

ACCELERATED INNOVATION



YAHARRA2070



What would life in 2070 be like if we prioritize technology to solve environmental challenges?

Accelerated Innovation is The Edge E-zine's series on places at the Innovation Revolution's front edge. To kick start it, we profile Wisconsin's Yahara Watershed.

ACCELERATED INNOVATION

Mid-sentence, Joel Shedden reached for his ear to silence his beeping iMind. "Sorry, my robot is texting me," he explained. The robot, a Cropbot Harvester, "texted" to alert him that it had finished up for the day and was heading back to the BotBarn. The RoboText App allows Joel to track the robot's every move, wherever he is. He doesn't have to be on the farm to keep an eye on things.

Joel owns and manages a clover and legume farm in Dane County, Wisconsin. Although it is one of the region's endangered family farms, Shedd Valley Farm is also among the most high-tech. Twenty-five years ago, after completing a Master's degree in Sustainable Systems Engineering at the University of Wisconsin-Madison, Joel returned home to take over the business and put his technological savvy to use. Within a decade he turned Shedd Valley into one of the Midwest's leading innovation farms. As early adopters of the stream of agro-technology that has emerged over the past few decades, innovation farms are both the guinea pigs and the pioneers of the agricultural frontier. But 2070 may mark the waning of their competitive edge, now that much of this technology has pervaded standard farm practice.

"The things technology lets us do on the

farm today would probably make my grandfather roll over in his grave," Joel joked. His grandfather, Henry William Shedd Jr., was an advocate of tradition and "quite the Luddite," according to Joel. All his life, Henry was adamant about preserving the family's livestock business. But he had been reluctant to change with the times, especially toward the end of his life, when times began to change at a quickening clip.

"I appreciate tradition," said Joel, "but the advancements we've seen in the past few decades have done a lot of good for farmers."

Joel is not the only Dane County farmer enamored with technology. Agriculture's swift progress through the Innovation Revolution has reaped more than just crops for farmers. The flood of innovation has greatly reduced the need for fertilizers, pesticides, and intensive irrigation. New planting and harvesting technology awards farmers larger yields in smaller plots. With finely honed precision tools and practices, they can adjust corn, soy, and other cash crops to fit hyperlocal climates and topography. With DIY-GE kits, they can genetically engineer their way out of nearly any ecological pickle. Corn is now nutritionally dense as well as fast-growing. Crops can help the soil build up organic matter or sequester phosphorus. Many formerly annual crops are now perenni-

als. And farmers can create all of these remedies in their own barnyards.

Farmland is not the only über-efficient piece of the Wisconsin landscape. Across its hinterland and cities, it is hard not to make a bad joke about the state's German roots showing through in the engineering prowess that has emerged in recent decades.

The Yahara Watershed, especially, has blossomed into one of the country's leading innovation centers. It has attracted flocks of biotech, high tech, and green tech firms, which have migrated or hatched here, enticed by a habitat rife with opportunity. The tech industry now employs roughly 75 percent of Dane County's population, its infrastructure dominates the landscape, and its products shape daily life.

The University of Wisconsin-Madison churns out some of the most cutting-edge solutions to the nation's environmental and health problems. Forward-thinking policies facilitate fruitful collaborations between some of the world's most innovative minds. This trifecta of industry, research, and policy has made a welcoming home for early adopters and has pushed southern Wisconsin to the front of the technology pack.

The Yahara is a poster child of the Innovation Revolution, what modern historians are calling the era that began about fifty years ago and continues today. In an attempt to turn back the dial on mistakes we humans made at the expense of our natural systems, we have changed our anthropogenic tune. Today, we



Shedd Valley Farm is a typical Yahara farm in 2070. The farm's owner, Joel Shedd, uses the most advanced technology, such as a CropBot harvester and an AgDrone, to grow legumes to be used for synthetic meats.

devote the vast majority of our technological energy to improving nature, while also improving human life. In fact, it is difficult to find or do something free of technology's touch.

But technology's pervasiveness belies the origins of the Revolution. What spurred the innovation spurt, and to where is it leading us? As we venture forth into the 2070s, eyes fixed on a prosperous future, *The Edge* editors took a moment to navel gaze upon the present and look retrospectively at the path that got us here. America has been steeping in the narrative of accelerated innovation for nearly a half century, but what does this narrative foretell for our future? A look at some of the nation's most cutting-edge innovation centers, such as the Yahara Watershed, may give us some clues.

The Fast Lane to the Revolution

Shedd Valley Farm underwent a transformation indicative of the broader changes that have occurred in the Yahara Watershed since the mid-2020s. When Joel took over the farm after graduate school, he had to save it from nearly going under. The beef industry was suffering, which meant business was suffering. On top of this, the farm was having trouble complying with new phosphorus runoff laws. In deference to his father's wish, Joel's father, Gerry, had been reluctant to invest in the technologies promoted to fix such problems. Determined to not let the family business die, Joel made the decision to end family tradition. In a move that would have undoubtedly disappointed his then-deceased grandfather, Joel converted the farm from cattle to protein-rich crops and began using some of the most advanced technologies on the market at the time.

