***Yahara Watershed: A Place of Change* Transcript**

Wisconsin Public Television

Originally aired: September 2016

- Zac Schultz:

A sunny July day is perfect for a boat ride on Lake Mendota in Madison.

- Dave Harring:

Okay, we might as well move the ladder back here more.

- Schultz:

But this boat is filled with researchers, not sunbathers, and their goal is to travel back in time.

- Stephen Carpenter:

We know from historical accounts that the lake was ringed with white beaches. It was just a beautiful...

- Schultz:

Professor Steve Carpenter is the Director of the Center for Limnology at the University of Wisconsin. He says white settlers first came to Madison in the 1830s and their written reports indicate the lakes were not brown and filled with green algae, as they are today.

- Stephen Carpenter:

One of them is dated early July and talks about being able to see to the bottom in very deep water and at the bottom it's white.

- Harring:

And we're going to add ice. Ethanol, ice, ethanol.

- Schultz:

Carpenter and colleague, Dave Harring, will use a freeze corer...

- Harring:

If you look down here, you can see where it's already starting to supercool.

- Schultz:

...to bring some of that white bottom to the surface.

- Carpenter:

What we're going to do is freeze a layer of sediment on the outside of that cylinder.

- Harring:

Okay, you guys ready?

- Carpenter:

The reason to core lakes is to learn about the history of the lakes. Each year, about a millimeter of sediment will be laid down in this lake. Previous core samples have shown the lake bottom changed from white to black between 1850 and 1870, a time when most of the land around the lakes was plowed and farmed for the first time.

- Harring:

See up here, though, the really soft stuff.

- Carpenter:

Right here is the boundary between the glop and the harder, lighter-colored sediment.

- Harring:

The dark stuff here is algae and pretty much from 'settlement-on' runoff.

- Schultz:

Today, the original white bottom of Lake Mendota is covered in about a foot of black goop, the product of 150 years of agricultural runoff. Carpenter says it's important for people to know the lakes weren't always green, and that the whole region continues to be in a state of transition.

- Carpenter:

There's a tendency to extrapolate from the present, both to the past and the future, and the sediments show us that this has been a place of dramatic change.

[music]

- Funding for *Yahara Watershed: A Place of Change* was provided by the Water Sustainability and Climate program of the National Science Foundation.

[music]

- Schultz:

As if turning clear lakes green wasn't enough... there may be even more dramatic changes to state watersheds in the future. Steve Carpenter is one of a handful of UW Professors and students working on a research project called *Yahara 2070*.

- Carpenter:

What we want to do is create a long-term perspective on change in the Yahara Lakes.

- Schultz:

*Yahara 2070* is funded by a grant from the National Science Foundation to look at the impact of climate change and human decisions on the Yahara watershed. The watershed is the 536 square miles that drain into the Yahara Chain of Lakes and eventually flows into the Rock River, which, in turn, eventually flows into the Mississippi. 2070 refers to the future.

- Chris Kucharik:

The time frame of using 2070 I hope is helpful to people to think about"Okay, that is my grandkid's or it is my children's future."

- Schultz:

Chris Kucharik is a Professor in the Department of Agronomy at the University of Wisconsin. He says most people consider long-term to be five or ten years. But environmental changes occur on a different scale.

- Kucharik:

They're embedded in 5, 10, 15, 20, 50-year, 100-year type of transitions that we make as a society.

- Schultz:

A trip to the bottom of the lake shows what the last 150 years of environmental changes looks like. *Yahara 2070* asks what the watershed *could* look like in the future, and it combines storytelling and science to paint a vivid picture.

- Carpenter:

Thanks to all of you for coming and joining us in what's really an experiment.

- Schultz:

A group of clean water advocates and activists are eager to learn about scenarios created to depict four possible futures in the year 2070.The researchers interviewed dozens of people to ask what they thought the future might hold for the watershed.

- Carpenter:

We gather beliefs about the future. So, what are people's hopes? What are their fears?

- Schultz:

Professor Carpenter and his team took those hopes and fears and created four stories... four different scenarios that tell what it's like in the year 2070.

