NESTED WATERSHEDS

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What would life in 2070 be like if we reform the way we govern freshwater resources?

In the Water Security Act's thirtieth year, Science Times takes a look at how 30 watersheds have changed. Staff writer Deborah Syler kicks off the series with her homeland, Wisconsin's Yahara Watershed.

have few childhood memories that are not saturated with water. The shores of Lake Mendota were host to my summers, even though swimming was often prohibited, on account of the algae. As a farmer's daughter, my life kept rhythm with the water of the seasons: the spring rains, the summer dry spells, the ice and snow. We lived at the whims of an erratic cycle of abundance, scarcity, and normalcy.

Today, water maintains an unpredictable and almighty presence in southern Wisconsin. This April's torrential rains and subsequent floods are sure to linger in people's memories. The devastating storms broke records, flood barriers, banks, and spirits. Parts of the drenched landscape bathed in the floodwaters for days and bore wrinkles for weeks.

The region in which my childhood home lies, the Yahara Watershed Subunit, was relatively absorbent, and lucky. Greta and Lou Donaldson, who own Donaldson Dairy, a small farm near my parents' former farm, think the watershed's performance was not just luck. They say it was the result of hard work and effective change. Easy for them to say—they managed to make a profit off the rain, for the output of their farm's pastures is not just milk, but also water.

The profits this sister-and-brother operation reaps from water normally flows at a steady

trickle year-round. This spring's rains and snowmelt bumped their earnings—a wellearned payoff for the sweat the siblings have put into their land. Where excess water used to erode the family farm's physical and financial ground, the Donaldsons have channeled this former liability into their liquid assets.

"We treat water like a crop, so we cultivate the land accordingly," Greta told me as she checked the recharge meter, a monitoring system for how much rainwater and snowmelt seeps back into the soil.

As it does all local farms, the Yahara Watershed Management Authority (YWMA) pays the Donaldsons by the gallon of nutrient-free water their fields feed back into the groundwater, the region's drinking water reserve. Small, pasture-based and buffered by restored forests and stream banks, the farm is well protected from floods such as this April's and well positioned to divert the floodwaters into their earnings. But profit potential was not the primary motivation for this business model—staying in business was.

Lou and Greta, 51 and 53 respectively, have been steadily "greening" the farm's acres since their father's death in 2039. Greta lives on the property with her partner Hanna and their teenage son. Lou lives with his family of four in nearby Waunakee. He works as a water quality specialist with the YWMA, but he helps



Donaldson Dairy exemplifies the average livestock farm in 2070. Formerly a confined dairy operation with nearly 400 cows, the farm now has 60 cows and practices rotational grazing. Greta and Lou also restored the stream banks on their land, to prevent erosion and runoff.

Greta with the water farming side of the business. When they were children, the farm was a confined dairy operation, and their father's land management practices, while well-intended, did not manage water well. During the wet springs, their land flushed out water and manure-soiled earth like a leaky toilet. When the Water Security Act passed a year after inheriting the farm, Lou and Greta faced a challenge larger than just caring for the herd: how to keep the farm.

Suddenly, the country's expectation of Midwestern farmers was more than just food

production. They also had to help supply the nation with clean freshwater. For an industry notorious for the opposite, this was no small charge, and not all farms could handle it. In fact, since the beginning of the twenty-first century, agriculture in the watershed has eroded faster than a tired cornfield in a thunderstorm. Farmland acreage is now half of what it was in 2000. Cultivating sufficient, clean water, in addition to crops, led to farmland's disappearing act.

"From a water quality perspective, this

watershed used to be way over-farmed," Lou told me somewhat apologetically.

Wearing the hat of farmer and that of the YWMA, Lou is well aware that the watershed's agricultural decline is still a sensitive issue. Its terrain mottled by farmland and development, Yahara has long had to balance the water needs of both agriculture and urban life, along with demands that extend beyond the watershed's boundaries.

Even with its abundance in water, no amount has been large enough to dilute Yahara's history of pollution. Since World War II, agricultural effluent saturated the watershed's water and soil with phosphorus and nitrogen, nutrients that become pollutants when in excess. While agriculture's roots in the region run deep, its political clout proved too shallow in the Water Security Act's wake. Yahara became one of the Mississippi watersheds charged with allocating its freshwater to the (virtually) waterless Southwest, a demand that only validated what experts had been predicting: saving water meant sacrificing farmland and some traditional ways.