"To be sustainable, I felt we had no choice but to get rid of our cows, get into the booming synthetic meat market, and get ahead in the technology rush," said Joel.

Fortunately for Joel and farmers like him, the financial resources necessary for such grand-scale changes were available. The government was practically handing out money to farmers to invest in technology. Most of it was intended to bring under control one of the Yahara's peskiest predicaments: its manure problem.

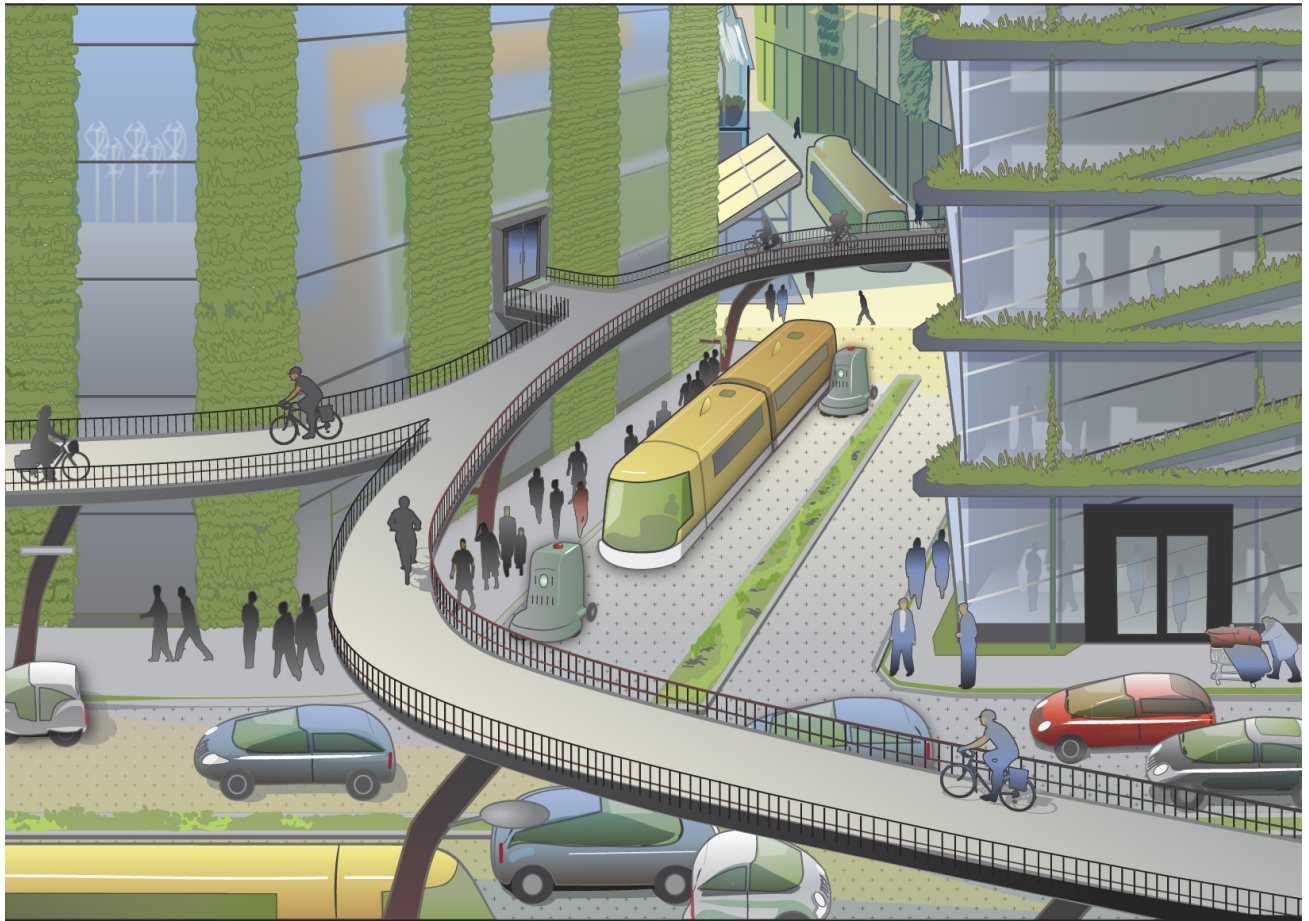
"The roots of the Yahara's Innovation Revolution lie in cow poop," said Dr. Andrew Barnard, a professor of U.S. technological history at UW-Madison. He recently published *Cow Power: The Technological Rise of Yahara*, in which he argues the region's progress can be traced in its bovine history.

"Our region's history with livestock production and, thus, manure provides a fascinating angle from which to view our recent era of innovation. Manure posed an incredible riddle to farmers, policy makers, environmentalists, engineers, and researchers for decades, and this riddle has inspired a torrent of innovation," said Barnard.

At the heart of this riddle is the very reason the Innovation Revolution unfolded: an environmental crisis—or, more accurately, crises. The issues clustered within the Yahara's persistent manure problem illustrate the very predicament the region and the country were facing earlier in the century—namely, degrading water quality, exacerbated by a changing climate.

