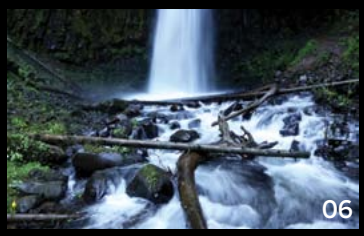
freshwater



Madeline Black

Frances Ashforth

contents

FEATURES

Jeremy Bauer

DEPARTMENTS

Front and back covers:
Series of paintings inspired by brackish inlets around Wellfleet and Orleans on Cape Cod in Massachusetts.

Front cover: "Tidal Inlet 4"; oil on panel; 11×14; 2014
Back cover: "Tidal Inlet 2"; oil on panel; 5×7; 2014
– Artwork by Frances Ashforth

Dr. Morley Read / Science Source

From the President

Vivian Johnson

"If we study the contours of our landscapes and our actions we can find at least as much opportunity for connection as for separation. And that's a better plan over time."

Lines have immense power. On a horizon, they can separate day from night; land from water. On a balance sheet, it can separate assets from liabilities. In a mind, a line can keep things separate that should be together. Marked as time, it can separate our past, our present and our future.

But as it relates to our environment, lines can mislead us — how many times must we learn the lesson that the natural world is an integrated whole, meaning that when we disrupt one of its processes, we impacts another? This issue of *freshwater*, prompted by the arresting lines drawn by artist Frances Ashforth, looks at this question anew while challenging us to continue searching not for lines so much as connections we missed before. It's a critical and constant need in a changing world.

Without fail, the moment we think we know it all, we learn something.

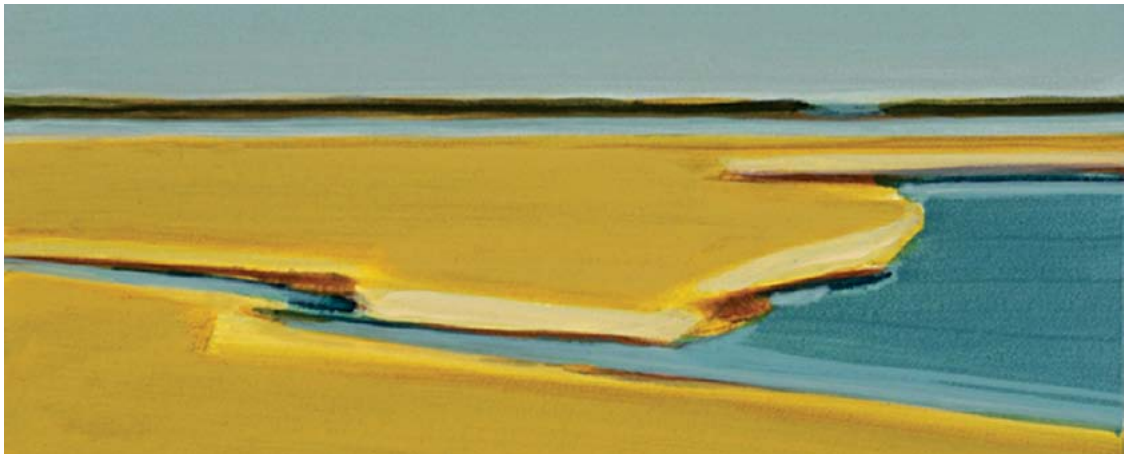
Hatcheries once viewed as fonts of abundance for fisherman have made it harder to catch fish and tougher for wild fish to persist. Stormwater originally designed to whisk problem water away actually grew to create more problems downstream. Agriculture designed only to maximize yields threatens to undercut its own natural resource base to grow things down the line (so to speak).

If we study the contours of our landscapes and our actions we can find at least as much opportunity for connection as for separation. And that's a better plan over time. We can have healthy soils, healthy agricultural production and healthy water. We can more cheaply create thriving fisheries by emphasizing natural rather than industrial inputs. We can connect the dots between community source waters and resilience in times of water crises.

There is a lot of work between here and there, but this issue will go a long way toward getting us all lined out. Enjoy the read.

Yours in conservation,

Joe S. Whitworth
President



Artwork by Frances Ashforth

The Freshwater Trust®

65 SW Yamhill Street, Suite 200; Portland, OR 97204
Phone: 503.222.9091 / Fax: 503.222.9187
Email: info@thefreshwatertrust.org
www.thefreshwatertrust.org

***freshwater* 2014 Spring Issue (vol. 6, issue 1)** is a publication of The Freshwater Trust, a 501(c)(3) not-for-profit organization with a mission to preserve and restore our freshwater ecosystems. Contents may be reproduced with the permission of The Freshwater Trust.

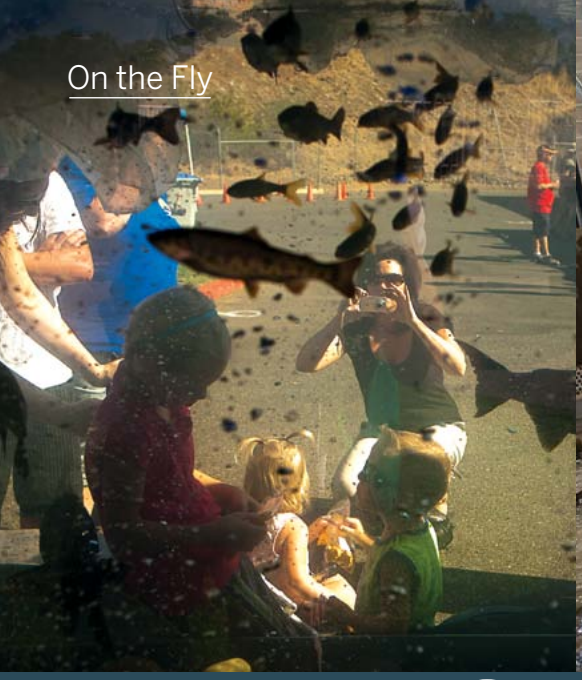
***freshwater* Magazine Staff**

Adrian McCarthy
Editor

Julia Bond
Michael Jolliffe
Kaola Swanson
Staff Writers

Erin Putnam
Graphic Designer

Levi Schmidt
Multimedia Designer & Photographer



Smolting Steel:

More evidence that gray infrastructure has built an inferior fish

Left: While hatcheries are harmful to wild fish, they do provide an opportunity for the general public to interact with salmon and steelhead.
– Nathan Weyland

Right: Employees of the hatchery pull salmon from a holding tank before beginning spawning operations. The fish will be killed and their eggs harvested and incubated at the hatchery.
– Nathan Weyland

by Michael Jolliffe

When I was a child, my grandpa and I would camp at a private lake. We were always the only people on the lake, and the fishing was amazing. Whatever I pulled from my tackle box and affixed to the end of my Snoopy pole — from a bitten-in-half and melted-flat plastic worm to a Rapala minnow that had lost its diving lip, leaving it to spin in circles on the surface as I reeled it in — I was guaranteed a fish. Most often it was an aggressive largemouth bass that bolted out from under the lily pads to engulf my meager offering. One summer, we returned to the lake to discover a boat ramp had been developed, and boats were coming in droves every weekend for the great fishing. It didn't stay great for long. Soon, my austere tackle box couldn't compete with live minnows or the fancy baits the adults used to catch and keep the lake's fish. There were trips where I didn't catch anything. The fishermen had changed the fishing, but it wasn't until years later that I wondered whether the fishermen had changed the fish.

A growing body of evidence says yes: recreational fishing programs and fisheries management have had significant impacts on fish behavior and physiology. In 2009, the American Fish Society completed a 30-year study of the effects of fishing on largemouth bass. The study showed that catching and removing aggressive, biting fish from the system produced a more cautious population that was less likely to bite. In short, the tendency to bite — or not bite — can be inherited.

This same culling phenomenon seems to be playing out with hatchery steelhead in the Pacific Northwest.

Bunk bunker babies

The Round Butte Hatchery, built in 1972, supplements the Deschutes River with thousands of hatchery summer steelhead each year, under the pretense that it allows anglers to enjoy the same opportunity to catch a magnificent sea-run fish as existed before the Pelton and Round Butte dams were built. Except, for some reason, those hatchery steelhead are mighty hard to hook. Data collected by Oregon Department of Fish and Wildlife (ODFW) over the past 20 years show that when you go fishing on the Deschutes for summer steelhead, you are twice as likely to catch a wild fish as a hatchery fish. So there must be twice as many wild fish running up the river, right? Not quite. According to *The Osprey*, a magazine published by Humboldt State University, there are typically three times fewer wild fish than hatchery fish in the river in any given year. To put it another way, because hatchery fish are so unlikely to bite compared to wild fish, the Deschutes would need five to 9.5 times as many hatchery fish as wild fish for an angler to have equal odds of catching each.

The Sandy River Hatchery began operation in 1951. Based on 2012 catch rates and abundance estimates published in angler surveys and the Sandy River Winter Steelhead Hatchery Genetic Management

Plan, 6.5 times as many hatchery fish as wild fish would need to be present in the Sandy River for an angler to have equal chance of catching each. In sum, 55 percent of all fish caught were wild, despite the fact that more than five times as many hatchery fish as wild ran up the Sandy River in 2012.