My parents' mid-sized corn-for-feed farm was among the sacrificed. Like the Donaldsons, my parents tended their land for water to comply with the new Act's water quality and supply standards. Unlike the Donaldsons, this meant giving up food cultivation altogether. Farming water became more lucrative than cattle feed.

Typically (and hereafter) referred to as merely the Reform, historians place the Water Security Act of 2040 on par with Roosevelt's New Deal. In response to a colossal national water crisis, the legislation transformed water management in the United States. It created our current water governance framework, Nested Watersheds, as well as strict new standards designed to meet the nation's complicated water needs. The Reform was a fix to a system that was not working.

The fix also transformed agriculture across the country and many a farmer's way of life my family and the Donaldsons are but two case studies. America's prioritization of clean freshwater ushered in a new era for Yahara's farming tradition.

One Nation under Water

On the eve of the Reform, the United States had a collective epiphany. Extreme climate change and tension over water resources had amounted to widespread crises for which the country was largely unprepared. Through the 2020s and 2030s, as the climate's instability intensified, severe drought left some regions without enough water; extreme storms flooded others with too much; and much of the freshwater the country did have was deplorably polluted. A water crisis had gone from anticipated threat to unanticipated reality.

The nation's unpreparedness was partly due to a warmer-than-expected climate.

"Early century climate projections turned out to be much too modest," said Jason Moore, a climate scientist at the University of Wisconsin-Madison. The atmosphere's unforgiving intensity caught scientists and the public by surprise.

Decades of political and public paralysis on climate change were also to blame. The country's inadequate political will and infrastructure left it fumbling for control over an unmanageable situation. For example, Moore pointed to the arid Western states' reluctance to reform their unsustainable growth policies, even as they faced catastrophic droughts. Their incessantly growing populations eventually sucked aquifers dry. People abandoned smaller cities and towns, and economically powerful megalopolises, such as Phoenix and Los Angeles, demanded that water-rich parts of the country share their liquid wealth. Meanwhile, violent tides and storms terrorized coastal communities on both sides of the map, and tidal floodwaters chased millions of people inland.

The Midwest was hit hard by the ripple effects of these crises. As the nation's "water tower," it became the target of the West's thirsty pleas. Their demands put pressure on the Great Lakes Compact states, Wisconsin included, to reconsider their pact to prohibit water from leaving their boundaries, which resulted in heated disagreements.

Also the nation's farm belt, the external demands for water on the Midwest only tightened the cinch on an already strained situation. Agriculture's insatiable consumption of water was at new odds with that of our own. Warming temperatures lengthened growing seasons and caused frequent summer droughts, forcing farmers to turn up the knob on irrigation. Wet springs juxtaposed the dry summers and exacerbated farmers' stress. Floods flushed tons of phosphorus from fields into waterways, worsening the increasingly sordid conditions of the Great Lakes, the Mississippi, and the Gulf of Mexico. Massive algae blooms exploded every summer.

Preexisting disharmony among the layers of governing bodies—from the federal to the municipal—that shared the management of these water bodies brewed only inefficacy at handling the messes. The discord escalated in the summer of 2035, when the Gulf's Dead Zone had grown to the size of Texas. Destroyed fisheries elicited uproar and a slew of compensatory lawsuits. Federal courts responded with new runoff rules that threw Upper Midwestern states off guard and into defense mode.

Then, the food crisis hit. It was 2036. The Midwest's spring was soggy, its summer long, hot, and dry. Really dry. I remember the dust of that summer. My brothers and I avoided going outside. The hot winds would blow the parched soil into our eyes and noses from our sickly cornfields. Blowing your nose always left interesting debris in the tissue. I also remember my father's mood that summer: withdrawn and tense. He and my mother stayed up late many a night discussing how they'd make ends meet. While my mother had a day job, her salary was pittance for a family of five. But it helped my parents avoid bankruptcy.

Not all farmers were as lucky. Unlike years before, just getting by had become a feat that many of southern Wisconsin's farmers simply couldn't pull off. They could barely put food on their own tables, let alone America's. The Farm Bill still didn't adequately account for climate-related impacts on crops. As repeated droughts and flooding destroyed yields, crop insurance payouts dwindled, making it increasingly difficult for many famers to break even. The accumulating insurance claims threatened to raise the taxpayer tab, which stirred public discontent.