By the mid-2020s, public concern about the global environmental mess had finally reached a boiling point. At the 2025 United Nations Conference on Climate Change, in a reexamination of the Sustainable Development Goals,

Urbanization increases during the Innovation Revolution, but development is highly dense and high-tech to reduce the urban environmental footprint.



world leaders reached a collective conclusion: the so-far incremental pace of technological advancement, even with occasional breakthroughs, was not sufficient to avert a global environmental disaster. Accelerated technological progress was imperative to tame the roaring climatic beast. By signing the Budapest Agreement, delegates committed their countries to reforming policies around, funneling investments into, and focusing research on improving and supporting sustainable development technology.

The United States was among the designers of the agreement. Then-President Nancy Lee-ward had already committed the country to an aggressive climate change adaptation agenda, reasoning there was no more time to waste. A spate of natural disasters on American soil had

sounded enough alarms to cause a stubborn ringing in the public and policy makers' ears. The country could no longer drag its feet. Reminiscent of the 1960's space race, her signature elicited a "man on the moon" moment. Across the nation, priorities shifted toward confronting climate change with every tool in the shed and making the United States a world leader in mitigation and adaptation technology.

Historians still debate why technology became the silver bullet. Some think the tangibility of technology as a solution and the seeming control over nature it gives us made it sound like the most viable solution in which to invest. Some think it is just our human nature to innovate and create. Those with a more skeptical take think technology seemed like a low-hanging fruit. "It seems easier to just engineer our

way out of a problem than to ask people to change their lifestyles,” as Barnard put it.

Whatever the motivation, investment in technology exploded across the developed world. In the United States, the private and public sectors poured money and resources into the environmental, health, and biotechnology fields. Innovation hubs sprouted up across the country, especially in nodes containing major higher educational institutions.

Dane County became one such hub. With its leading research university, its centrality for regional governance, its agricultural moxie, and its potential for private sector growth, it blossomed into one of the nation’s most innovative solution centers in a shockingly short period of time. Through concerted efforts between the state and county governments and the business community, investments rained down on research and development in the environmental and health fields, yielding unprecedented economic growth. The state created new policies and adjusted existing ones to welcome more businesses and entrepreneurs to Wisconsin. Existing companies grew and new ones took root. The university’s science and engineering departments expanded rapidly, recruiting some of the world’s brightest minds and unleashing a flood of invention. Soon, technology and innovation became as salient as cows and lakes in the regional identity.

Which brings us back to manure.

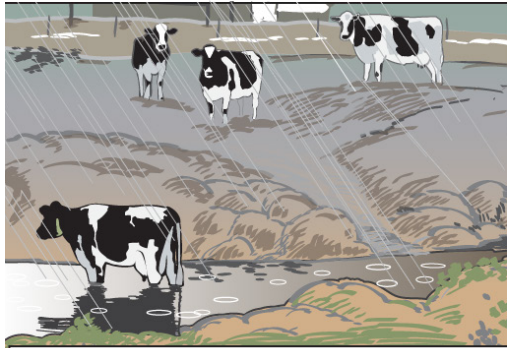
Following in the footsteps of Dane County’s “cow power” initiative, an effort to develop the infrastructure for manure digesters, much of the region’s technological development and economic growth sprang from what to do about cow poo. Research and development focused on new ways of extracting and repurposing

renegade phosphorus, generating renewable energy, and capturing greenhouse gas emissions. Subsequent branches of innovation became an abundant byproduct.

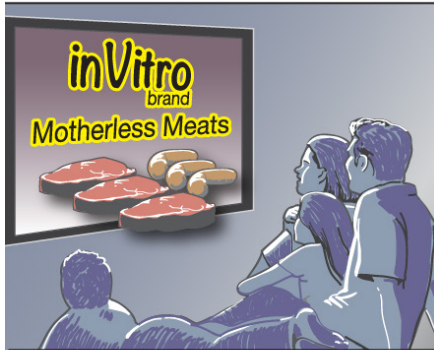
Another byproduct of this innovation push was Dane County’s growth spurt. Its population doubled in the span of five decades. People from around the country and the world followed the scent of opportunity Midwestward, snatching up jobs, starting businesses, or pursuing higher education degrees. From city center to farmland, no corner of the watershed escaped the population boom and accompanying urbanization.

The Yahara’s cities and towns grew in thick with infrastructure, most of it a shade of “green.” With the aid of policies mandating the standardization of high performance green building, architects and engineers experimented with increasingly advanced sustainable building techniques, which resulted in ever-shrinking environmental footprints. A renewed interest in public transportation, boosted by a healthy helping of funding and research, fueled the evolution of an expansive network of emission-free transit options. Over time, the built environment became reengineered to support and preserve the many goods and services the natural environment provides the region.