- Carpenter:

Each of these stories is fiction because nobody knows what's going to happen in 2070.

- Schultz:

In each scenario, climate change in the 2030s and 40s causes a major shift in how society survives. Professor Carpenter says the ideas may sound like science fiction, but they're entirely plausible.

- Carpenter:

So everything exists now, it's just that we amplified certain elements in each story. So in "Connected Communities," for example, we amplify sustainable values.

- Schultz:

In a future with "Connected Communities," consumer choices and supportive policies help farmers implement more conservation practices, in order to reduce agriculture's impact on the land and lakes.

- Carpenter:

In "Abandonment and Renewal," we amplify doing nothing and complacency about environmental problems.

- Schultz:

In this scenario, a focus on increased farm production leads to more runoff, and a toxic bacteria invades the lakes. The bacteria emits a poisonous fume that kills thousands and causes even more to flee the area. By 2070, people are coming back to find a changed watershed.

- Carpenter:

In "Accelerated Innovation," we amplify technology.

- Schultz:

In the "Accelerated Innovation" scenario, society relies on technology as a way out of environmental disaster. But there is a trade-off: more synthetic meats and less emphasis on livestock.

- Carpenter:

In "Nested Watersheds," we amplify the role of governance.

- Schultz:

In the final scenario, the boundaries and focus of government is shifted towards water, with water becoming a type of crop to be harvested and sold. The scenario stories are more than just conversation starters. They are the fleshed out details of four possible futures. The *Yahara 2070* project will support that flesh with a skeleton of hard science, which comes in the form of a state-of-the-art computer model that allows the researchers to answer all sorts of questions.

- Kucharik:

What would water quality look like50 years or 60 years from now? What might crop yields look like? How might we be flooding with better land management decision making?

- Schultz:

So what is this computer model? Start with the water cycle, the most basic concept of how water moves through the environment. When it rains, water can either flow into the ground or into a lake or stream. Some of that water evaporates and becomes part of the next rainstorm. The *Yahara 2070* model takes an action like rain falling on the ground and then uses equations and algorithms to determine how much soaks in and how much runs off. And the computer models more than just water.

- Kucharik:

They represent cycles of how carbon, water, energy, nitrogen, phosphorus move through the atmosphere, through plants, through the soil, through the ground water system, and then, how those feed back to the plants themselves.

- Schultz:

The computer model is thousands of lines of code, all equations that deal with different variables in nature.

- Kucharik:

Where do those equations come from? They came from people going out in the field and collecting data and taking measurements.

- Schultz:

Eric Booth is an assistant research scientist on the Yahara Project. One of Booth's jobs in modeling the water cycle is to learn just where the water goes when it lands on the ground, and how that's impacted by what's growing there.

- Booth:

The corn is going to behave a lot differently than witchgrass when you have a one-inch rain event, for instance.

-Schultz:

Some of the water will be used by the plant to grow, but some of that water will be given off by the plant *later on*.

- Sam Zipper:

You always want to do a sunlit part of the leaf.

- Schultz:

Sam Zipper is a research assistant.

- Zipper:

Got a value of about 200 millimoles per square meter per second.

- Schultz:

Zipper uses a porometer to see how much water is leaving this corn plant in a process called "evapotranspiration."

- Zipper:

Kind of looking at how water moves from the soil into the atmosphere. There's a continuum from the soil to the plant and then moving up into the sky.

- Schultz:

Measuring individual corn stalks or leaves of grass can be a tedious process, but all water needs to be accounted for in the computer model.

- Zipper:

This is one of the big parts of the water balance and it's definitely the hardest one to get a handle on.

- Booth:

We have several stations around the watershed that are looking at soil moisture in a whole bunch of different land cover types. We got forest, wetland, a couple of corn fields, grasslands, even some urban areas, some turf grass.

- Schultz:

How water reacts in different environments and in different parts of the growing cycle will impact how water is handled by the computer model.

Booth needs to map the groundcover across the whole watershed. So, he takes to the air. There is a generalized big picture to the Yahara Watershed. Dairy dominates the north.

