisiana border was where the initial Gulf Coast infestation that really has caused problems came in. This population quickly spread throughout the region.

Giant salvinia can be found in 12 states. In the South and in the Southwest. In some cases, we've actually seen eradication. Most of the time, it doesn't go north of the I20 corridor, which is almost at the Louisiana/Arkansas border, and across to Dallas. If you go above this line, in general, the plant will not survive. And that's because the winters are too severe for the plant to survive.

Once you get multiple days of ice-over and freezing, the plant will actually not be able to survive because of cellular destruction. But, if there's only a few hours of periodic freezing temperatures, the plants are temporarily injured and will likely survive. In addition, these sites often have a lot of canopy cover from Cypress trees and other vegetation as well as hollow stumps to hide. Sometimes, the water dry up and generally the plant will die.

But, if it's not severe enough, it won't die. If you were to put the plant on dry ground or put it in between a boat and a trailer (soft, cushiony area), you have a sponge that holds water for long periods of time. Research has shown holding these plants under these conditions for 10 to 14 days, the plant will survive in those moist conditions. Even when the plants are mechanically harvested and placed in a big pile to dry out, plants in the middle will survive

for an extended period of time. So, cold and drought conditions may provide control if conditions are right.

We see this plant mainly in the New Orleans, Fort Worth, and Vicksburg Districts, even though they're not necessarily in a Corps reservoir. In some places we have limited Corps reservoirs in these states or in these districts.

We'll see them in other places such as Florida, Alabama, but resource managers are trying to eradicate these populations or keep them out. But, these two states (LA and TX) are where most of the problems occur. There is potential to spread in the Galveston, Mobile, and Jacksonville Districts, but in actuality a few infestations do exist.

Some of this would be temperature dependent, but also seeing nutrient and pH limitations. Another factor that really makes this plant thrive is a low pH water. Most of the time, giant salvinia prefers neutral and acidic water conditions. If you have a water body that has a pH anywhere from eight to nine, or ten, it's not going to thrive.

It may be introduced in that system, but I think in the long-term it's not going to be able to survive because it really likes those more acid environments. If you put plants in a system with a pH of around six to seven, it will thrive. I've even seen conditions where the water pH is around four. Even though that's extremely acidic, I have stock tanks at my research facility at LSU. I put in giant salvinia and the water pH started off around seven.

Over time, what we're seeing is that rain water is driving the pH downward. It's the opposite of what hydrilla has the tendency to do when it drives pH up and can grow in more basic conditions because of the bicarbonate and CO2 in

that water. With the Giant Salvinia, it's pushing the pH downward. And, it's actually surviving down to 4.0 under very acidic conditions.

Within our systems, we're also seeing key infestations in Toledo Bend, Sam Rayburn reservoir and Steinhagen reservoir, within the Fort Worth district. And then, Caddo Lake in Texas, Turkey Creek in Louisiana, Lake Bistineau in Louisiana, Lake Conroe in Texas, and even the Red River, which is a flowing water system. Naturally, you would think a floating plant would get flushed out and moved down river to the Gulf.

You have the backwaters and areas where the plant gets established, and eventually you get a rise in water, and you have flooding. The plant is brought over into these ponds, these oxbow lakes or these borrow pits. The plants will thrive there in these small ponds. And then when the water comes back up or rises it can get brought back into the system as the water comes down.

There's a continuous nursery or stock location for re-infestation. Giant salvinia thrives along the coastal marshes because we don't see the cold temperature extremes, below freezing conditions, and minimal frost. So it'll survive there along the coast.

Giant salvinia can be managed with a few tools. I'm going to talk about six of them. The main two are the first two listed. Aquatic herbicides and Giant Salvinia weevils, which I will discuss in more detail in future slides. Here's a picture of the weevil in the upper right hand corner. Also, a picture of a weevil on top of a frond. And here's an herbicide application from a boat, and then you have a mechanical harvester.