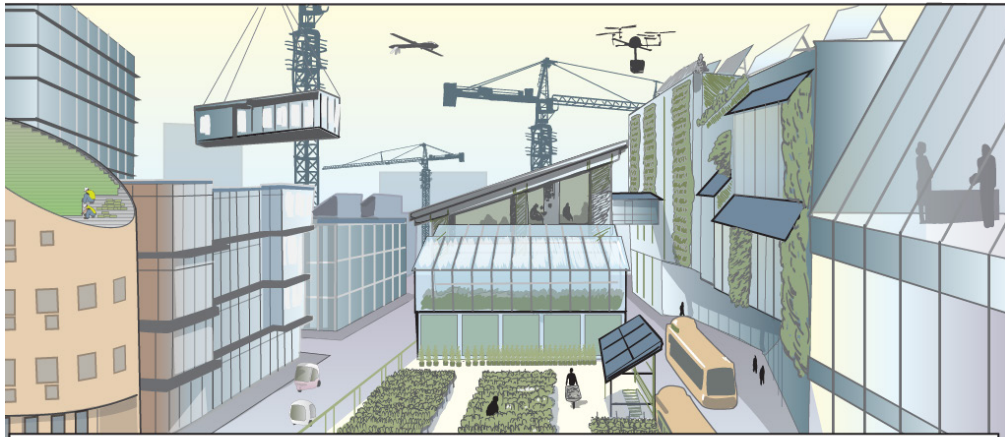
Amid this growth, it was impossible to avoid crowding out some forest, prairie, and wetland. Farmland, too, had to be trimmed. But, with the innovation surge, less land did not mean smaller yields. Digitally driven precision farming, small-scale genetic engineering, and advanced information-sharing networks allowed farmers to make up for the lost acreage. While corn and soy production remained relatively steady,



The impacts of climate change incite a global effort to combat them with technology.



Synthetic meats and DIY genetic engineering help reduce agriculture's environmental footprint.



The Yahara Watershed experiences rapid growth and becomes an innovation center.

Throughout the 2020s and 2030s, the United States struggled with extreme weather; in Yahara, this meant heavy rains and flooding. The subsequent declaration to prioritize technology to solve environmental challenges led to the Yahara Watershed's rapid growth.

farmers increasingly switched to fruits and vegetables and away from small grains, alfalfa, and hay.

Which, once again, brings us back to manure.

“The decline in alfalfa, hay, and even pasture in the Yahara is tied to the rapid decline in livestock production, a trend we’ve seen na-

tion-wide,” Barnard explained.

Underlying this trend is the national plan to reduce the country’s greenhouse gas emissions. One priority has been cutting the impacts associated with America’s insatiable appetite for meat—namely, the gaseous and solid end products of livestock digestion, from which tons of methane waft. By the 2030s, livestock

production had become responsible for nearly a third of global greenhouse gas emissions, an impact redoubled by livestock's enormous water consumption and pollution footprint. But despite the constrictions climate change was making on the average American lifestyle, the average American seemed unwilling or unable to kick the burgers and bacon habit. Meat persisted as a daily staple. So, decision-makers decided to infuse R&D investment into a formerly fringe industry: meat alternatives.

While meat alternatives have been around for nearly a century now, the R&D push invigorated the industry and led to the creation of highly advanced, low-impact, and actually-looks-and-tastes-like-meat alternatives made from both protein-rich plants and "motherless meat," or lab-grown meat created with animal stem cells. Despite some initial public wariness, the alternatives eventually exploded in popularity, as prototypes were perfected, products became cheaper, and the real stuff grew increasingly more expensive. Scientists also figured out how to mimic the chemical processes of bovine mammary glands to produce motherless milk. By 2040, synthetic meat and dairy had shed their image as only vegetarian fodder and pushed the real stuff to the fringe.

To stay in business, many Yahara livestock farmers, like the Sheddens, had to sail with the wind. Feed prices had soared, as most corn became fake-meat fodder, instead of real-cow fodder. While larger farms were able to maintain their livestock operations, many medium and small-scale operations transitioned away from fauna and toward flora with the help of government subsidies. In respect of its meat tradition, Joel decided to join the synthetic meat bandwagon and converted most of his

land to legume fields. He even salvaged a patch of his grandfather's beloved pasture to experiment with a nascent commercial crop: clover, an edible, protein-rich weed.

While a loss for tradition, the weakening of livestock farming was a win for manure reduction and, ultimately, a win for the Yahara. "The convergence of advancements around minimizing the environmental impacts of livestock put the Yahara on the Innovation Revolution map," claimed Barnard. "But, really, all this technology was answering to changing human demands, and those are what fundamentally transformed the region."

A Pit Stop in the Present

One of the most stubborn human demands is the need to eat, and the technology we've created to pry the most sustenance most efficiently from the land is indicative of how far human intelligence has taken us. Since John Deere's invention of the steel plow in the nineteenth century, farmland has transformed dramatically at the hands of machines and the humans driving them. Deere probably could not have fathomed the feats of today's machines. Shedd Valley Farm, for example, has an interconnected community of sensors, computers, robots, and other gadgets that test the land for optimal planting conditions, ensure the crops behave according to Joel's wishes, and prevent as much soil, phosphorus, and nitrogen as possible from escaping with rain and snowmelt runoff.

Shedd Valley, specifically the Shedd family, also serves as an example of the narrative of today. A technology fanatic like his father, Joel's eldest son, Jed, is among those galloping ahead on the technological frontier.

Joel's youngest son, Cole, does not share their enthusiasm, however. His is the voice shouting from behind that we shouldn't throw caution to the wind—criticism to be examined later.