Marty Sheppard, a Sandy River flyfishing guide, confirmed that 2014 has seen even starker results for fly anglers. "I have pretty good authority to say that 80 to 90 percent of fish landed by fly anglers have been wild."

In his book, *The Greatest Show on Earth*, author Richard Dawkins discusses a poignant example of the power of artificial selection. Russian biologist Dmitry Belyaev was responsible for selectively breeding wild foxes in an attempt to domesticate them by mating only the tamest foxes of each generation. Balyaev initially bred the foxes that let him get closest before exhibiting a flight response. That was as close to tame as he could find. After only six generations of choosing and breeding foxes that were the least fearful of human presence, 18 percent of the population was "eager to establish human contact, whimpering to attract attention and licking experimenters like dogs." After 35 generations, Evan Ratliff reports in "Animal Domestication: Taming the Wild" that close to 80 percent of the capitively-bred population was exhibiting dog-like behaviors, such as tail-wagging and coming when called. A few experiment staff even adopted the foxes as pets.

Likewise, hatchery programs favoring fish that successfully make it back by not biting could inadvertently be selecting for subsequent generations that are less and less likely to bite. If biters are landed and dispatched, the only individuals providing genes for the next generation of hatchery fish are those that didn't bite.

Fixing the fish you broke

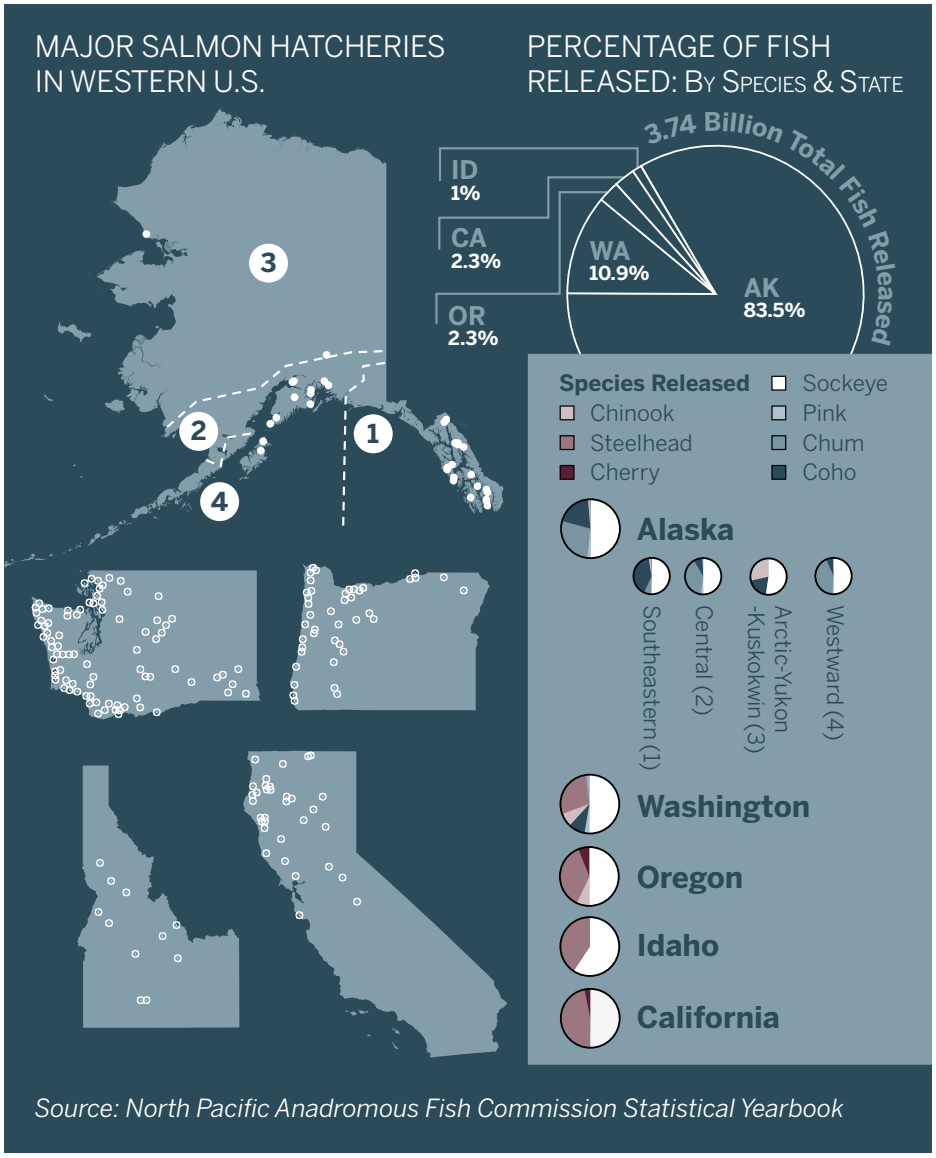
The Oregon Hatchery Research Center (OHRC) convened to research the differences between wild and hatchery salmonids and improve the survival and contribution to fisheries of hatchery fish. Funded by the ODFW and Oregon Watershed Enhancement Board, the OHRC plans to research "whether the source and treatment of hatchery broodstock will change the success rate of anglers on returning fish." OHRC's prediction is that offspring of parents that were not caught — hatchery returns, plus trap-caught wild fish — would be less likely to be caught by anglers than offspring from parents that were caught (caught and donated hatchery fish, plus line-caught wild fish). In short, the OHRC, "prodded by fishermen … has agreed to see if it can breed the bite back into hatchery steelhead."

But this begs the question, if we are already spending more than $1 million of public money a year on the Sandy and Round Butte hatcheries alone, is spending another $7 million to improve those fish really the best use of those funds? What if those monies were directed, instead, to improving the populations of far-superior wild fish through habitat restoration, removal of obsolete passage barriers that nobody seems to have the money or legal obligation to remove? Or building an endowment for each river that acts as insurance in the face of a growing human population, protecting against or ameliorating future degradation of the conditions that support these native fishes?

Resource managers have had decades of opportunity to fix ecological and recreational problems of declining wild fish populations with gray infrastructure solutions like hatcheries, and it is increasingly clear this effort is costly and unfruitful. Instead of directing these funds to making the broken hatchery fish behave like the few wild fish that still persist, let's invest in wild populations through habitat restoration and river trust funds. As we face an uncertain environmental future, supporting the most resilient solutions just makes more sense.

Michael Jolliffe works for The Freshwater Trust and can be reached at mike@thefreshwatertrust.org.

Fresh salmon roe is prepared for incubation at the Feather River Fish Hatchery in Oroville, California – Nathan Weyland



BEYOND THE FAUCET:
Protecting Water at its Source

by Lori Benjamin

For many of us in the United States, it's still easy to take water for granted. Of course, we see evidence of an ever-decreasing supply: California's State Water Project running dry for the first time this year. Mountain snowmelt at a tiny percentage of normal in various parts of the country every year. Annual wildfires wiping out communities and filling reservoirs with sediment. And yet serious water emergencies rarely, if ever, affect our ability to turn on the faucet and get a drink when we need it — especially if we live in a major city.

By and large, government from the federal level on down has done a decent job of protecting this seemingly inalienable right to clean, drinkable water. The National Forest System was established, in part, to "secure favorable conditions of water flows" for the people downstream. Nevertheless, today those water flows are more endangered than ever. The forests that protect our mountain watersheds suffer from large-scale changes in vegetation and the rapid spread of endemic species, such as the mountain pine beetle. The fire suppression techniques we relied on for decades have made those forests more prone to severe wildfire, not less. Demand for the logging, mining or petroleum resources that watersheds may contain grows ever stronger. And as if those challenges weren't enough, a changing climate makes everything worse: winters get warmer, snowpack decreases and extreme weather becomes the norm.

Source protection best practices

Clearly our watersheds require additional support if they are to continue their life-sustaining flows. People all over the West understand that, as Denver Water's Ron Lehr puts it, "Water doesn't come out of the stream — it comes out of the forest." But it isn't always easy to agree on what the support of those forests should look like. So, a few years ago, the Healthy Headwaters Alliance was formed to bring together water utilities, conservationists, public agencies, and recreation and business interests. This diverse coalition with their varied perspectives, political alliances and experiences have developed a common set of goals and actions to improve water security in the American West. The conversation resulted in the following best practices to protect our source water:

Lori Benjamin writes for Carpe Diem West, which leads a broad-based network of experts, advocates, economists, decision makers and scientists focused on addressing the profound effects that the growing climate crisis is having on water in the American West. To learn more about Carpe Diem West and Healthy Headwaters Alliance, visit carpediemwest.org.

→ **Collaborative, Community-Based Partnerships**
Sixty percent of the water that comes out of western faucets originates on National Forest System land, so the agency plays a critical role in addressing headwaters threats. But they can't do it alone. Successful watershed protection and rehabilitation must take community priorities into account. Local support and the financial investment of land managers, utilities, businesses and other water users is essential.