Now stuck in the quagmire of a food and water crisis, public outcry crescendoed to a deafening roar. Not since the Dust Bowl had Americans found themselves in so desperate a state. Across the country, people lived in fear





their taps would run dry. The media stirred the pot with sensational headlines about water disputes. Experts scolded society for ignoring the warning sirens. Many fingers were pointed at the recklessness of agriculture, and agribusiness cowered under the pressure.

At the time, I was reading Silent Spring,

the classic book by biologist Rachel Carson that exposed the dangers of pesticides and ignited the twentieth century's environmental movement. I couldn't help but think that history was repeating itself. We were stuck in another episode of unintended consequences.

Ultimately, the water crisis spurred a shift

similar to that rallied by Carson's writing and the Dust Bowl's destruction: government intervention. Americans beseeched their leaders for reform. With public outcry reverberating through the Capitol's halls, all Congressional hands were on deck.

Unfortunately, Washington's first stab at a solution failed. In 2037, the United States joined an international geo-engineering collaboration, convinced the solution was to force global temperatures back down to normal. To cool things off, specially equipped jumbo jets sprayed sulfate aerosol into the stratosphere, mimicking an enormous volcanic eruption, a natural cooling process. Despite the world's high hopes, the experiment backfired. The sulfate treatment only further dried out some world regions and flooded others, creating pockets of winners and losers. Anger over the failure flared, especially among the losing regions. Some losers even issued threats of military or counter-cooling action. Needless to say, global cooperation fell apart. With the hope of climate mitigation lost, the United States turned its full attention inward and to adaptation.

The geo-engineering endeavor's only success was its accentuation of the crisis. It made clear that protecting the American people required protecting their water, air, soil, food, and health. Resource scarcity, degradation, and disparity became the gravest threats to the American Dream. According to former U.S. House Representative for Wisconsin Natalie Harris, it was at this pivotal moment that the conversation around national security began to shift.

"It became clear security extended beyond borders, energy, and defense. Water had essentially become America's new oil," Harris told me when I visited her in her Middleton home. A lifelong politician, Harris got her feet wet in the boiling water crisis, the type of introduction that could make or break a political career. It made hers.

Harris was among the newly elected House Representatives in 2038. A Yahara native, she was a plucky, up-and-coming leader and an expert in water policy. She won her Congressional seat by an unprecedented margin. Public confidence in Congress had plummeted after the geo-engineering letdown, causing a drastic electoral shift in the 2038 elections. Candidates who stood on a strong environmental platform were overwhelmingly victorious. Experts claim the political sea change was what allowed the Reform to happen, and happen guickly. They also credit Harris for championing the Reform's game plan, a strategy inspired by something written in the footnotes of American history.

Nineteenth-century geologist and explorer John Wesley Powell is best known for his adventures in the American West. He is less known for his prescience about governing the frontier. Predicting the West's aridness would eventually lead to conflicts over water, he had suggested that state lines be drawn around watersheds. In fact, according to Harris, if we had asked ecologists to divide up the United States, they would have done so by watershed.

Watersheds are natural boundaries for ecosystem management. Everything in a watershed is essentially swimming around in the same pool, making managing water explicitly by watershed, instead of across them (as we used to), more effective for conservation.

Powell believed a West designed by watershed would allow for better control of water



Under Nested Watersheds, Wisconsin's water governance is split between the Upper Mississippi Watershed Unit and the Great Lakes Watershed Unit. The Yahara Watershed Subunit is part of the Upper Mississippi Watershed Unit, since its waters ultimately flow into the Mississippi River.

use and, thus, better prevent conflict. Harris believed he was on to something.

"Given the scientific knowledge we had gained over the two centuries since Powell, it was clear our former system for governing water resources was not optimal," she said.

And so, with Harris at the helm, the Water Security Act of 2040 swept through the Legislature, flew off President Braun's desk, and brought into existence Nested Watersheds. As all high school students now learn, the Act redesigned how the nation manages its water resources, erasing the former state boundaries and tracing them around those originally drawn by nature—the topographic lines of the nation's major watersheds. While states retained the governance of all other matters, water governance took the form of a Russian nested doll. Major watersheds became watershed governance units. For example, otherwise still a unified state, Wisconsin water governance was split in two: the east and northwest became part of the Great Lakes Watershed Unit, and the remainder of the state was absorbed by the Upper Mississippi Watershed Unit. The units became responsible for meeting federally mandated standards and goals for water quality and supply.