- Booth:

We have a lot of livestock, particularly in the upper part of the watershed.

- Schultz:

The lakes and the urban core sit in the middle.

- Booth:

In the southern part, it's mostly commodity grain farming.

- Schultz:

Booth breaks the Yahara Watershed in to grid cells of about 12 acres, and then determines what is growing in each cell. He even factors in animals like cows and how they impact the landscape. This is where reality is first measured and then converted into equations and computer code.

- Kucharik:

It's that system of equations that really go into making a more complex model that represents the physics, the chemistry, the interactions of how things in an environment work together.

- Motew:

This is computer code.

- Schultz:

Melissa Motew is a graduate research assistant on the Yahara project.

- Motew:

I'm making lots of graphs and animations and things to help get an idea of what the numbers are saying.

- Schultz:

She's part of the team working on writing the code that makes up the computer model. Her graphs help her understand if the model is producing accurate results.

- We're seeing what the model is generating, checking to see: "Do these numbers make sense? Do they agree with what we've seen in the past? What we understand from previous research?"

- You can go out and take fancy equipment and collect a bunch of junk measurements.

- Schultz:

Professor Chris Kucharik says the model is more than just a sum of their measurements.

- Researcher:

71.5...

- Kucharik:

While everything is rooted in reality, once you put all the equations together, there's usually some type of uncertainty when things start interacting with each other.

- Schultz:

They have to make sure the predictions of the computer model matches reality. This process is called "calibration and validation."

- Motew:

We have to test them against real observations.

- Schultz:

Validation is putting field data for past years into the computer model and seeing if the prediction matches what actually happened.

- Motew:

We run simulations of the past and then we compare the two.

- Schultz:

If the prediction doesn't match reality, they have to calibrate or adjust the computer code.

- Motew:

So then we go out, and we might take measurements and refine our models so that they better capture that process.

- Schultz:

The modeling group meets weekly to compare results and troubleshoot.

- Kucharik:

We probably spend more of our time on calibrating and validating these models.

- Schultz:

But even a fully calibrated and validated model needs details. How do you get field data from the future? Without the computer model, the scenarios are just stories. Without a vision of the future provided by the scenarios, the computer model is just a fancy algorithm. So researcher Eric Booth is looking to the details written in each scenario to help him predict the landscape of the future.

- Booth:

Okay, how are we getting energy in this scenario? What are we eating in this scenario?

- To simulate the future presented in each scenario, the team has to tell the model details like what's being grown and how much has the urban center expanded. Each scenario story describes the severity of climate change, and gives hints at the lifestyles of the people.

- Booth:

We're just trying to follow kind of the logical consequences of what has already been decided in the story line.

- Schultz:

To demonstrate how lifestyle can influence land use, Booth turns to pizza. Today, the northern part of the watershed is dominated by dairy farming, and a lot of that milk becomes cheese.

- Booth:

A lot of the cheese that we make in this country– and Wisconsin is obviously a big player– ends up on pizza.

- Schultz:

As long as pizza remains one of the most popular foods in America, there will be a strong demand for cheese, and therefore milk, which means a lot of cows producing a lot of manure.

- Booth:

That's connecting diet to what we see on the landscape today.

- Schultz:

The "Abandonment and Renewal" scenario calls for a mass exodus of people from the watershed due to poisonous algae. In that case, Booth predicts demand for milk and pizza would go down and Booth has fewer cows on the map.

- Booth:

What happens on a landscape just doesn't happen in a vacuum. It's a reflection of consumer demand for different food products.

- Schultz:

On the other hand, in the "Connected Communities" scenario dairy demand remains high. Booth has to calculate the amount of manure those cows will produce and the impact of growing corn to feed them.

- Booth:

Each animal is going to produce a certain amount of manure, on average, each year, and in that manure is going to have nutrients, phosphorus, and nitrogen.

- Schultz:

Booth even needs to estimate in the future how much manure is likely to be piped to digesters, where the phosphorus is removed, and how much gets spread on fields, especially frozen fields, where it is much more likely to run off in the lakes during the spring melt.