Drawdowns can be used. Unfortunately, with drawdowns, homeowners are not exactly thrilled with this form of management because you're taking away

their access to water, and they feel their property value decreases. If you bring the water level down, their docks are useless. Giant salvinia can be managed with this technology, but you have to bring the water down several feet.

The goal is to bring plant material into a smaller area. For example, instead of an 8000-acre lake, we can bring it down to 6000 acres, so we don't have to put out as many weevils. Or we don't have to put out as many herbicides. Regardless of size, we can focus on a smaller area to manage.

Mechanical harvesters are used to manage this plant. We don't see as much success because it's a very slow process. These harvesters are approximately the size of a large vehicle or small bus. They're very efficient since they collect a lot of material. But, then you have to transport it to land, drop it off, and then transport it somewhere else.

Some harvesters shred or chop the material once loaded. And what's happening is that these choppers will slice the plants into smaller pieces. But often the material, even though we think it's destroyed/damaged and sliced into fragments, if you have just enough pieces, can then actually re-establish and re-infest the site, so it's kind of a temporary Band-Aid.

Plus, those mechanical harvesters are very expensive to operate per acre. We're probably talking in the neighborhood of 1000 to 2000 dollars per acre top operate and they're very slow. Integrated, which is a newer concept, is being evaluated by combining herbicides plus a bio-control agent or other control method.

Integrated pest management is being evaluated on the small-scale research side of things, but we really haven't done much of it at the moment. And, of course mother-nature is the backup plan. If we can get a cold winter, the

plants can be taken care of, especially in the central and northern portions of Texas and Louisiana.

You really have to have luck on your side, such as 2009/2010 and the '10/'11 winters where several of the lakes in the central portions of these states were infested and getting to the point where it was bad and the chemical control really wasn't working well. The weevils weren't really utilized at this point in time.

What happened is that the winter came along and knocked a lot of it back so it made management the following year easier. It restarts the cycle in the process. Here's just some budgets and acres of the Giant Salvinia manage. We do see that most of the work in spending has been done by the Louisiana Department of Wildlife and Fisheries.

These are some of the recent budgets. We're seeing about eight million dollars in LDWF, 52,000 acres in LA, and anywhere from 19,000 and 18,000 depending on the year of management. Now, this in Louisiana is just what's considered on public land and these are estimates. We also know that in the coastal marshes of South Louisiana we don't count those because that's private land. No one provides those figures.

Then we're not counting small ponds. For Texas numbers, we're looking at the Fort Worth District with approximately $400,000 on 2500 acres in these 2 reservoirs. Those numbers were a lot lower earlier in the year. With all of the rainfall that occurred early in the summer, the plants were pushed back further and further away, and when the water started to recede, all of that Salvinia came into the main part of the lake and really took off. The District, had to put more money and effort into that as well.

I don't have any numbers from the Texas Parks and Wildlife unfortunately. I don't have those numbers and figures, but I know it's similar as far as acreage and the amount spent. A little less than LDWF but upwards in that neighborhood. Now, as far as the New Orleans District and the removal of aquatic growth program (RAG), there have been budget cuts over the last few years.

Currently, there are no funds being spent on salvinia and part of that's because the Louisiana Department of Wildlife and Fisheries has an agreement with the district to manage some of those lands. Due to the costs, we're looking at 28 to 32 dollars, probably pushing more above 30 dollars an acre, to spend on these treatments and that's just herbicides.

It's more efficient to manage some of our other invasive species. Often the district is responsible for spraying in the coastal area, so water hyacinth is more of a problem species, so you don't really see as much on the New Orleans side of the spraying at the moment.

As far as aquatic herbicides with Giant Salvinia activity, we're looking at this list right here. These herbicides vary in their level of activity and what level of control they provide. We see glyphosate as the most popular.

Glyphosate is applied as a foliar spray at high rates anywhere from 96 to 120 ounces per acre. Diquat is applied in combination with glyphosate. Often diquat is used as a tank mix partner and it's applied at a really low rate anywhere from that 12 to 32 ounces per acre.