→ **Comprehensive Watershed Plans**
A watershed plan is like a business plan; it's visionary enough to address all the ways water quality and quantity is affected, whether it originates on public or private lands. It looks to the future, establishing resilient watersheds that can evolve and adapt to unpredictable conditions over the long term. But a good plan is nothing if not also realistic. To identify the most effective protection and restoration actions, you must take into account the best science and evidence available, including local knowledge based on long-term observation of conditions. Then you prioritize those actions by getting input from affected landowners, agencies and the public. When done well, a watershed plan has broad public support behind it, and is an important tool for attracting the investment necessary to carry out this work.

→ **Broadly-Shared Investment**
To rehabilitate forests, place watershed lands into the public trust and reduce fuel loads in fire-prone areas, you have to harness some serious financial commitment, and that should come from as many varied sources as possible. Until recently, the benefits of healthy watersheds — including flood control, water filtration and fire hazard prevention — were all but taken for granted. Today, water managers and policy makers are beginning to calculate the value of a healthy watershed in terms of downstream benefits. Those calculations can make it much easier to broaden the funding source pool, uncover alternative finance mechanisms and start thinking differently about land-use policies.

→ **Education and Outreach**
Funding is never only about proving value — it's also about winning hearts and minds. Today's water managers are reaching beyond the flyer-in-the-monthly-water-bill method of building community support. For example, the Santa Fe Watershed Association spearheads an extensive education and outreach effort. Its centerpiece program puts water managers into fifth- and sixth-grade classrooms and then takes the kids to rivers and streams for some hands-on environmental monitoring experience.

Securing the future, community by community

Though we are making progress, we still have a widespread emergency on our hands when it comes to securing the water supply of everyone in the West, especially our most vulnerable rural communities. La Jara, New Mexico provides an all-too-common example: Ranchers and property owners at the edge of the dry tinder box that is the Jemez Forest face a grim fire season and a tough choice. They could thin the forest themselves, but that would violate federal law. The Forest Service has plans to do it, but residents fear it may not happen in time to save the community and its watershed.

Fortunately, there is hope that such dilemmas will be a thing of the past, as watershed investment programs of all kinds build optimism and resilience in communities across the American West.

→ In 2010, Denver Water partnered with the Forest Service to treat nearly 40,000 acres of land, thinning forests and reducing fire risks in five priority watersheds.

→ In Oregon's Tualatin River Valley, Clean Water Services helped the community restore habitat and aesthetic value to the watershed — and saved taxpayers millions of dollars in the process.

→ In Salt Lake City, residents pay a modest water bill surcharge that provides about $1.5 million per year to buy watershed lands and conservation easements.

→ In Santa Fe, water customers share the cost of an ongoing program to reduce fuel loads in surrounding forests, in addition to paying for water treatment and delivery.

The West, as Wallace Stegner said so poignantly, is "the native home of hope." Each community working together to build a more secure future stands as a model for communities who have yet to take the challenge by the horns.

WATER TREATMENT & CHEMICAL COSTS BASED ON PERCENT OF FORESTED WATERSHED

Not only do healthy forests provide water, but they also clean and filter our water.

% of Watershed Forested	Treatment & Chemical Costs (per million gallons)	% Change in Costs	Average Treatment Costs (per day at 22 million gallons)
10%	$115	19%	$2,530
20%	$93	20%	$2,046
30%	$73	21%	$1,606
40%	$58	21%	$1,276
50%	$46	21%	$1,012
60%	$37	19%	$814

Source: American Water Works Association

Photo by Angie Marcelynas

Photo by Center for Contemporary Printmaking

Q&A with Frances Ashforth OBSERVER. ARTIST. STEWARD.

Raised in a family of artists, Frances Ashforth has always been drawn to line and color. Her time spent outside on her grandparents' farm helped cultivate her view of the horizon line and its relationship between land, water and sky — and spawned a belief that fond memories of the beautiful outdoors can help us all become better environmental stewards.

Frances has recently taken up studying the contrast of arid land and wetlands, as seen in this photo of the Great Salt Lake in Utah.
– Renee Keith

From top:
"Bear River Looking South"
oil on panel; 30x40; 2012

"Eastern Idaho 2"
oil on panel; 11x14; 2012

"Collon Cura"
oil on panel; 16x20; 2010

– Artwork by Frances Ashforth

Your art is clearly inspired by the natural world. Where is that inspiration rooted?

The roots of my inspiration were nurtured from growing up in an extended family of artists who loved the outdoors. My grandmother was a painter, my mother was a sculptor, and I was surrounded by many aunts and cousins who were painters and printmakers. My grandparents' beautiful farm overlooked the Connecticut River Valley in New Hampshire. This was sort of my early geographic center or my 'sense of place'. We spent many weekends and summer vacations there, walking through the woods, enjoying the view from the porch and riding on my grandfather's tractor. It seemed as if we were always getting ready for a hiking, camping, skiing or canoeing adventure of some sort.

Walk us through your art process.

What inspires me is almost always triggered by memory. Whether it's a particular place, view or color, there is this innate need to commit that flash of memory to paper, panel or printing plate. I generally draw and take notes first, trying to remember the light, weather or particular composition. But then a feeling of history creeps in. We often see a beautiful view, but rarely think of what happened there years ago, how the land has changed or who changed it and why. I am always so amazed to think that most of this earth has been traipsed upon. I am fascinated by the names we have given our rivers and landmarks over time. Often I will do research of a specific area I am in and try to understand the geography. It means so much more to me when I really understand what I am working on. At that point I decide whether to work on drawings, paintings or prints, very often working on a number of pieces at the same time.

What does the horizon line represent to you?

I have always loved line. Whether a drawn line with pencil, ink or paint, line has always intrigued me, and I have always gravitated towards landscape and architecture. After a Fine Arts degree in Drawing & Printmaking in college, I went on to drafting school to become an architectural illustrator. I immersed myself in that form of line for about eight years and then circled back to landscape. The horizon line became my focus. It is a basic linear structure that provides me with the challenge to portray the tenuous balance between land, water and sky. *Merriam-Webster's Dictionary* defines "horizon" with a paragraph of possibilities, and three I gravitate towards are:

1. "The apparent intersection of the earth & sky as seen by an observer: also called 'apparent horizon', 'visible horizon.'" 3. "The range of an individual's

knowledge, experience, observation of interest." 4b. "A specific layer of soil in a cross section of land."

I think for many of us a view of the horizon gives us a sense of solitude and possible hope. We very often don't know what's out there, and taking time to enjoy the view, with luck, provides us with a moment of reflection before we return back to the distractions of our daily lives. Our world moves at an alarming pace, and I feel it is imperative that we not take our view, our land, our water or our horizon for granted.

As an artist and environmentalist, how can these two passions intersect to affect change?

I am not a very confrontational person, so my thoughts and my work represent my experience with the environment in a peaceful way. That's not to say that certain environmental issues don't truly disturb me, it is just that my studio is my refuge from the chaos. My work is often viewed as serene and calm. I am not trying to portray landscape in a syrupy way, but in a memory-based way. Perhaps my goal is for people to just slow down and take the time to honor their view, to look again and have a bit more appreciation for anything from nature that they pass by each day. With the appreciation and memory of a familiar place, perhaps then we will all be better stewards of the land. My hope is that during childhood, wonderful and crucial land-based memories can be "set" and then rekindled during adulthood. I think that is when true appreciation for protecting our environment really begins.

What has your focus been in the past few years?

I have spent a great deal of time studying clouds and weather and how they react with land and water. I am also fascinated by arid lands and wetlands. I have recently spent time in the Great Basin at Great Salt Lake and Bear River and also in southern Oregon last August as an artist resident at Playa at Summerlake. It was a fascinating arid lakebed to hike across, draw and research. It is a remarkable place with all sorts of history. I was also interested in the placement of the myriad irrigation ditches on the nearby ranches; perhaps just the vision of cool water on a 90-degree day was what kept me spellbound. At any rate, the memories of the Great Basin and its tremendous variety have helped direct my compositions back to inlets and wetlands and the habit of water in general. It is imperative for me to be authentic to my work and to know my subject matter clearly. One of my favorite authors, Barry Lopez, said it perfectly: "To do this well, to really come to an understanding of a specific American geography, requires not only time but a kind of local expertise, an intimacy with place few of us ever develop. There is no way around the former requirement: if you want to know you must take the time."

WHY WORRY ABOUT THE RAIN?

by Seth Brown and Kristina Twigg

Stormwater, as the name suggests, is water generated from rain, snow, hail or other precipitation after the landscape has become saturated. In the natural environment, soils soak up rain while plant leaves and roots intercept it. But when the landscape reaches capacity, rain turns into stormwater runoff. These natural processes of rain and runoff have shaped rivers and streams as well as hills and valleys throughout history. Runoff collects across watersheds, making its way to larger and larger rivers and eventually the ocean. Throughout its journey, water evaporates and gathers into clouds that deliver precipitation to the landscape again, forming the hydrologic cycle.

The amount of runoff generated on natural landscapes varies greatly depending on many factors, such as soil composition and condition, land use and the type and density of plant life. While climate is variable, under pristine conditions the hydrologic cycle leads to surprisingly stable and consistent forms across landscapes.

Disruptions in the hydrologic cycle

When significant changes occur on the landscape, the hydrologic cycle is disrupted. Historically, agriculture and grazing were the first man-made disruptions to this cycle.