Most of the actual decision making happens at a finer scale than the watershed unit. however. Embedded within each unit are a couple of layers of watershed subunits, or the collection of regional watersheds that feed into the unit. For example, the Yahara Watershed is a tiertwo subunit nested within the larger tier-one Rock River Watershed Subunit, a basin that crosses Wisconsin's border with Illinois and feeds into the Upper Mississippi Watershed. Each governed by a Regional Watershed Management Authority, subunits have the power to custom design local policies, programs, and priorities to best meet regionally specific water management requirements. Though rigorous, the requirements are designed to be attainable according to each watershed's unique attributes, such as its average annual rainfall, soil types, and topography, all of which impact the water that flows across the landscape.

Upper Midwestern watersheds share three overarching responsibilities. They must refill their groundwater supplies with a specified fraction of their precipitation; hit reduction targets for a host of pollutants, ranging from phosphorus to pharmaceuticals; and help keep the mighty Mississippi tamed by controlling floodwaters within their boundaries. Incentives and regulations for meeting requirements trickle top-down from the federal level through the nested layers. The federal government's carrots and sticks go directly to tier-one subunits, which subsequently allocate their own set of carrots and sticks to tier-two subunits. Thus, the money and mandates come from above, but the specifics of water management are locally determined.

For Yahara, this means it must help the Rock River Subunit meet specific targets for the quality and quantity of the water that flows from the Rock River's mouth into the Mississippi. If successful, the federal government rewards the Rock River Watershed Management Authority (RRWMA) with payments. If a target is missed, the RRWMA will be fined if it doesn't remedy the situation within the probationary period. Subsequently and similarly, the RRWMA incentivizes and regulates Yahara and its other tier-two watershed subunits based on their contributions to the Rock River's performance.

Pledging our allegiance to water initially caused some growing pains, as subunits scrambled to get organized and standard compliant. Expectations for Nested Watersheds were high, and the pressure to meet them intense. In the United States' nearly three-hundred-year history, change this drastic was rare, and it would take some getting used to.

United We Stand

In her 2068 memoir, United Watersheds,

which chronicles the preceding and early years of the Reform, Harris shares the raw emotion of her own pressures. Showered with public praise and speculation of an eventual run for presidency, she felt somewhat obligated to stay in Washington after the Reform passed. But she also felt called back to Yahara, her home. She felt a deeper obligation to help guide it through the transition. Ultimately, her loyalty to Yahara outweighed her federal pursuits and she followed her heart, running for the first Yahara Watershed Management Authority Executive seat. She had victory in the bag.

An immediate order of business was to reassure Yahara's farmers. The Reform's inclusion of an updated Clean Water Act presented farmers with a long list of new or stricter existing rules: groundwater recharge quotas, irrigation restrictions, climate change adaptation requirements, animal unit limits, runoff limits, tax penalties for surpassing limits, and so on. Despite the incentives issued to ease the regulatory weight, many farmers felt their centuries-long tradition was under threat.

"Farming has long been a piece of Yahara's identity. My own family has farming roots here," Harris told me with careful words. After a thoughtful pause, she continued, "But, I think it was Woody Allen who once said, 'Tradition is the illusion of permanence.'"

While the Reform disrupted tradition, it altered rather than ended it. Underlying the list of rules was the principle that farming had more to contribute than just food and fuel. Clean water, healthy soil, wildlife habitat, and flood control are services that can go handin-hand with commodity production. Harris understands the Reform as an enhancement to agriculture's purpose to society. "Farming has many functions. The Reform merely incentivized the conservation services it can provide," she said.

The Farm and Water Bill, another piece of the Reform's package, helped nurture farming's many purposes. Formerly just the Farm Bill, Congress overhauled the legislation to orient agriculture around effective water management and help farmers ensure they can still reap a profit off their land. In other words, it set farmers up to treat water like a crop, and shifted agriculture's gears from maximizing to controlling production.

The Farm and Water Bill restructured subsidies, tax incentives, and crop insurance requirements to be tied with water and land conservation. It diverted funds once meant for corn and soy production to soil and water conservation. Land once meant for corn or cows became more profitable as grassland, wetland, or forest. Fields too saturated with phosphorus or too susceptible to erosion found new lives as pasture. Subsidies were assigned to perennial crops, such as herbs, fruit trees, asparagus, and switchgrass. As high value crops that reduce erosion and make soil healthier, these year-rounders help keep waterways clean and clear of excess sediment and nutrients.