And, this is just an additive to the tank mix to increase the level of control and to speed things up. Flumioxazin is very similar to Diquat as a tank mix partner, but it also can be applied alone as in-water treatment. We need to put

these out at low rates due to the expense, but also because glyphosate is the product that's the driving force or more efficacious of the two products.

Penoxsulam is used less than the others but also has some activity similar to fluridone as an in-water treatment. Fluridone is applied sub-surface, so we're talking about putting it in water and using it for treating the entire water column. It's a bleaching herbicide, that needs be applied to the entire system.

That's the problem with a lot of these herbicides that are slow-acting systemic such as penoxsulam and fluridone or even bispyribac or topramezone. In order to effectively control these plants, you need to put it out at five to ten or more parts per billion (micro grams per liter), and you need to spread it out over the whole system. The concentrations need to be maintained from 30 to maybe even 60 days after treatment.

We're talking 8 up to 12 weeks of exposure just to control these plants. Think about how much rainfall we get in Louisiana and eastern Texas. If you get a hurricane or tropical storm or just any kind of significant rain event, all of that rain comes in and it brings the water up several inches. Unfortunately, the treatment is diluted. And we're seeing that the herbicide gets washed away.

Glyphosate, diquat, and flumioxazin are applied as foliar sprays from the spring to the fall. In the wintertime, more Diquat is applied.

Giant Salvinia is also managed with the giant salvinia weevil. The weevils have been released since the early 2000's. Right after the plants were introduced, many agencies in addition to the Corps of Engineers (Engineer Research and Development Center) began utilizing this insect. Research has been conducted by universities and state agencies such as Louisiana

Department of Wildlife and Fisheries, the LSU AgCenter, Texas Parks and Wildlife, Texas A&M.

The Giant Salvinia weevil has been very effective. The development and use has come along a lot, especially in the last five years. We've seen the weevil, even though it's limited by its spread and distribution, become more successful treatment option.

After release, it takes two to three years to provide control in some sites, but it does provide selective control immediately. We're not seeing any damage on any other non-target plants. But we're seeing an acceptable level of control. Besides the original and initial work that's put into the rearing and releasing operations, it is a low-cost maintenance process of just adding weevils every year.

So, you have a lot of man-hours on the frontend, but other than that you don't have to put in a lot of effort. And, the only limitation of course would be the wintertime. Up north we're seeing that there are some setbacks because we're seeing temperatures dipping to 30 degrees and below. Unfortunately, the plants can survive these temps. That's about their threshold.

But, if the temperature gets below freezing for several hours and longer, the weevils are really stressed. And, unfortunately that stress is killing off the weevils or really knocking back the population. Every year these weevils are being reintroduced into these lakes. Currently, there's work being done by the Corps of Engineers by Julie Nachtrieb out of the Lewisville facility and she's looking at the release and following up of monitoring of the weevil.

She has contracts with the State of Louisiana and the Fort Worth District to release weevils on a yearly basis. She rears them in an outdoor, open-ended

greenhouse, or shade structure that she maintains throughout the winter. Then, she releases them when it gets the warm.

And, she's following up with monitoring, looking at nitrogen levels, tracking weevil distribution, looking at establishment of weevils on both common and Giant Salvinia. She's been doing that for a number of years.

In conjunction with the Red River, Waterway Commission, and The LSU Ag Center, and LSU, I have a graduate student that's also doing some work with weevils. There are two LSU graduate students (1 full time, and 1 part time) and they're trying develop a cold-tolerant weevil. They're trying to find a weevil that will be able to survive the colder temperatures.

Unfortunately, when the weevils came in from South America when they went through quarantine, they were brought to Mission, Texas, which is one of the warmest places in the country. The weevils that survived were more heat tolerant. All of the ones that had cold tolerance from a genetic standpoint didn't survive.

We're finally starting to see that more and more weevils are surviving the winters. My graduate student, and then the one that's also working here at LSU, are trying to find some weevils that will survive these colder temperatures.