Massive alterations associated with certain agricultural activities, such as deforestation or destruction of native prairies, lead to large increases in runoff. With the loss of protective plant cover, exposed soil begins to erode from the impact of raindrops as well as from runoff streaming across the land.

Runoff carries detached sediments into streams and rivers. In the U.S., significant changes occurred during the colonial period, leading to sediment-choked streams. Mill dams constructed in small and medium-sized streams, especially along the East Coast, only made the problem worse.

As cities began to expand, so did impervious surfaces — rooftops, roadways and sidewalks — that prevent stormwater from soaking into the soil. City footprints have expanded exponentially since the early 1900s, as suburbs expand outward from urban cores.

The result is severely eroded urban streams, which are over-widened as well as deep and gully-like. While natural landscapes hold and delay stormwater, urban areas, with their impervious surfaces, generate more runoff, more quickly. Urban watersheds are flashy, characterized by peak stream flows that are sometimes greater than those occurring naturally. These higher peak flows also can occur two to three times more frequently than under pristine conditions.

Corrupting the rain

As a result, these flows — greatly increased in volume and velocity — send sediments downstream in large pulses, or flashes. The sediments come from land surfaces, such as poorly managed construction sites and uncovered fields, as well as the streambed itself. Studies show that up to 60 percent of sediment loads in the Chesapeake Bay come from in-stream erosion. In excess, sediment can overwhelm ponds, lakes and wetlands. Sediment not only affects aquatic vegetation — especially grasses that are critical for habitat — but can also transport other pollutants.

As cities began to expand, so did impervious surfaces — rooftops, roadways and sidewalks — that prevent stormwater from soaking into the soil.

In addition to sediment, nutrients, like nitrogen and phosphorus, are another major focus of stormwater management efforts. Nitrogen and phosphorus are the main culprits of hypoxic or dead zones — areas of water with limited oxygen. Nutrients can cause massive fish kills in coastal zones around the U.S. The Virginia Institute of Marine Science currently estimates that 405 of these areas exist across the world, affecting 95 million square miles. Each summer the hypoxic zone in the Chesapeake Bay covers about 40 percent of its area and five percent of its volume.

Fertilizers applied on agricultural fields are the most common source of nutrients in the U.S., but in urban and suburban areas, lawn-applied fertilizers can also generate massive amounts of excess nutrients. In the Chesapeake Bay, grassed lawns cover about ten percent of the total watershed area. The Chesapeake Bay Network estimates that nearly 215 million pounds of fertilizers and 19 million pounds of pesticides find their way to the bay watershed each year as a consequence of well-manicured suburban landscapes that have become the norm.

Beyond erosion and nutrient pollution, the urban landscape also delivers other pollutants, such as heavy metals, bacteria and oil. Dust from brake pads containing copper and zinc are deposited on roadway surfaces. Leaky vehicle fluids, like oil and power steering fluid, often pool in parking lots and driveways. Salt used to melt snow dusts streets and sidewalks during the winter, and pet waste piles up in suburban backyards. All of these become sources of water pollution when the rain comes.

The types of materials used in the urban environment also can be a source of pollution. Pavement sealants, such as coal-tar, contain known carcinogens and significantly affect downstream waterbodies. They have been banned in a number of states and counties across the U.S., including the District of Columbia. Even the temperature of runoff can affect streams; runoff from urban surfaces is generally much warmer than stormwater coming from natural landscapes, and can adversely affect sensitive aquatic life.

The problem with combined sewers

While the effects of urban runoff are significant, the majority of stormwater management resources in the U.S. are tied to reducing combined sewer overflows (CSOs). Combined sewers collect and convey both stormwater and wastewater, and overflow events occur in nearly 800 U.S. cities, primarily in the east and west where combined sewers were commonly built in the mid-to-late 19th century. Relief points, or overflows, were an integral design element of combined sewers. At these points, sewage and runoff are released directly to downstream waters without treatment when the system is overtaxed, which typically occurs during rain events.

These systems worked remarkably well in their time

Inspecting a new pump station constructed from Proposition 1E stormwater grant to improve urban flooding issues in southeast Fresno.
– California Department of Water Resources

by improving on the efficiency of sewer systems. However, public health impacts from sewer overflows were not well understood at the time. Increases in runoff associated with urban growth were largely unaccounted for in the original sewer design and have only expanded the water quality problems associated with combined sewers. Today, billions of gallons of raw sewage spill directly into urban waterways in cities like Philadelphia, New York and Cleveland. Many cities throughout the U.S. are now spending billions of dollars to address this issue.

Managing runoff – Phases I and II

Ancient Roman urban design included gutters to divert excess runoff along roadways. This philosophy of collecting runoff and conveying it away quickly and efficiently has remained the central theme of urban drainage for two thousand years, even during the establishment of the Clean Water Act. Urban runoff was not regulated in the original version of the Act. Instead, the law's focus was rightly on the water quality issue of that era — discharges from municipal and industrial wastewater. It was only in 1987 — 15 years after the passage of the Act — that urban runoff was considered significant enough to regulate.

The basis of this regulatory change was in part influenced by a breakthrough study under the National Urban Runoff Program (NURP). Researchers found that the level of pollution in urban runoff was much higher than anticipated. They also discovered that runoff washes pollutants collecting on the land — primarily on impervious areas — into waterways with the first half-inch of runoff, referred to as the "first flush."

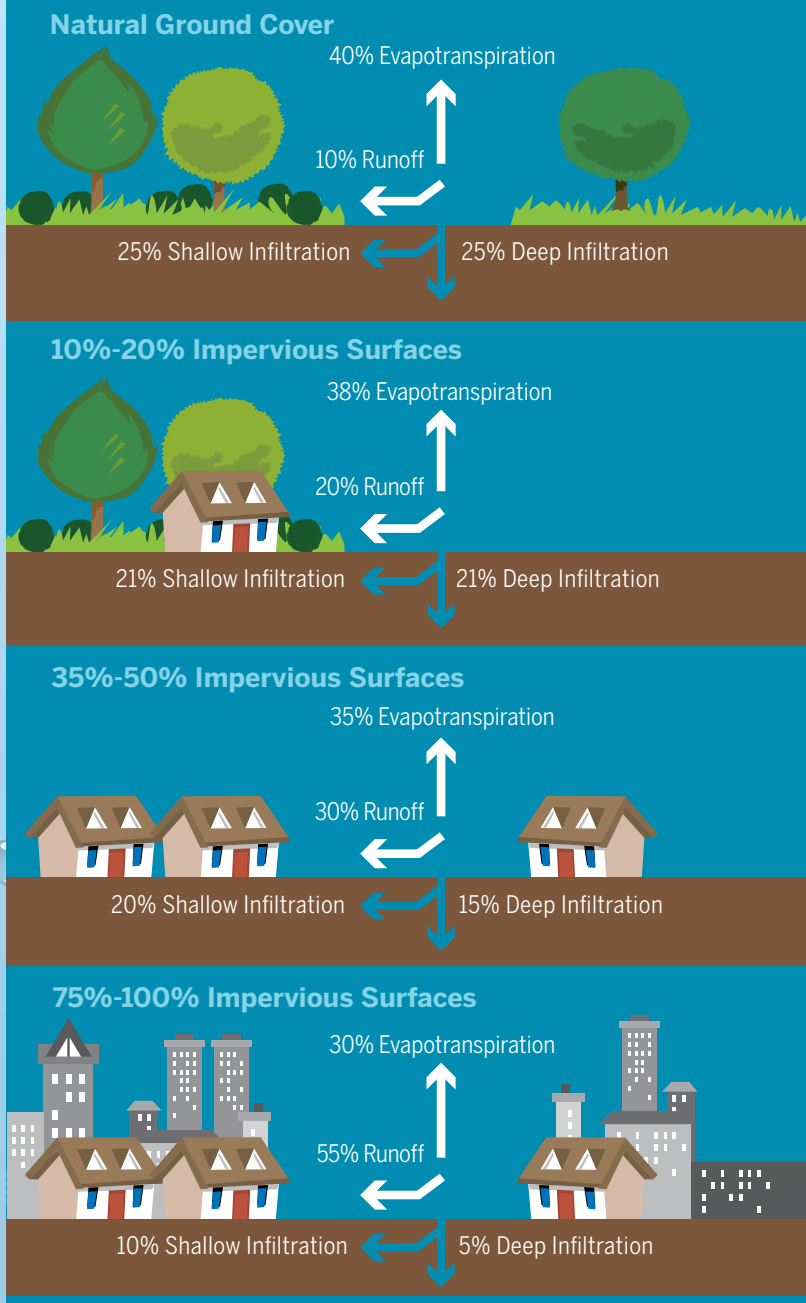
The U.S. Environmental Protection Agency's (EPA) initial stormwater program — known as Phase I — targeted large urban areas with populations greater than 100,000 as well as large industrial sites and construction sites larger than five acres. Prior to the launch of this program in 1990, managing runoff to reduce flooding was the focus of state and federal efforts. In contrast, Phase I represented the first time stormwater runoff was being treated to improve water quality. The national stormwater program is managed under the EPA's Office of Wastewater Management and is part of the same regulatory arm associated with the wastewater sector — the National Pollutant Discharge Elimination System (NPDES).