At the local level, the YWMA created its own programs to help farmers adapt to the Reform. Its flagship program, Climate Ready Farms, helps Yahara farmers meet water requirements, while also coping with climate change. It provides farmers grants, tax incentives, and technical assistance to undertake practices and projects for meeting water management and climate change adaptation standards. Farmers across the watershed have converted cornfields to green space, replaced corn and soy with a cornucopia of non-commodity crops, downsized cattle and pig herds, and installed myriad gadgets and systems to capture and monitor phosphorus, nitrogen, and carbon. In partnership with UW Discovery Farms, an on-farm research program of the University of Wisconsin Extension and UW-Madison, the YWMA also pays select farmers to use their fields as demonstration sites for new techniques and technologies.

Donaldson Dairy is a Climate Ready demonstration farm. As loyal UW-Madison alums— Greta studied dairy science, Lou studied water chemistry—the Donaldsons were eager to participate in the two long-term adaptation studies currently happening on the farm. Lou explained that climate readiness has helped them not only weather unpredictable growing seasons, but also become a profitable enterprise. "The nature of the business has always required farmers to adapt to nature," he told me.

The siblings now practice Managed Intensive Rotational Grazing, a method that surged after the Reform for its water-friendlier manure management. On the day I visited the farm, I helped Greta drive their 60-head dairy herd to a new pasture. The cows had stripped the previous pasture of most of its edibles, making the balding soil susceptible to erosion. Donaldson Dairy lies within the Sixmile Creek Watershed, one of the relatively livestock-heavy sections of the Yahara Subunit, which means Greta must keep a close watch on what the girls leave behind.

"It just made economic sense to convert to pasture," Greta told me as she clipped shut the electric fence after the last cow.

The dairy farm hadn't changed much through its previous generations, aside from



Yahara's landscape transformed under the Reform, as this farmland north of Lake Mendota shows. Grasslands, wetlands, and forests have replaced thousands of cropland acres.

slight adjustments to herd sizes and industry trends. But with the farm's future suddenly precarious post Reform, Greta and Lou decided Donaldson Dairy needed to get rid of a few hundred cows (the herd's previous headcount was nearly 400) and its conventional ways. The incentives to change were enticing, the potential costs otherwise too immense.

For one, the manure treatment for mid- to large-scale farms that was mandated initially, manure digesters, was cost prohibitive to many farmers like the Donaldsons. Eventually the technology became obsolete anyway. It turned out digesters weren't capable of keeping even large farms within their runoff limits, since they still depended on erosive row crops to feed their herds.

Heavy production taxes, meant to account

for meat and dairy's water impacts, would also be too burdensome. Switching to grass seemed the only economically viable option for keeping the farm, especially with the tax incentives for pasture.

And then, of course, there was climate change and all the uncertainties it promised. Rotational grazing would make it easier for the farm to withstand drought, for example. So, like many livestock operations of a similar size, the Donaldsons downsized and adapted.

"It was go small or go home," Greta joked.

Farms that were already small found themselves well primed for climate readiness. Small-scale farms tend to have higher crop diversity and lower water use, which enables them to use less fertilizer and pesticides, keep soils healthier or more stable, and better withstand drought without heavy irrigation.

An interesting byproduct of the small farm advantage was a shift in Yahara's farming demographics. Namely, Hmong farmers now take up a larger percentage of agriculture's demographic pie than ever before.

"We've been farming the same way for generations, and some of our traditional practices happen to help us conserve water fairly well already," said Daniel Phang, a fourth generation Hmong farmer and outreach specialist with UW Extension. He explained that the Reform has made farming generally more lucrative for Hmong farmers, which has in turn made land ownership more accessible to them—most used to rent their land.

The biggest changes were made by Yahara's biggest farms. In general, the larger the operation, the larger the water footprint, and the harder and more expensive it was to meet water standards. Water conservation requirements forced a substantial number of largescale corn, soy, and livestock operations to put thousands of crop acres and cows out to pasture, literally and figuratively.

Some farmers were limited by the inflexibility of their land. They made a better profit giving their finicky fields back to nature. My family's farm was one such example. In addition to our erosion-prone fields, we were facing the erosion of feed corn's economic value, as so many livestock farms transitioned to grass. To my parents, the most economically sensible option was to restore 95 percent of their land. They could make a better living off the combination of tax incentives for ecological restoration and payments for water "services," such as recharging groundwater and providing wildlife habitat. The oak forest that now covers our property is providing these services, as it grows and matures over the roots of my family's 150-year tradition.