She is screening them and subjecting these weevils to temperatures below 32 degrees for x-number of hours and looking to see if any weevils will survive.

These are the agencies that distribute weevils. Lewisville is sending them out, the Ag Center in conjunction with the Louisiana Department of Wildlife and Fisheries, Texas Parks and Wildlife, as well as in the Red River Water

Commission. All of those agencies are releasing weevils throughout TX and LA at different life stages, from larvae and adults. The larva and the adults are the two most destructive phases. The adults tend to focus more on the emergent frons and the larva are more on the rhizomes and submersed fronds - so below surface versus above the surface of the water.

Julie is looking at the release characteristics, my graduate student and another student are trying to find weevils that have cold tolerance. Our goal is to find a weevil or population of weevils that can be released and maybe have better control in the field.

Also, my graduate student is evaluating integrated pest management with the weevils and herbicides. That work just started this year. We're seeing some potential results. There was some work funded a couple of years ago through the APCRP. My graduate student is combining the two technologies together for increased control. So these are the herbicides I spoke about earlier and this is the table with the various rates, herbicides, combination, etc.

Now this list isn't finite. You can certainly go with the other combinations, but this is really what the field is using. Various researchers including myself have tested various rates, whether in small scale mesocosm or even in the field have shown that these rates are very effective.

Since 2008 when I joined the US Army Engineer Research and Development Center, I've been working on giant salvinia research. Prior to that Dr. Linda Nelson had been doing a lot of research when the salvinia was introduced into the United States. She conducted herbicide screening trials, looked at spray volume and other herbicide trials and then I picked up from that stage on. We're also seeing other universities researchers conducting similar work. In particular, I'm screening new and experimental herbicides. Those compounds

that are numbered or registered in a non-aquatic market (i.e. agriculture, right of way, turf, etc.).

They're used in a non-aquatic market such as rice or soybeans but may be applicable to the aquatics market for toxicology purposes, but the goal is to find products that are efficacious against giant salvinia, but are they safe on non-target plants and animal species. I also looking at new use patterns, seasonality, timing, and etcetera.

Just looking at those various things in combination as well as integrated pest management. I have another student - PhD - who is looking at over the top applications of herbicides on trees. Can you go during the winter time when biomass is at its lowest and there's one layer of salvinia and the plants are already injured from the winter and you can see slow growth. Can you actually come in with an application on top of trees to manage these plants? Also he is researching salvinia ecology, biology and sampling/monitoring of operational treatments, which ties into my APCRP work unit.

That was the beginning part of what's being done and I wanted to give you a brief overview of some of the current work that's being done with the newer technologies. This research will focus more on the use of herbicides effectively to manage these plants.

We see that these days no matter what sector you're in - no matter if you're managing weeds, you're looking at soils, you're looking at roads, environmental - whatever it may be. Operational budgets have been diminished. We've seen less field personnel, but we're still continuing to find plant in new locations. This plant is spreading and I think it's somewhat slowed down, but any day now it could jump into another state, another area and the weed will take over. So it's not going anywhere any time soon.

So what we're seeing is the limited budgets and personnel are hindering our accurate plant surveys. What we need is a fast reliable and efficient way in technology to monitor these plants and these sites. The field monitoring would be one aspect to go over all these acres because we're seeing thousands of acres managed yearly. As a researcher, I develop new ideas with the technologies - whether it came before me or I'm integrating new technologies- or coming up with completely different use patterns.

This information starts at the small scale level and I pass it on through tech transfer in a paper. Or I receive a call from a district or state agency to investigate a weed problem and conduct a demo trial. Regardless, I know that the herbicide works on a small scale and pass information on to a resource manager. What happens after that is unknown. A lot of times the area will be sprayed, but then after that the sites are not followed up and monitored.