The cities and entities regulated under Phase I are referred to as "Municipal Separate Storm Sewer Systems," or MS4s. These systems differ from combined sewers in that they convey only stormwater runoff, usually carrying the runoff from streets and sidewalks directly to the nearest waterway via catch basins and pipes.

After the Phase I program took effect, MS4 communities were required to develop permits documenting how they would address not only the quantity of runoff but also its quality. The performance standard for these communities often focused on capturing the first half-inch of runoff based on the NURP study results. Best management practices (BMPs) to address impacts at the time included detention ponds, wet ponds and other practices. These controls offer some water quality treatment because they detain water over a period of time, allowing sediments and pollutants to settle out.

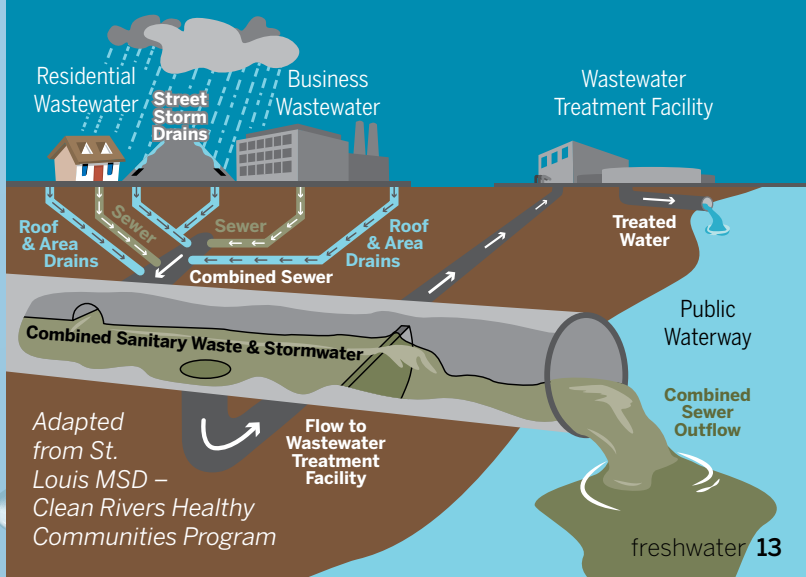
After about ten years, the EPA initiated the Phase II program, increasing the number of communities regulating stormwater discharges from approximately 750 to 7,500 by focusing on smaller storm sewer systems. The threshold for construction sites was also

HOW URBAN HYDROLOGY GENERALLY FUNCTIONS



Source: Federal Interagency Stream Restoration Working Group

COMBINED SEWER OUTFLOW



Adapted from St. Louis MSD – Clean Rivers Healthy Communities Program

WHAT CAN YOU DO?

1. Only rain belongs in the drain! And only after a storm event. Don't dump anything down storm drains. Be sure to clear away leaves and debris. Make sure storm drain outfalls are not running in dry weather. If it hasn't rained in 72 hours, it should not be flowing. Call your municipal stormwater contact if it does.

2. Keep your car clean and well maintained. Wash your car on your lawn, to neutralize the soap and grime. Use biodegradable or non-toxic soap that is phosphate-free. Or take your car to a commercial car wash where wastewater is either recycled or treated. Maintaining your car is also important, make sure to fix any fluid leaks promptly and clean up any spills.

3. Disconnect your downspouts. Use your lawn, plant a rain garden or install a rain barrel or cistern to capture roof runoff.

4. Take care of your lawn. Use lawn and garden chemicals sparingly – choose organic when possible and avoid applying them before a storm event. Plant native and low maintenance plants and grasses. Don't over-water your lawn and garden – keep sprinklers on a timer and avoid pooling water.

5. Clean up pet waste. Bag up pet waste and dispose of it in the trash to prevent harmful bacteria from washing into local waterways.

6. Be sure to minimize the amount of ice-melt used. Do not over-apply salt, or choose a more environmentally-friendly alternative.

7. Consider minimizing impervious surfaces around your home. Use bricks, gravel, cobbles, natural stone, or permeable pavers instead of asphalt or concrete when possible.

8. Keep your septic system well-maintained to prevent leaks. A leaking septic system can leach harmful bacteria into storm sewer systems and local waterways. It is important to keep your system well-maintained to prevent costly repairs as well.

9. Walk, bike, or share a ride when possible. Driving causes air pollution, which can contaminate our rain and end up in our streams and lakes.

Adapted from Erie County Department of Environmental Planning

lowered from five acres to one acre, and more industrial facilities were brought under regulatory authority as well. During this time, performance standards also shifted, and cities were required to capture and treat larger amounts of stormwater before releasing it downstream.

The advent of LID

During this era, a new approach to stormwater management surfaced — low impact development (LID). This approach, sometimes referred to as green infrastructure, includes practices such as rain gardens, bioswales and permeable pavers that allow stormwater to soak into the soil. LID practices, unlike detention basins and other predecessors, focus on pollution prevention by stopping runoff at its source before it leaves a site. In this context, pollution prevention is simply reduction of stormwater runoff volume, which is the heart of what drives stormwater pollution in the first place.

Another goal of LID is reducing the effects of development on the environment. The standard approach to development is to clear vegetation and construct hardscape — wide roads and driveways as well as sidewalks on both sides of every street. Traditional development also includes curb-and-gutter and other drainage infrastructure as needed to divert runoff away from buildings and roads, reducing the risk of flooding. Runoff is usually conveyed from neighborhoods to a pond where it receives basic water quality treatment.

The LID approach questions the motivation behind using hardscape to convey runoff in gutters. In contrast, LID systems attempt to mimic nature and allow water to infiltrate the soil. In turn, the rain can recharge groundwater sources, which are often sorely depleted in urban landscapes.

When LID practices are used together in treatment trains, the need for gray infrastructure for stormwater and the size of detention basins can be reduced or eliminated, decreasing costs. Sites using this approach have achieved cost savings of ten percent or more, although site conditions and other factors affect the cost-efficiency.

LID was embraced by some, but a majority of regulated communities and entities still managed stormwater runoff through the traditional collect-convey-capture-release paradigm.

While progress was taking place in the MS4 world, other changes were afoot in the combined sewer system sector. Most notably in 1994, the EPA released its "CSO Control Policy," which laid out nine minimum control measures wastewater collection and treatment systems were required to meet. The measures included actions such as notifying the public in the event of overflows, reducing litter in the combined sewer system, and most importantly, monitoring CSOs in an effort to minimize these events.

From this policy grew a popular approach to controlling CSOs — large storage tanks and tunnels that hold millions of gallons of sanitary effluent and urban runoff during wet weather. After the storm, stored water is partially treated and released. These tunnels can be miles long and more than 20 feet in diameter. They often cost billions of dollars and decades to implement.

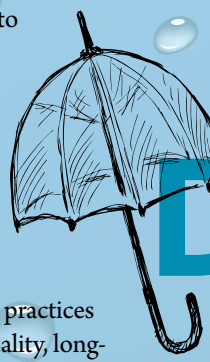
Putting the pieces together

Through the 2000s, Phase I communities continued to progress on their stormwater programs. Phase II entities were initiating their programs and wastewater utilities continued to contend with wet weather by constructing large tanks and tunnels to reduce CSOs.

Non-point source pollution, like oil from streets, enters our river systems through drainage pipes. – Matthew Rambo

In 2009, however, a significant report, "Urban Stormwater Management in the United States," stated that current approaches to stormwater management were not working. The National Research Council of the National Academy of Science, which led the study, recommended a focus on retention-based programs using LID in lieu of traditional treatment. The basis for this position is that retention-based practices provide water quality treatment, reduce the effects of stormwater on headwater streams and are holistically more favorable in terms of creating vibrant communities.

In 2010, the Philadelphia Water Department announced that rather than spend billions of dollars to address CSOs using tunnels and tanks, it would invest more than $1 billion in green infrastructure. Since this announcement, many cities including Washington, D.C., Cleveland and Louisville have committed to using this approach to address at least a portion of their CSO flows.



Green infrastructure practices — such as green roofs and cisterns — applied in ultra-urban settings can reduce the volume of stormwater runoff in combined systems, thereby reducing the number and magnitude of CSO events. Beyond water quality benefits, these practices have many co-benefits, including improved air quality, long-term job creation and enhanced social wellbeing. Green infrastructure also provides economic advantages, such as improved property values near green space, urban revitalization and reduced costs compared to using gray infrastructure options alone.

Another important facet of green infrastructure is increased adaptability and resilience. Climate change is expected to increase the frequency of high-intensity storms. Green solutions, much like nature, are inherently more adaptive because they are comprised of thousands of disaggregated projects across the landscape. Studies have also shown that practices can infiltrate and retain more water as plants mature. Investments and construction can quickly and readily match the needs of a changing environment. In contrast, the capacity of tunnels and tanks is fixed, and altering these systems would be a timely and costly endeavor.