According to Greta, the inflexibility of some farmers forced change upon them. "The agricultural community had a historical discomfort with the government, and these inherited ideas were still present during the Reform years," she said.

Some farmers thought the government was bluffing and wouldn't actually enforce regulations. The YWMA wasn't bluffing. Eventually, the strict regulations and water use taxes dragged the most obstinate farmers into financial trouble. To avoid failure, many ended up selling their land to the YWMA or a local land trust, and their acres became conservation easements. Any residual uncooperative attitudes were subdued by public disapproval.

Flexible farmers with flexible land were able to adapt. Many of them embraced the rising star crop: switchgrass, the Midwest's new energy security sweetheart. A fast-growing, perennial, erosion-preventing plant that requires little fertilizer, switchgrass outperforms corn in water quality. It can also adapt easily to fluctuating climates and growing seasons. With the death of corn ethanol support, switchgrass (a.k.a. cellulosic biofuel) received a booster shot of federal money that accelerated research and development. In 2045, the long-awaited breakthrough that made it a commercially viable energy source finally happened, and largescale farms were quick to jump on the bandwagon. Today, roughly 18 percent of Yahara's farmland is working full-time in cellulosic biofuel production.

As farmers adapted, Yahara's cropland became a shadow of its former self. Since the

beginning of the twenty-first century, the percentage of Yahara that is covered in corn has dropped from just over one-quarter to four percent; soy dropped from 8 percent to not even one percent. Yahara's pastureland has tripled; although it is still a mere 3.4 percent of the total landscape. Forest and wetlands replaced a large portion of the cropland, both ecosystems nearly doubling and now hovering just below 12 percent of the landscape each.

But the drop in crops did not degrade the region's food production, as farmland that feeds humans directly has been well preserved. In fact, water-centric farming bolstered the local food economy, boosted Yahara's food security, and changed the way Yahara eats. While the prices of meat and dairy have risen, their consumption has fallen. The higher abundance of farms growing food for people has made local fruits and vegetables increasingly affordable comparatively; although, their prices have increased somewhat to account for their water demands. Food waste, which wastes water, has decreased substantially. A regional food hub is thriving more than ever. Small, local businesses partner with local farmers to grow, collect, and distribute food across the watershed. Schools, cafes, restaurants, hospitals, and food pantries can easily trace the tracks of their food from farm to table.

As Lou implied, the Reform let agriculture's adaptive nature shine. Farmers proved they could improve their water management and adjust to the warmer climate. Higher crop diversity and water-efficient planting and irrigation lessen farms' thirst during drought and the longer growing seasons. The refurbished farmland more easily absorbs the excess water left by heavy rains. "The Reform essentially enabled farmers to become more active in watershed planning, which I think has greatly improved the Yahara's water security," said Lou.

But Yahara's security is not absolute. The capricious climate has a tendency to highlight our shortcomings, such as it did with this year's saturated April, which could cost Yahara millions of dollars in damage and fines, when all tallied. Even with its adaptation efforts at full steam, government is still prone to a snail's pace. It is typically just catching up from the previous disaster when the next one strikes.

While some setbacks can't be predicted, they can be anticipated, which is exactly why the YWMA created its nutrient trading scheme. All of Yahara's farms are hooked up to a network of sensors and satellites, which keep a sharp eye on what goes into and out of the soil. The monitoring data help farmers know if they will be able to meet water supply quotas and runoff limits, or if they will need to buy credits to avoid hefty fines.

"In the past, many farmers were reluctant to disclose so much data. Now, disclosure can only help them," said Lou.

Nutrient trading and data sharing exemplify the holism the Reform has granted water management. Holistic management entails harmony between not only management options, but also urban and rural efforts. All major contributors to the state of Yahara's water quality and supply—from business to neighborhood—are part of the nutrient trading pool. For example, a subdivision can trade with a nearby farm, or one smaller watershed can exchange with another, all to ensure the Yahara Subunit as a whole hits its water quality marks at its outlet into the Rock River. Everyone wins when Yaha-



Yahara's neighborhoods conserve water and prevent runoff with features such as pervious pavement, rain barrels, rain gardens, green roofs, and improved public transportation.

ra meets its targets; the prize is tax credits for everyone. The penalty of failure is a universal nutrient surplus tax.