So much area that it's not easy to follow up and look at that wide spread of acreage and actually be able to tell how much was controlled. Whether it's quantitatively or qualitatively. What's happening is that a lot of these sites - even though it's managed (treat thousands of acres), you can treat 200 acres per day on a boat and you're doing it over and over and at several sites by several states, resource agencies etcetera. This is a problem if you don't follow up in two, three or four weeks, etcetera and we don't know when new plants came in or new plant material. What's happening? Was the new infestation due to plant recovery, or off-site movement of untreated plants into the area natural occurrence or from storms, waterfall or tides.

These plants are floating and sit on top of the water. One, two, three, four layers thick and you get rid of one layer at a time by chemical control. When plants start to come back and you see more green material, you haven't looked

at the site in maybe a month or two. Is that a re-infestation from regrowth or a new plant population? Even though you try your best to manage all plants in a system and have the best applicators in the world, problems occur.

Sometimes you're going to miss plants. Whether it's around a tree, around a bank or the boat went over it - you have airboats or mud boats pushing the plants around and you're stirring up the mat. Your prop may wash the herbicide spray off, or water via rain occurs within an hour after you spray. Whatever it may be, you can get stuck with a situation where post-treatment you don't know if these plants are recovering or is that a re-infestation from somewhere else. And that's kind of how this research is evolving. In this picture right here, these areas were monitored and closed off. We knew it happened in North Louisiana and saw recovery on these top pictures on the right. You can see new green plants.

That's the new plants coming back. This is a solid re-infestation effort on the bottom right, but it was an area that was roped off that we knew that we treated every bit of plant material. An influx of new plants were pushed in from outside the plot. But once you get to a certain stage it's hard to tell re-infestation versus recovery.

So as part of this (APCRP) work unit, I'm conducting field sampling and monitoring research. I want to evaluate these techniques to quantitatively and qualitatively assess the treatment efficacy using software and an iPad, then provide this information to our districts and other field managers in state and federal agencies. Saline Lake, which is located approximately 20 minutes from (unintelligible) in North Louisiana just south of Shreveport was chosen for the research project. This is an 8400-acre lake that is filled with Cyprus trees and tons of giant salvinia. It's not short on plants. Here's an idea to show

you what the treatment area looked like. A polygon created by Louisiana Wildlife and Fisheries. That's where they wanted to treat.

All this area down here on the bottom where it says CheeChee Bay in the blue is tannin and dark colored water, but you also see there's a lot of spots. Some of that is giant salvinia, but a lot of that are Cypress trees and a lot of times lakes in North Louisiana and other parts in Texas are littered with an abundance of trees. It's difficult either from the aerial application or even a boat to get in there and do an accurate spray to cover all plant material.

So what I had here was a site of continuous giant salvinia approximately one layer thick. LDWF treated 250 acres with the mixture of glyphosate and diquat. This mixture I briefly discussed earlier, but it is used across Louisiana, in Texas and other places as well because of low cost and efficiency. I picked a 50 acre block right in the middle of the treated area - 25 acres was treated and 25 acres was untreated.

I monitored it every two or three from July to September. Samples were collected on a predetermined 50 meter sampling grid. Hardware and software use. An iPad with a GPS capability and File Maker Go App. This technology is actually being developed by one of my colleagues, Dr. Mike Netherland at the University of Florida who is the corps employee who is stationed at UF. They're looking at this iPad for mapping and monitoring of hydrilla and other plants. We used a mud boat because you would get stuck with a traditional outboard boat.

I collected various data, such as % coverage, % injury, % plant recovery over time as well as collecting plants in the field for mesocosm monitoring purposes for plant recovery and future comparison purposes.

Here's an idea just to show you what the treatment site looked like. Over time we have a pre-treatment on the left. You can see a yellowish greenish tinge, happy, healthy, giant salvinia one layer thick. At two weeks, the plants turn brown with this glyphosate plus diquat mixture. Most of the plants will turn a brownish color within two days. Most of the time it's within hours on a good sunny day if you spray first in the morning or a day at worst case.