The stormwater rule deferred

Equipped with the National Research Council's report and motivated by a lawsuit from the Chesapeake Bay Foundation, the EPA justified the need to once again enhance the national stormwater program. A national stormwater rulemaking began in 2010 with the goal of releasing a final rule by June 2012. The rule was expected to — among other elements — create the first national performance standard for stormwater based on retention requirements. The EPA pointed out that 18 states already have retention-based performance standards. This illustrates the applicability and feasibility of this approach and highlights the role of states as laboratories for new approaches.

During this time, performance standards also shifted, and communities were required to capture and treat larger amounts of stormwater before releasing it downstream.

The significance of this proposed update to the stormwater program cannot be overstated. For instance, a national performance standard requiring secondary treatment for wastewater treatment plants was

a centerpiece of the Clean Water Act. Previously, states were allowed to determine these wastewater treatment performance standards — similar to the current stormwater program. As a result, just before the Clean Water Act was passed, 16 percent of wastewater plants still discharged raw sewage, and only three percent used advanced treatment technologies. After the Act went into effect, raw discharge dropped to 0.6 percent, and advanced treatment grew to 19 percent.

Innovative technologies are being deployed and progressive financing approaches are being tested. These programs and tools may help turn the corner on stormwater pollution.

The hope was that a national performance baseline for stormwater might similarly improve treatment in the MS4 sector. However, the EPA announced in March 2014 that it was deferring on the rulemaking effort to focus on strengthening the existing stormwater program. While this decision takes some wind out of the sails in stormwater — with a quarter of Phase I permits and half of Phase II permits currently expired — there is clearly room for improvement in the current program.

Funding improvements in stormwater

The stormwater sector is often left scrambling for public dollars when competing with other infrastructure needs, such as roads, ports and drinking water. Stormwater utilities, which can charge service fees similar to water and sewer bills, have been successfully established in more than 1,300 regulated communities, representing 17 percent of the 7,500 MS4 communities. And yet, even in many of these communities, the funds provided are inadequate, especially given the aggressively changing stormwater regulatory climate. Further, communities continue to face difficult public acceptance battles when implementing stormwater fees. In Maryland, where the state has required its most populous cities and counties to implement watershed protection fees, the fee is often referred to unfavorably as a rain tax by some communities.

Other potential investment options are State Revolving Funds (SRFs), which provide funding to the drinking and wastewater sectors. Historically, this has not been an attractive option for stormwater. By 2008, less than one percent of SRF dollars were invested in stormwater and green infrastructure. This may be changing as more wastewater utilities address wet weather issues with LID. However, SRF dollars for stormwater are still expected to be small compared to traditional wastewater projects.

To surmount these fiscal challenges, some communities are looking to innovative new frameworks. For instance, a water quality trading market established in Washington, D.C. is allowing the generation and purchase of Stormwater Retention Credits.

Water quality trading can reduce overall program costs by allowing stormwater controls built offsite on non-regulated properties, such as developed sites built prior to any stormwater regulations, to substitute for those in expensive, ultra-urban settings. Through the market, credits are generated for these offsite practices and can then be purchased by regulated property owners and developers.

Another example of an innovative framework is the aggressive credit program used in Philadelphia. Private property owners who install green infrastructure practices that capture at least one inch of runoff are eligible to receive an 80 percent reduction on their stormwater fee.

A rooftop garden atop Chicago's City Hall is one of many green infrastructure additions to the city's landscape, helping to manage stormwater.
– AP Photo/Chicago Department of Environment, Mark Farina

Lastly, Prince George's County in Maryland is pushing the envelope by using the stormwater sector's first public-private partnership to address the projected $1.2 billion cost of retrofitting 8,000 acres of impervious cover. The retrofits are required to meet the Chesapeake Bay "pollution diet," known more technically as a total maximum daily load (TMDL). The bay TMDL is a major driver of stormwater activity on the East Coast, with seven bay jurisdictions trying to achieve nitrogen, phosphorus, and sediment reduction goals by 2025. The county's public-private partnership approach is estimated to provide 40-60 percent cost savings compared to traditional infrastructure investment approaches. It is also expected to create 5,000 new jobs within the county. If this funding model proves successful, it may well become a widely-used approach for large-scale stormwater infrastructure investment.

Cause for optimism

Decades of land development and urbanization have produced approximately 100 million acres of developed land in the contiguous U.S., much designed without regard for stormwater management. The projected annual rate of development is between 800,000 and 1 million acres for the next 30 years. Without significant investments in stormwater infrastructure, especially in stormwater retrofits, the degradation of the water environment is a major threat.

However, there is much to be optimistic about. Innovative technologies are being deployed and progressive financing approaches are being tested. These programs and tools may help turn the corner on stormwater pollution. With the costs of water quality monitoring dropping and the rise of real-time controls to optimize stormwater programs, the efficacy of stormwater infrastructure will surely improve. When coupled with innovative investments, the sector may experience even more accelerated growth in stormwater infrastructure implementation scale and performance.

William Ruckelshaus, the EPA's first administrator, said that stormwater runoff is the water quality issue of this era. In 1970, Ruckelshaus pointed out that 85 percent of water quality impairments were associated with point source pollution from industrial pipes, and the remaining 15 percent came from agricultural and urban stormwater runoff. Fast forward to today and these values are exactly opposite. Indeed, 85 percent of impairments stem from nonpoint and urban stormwater discharges. This fact is the motivating force for progress — when regulatory drivers mix with innovation and funding.

Seth Brown is the stormwater program and policy director at the Water Environment Federation. Seth is a licensed professional engineer, and has practiced in the field for over 15 years. He has Bachelor's and Master's degrees in Civil and Environmental Engineering and is currently pursuing a PhD in Civil, Environmental and Infrastructure Engineering at George Mason University focusing on innovative stormwater infrastructure investments policies and strategies.

Kristina Twigg is associate editor of World Water: Stormwater Management at the Water Environment Federation. She has a Bachelor's degree in Bioenvironmental Sciences and a Master's degree in Science and Technology Journalism from Texas A&M University.

WHY GREEN INFRASTRUCTURE?

Water Quality: Stormwater from urban areas delivers many pollutants to our streams, lakes and beaches — including pathogens, nutrients, sediment and heavy metals. In cities with combined sewer systems, high stormwater flows can also send untreated sewage into our waters. By retaining rainfall from small storms, green infrastructure reduces stormwater discharges. Lower discharge volumes translate into reduced combined sewer overflows and lower pollutant loads.

Flooding: Conventional stormwater infrastructure quickly drains stormwater to rivers and streams, increasing peak flows and flood risk. Green infrastructure can mitigate flood risk by slowing and reducing stormwater discharges.

Water Supply: Rainwater harvesting and infiltration-based practices increase the efficiency of our water supply system. Water collected in rainwater harvesting systems can be used for outdoor irrigation and some indoor uses and can significantly reduce municipal water use. Water infiltrated into the soil can recharge groundwater, an important source of water in the U.S.

Private and Public Cost Savings: When stormwater management systems are based on green rather than gray infrastructure, developers often experience lower capital costs. These savings derive from lower costs for site grading, paving, and landscaping, and smaller or eliminated piping and detention facilities. In cities with combined sewer systems, green infrastructure controls may cost less than conventional controls, and green-gray approaches can reduce public expenditures on stormwater infrastructure.

Adapted from the Environmental Protection Agency

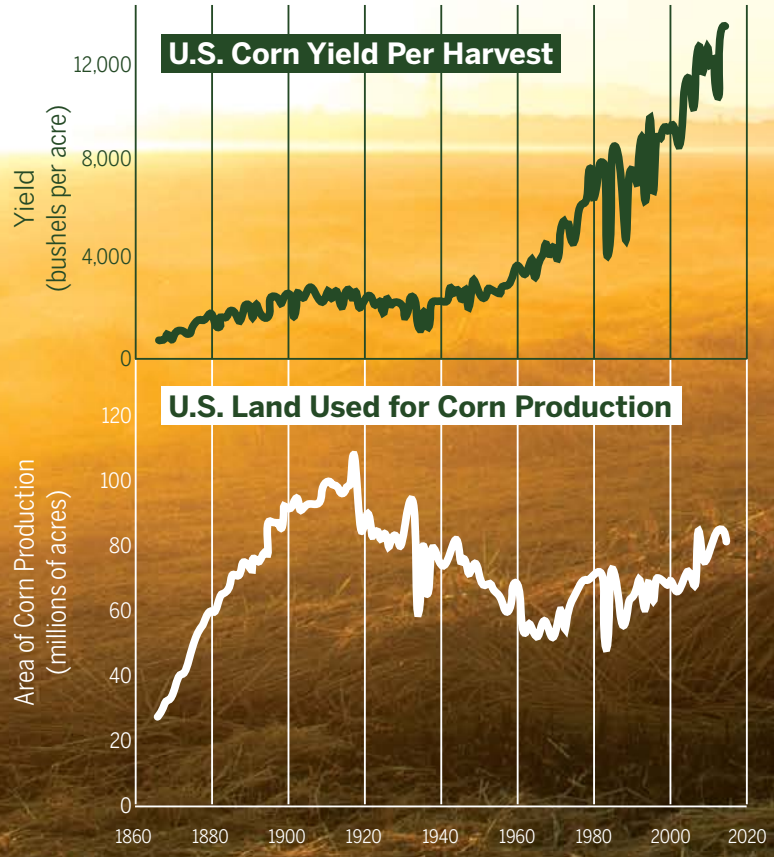
Managing for Multiple Outcomes:

Agricultural Challenges & Opportunities

by Julia Bond and Kaola Swanson

Agriculture is facing an ever expanding challenge: how do you feed an increasing population while preserving soil health and minimizing environmental impact?