While the trading system normally helps Yahara adhere to standards, this year's soggy April may threaten the subunit's mostly clean record. When I visited Donaldson Dairy, Lou had just come from his YWMA office, where he had been sorting out a mess in the Lake Kegonsa Watershed. It had missed its water quality targets in the flooding. The lake's shallowness and hefty inheritance of polluted sediment make it a consistently weak link for Yahara.

According to Lou, the failure of one only emphasizes the wholeness of the watershed. "Water is a shared resource. What happens to water in the upper part of the watershed affects the lower part; what happens on a farm affects a neighborhood, or vice versa. We're all in this together," he said.

Togetherness is treating the watershed as a whole and governing water as an inherently united system, where a single failure—or success, for that matter—will affect everyone. For example, the YWMA has channeled funding streams to flow between farmland and cityscape. Tax revenue from water-intensive farms and urban water squanderers feed grants for innovative water conservation measures, and individual runoff fines support lake management for the collective.

The layers of urban initiatives in Madison and the YWMA's other municipalities further reflect this spirit of togetherness. The rain barrel program helps households control their runoff by collecting rainwater. Tightened urban runoff laws and taxes on water-unfriendly building materials have made the suburban addiction to asphalt and cement an expensive habit, rendering low-density development cost-prohibitive and high-density highly attractive. Even though the watershed's population has grown by over 150,000 since the beginning of the century-many people were drawn to the region's water-richness and its relatively good performance in climate change adaptation—the YWMA's regulations have kept this growth well contained.

At the infrastructural level, fortified public transit has further lessened the craving for pavement. City streets and neighborhoods have sprouted pervious surfaces, bioswales, rain gardens, and other green stormwater infrastructure. When the rains go wild, the upgraded Tenney Park and McFarland locks help keep low-lying, lakefront neighborhoods drier than ever before. The YWMA made more room for floodwaters by dredging and widening the channel between Mud Lake and Lake Waubesa. Restored urban ecosystems, such as lakeshores and wetlands, give city engineering a hand in keeping floodwaters at bay. Water-centric growth has also nurtured changes at the economic level. Not surprisingly, the Reform shifted Yahara's workforce, causing a symbiotic boom in the public and private-contracting sectors. The YWMA employs a significant workforce, and a large number of private firms run and manage its projects and programs. Conservation job programs, such as Yahara Conservation Corps, do triple duty in alleviating unemployment, reducing poverty and supplying labor for some of the YWMA's restoration projects. Moreover, government grants for water management innovation have sparked a flurry of entrepreneurial activity.

Even with this impressive set of measures, the YWMA recognizes that the united Yahara is made up of a collection of individuals, and water conservation would be remiss without behavior change at the individual level. A leaky tap or a lengthy shower can steal precious drops from the regional water supply.

From the start of her YWMA Executive term, Harris pushed for a strong focus on changing Yahara's water use culture. I recall the massive outreach campaigns of my youth that chanted the mantra of water security. The YWMA reinforced good behaviors, such as planting rain gardens, with incentives and discouraged water spendthrifts with taxes and fines. While we are still not on our perfect behavior, average household water use has plummeted in the past three decades. As Harris put it, "water conservation has become the new normal."

Yahara's Watery Future

When I asked Harris what she thought the new normal meant for Yahara's future, she joked she was too old to see that far anymore. Joking aside, she continued, "I think the Nested Watersheds framework gives Yahara much more flexibility in dealing with whatever challenges may arise." As John Wesley Powell suspected, water governance at a scale that honors the boundaries drawn by water itself has assuaged the threat of another crisis and has created a system that can be effective and adaptable in the face of unexpected natural events.

The durability of Lakes Mendota, Monona, Waubesa and Kegonsa in the watershed's collective identity may also bode well for the future, Harris claims. "We are a community built around the lakes, and I think the Reform has only reinforced their meaning to us," she told me.

Surveys conducted annually by the YWMA seem to concur. Yahara residents have increasingly perceived themselves as a united watershed, and their attitudes have progressively shifted toward supporting a collective responsibility to protect water. Notably cleaner waters for Lakes Mendota and Monona seem to validate this duty, while the persistence of murky waters for Waubesa and Kegonsa, due to their unfortunate geography and phosphorus-clogged soils, reinforce the collective urgency. The enhanced spirit of togetherness has even spilled over into other social spheres, strengthening regional coordination in transportation, healthcare, and education, for example.