Plants become crispy in two weeks and you can start to see plants becoming mushy afterwards. Here you can see open water and the plants are turning grey. By the time we get to four weeks we're seeing increase in injury and plant death, but some of the plants were green. Some of this is recovery, but also look at the picture at the bottom in the middle. Right around these trees are healthy plants and this is due to applicator error. It's difficult to make contact with every plant.

I've done this application myself. When you have people that are new to this profession, it can cause problems and that was the case in this situation. When you're going around trees and you have thousands of trees throughout this lake and you're treating 270 acres, what we're seeing is there's a lot of misses. You don't want to damage a Cypress tree even though the herbicide it will be minimally absorbed by the branch and the trunk - it won't hurt the tree, but if you spray it around here you try to avoid some of foliage, you're going to miss some spots. But we see a lot of open water and that's what's right here - open water. But right here you can a clean barrier between treated on the right and untreated on the left.

Plants look a little sick on the left, but as you get later in the season you get a lot of sun damage - direct sun will cause some injury to plants. How are you going to be able to tell the difference between the two areas? Because there's going to be clean lines where they treated and not treated, but, fortunately, we

didn't have a whole lot of rainfall events. We didn't have significant wind. So we didn't see a lot of turnover or movement in plant material between the two areas, treated and untreated.

So you can see up to nine weeks after treatment some sites and areas were getting pushed in from the non-treated side because as the treated material started to decay and die, the plants lost buoyancy and started to sink. And all of that material outside the plot came in. But after four weeks you could actually see it the movement begin. You can monitor these sites over time and get some good information. Here's one of the graphs that was created with the folks at Gator Creek Technologies.

They created map to show recovery, injury, coverage, and density. I can assign various numerical values or give it a visual assessment and then put those numbers here. The numbers were grouped for every 20%. I can click on here and this came off a website and then I could put it onto the map. Here's our waypoints to show initially the plant - the plot was right along here. You can see plot shape (treated and untreated areas) and the area was maintained for seven weeks. At this point, the plants were starting to recover

I followed the 50-meter grid and you start to come into plot here and I was making the assessment and then right away the plants started to move because of the boat. Before you complete the rating you may get to another point. So you're quickly trying to come up with values for that spot (sampling point). One week to next, you have some movement and you try to sample from the exact point each time you collect data. You will see some open areas with no plants eventually.

So over a seven week period when we have one layer at the end of July and we get into September (seven weeks later), you will eventually see three

layers of plant material. So if you don't manage this plant over time, you will accumulate a lot of material as the mat becomes thicker and thicker. And it's not going to stop. It's only going to get worse until the winter comes or you manage it with weevils or herbicide.

We're still in the early stages, but it is very definitive. You can come up with qualitative and quantitative field monitoring assessments. The equipment is very user-friendly, very rapid and fast to use. You can distinguish between recovery and re-infestation as long as you go out every so often. It's going to be a little more difficult when you get into seven to nine weeks or beyond, but if you do it on a regular basis it provide useful information.

Your biggest limitation will be going over these areas with a boat initially at the pre-treatment and maybe one or two weeks out after treatment when the mat is still thick. If you have an airboat it should be no problem. And that's why there's challenges to provide complete herbicide coverage. You saw some of those areas where the plants weren't managed. You saw green material that was missed with the application and that can not only skew data, but also provide a new site for re-infestation late in the growing season or the next year. So you've got to be on top of that.

In FY16 this work is going to continue for this work unit. I'm going to monitor giant salvinia in Louisiana, but I'm going to switch over and do a little more work with the Ft. Worth district and the (LNVA) around Beaumont and look at some of their reservoirs. Because I think I'm going to have a little more consistent coverage and spray with the contractors in TX.

I hoping to have better application techniques. But I also want to find tune some of this data collection, increase size of the plot, the grid, the number of sample points, etcetera. Just year one with the pilot study and really found

some good data, but we need to expand it and maybe also investigate other hardware and software. And that's when my graduate student is going to be doing it at the same time as me and leverage activities. He's going to look at other handheld units and other ways to monitor Salvinia while I'm using the iPad.