- Carpenter:

We're certainly seeing the effects of phosphorus runoff in poor water clarity.

- Schultz:

Which leads us back to Lake Mendota and Professor Steve Carpenter.

- Carpenter:

There is a tremendous amount of phosphorus in our soils and in the sediments of our streams and in the sediments of our lakes.

- Schultz:

Phosphorus is a big focus of the study because when it runs off in the lakes, it leads to bigger algae blooms and poor water quality. Professor Carpenter says algae blooms are more than just a cosmetic issue. Different types of algae contain toxins known as *cyanobacterium*.

- Carpenter:

The toxins, when they're present, are quite deadly. They are liver toxins and brain toxins.

- Schultz:

Professor Carpenter says there is a connection between our food choices as consumers and water quality.

- Carpenter:

The enabling factor is the continued runoff. If these lakes were not so polluted with phosphorus, we would not have to worry about toxic algae problems.

- Schultz:

While phosphorus runoff is the oldest and most persistent threat to water quality in the Yahara Watershed, other threats like invasive species are emerging.

- Carpenter:

All right, let's see what we got. Oh, yeah! There are a lot of animals in here.

- Schultz:

Professor Carpenter is pointing to a native water flea called "daphnia."

- Carpenter:

Water fleas are really good at eating algae so the water fleas actually improve water clarity.

- Schultz:

With plenty of algae to eat, daphnia should be abundant.

- Carpenter:

Recently, this lake was invaded by an animal called the "spiny water flea" and the spiny water flea eats the daphnia.

- Schultz:

Recent samples have shown the daphnia population has dropped 95%, and water clarity has gone down as well.

- Jiangxiao Qiu:

So that's how they move. See it here, like a snake movement.

- Schultz:

The invasive species that could drastically alter the watershed aren't just in the water.

- Monica Turner:

They're known as the "Asian jumping worms"or "Asian crazy worms."

- Schultz:

Professor Monica Turner and her student assistant, Jiangxiao Qui, are looking at how a new invader can change the forest floor. Their research shows crazy worms eat through the top layer of the soil twice as fast as the common earthworm. Most of these invasive species are new to Wisconsin, and no one knows what new species will come between now and the year 2070.

- Turner:

When we have a new invasive species show up in our area, that may change things in ways we don't even necessarily anticipate.

- Schultz:

The impact of invasive species like crazy worms will likely factor into a future computer model.

- Motew:

And here we go...

- Schultz:

Meanwhile, the model created by the *Yahara 2070* team is ready to run now. The team has estimated details like the climate, ground cover, and population growth for each of the four scenarios, and they've plugged that hypothesized field data from the future into the computer model.

- Motew:

It is going to now simulate every hour of every day from the year 2014 to the year 2070.We have 120 processors in this computer. Each processor is simulating a chunk of the Yahara Watershed.

- Schultz:

Each of the four scenarios takes two days to simulate.

- Motew:

All those pieces will be stitched together into one gigantic dataset.

- Schultz:

Finally, they'll have results and just one job left.

- Motew:

Analyze the heck out of it.

- Schultz:

Researchers like Chris Kucharik want to make it clear the results of the computer modeling are closer to a forecast than a prediction.

- Kucharik:

We're not trying to predict things. We're trying to offer perspectives on, “What are the plausible outcomes that might happen as a result of these decisions that might be made?”

- Schultz:

The idea is to add data to the stories, so the tradeoffs in the different scenarios can be discussed through science, not speculation.

- Kucharik:

If we go in this direction, “What are the types of responses that we're likely to see?” If we go in a different direction, “What do the models suggest things might be like?”

- Schultz:

They might learn the stories in the scenarios contain false assumptions.

- Motew:

We don't actually know if what's in the scenarios will play out. So that's kind of one of our questions:

"How good are the assumptions there?"

- Schultz:

In fact, that ends up being one of the major take-away from the modeling results.

- Motew:

One of these things doesn't look like the other, right?