When I asked Moore, the climate scientist, the same question, he was skeptical of the new normal's longevity. Like a growing number of experts, he thinks the United States has been lucky that Nested Watersheds has worked well enough so far. He agrees the Reform has improved water management on the whole, but with a caveat—real progress may be impeded by unrelenting change and the weight of heavy constants.

"We are essentially stuck in a position of continuous adaptation," Moore told me. He thinks land management under the Reform has built some climate resiliency, but unexpected disasters could continue to challenge the adaptations we have made. We could end up exhausting our resources, with nothing left to make longer-lasting change. Or, as the Red Queen put it in Lewis Carroll's *Through the Looking-Glass*, the sequel to his classic *Alice's Adventures in Wonderland*, "It takes all the running you can do, to keep in the same place."

Like many climate scientists, Moore mourns the world's lost opportunity to mitigate climate change earlier on and thinks we are still not doing enough to curtail greenhouse gas emissions. Indeed, the United States has done very little on this front. Even with water as its new oil, and despite the advancements in biofuels, the country still relies on the old oil and natural gas, ironically water-reliant energy sources.

"If the country does not spend more money and effort on renewable energy innovation, climate change effects will only continue to intensify," said Moore.

Continued nationwide population growth and unquenchable water demands could also keep us running in place. Water equity will be a constant and precarious balancing act. The Upper Mississippi Unit still carries most of the weight in supplying water to the left-over and dehydrated Southwestern communities, since legal disputes over water allocations from watersheds within the Great Lakes Compact of which Yahara is not one—still linger in limbo. The massive payments Southwest residents make to the Upper Mississippi watersheds to cover piping costs may never ameliorate the grievances of Midwesterners who frown upon the neediness of their water beneficiaries. Increasingly severe droughts, such as those that dried out Yahara in 2060 and 2065, have tested the durability of the system and exacerbate the pipeline tension.

Constant adaptation could end up preventing us from doing what Moore and other experts claim we really need to do: transform. Water management has transformed, but not much else. Stuck in a constant cycle of incremental adaptation, we may merely be creating a more complicated system for maintaining the status quo. The real problem may be the status quo. This year's flood was a case in point. The flood infrastructure the YWMA built in the 2040s has been good enough for the decades since, but April's rains took their toll. Some YWMA engineers are worried that a rain event any more intense would be too much for the current structures. Moore and other climate scientists are predicting an increasingly watery future, rendering the infrastructure's longevity precarious.

"We need to be thinking at a time scale much longer than we have been, if we're going to be able to sustain our water resources into the future," Moore cautioned. He is part of a research team at UW-Madison that is inves-



Even though water management has been greatly improved, Yahara is stuck in a cycle of incremental adaption, which complicates more meaningful transformations. April's flood caused setbacks, such as heavy runoff into Lake Kegonsa.

tigating how the watershed could sustainably manage water into the future.

But while scientists like Moore believe a long-term view is a necessity, others argue it is a luxury. With water quotas to fill and phosphorus limits to obey, the focus is fixed on shortterm goals rather than on transformations that will help further down the line. Thus may be the riddle of the treadmill of adaptation.

Sitting in their kitchen, chatting over glasses of fresh chocolate milk, I asked Greta and Lou their visions for Yahara's future. Lou was ambivalent about the steadiness of the strong government hand. "Nested Watersheds has made government, agriculture, and communities more adaptable to environmental change, and it's made me feel like we could more easily get somewhere with water quality. But it's not perfect, and politics are not static," he told me, referring to the resurrection of a political camp calling for smaller government. The recent release of the YWMA Budget elicited some political grumbles over the funding for some programs, including the one under which he works.

Greta says she thinks about her potential grandchildren. She hopes Yahara will stay a great place to live, the lakes will continue to become cleaner, and water will make the region prosper. When I asked Greta whether she thought agriculture would ever make a comeback, I knew I had found my note to end on.

"Agriculture never went away. It just looks different now. We farmers contribute even more to the region's wealth—that wealth being water," she answered.

Credits

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Nested Watersheds is one of the four Yahara 2070 scenarios, which present fictional yet plausible futures for human well-being in Wisconsin's Yahara Watershed. The scenarios are intended to encourage long-term thinking in local decision making and spark broad discussion about what is desirable for the future. Yahara 2070 is part of the UW-Madison's Water Sustainability and Climate project, a research effort to understand how water and the other benefits people derive from nature could change over time. The project is funded by the National Science Foundation. For more information, visit **yahara2070.org**.