Jed is the Chief Innovation Officer at Dane County's leading green tech firm, P Cycles. Like his father, he sees the Innovation Revolution as humanity's savior from ecological disaster.

"If the United States hadn't pushed the envelope, I think we would have been in much worse shape than we are now. Technology has enabled us to turn collapsing systems into productive factories," he remarked when giving us a tour of one of his field sites.

Indeed, the Yahara's landscape—from its farms to its lakes—works like a factory. Hi-tech systems, both complex and simple, ensure its ecosystems function efficiently and consistently in producing the numerous benefits we demand of them. In fact, little about this engineered landscape can be considered "natural" anymore. Just about the only freedom nature retains is the weather.

Jed, like many, believes nature's losses are our gains, however, especially in terms of productivity and control. We have been able to turn some of the past's most persistent environmental troublemakers into valued commodities, as well as derive products and services

Jed Shedden works for P Cycles, a company that uses solar-powered buoys to collect phosphorus from waterways to recycle it. Such technologies have turned former environmental nuisances, such as excess phosphorus and nitrogen, into profitable products.



from ecosystems that never before existed.

For example, P Cycles specializes in turning one long-time troublemaker, phosphorus, into a moneymaker. An essential nutrient for plant growth, phosphorus was once seen as a pollutant when in excess; the excess is now a profitable product. Today, we have innumerable methods to capture, store, reduce, reuse and recycle this nutrient, and P Cycles is among the leaders in the field.

Twenty years ago, the firm's founders developed an innovative way to harvest and recycle phosphorus runoff in the lakes. They created solar-powered electrophoresis stations, which use an electric field to separate phosphorus from the water. Buoys equipped with these devices are placed in streams and lake inlets to fish excessive amounts of phosphorus out of the water before it makes it to the lakes. The phosphorus is then collected from the buoys and recycled as fertilizer and other industrial products.

Phosphorus isn't the only nuisance-turned-resource. A multitude of devices can harvest the excess of other natural byproducts and turn them into beneficial products. For example, another local company, Bloom to Boon, developed an advanced system to harvest algae and give them a variety of afterlives, such as unique oils, fatty acids and vitamins for human nutritional supplements, and proteins used in processed foods. Soil Savers are the brainchild of a Sun Prairie firm, which has become a leader in soil erosion prevention technology. And a sister company to P Cycles, ReChem, uses a similar buoy system to remove toxins that escape with road runoff, such as mercury and heavy metals, which can then also be recycled.

"The watershed is a rich source of all these

ENERGY INNOVATION

Runoff isn't the only environmental problem turned profit-maker. Incredible leaps in renewable energy and energy efficiency have allowed America to get a better handle on its greenhouse gas emissions with an economic bang. Yahara was the launching point for several of these advancements.

Following in the footsteps of its German sister city, Freiburg—long known as the official solar capital of Germany—the Madison metropolitan area has risen to the top in solar technology. Contrary to the perceived dreariness of Wisconsin, technology has proven the state gets plenty of rays, trumping even Freiburg. Advancements in solar cells and batteries, led by university researchers and local entrepreneurs, have made solar lighter, cheaper, more efficient, and more ubiquitous than ever before.

Nuclear energy also experienced a renaissance. It got big by going small. Yahara is now a manufacturing-and-distribution hub for mini-nuclear power reactors. While they generate only about one-tenth the power of a full-sized plant, these self-contained reactors are about the size of a house trailer and are modular in design, making them a highly accessible option.

The Yahara is also a demonstration site for the mini-reactors. After a bit of energy grid restructuring, the region now hosts about a dozen reactors, which have largely replaced coal power plants. Advancements in safety and efficiency have allowed nuclear power to find a comfortable place in the arms of social acceptability, although critics remain.

Overall, the region's expanded portfolio of renewables has pushed fossil fuel use out of style. Coupled with advancements in energy efficiency technology and a smarter grid, greenhouse gas emissions have plummeted, despite the simultaneous doubling of the population and increased per capita energy use. Technology has made up for what humans are not willing to sacrifice.

valuable products that were useless before the Innovation Revolution,” said Jed. “It’s amazing what we’re able to do these days.”

What is also amazing is how the tides are turning for the lakes. Well, at least for two of them. The waters of Lake Mendota and, to a lesser extent, Lake Monona are now slightly cleaner than they were at the beginning of the twenty-first century. Getting Waubesa and Kegonsa to catch up with the upper lakes, on the other hand, may take some patience and an uncertain number of generations more.

The success in bringing hope back to the upper two lakes lay in a bio-engineering breakthrough: the creation of a virus catastrophic to a tiny critter that almost ruined everything earlier in the century, the spiny water flea. This invasive invertebrate once dined insatiably on another invertebrate, *Daphnia*, a native vegetarian species that is a ring above algae in the food chain. The fleas’ gluttony eventually caused a virtual disappearance of *Daphnia*. With nothing left to eat the algae, there seemed to be no hope for lake water quality.

That is until UW-Madison researchers bio-engineered a virus that targets and kills only female spiny water fleas before they reproduce. The females died en masse, leaving the males lonely and confused and leading to the water fleas’ eventual demise. The die-off enabled hearty *Daphnia* eggs that survived for decades stored in lake sediment to hatch and make a comeback.