By 2050, the world's population will exceed 9 billion people. To meet the growing demand for food, agricultural production will need to increase. Simply expanding the amount of land currently under production will likely not solve the problem. According to the USDA, more than half of the 2.3 billion acres of arable land in the United States are already dedicated to agricultural production. National Geographic reports in an article entitled "Feeding Nine Billion," that "globally, almost 40 percent of the ice-free land is under agricultural production and new agricultural land is created at the expense of cutting down forests and converting other natural landscapes to fields."



Source: United States Department of Agriculture Economic Research Service

If expanding the amount of land under production is not a viable option, we need to be more creative in using the land we already have. That means increasing efficiency: growing more food on less land. Advances in technology have already helped us increase crop yields. Using modern practices and breeds of corn, we are now able to grow five times more corn today than we could in the 1940s on the same area of land (see graphs below).

Producers adopted a number of new practices to generate this staggering increase in yield. One of the main factors was changes to corn genetics. After the Dust Bowl, farmers began planting hybrid corn breeds, which led to higher yields than traditional corn breeds. In addition to these new, more vigorous varieties of corn, farmers also increased the amount of fertilizer applied to each field while pesticides and tillage methods also were becoming more effective. Combined, all of these technological innovations allowed farmers to produce more food on less land.

Photo by Nathan Weyland

This algal bloom in the Thames River estuary is created by water pollution from fertilizers, which accelerates algae growth. When the algae die, they sink to the bottom of the river and are broken down by bacteria, depriving the water of oxygen. – Robert Brook / Science Source

Environmental impact of agriculture

Growing more on less, however, is not without its problems. The agricultural sector has a major environmental footprint. According to the EPA, agriculture accounts for 10 percent of U.S. greenhouse gas emissions and contributes excess nutrients and sediments that affect water quality in all 50 states. Agriculture also has a hefty water footprint — 80 percent of all consumptive water use is for irrigated agriculture, reports the USDA. Below are some examples of agriculture's primary environmental impacts.

> Innovations in agricultural practices have revolutionized our ability to produce more food on fewer acres, though often at the expense of environmental health.

Biodiversity: In a study on food and agriculture worldwide, the Food and Agriculture Organization of the United Nations (FAO) reported that clearing land for agricultural use threatens biodiversity in a number of ways. When land is converted to agriculture, habitat for native wildlife species is reduced, or lost entirely, which can increase pressure on native species. Agricultural crops are also increasingly homogenous. In the last 100 years, the genetic diversity of crops has dropped by 75 percent across the globe.

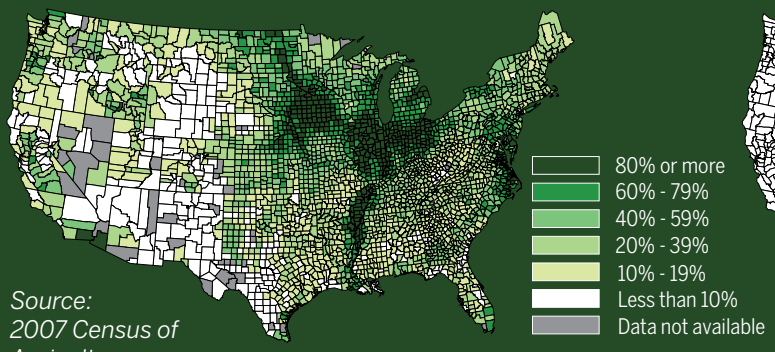
Greenhouse Gases: In the same study, the FAO found that agriculture contributes to greenhouse gas emissions in several ways. Land clearing, especially converting forests to fields, releases carbon dioxide, the primary greenhouse gas, into our atmosphere. Excess application of nitrogen fertilizer leads to increased rates of nitrification and de-nitrification, which can add nitrous oxide, another greenhouse gas, to the atmosphere. Finally, livestock — especially cattle — are the source of 20 percent of methane emissions in the United States. Methane is 86 times more effective at trapping heat in the atmosphere than carbon dioxide, making it a very potent greenhouse gas.

Soil Health: Topsoil is a precious natural resource. Nationwide, approximately 2.7 tons of soil is lost from each acre of farmland every year. When soil is lost by erosion, the organic material, nutrients and microbiota (bacteria and fungi), that make farm land productive, also leave the field — rebuilding healthy topsoil can take years.

Water: Globally, FAO reports that agricultural use accounts for approximately 70 percent of all water withdrawals. In the U.S., agriculture uses 80 percent of all consumptive water use. These statistics highlight the extent to which water quantity is affected by agriculture. To put the statistics in perspective, consider the mighty Colorado River. Water demand, particularly for agriculture, is so large that most months the river never reaches the ocean.

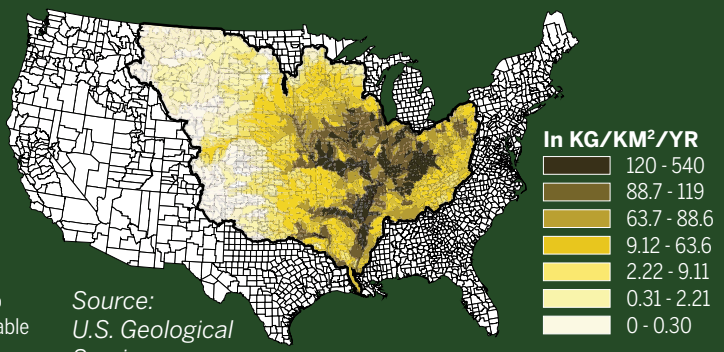
In addition to water quantity, agriculture has a substantial impact on water quality. Not all of the fertilizers, pesticides and herbicides that are applied to agricultural fields to increase crop productivity stay on the field. The National Water Program, a non-profit that reports on water quality, found that almost all states have detected pesticides in their groundwater and all 50 states suffer from nutrient pollution in surface waters. Nutrient enrichment, or eutrophication, leads to increased algae and plant growth. In lakes and streams, excessive algal growth is not only unsightly, but it can also degrade water quality. How? When plants and algae die, they sink to the bottom of the waterbody and start to decompose. The decomposition process consumes the oxygen in the water, which is not replenished. Over time, waterways with high rates of plant and algae growth are likely to become oxygen starved, or hypoxic. Oxygen-starved waters can cause fish kills and be toxic to human and animal health. The impact of eutrophication is glaringly evident in the Gulf of Mexico. As a result of excess nutrient loading from the Mississippi River, the Gulf of Mexico now has a dead zone that

PERCENT OF AGRICULTURAL LAND HARVESTED FOR CROPS



Source: 2007 Census of Agriculture

TOTAL PHOSPHORUS (i.e. Nutrient Pollution) DELIVERED TO WATERWAYS IN THE MISSISSIPPI BASIN



Source: U.S. Geological Service

covers more than 5,000 square miles of water, according to the EPA. That's an area about the size of the state of Connecticut that, each summer, has little to no dissolved oxygen.

Innovations in agricultural practices have revolutionized our ability to produce more food on fewer acres, though often at the expense of environmental health. To that end, recent advances in technology and more sustainable practices are now being combined to increase crop yield, while reducing farm inputs through more efficient application of inputs like water and fertilizer. New precision agriculture technologies — like sensors and timers for irrigation and fertilizer applications and automated tractors — allow producers to use only as much as they need to produce healthy crops. Just as importantly, producers are employing best management practices that are designed to protect soil health and water quality, without limiting crop yields.

What are best management practices?

The practices a producer employs to grow crops can have varying effects on soil health. Using heavy equipment can cause soil compaction, intensive farming can deplete the soil of essential nutrients, and topsoil can be lost through erosion. Best management practices, or BMPs, are simple on-farm changes that producers can make to reduce the environmental impact of agriculture. In many cases, BMPs will also reduce operational costs, increase crop yields or do both.

Agricultural BMPs aim to protect water quality and soil health by reducing or preventing runoff from agricultural operations. When soil is lost to erosion, the organic material, nutrients and microbiota that make farmland productive are also lost. The eroded soil, along with fertilizers and pesticides, enters nearby streams, leading to eutrophication and other water quality impairments. When topsoil remains on the field it benefits both the producer and water quality.

Practices oriented to cultivating and protecting soil health can be very successful. These practices encourage the infiltration of water into the soil. Increased infiltration both reduces soil erosion, and makes more water available for uptake by crops. Over time, practices that promote soil health can reduce the need for synthetic fertilizers by building nutrient concentrations in the soil naturally. Less fertilizer means cost savings for the producer.

BMPs can also increase crop yields for the producer. By maintaining nutrients and organic material in the soil, farmers can more efficiently apply irrigation water and reduce tillage, decreasing the amount of fuel and the labor time required per acre of production. Cost savings and increases in crop yield can lead to increases in profits for the producer while protecting water quality and soil health.