So with these work units, APCRP and particularly this one can be used to determine if the current herbicides application methods for managing giant salvinia are effective. We can actually say, yes. We know on a small scale that it works. It works on the garbage can scale, and it works in a pond. We can visually see it and keep on top of it. But what about in the field? And I think this technology will give us an idea into what we're doing. Are we effective? Do we need to switch it up? You can monitor your applicators to determine if they're doing a good job. And if we want to also determine that if the herbicides are reliable, which I think yes. If it is, then that information, technology, and guidance can be passed on to our Corps Districts, state agencies and water management districts to better manage these plants.

There was several cooperators. The main source of funding to cover this work was provided by the aquatic plant control research program (APCRP), which is through the engineer research development center out of Vicksburg, Mississippi. The Louisiana Department of Wildlife and Fisheries provided the herbicide. They were doing the actual treatments on their land where they manage. The LSU Ag center and the Red River waterway commission assisted. These were graduate students - whether it's driving the boat, collecting the data, etcetera.

The University of Florida and the Gator Creek Technologies provided not only guidance, but they provided the iPad and produced the maps. As well as some reliable information on how to use this technology and make it better.

With that, I thank everyone for their time and if we have any questions I'd be more than happy to entertain.

Courtney Chambers: At this time if any of you have a question for Chris feel free to unmute your phone and go ahead and ask or you can utilize the chat box in the lower right-hand corner. If you don't mind, send that question to everyone once you can select from the drop down menu. Thank you.

(Michael Saucier): Hey, Chris, this is (Michael) in New Orleans.

Dr. Christopher Mudge: Hey (Michael).

(Michael): You said you put out the glyphosate + diquat mix with glyphosate 96 to 128 ounces per acre. Give me an idea of how many ounces per gallon that is. You put 50 gallons per acre?

Dr. Christopher Mudge: Anywhere from 50 to 100. I have not looked at 25 gallons per acre. I know some of the crews have gone down really low with the mix. The higher your volume your carrier, the better with diquat. On average most are probably going to 100. Your limitation is this, when you have a boat - unless you have a really big boat or airboat and LDWF has come across this a lot - you try to spray out 100 gallons of water and if you have a surface drive or pro drive boat, one of those mud boats. It really gets weighed down with the extra water and what they're trying to do is that limit the amount of water in the carrier because of the thick salvinia mat.

So if they just have liquid formulations, they use metered systems, but there are issues with the accuracy because you're talking about mixing the herbicide literally at the last second into five gallons of water or 20 gallons at the most

So you're having to basically syphon out anywhere from three to four jugs of chemical and surfactant.

(Michael): Right.

Dr. Christopher Mudge: The contractor may have a 100 gallon tank to use with flumioxazin (dry formulation). You have to mix that in a high volume of water. Otherwise, you're going to have a very thick paste and it's going to be inaccurate. So 100 gallons is pretty standard unless they just have a small boat then they're doing a metered system.

(Michael): I'm doing - we don't have much giant Salvinia. It's popping up sporadically. I've never seen any large infestation, but I've got a 50 gallon tank mix on the surface drive boat and I'm just trying to get an idea of what's the - how much glyphosate + diquat are you using?

Dr. Christopher Mudge: We're seeing very little differences. Right now they're using a mixture of (Aqua King), which is kind of a buffering agent and Air Cover, which used to be called Thoroughbred (they changed the name a couple of years ago), but it's more of like an NIS. Or what they're substituting now instead of going with the a two (unintelligible) mix they're using - usually it's called Inergy, but now it's called Turbulence. And that's a Winfield product used at 32 ounces. So regardless if you're going with a 50-gallon sprayer mix or a 200 gallon per acre it's still going to be the same amount of glyphosate + diquat. You're still using that - in most of the cases. We're using 96 oz/A glyphosate, 32 oz/A Diquat and then 32 ounces of your Turbulence.