- Schultz:

Melissa Motew presented the results on phosphorus at a research symposium for all the project members. The models predict climate change in the 2030s and 40s will dramatically increase the levels of phosphorus in the landscape and in the lakes. In theory, as societal changes occur in the scenarios leading up to the year 2070, soil phosphorus should decrease.

-Motew:

Three of these scenarios are able to turn the corner, they've reached their thresholds, they're starting to come back down, or at least to level off.

- Schultz:

The outlier is "Connected Communities."That's the scenario that emphasized societal values to improve the water quality. The computer model says in 2070, it has the worst phosphorus problem.

- Motew:

We have "Connected Communities"which is kind of running away.

- Schultz:

In the "Connected Communities" scenario, people don't plant many cornfields because they are prone to erosion. This is an example of conventional wisdom leading to unexpected results. With corn, there is too much erosion which leads to phosphorus in the lakes. However, corn plants take the most phosphorus out of the soil. So without corn, too much phosphorus remains in the soil and any erosion from flooding leads to phosphorus in the lakes.

- Kucharik:

Surprised, a little bit.

- Schultz:

Even more surprising is that none of the big changes in the scenarios made the water quality better than it is today.

- Kucharik:

Even though the scenarios were not designed to solve the water quality problems, you'd like to think that those large-scale changes would have had some immediate impact.

- Carpenter:

I had expected that some of the scenarios would show improvements and some would show things getting worse. And in fact, all of the scenarios are worse than today.

- Schultz:

The scenarios tackled the problem through government, technology, abandonment, and sustainable values. Despite the differences, the end result is nearly the same.

- Kucharik:

There's just a long legacy of buildup of soil phosphorus, that seems to be overwhelming the system. And when you superimpose changes in climate on top of that, it's kind of a one-two punch.

- Carpenter:

Almost no matter how you manage phosphorus in, say, 2050, you've got big rainstorms and all this phosphorus in the soil already, and it's coming into the lakes and causing problems.

- Schultz:

This is more than just bad news for the year 2070.While the scenarios assumed the worst climate change would take place in the 2030s, in reality scientists say climate change is already underway.

- Kucharik:

I think all of the best management practices that have been going on in the watershed in the last 30 years or so have sort of held their own against the changes in climate, but I'm worried we might be reaching a tipping point where we sort of wear those effects out.

- Schultz:

Most efforts to battle phosphorus in the water depend on activists and volunteers who believe their efforts are making a difference.

- Carpenter:

These projections of water quality changes are bad and potentially discouraging to people. We're going to end up in a worse place pretty quickly.

- Schultz:

They hope the activists won't give up, because despite the unexpected results, Professors Kucharik and Carpenter can see a silver lining.

- Carpenter:

As a result of this project, we have created a new generation of models for understanding water quality that are better than what we had before.

- Kucharik:

Now we can start to use the modeling tools to maybe design, come up with alternative scenarios that might actually show what you have to do to get to the point that we want to be at in the future.

- Schultz:

The researchers say the next step is to get the public and policymakers on board.

- Steve:

I would like to see land use planning taking a long view, longer than the usual decade or so.

- Kucharik:

There's a lot of things that have happened in history that you could never have thought would have happened 50 years into the future.

- Carpenter:

Economic incentives could change. The value of water could change.

- Schultz:

Now that they've developed the computer model, they'd like to see what results different scenarios could produce.

- Kucharik:

A bigger question is:

"Is there a mosaic of land use, land cover that sort of gets us our biggest bang for the buck?"

- Schultz:

The water quality problems took decades to build up, and will likely take decades to solve.

- Carpenter:

It'll be slow, but over a generation or two, there could be big changes. All right, let's see what we got.

- Schultz:

Professor Carpenter has dedicated his life to studying lakes, but over time, he's learned to expand his view beyond the shore.

- Carpenter:

You can't understand the biology and ecology of a lake without understanding the priorities and values and activities of the human beings around a lake.

- Schultz:

He hopes this project will help with that understanding.

- Carpenter:

I think the efforts of this project really will have long-lasting benefits.

[music]

- Funding for *Yahara Watershed: A Place of Change* was provided by the Water Sustainability and Climate program of the National Science Foundation.