With things looking up for the lakes, there’s been a resurgence in monitoring their progress and that of other ecosystem services. New technologies have enabled resource managers and businesses to easily measure critical ecosystem variables with real-time data. Sensors

keep a constant pulse on microclimates, water flow, soil chemistry, groundwater and surface water, and feed information to a computerized data storage and analysis network. Once analyzed, the data inform the creation of responsive adaptive management strategies. With a tweak here and a tinker there, managers can optimize the productivity of nature’s inputs and outputs.

Better data has also made tracking and trading ecosystem products and services much more efficient, providing accurate and consistent numbers that enable economists and traders to determine current and future dollar values. In fact, the ever-improving data procurement is credited as the catalyst for the widespread establishment of market solutions to environmental problems and the creation of the Ecosystem Services Exchange Commission (ESEC).

An effort spearheaded by President Leeward just before completing her second term, the ESEC sets and maintains the economic value of the numerous benefits nature provides us, or ecosystem services, and regulates their market with a toolbox of taxes, incentives, financial penalties, and strict pollution-reduction policies. The ESEC provides the stability that allows businesses and industry to invest and trade accurately and fairly. It also created and enforces the standards to which corporations and industries must adhere, in order to minimize or, in some cases, eliminate their environmental impact.

The ESEC is a powerful regulating force, and it uses its strength unsparingly. For example, three years ago officials reprimanded and fined one of Dane County’s biggest biotech companies for not updating their chemical



By 2070, technology is pervasive on the landscape and in lifestyles. This view of the Beltline, where it crosses the Yahara River near the Lake Monona's outlet, gives a glimpse of the high-tech landscape.

waste recovery system. The ESEC was also responsible for creating the widely successful all-or-nothing greenhouse gas and nutrient storage credit program; users and manufacturers must buy credits or risk getting shut down. Just last year, one Fitchburg developer's plans were stalled when officials discovered the firm had not purchased adequate phosphorus storage credits to account for the potential impacts of the planned subdivision. To avoid aborting operations, the developer was forced to close the credit gap.

This market-based system has also transformed how we manage natural resources. For example, land preservation is no longer based on the ecosystem's intrinsic or symbolic value, but rather its market value. Forests, prairies,

and wetlands that produce lots of benefits for humans, such as trapping large amounts of carbon or phosphorus, have high market values and thus remain protected. An unexpected, but welcomed outcome of this approach has been stronger wild land and biodiversity protections—the many services they provide us render their market value high.

The ecosystem service market has also rerouted funding streams for natural resource management. Fees and taxes from ecosystem use are channeled directly into ecosystem improvements. In the past, these funds merely disappeared into the general revenue. Looking to existing models, such as the fishing tackle taxes that fund sport fishing access and guns-and-ammo taxes that fund wildlife conserva-

tion, policy makers merely replicated them throughout natural resource management. For example, the taxes and fees associated with lakeshore properties and lake recreation (fishing, waterfowl hunting, and boating) directly feed the lake management coffers. These funds are doled out for flood control, water quality control, phosphorus storage systems, and the like.

The market has also altered land management. Cropland that has higher potential value as wetland or prairie, which help replenish groundwater and prevent flooding, is often converted. For farmers, losing crop acreage can be more economical than the risk of losing crops to extreme weather. Similarly, private property is managed according to the breadth of benefits the land provides. For example, land owners of natural or artificial wetlands, which store phosphorus and help prevent runoff, receive compensation to maintain them.

The Yahara is a prime example of the success of the ecosystem services market approach. Its employment rate and business atmosphere are the best they have been in decades. The region has become a mecca for many professional fields. In addition to the flocks of engineers and economists, other burgeoning professions, such as environmental banking and ecosystem service sales and marketing, have strong presences in the region. The growth spurts of some industries have had positive ripple effects on well-established ones. For example, the expansion of the biomedical industry expanded the boundaries of the agricultural industry, as many farmers have entered the lucrative business of pharmaceutical crops.

“The ecosystem services market has cer-

tainly been revolutionary in terms of job creation and economic development,” said Rachel Harding, Vice President of Entrepreneurship and Innovation at the Wisconsin Economic Progress Department. One of Harding’s primary roles is to facilitate the state’s public-private partnerships, which have enabled many innovations and subsequent job growth. The county, municipalities, state, and the university frequently work in concert with technology firms and companies to orchestrate solutions to natural resource management issues. Such partnerships bring together the financial and intellectual resources needed to birth ideas and nurture them into maturity. Many experts, such as Harding, attribute the region’s rapid economic growth and prosperity to these partnership models.

A new public-private partnership that could up the ante even more on the region’s success is a highly advanced smart stormwater management network, a collaborative project between the Madison Area Municipal Storm Water Partnership and a prominent ecological services consultancy. Using seed money from the National Technological Advancement Foundation, this team is developing a sophisticated landscape-scale system of rain gardens, infiltration swales, reconstructed wetlands, and bioretention areas. These catchment areas will divert rainwater into the region’s aquifers, instead of into its lakes, helping to both prevent excess runoff and replenish drinking water supplies. Such a system is critical for reducing the impacts of the urban swell, especially flooding in high- and medium-density areas.