(Michael): Okay.

Dr. Christopher Mudge: Yes, it's the same.

(Michael): All right, so that's the recipe. 96, 32, 32 for 50 gallons.

Dr. Christopher Mudge: Yes, 50 - up to 200. It's all the same. It's very limited differences.

(Michael): Okay. Thank you Chris.

Dr. Christopher Mudge: Sure.

Courtney Chambers: All right, any other questions this afternoon? And I realize we've had reports and personal experience with internet issues across the board today. So if anybody is on the phone line and has a question be sure to pipe up and we'll be glad to get to it.

Julie Marcy: Chris, this is Julie Marcy at ERDC EL. You talked about investigating other hardware and software. I know some of our state partners may have a little more flexibility, but have you looked at whether the software is compatible with one of the Dell laptops in the ACE IT system that our field - our Corps field offices might be limited to purchasing?

Dr. Christopher Mudge: That's a good question. And that's where I originally came into the problem. Being a Corps and DOD employee, we're no longer allowed to use and have the iPads. We had them for a little while and they were taken away. So what I did - I borrowed this iPad since we're cooperating with (Mike Netherland) at the University of Florida. His guys use it at UF and they let us borrow the iPad as much as we want to and I can get one through LSU because of my position.

Other - and the thing is that the apps that they have right now - I've spoken to the App developer about making it available on a PC or other tablet like a

Microsoft Surface. They're thinking about it, but they'd have to develop it first. It's easier right now because it's an App on an iPad instead of a program and I'm not sure from the technical standpoint how all of that is developed and used. Currently, that's the only one available. So either they need to come up with a newer technology or what my graduate student is doing is they have those units they call Trimble units. And they have GPS capabilities.

My student will use a Trimble, but computer hybrid and he can actually - he's got a little pen and he can go to a plot or a point on there and click and then give it a value just like this one. The good thing about that capability is if you got any kind of remote sensing or GIS background you can actually use that and make your own maps. We're, unfortunately - at least me, I'm having to send off to Florida.

Now my graduate student has a little bit of a background in this field and he believes he can take that information from the iPad, send it on the cloud and build his own map, but unfortunately at the moment we don't have one. But that's what needs to be made. This technology a year ago was not even being used. This is something that was literally developed through the winter because. A pen and paper were previously used and having this iPad has been much faster. Yes, it does have limitations for our Corps people to not be able to purchase these items and use them. So we're hoping to get something better, more efficient. So that's going to have to be worked out. But I will certainly pass information on to Mike Netherland and Dean Jones at UF.

Julie Marcy: Thanks Chris. Many of the Corps field offices have Trimble GPS units, so they might want to look at providing instructions for that first.

Dr. Christopher Mudge: Okay, I think that hopefully with my graduate student (Bradley Sartain) that he can have that - if we're out at the same time and he's

collecting the same data then it doesn't matter if you got the iPad or you've got the Trimble. Whatever your agency allows, whether you're state or federal, this is what you can or cannot use and I'm hoping that the technologies are very comparable. Basically, you are recording data instead of using pen and paper. You're able to send it to a cloud or store it on your device and then you can put it in the Excel spreadsheet and if you have the backgrounds you can build your own maps later and have the information. So it's just different way of getting the same information - the same end user type thing.

Julie Marcy: Thank you.

Courtney Chambers: Very good, any additional questions this afternoon? Okay well, Chris, thank you very much for taking the time to share with us and I apologize for the mix up with the slide.

Dr. Christopher Mudge: It's good. I'm glad we were able to fix it. It was making me nervous. You know, but I thank you all.

Courtney Chambers: Yes sir and participants thank you for joining. Thank you for persevering through any technological difficulties, and we'll be sure to have the recorded presentation loaded to share with our colleagues that may not have been able to join in today. Chris thank you again. Have a wonderful rest of the week and a happy Thanksgiving next week.

Dr. Christopher Mudge: You all too, thank you.

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