“Innovation does not happen in silos. It requires fruitful collaborations across sectors and synergies of knowledge, funding, and ca-

capacity,” said Harding. “The Yahara’s excellence in collaboration has put us on the leading edge of water resource management technology.”

But applause for what the ecosystem services market has enabled is not widespread. Wary of the increased accessibility of information, a Yahara-based coalition of watchdog

groups recently launched the campaign “That’s Our Business” to sound an alarm against pervasive data mining, surveillance, and smart networks. The group claims legislation and social awareness has not been able to keep up with the rapid growth of technology. “These machines and their controllers have so much information about us and about the environment. We fear our individual privacy and collective safety could be in danger,” said Dominic Kelly, the campaign’s spokesperson.

Moreover, and despite its relative stability thus far, some experts warn the ESEC is not a perfect system and its luck might not persist. The market is vulnerable to mistakes and uncertainties, as the science on which it rests—our knowledge of nature—is volatile. Transformational scientific discoveries could easily trip

the market’s step. Likewise, even with their advanced precision, the technologies the market relies upon are not perfect. Some ecologists worry an unintended technological backfire could someday ruin an ecosystem service and thus cause a market crash, in addition to an ecosystem crash. Neither is human judgment

of nature’s value, the real basis of the market, flawless.

According to Barnard, the rise of the ecosystem services market is indicative of fundamental shifts in how many Americans have come to view nature.

“Nature has become even more commodified than it was earlier in the century. We see nature as this service provider. Its value rests in its ability to supply us with the numerous benefits we use in everyday life,” he said.

The Yahara Lakes are an illustration of

this new worldview. Many people, especially natural resource managers, businesses, and policy makers, see more than just fish swimming in the lakes. They also see economic development and profit-making enterprises. Water-based industries, from recreation to phosphorus harvesting, employ one-fifth of the

The Climate: A Work in Progress

The country’s aggressive mitigation efforts seemed to have done the intended trick. Aided by a tamer-than-predicted climate, and largely funded by revenue from the global climate tax, the flurry of mitigation and adaptation technology succeeded in moderating the rise of the temperature curve.

However, even if moderated, global warming’s continued upward trajectory has left a mark. The altered climate has affected many ecosystem services. Yahara fisheries, for example, have had to adjust to the decline of coolwater fish species, such as muskie, northern pike, walleye and perch. Lake herring went extinct, and trout have dwindled. On the flip side, largemouth bass, sunfish (including a newly introduced southern species) and other warmwater species are flourishing.

population, encompass fifteen percent of businesses, and have had the highest growth rates in the past twenty years. The lakes have become a symbol, and barometer, of the region's economic well-being.

"The lakes have been crucial actors in the growth we've experienced through the Innovation Revolution. I believe the prosperity they have brought us have made them even more important to the regional identity," said Harding.

Not everyone feels this commodification of

nature is a good thing, however. In fact, it has some looking warily at the road ahead.

Our Ultimate Destination

Cole, Joel's youngest son, is facing a difficult decision: whether he wants to take over the family farm when his father retires in a few years. A lucrative farm, Shedd Valley could provide him a decent, comfortable life. But Cole longs for a different sort of farm life, a life that can now exist only in fading memory.



Innovations such as the Bloom-to-Boon algae harvesting technique have improved lake water quality, and devices such as the phosphorus monitor in the foreground allows for advanced data gathering, which supports the ecosystem services market.

“Farming isn’t the hard work it used to be in the old days,” Cole lamented. “Back then, farmers actually got dirt on their hands and tans from the sun. Today, we’re missing that connection to the earth that used to be the lifeblood of our profession.”

Cole doesn’t actually remember the old days. He is too young. At 30, he is part of the farming generation that grew up with Crop-bots, AgDrones, Precision Planters, and home genetic modification kits. He knows of the old days only through history books, documentaries, and handed-down family stories. Nonetheless, he yearns for what traditional farming had: a romance with nature that he thinks has dried up.

Cole’s longing reflects an outlying, though outspoken critique of American society’s obsession with and dependency on technology. While today’s efficient landscapes produce a wealth of benefits for us, a movement of “techno-skeptics” is still not won over by the progress. In fact, they question whether we have really progressed at all. Many see technological fixes as only temporary, as merely ways to stall another inevitable crisis. The outspoken economist and syndicated columnist Edward Grey repeatedly reminds us that we still have not fixed an underlying problem: massive per capita consumption. Despite lowering the human footprint, technology has not curbed the collective appetite for energy and things.

Skeptics also complain the country’s market approach to managing nature exploits and oppresses its intrinsic worth. “The soil, water, air, plants and animals are more than whatever dollar amount we assign to the goods and services they provide us,” said Cole. “You can’t put a fair price on nature’s ability to adapt and

evolve on its own, its aesthetic qualities, the beauty in its flaws, or its resilience.”

Some skeptics, such as Willow Snow, believe humans and nature are losing their capacity to survive on their own. “We’ve surrendered many of our natural skills to robots, machines, and computers,” said the thirty-something ex-civil engineer, who is making sure we don’t lose these skills forever.

Jaded by what she calls the “fix it” mentality, Snow fled the industry four years ago to start a Dunn-based community center called The Homestead with her partner, Jacob. A member-owned business, The Homestead serves to restore people’s spiritual connection with the land by nurturing a physical relationship with it. The center offers classes and workshops on dying “survival” skills, such as gardening, carpentry, permaculture, ecological restoration, and traditional farming methods. In defiance of the perceived commercialization of nature, students pay for classes through a barter system, trading their time via a volunteer time bank, their knowledge through a mentoring program, or the fruits of their labor at the on-site general store.

“We think it’s really important to preserve these skills and this way of life in the human race, you know, just in case technology does fail us someday,” said Snow. Reflecting this sentiment is a quote by anti-technology writer and activist Terry Wilhelm that is woven through a mural at the center’s entrance: “Resilience lies in the ingenuity and adaptability of our communities and ourselves, not in our machines.”

Perhaps there is just cause for this subculture’s caution. Despite technology’s power, its failures and unintended consequences hint at

its limitations. Last year, apple orchard farmers discovered this the hard way. A mutated virus attacked the Yahara's orchards, duping the apples' kill gene and destroying nearly half of the year's harvest. Officials followed the virus' trail to one farm, where they suspect the farmer unknowingly erred when editing an apple genome. When the defective apple trees were in bloom, pollinators carried the faulty gene from orchard to orchard, spreading the seed of destruction.

In another case of genetics gone awry, five years ago an antibiotic-resistance gene spread into an algae farm, infecting the crop. Somehow, the gene made its way from the farm to Lake Mendota, where it spread further to algae and bacteria, including human pathogens. When the hot summer months hit, and swarms of swimmers dove into the lake, the altered human pathogens attacked their hosts, causing a wave of antibiotic-resistant infections.

"History has a way of reminding us that we shouldn't become foolish about our seeming ability to control nature," cautioned Barnard. "Despite our successes, I imagine we have some surprises in our future—surprises that we will ultimately have caused and which we may not necessarily be prepared to handle, for better or worse." He is currently working on a new book that chronicles the most significant surprises since the start of the Innovation Revolution.

But many feel these blunders are not necessarily cause for alarm, and further innovation is all the remedy we need. "Mistakes are just part of the innovation process; they happen. As long as we stay vigilant and responsive, we can engineer our way out of any mishap these days," said Jed.

Human ingenuity has a thorny underbelly, however. Technology's broad accessibility has made us more susceptible to human misbehavior. For example, while the ubiquity of genetic engineering has done wonders for agricultural efficiency, when this technology gets into the wrong hands, bad things can happen. A whole new form of crime has developed as a result: bio-profiteering, or the intentional creation of pests and viruses in order to profit from simultaneously created solutions. The most prominent case of bio-profiteering was the BioPharm scandal of 2064, when a sudden virus epidemic erupted among people who took the high blood pressure drug metolazone. While it seemed the pharmaceutical company, BioPharm, had saved the day with its fast-acting cure, an anonymous insider leaked to officials the horrible truth: BioPharm had actually created the virus, which it attached to the drug, and it developed the cure, in order to boost company profits and prestige.

Ethical questions also lurk behind some of our technological pursuits, leading some techno-skeptics to warn that humans are dangerously playing God. That is, even though we have the technology to do some impressive things, does it mean we should? The heated debate around climate engineering is one such slippery slope. On one side are those who say climate tinkering is necessary to continue repairing the damage humans have done; on the other, those who say the risks of unforeseen consequences are too great. Even among those waving the climate engineering flag, there is argument over at what temperature we should set the Earth and who should be controlling that thermostat.

In another fine-line example, biotech has

entered the uncharted waters of human engineering. With scientists' persistent search for more ways to shrink the human environmental footprint, especially if world population continues growing, some are entertaining the controversial idea of genetically modifying humans to fix environment-unfriendly traits or create new, environment-friendlier traits. For example, a couple of UW-Madison researchers are petitioning to do a study on shrinking footprints by shrinking humans. Their hope is, over the next five generations, the average human body will become smaller (and cultural height preferences will follow suit). Combined with the ongoing pursuit to slow population growth, smaller people could cut our impact on nature by half.

A final and tenacious dilemma that perhaps no technology, however brilliant, can fix is inequality. Even though the Innovation Revolution has broadened access to technology, the Yahara is still marred by disparity. Nonprofit organizations are kept busy with their continued fight for universal access to good health-care, education, and other social services—

new gadgets don't seem to do much for such missions.

Potential risks and evident shortcomings aside, it seems most people in the Yahara are optimistic technology will continue to bring prosperity to the region and will help them through whatever ecological calamity may arise in the years to come. Never mind the vulnerabilities and unintended consequences; a new solution is always on the horizon. The normal friction of innovation—expense, trial and error, periods of unequal access, mistakes, etc.—is but a drop in the bucket of progress.

In this sense, Shedd Valley Farm serves as a microcosm for the greater Yahara. As a devoted champion of technology, Joel speaks for his region.

“Our standard of living is higher than it ever was before. We're on the right track for cleaner water and a calmer climate. And we maintain a profitable farm. As long as we can keep up the momentum of progress, I am confident our future is bright.” ■

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