BMPs fall into two main categories: structural practices that require installing equipment or planting permanent vegetation, and nonstructural practices that require a change in the way fields and crops are managed.

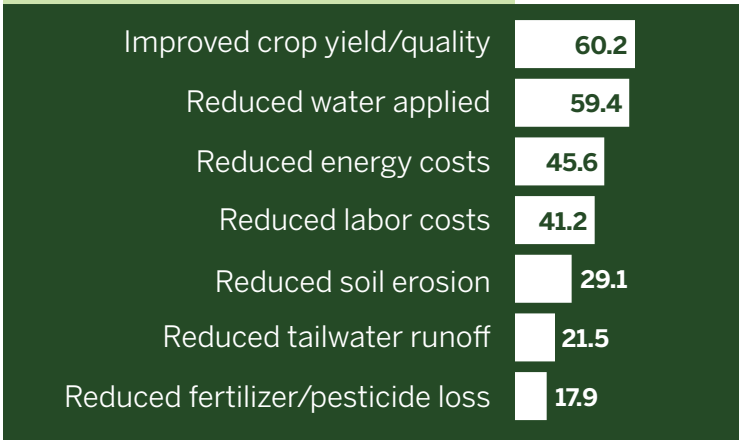
BMP examples

Conservation Tillage: Conservation tillage aims to reduce soil erosion and build organic matter in the soil. Conventional tillage practices mechanically disturb the soil to loosen and aerate it prior to planting. Fields that are conventionally tilled have a higher risk of soil erosion and are more likely to negatively impact water quality.

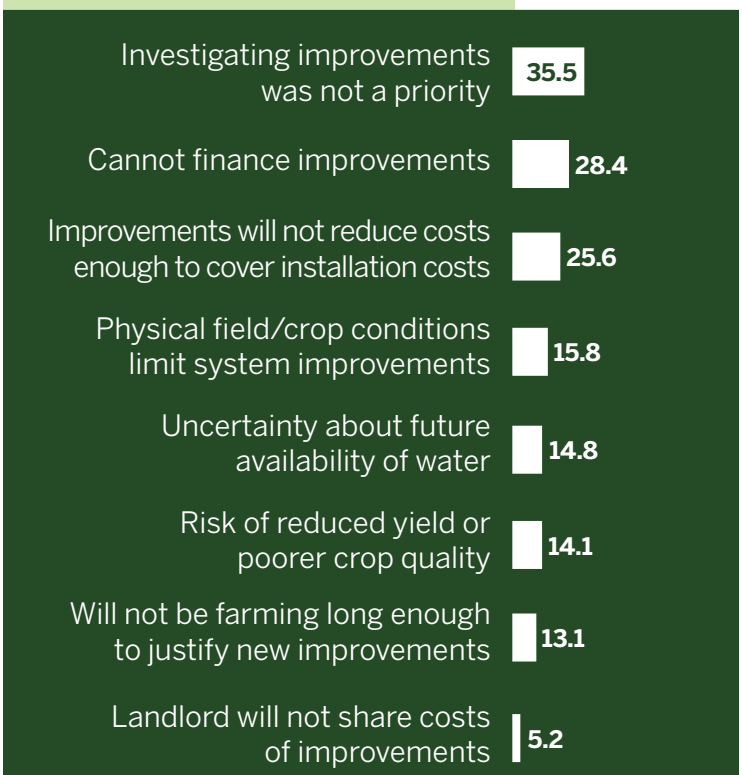
When a producer employs conservation tillage practices, instead of tilling on either side of a planted row, either one (reduced tillage) or both (no tillage) sides of a planted row are left untilled. This leaves some plant residue — like corn stalks and leaves — from the previous year's crop on the field, which protects the soil. The decomposing crop residue acts as a natural fertilizer for future plantings, reducing the costs of fertilization. Additionally, the extra material slows irrigation water, allowing for increased water infiltration and reduced runoff. Labor requirements can also be lessened because the time required for tillage is decreased or eliminated.

U.S. FARM & RANCH SURVEY: IRRIGATION SYSTEM IMPROVEMENTS & KEY BARRIERS

# of farms implementing improvements = 74,846



# of farms w/ barriers to improvements = 131,988



* Respondents were allowed to select multiple responses.

Source: Water Conservation in Irrigated Agriculture: Trends & Challenges in the Face of Emerging Demands, Economic Research Service/USDA, 2008.

Left: Farm laborer moves sprinkler piping in the San Joaquin Valley. Right: Javier Rodriguez poses for a portrait in a field being flood irrigated. Rodriguez ensures the water flows correctly through the young orchard. Flooding crops is inefficient and can negatively impact crop yield and water conservation when compared to drip irrigation, which this farm will switch to once its well is completed. – Nathan Weyland

Cover Cropping: The goal of cover crops is to promote long-term soil health. Cover crops reduce the need for fertilizers by enhancing nutrient retention in the soil, increasing water infiltration, building organic matter and suppressing the growth of weeds. Cover crops are planted when a field would otherwise lie fallow and can be fit into existing crop rotations. They are usually close-growing crops like clover, vetch and grasses which can be harvested and sold as livestock feed. Farmers can plant certain cover crops to build nitrogen in the soil, provide natural pest management, protect water quality or provide a combination of these benefits.

Irrigation Management: For some farmers, keeping better track of the volume and frequency of irrigation applications can be a big step toward improved irrigation efficiency. Soil moisture sensors allow producers to determine exactly when they need to irrigate a field and how much water the plants need. Irrigation management ensures that only as much water as is needed is applied, which minimizes runoff.

Another irrigation BMP is changing from a surface irrigation system (i.e., flood and furrow irrigation systems, where water is applied in large volumes to the surface of the field) to a pressurized irrigation system (i.e., overhead sprinkler systems, such as wheel-lines or center pivots). These conversions can be expensive, but allow for more precise control over where and when irrigation occurs. Improved irrigation management reduces runoff from the field and typically provides crops with better access to water, promoting higher yields and an increased profit for the producer.

Riparian Re-vegetation: Replanting native plants and trees promotes healthy riparian areas, the land buffer between a river and an upland area. Trees, shrubs and grasses all slow the flow of water from the field into the river. When a riparian buffer slows agricultural runoff, it gives sediment a chance to settle out of the water and riparian plants a chance to absorb excess nutrients before they reach the river. By planting a mix of native species in degraded riparian areas, water quality, habitat and wildlife all benefit.

With the help of technological innovations, we can now produce more food on less land. Such agricultural efficiencies are essential if we are to keep up with increasing population growth. But as agricultural production expands, we need to ensure that we are not degrading soil health and water quality along the way. As we have seen, the negative environmental impacts can be significant. Harmful algal blooms resulting from eutrophication are plaguing the Chesapeake Bay, Great Lakes and Gulf of Mexico. We are losing soil ten times faster than the natural rate of replenishment. Not only does this level of soil erosion degrade water quality, it also reduces cropland productivity, leading to future food security concerns.

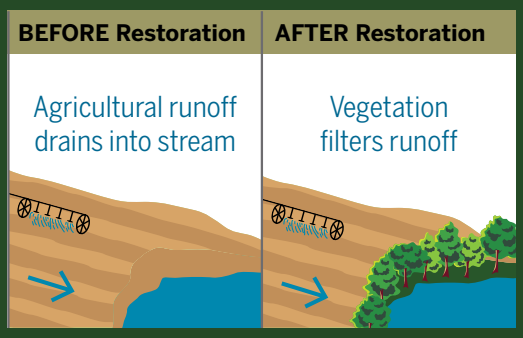
The implementation of agricultural best management practices is an important step in protecting both our agricultural and natural resources.

The implementation of agricultural best management practices is an important step in protecting both our agricultural and natural resources. When implemented properly, best management practices can protect soil health and water quality, while decreasing operational expenses and increasing crop yields.

Julia Bond and Kaola Swanson work for The Freshwater Trust and can be reached, respectively, at julia@thefreshwatertrust.org and kaola@thefreshwatertrust.org.

RIPARIAN RE-VEGETATION FILTERS RUNOFF FOR HEALTHY RIVERS

A major water quality concern across the United States is the abundance of nutrients such as nitrogen or phosphorus in our freshwater systems. High levels of nutrients promote excessive plant and algae growth, choking other aquatic species. Replanting native vegetation in riparian areas helps to reduce agricultural runoff by filtering the water before it enters the stream.



BLUEPRINTS

(previous page)
Named after a nearby village of Native Americans, Wahclella Falls in Oregon is divided into upper and lower segments with a combined height of 350 feet.
– Don Jacobson

Clockwise from top:
A salmon jumps up Lucia Falls on the Lewis River in southern Washington state.
– Kim Coffman

A glacier-fed lake in Banff National Park in the Canadian Rockies, Peyto Lake gets its bright, turquoise color from large amounts of glacial rock flour that enters the lake during the summer.
– Renee Bryant

Honey Island Swamp in Slidell, Louisiana is said to be one of the least-altered river swamps in the United States.
– Marlynn Rust

A salmon fly lands on a young fisher along the banks of the Deschutes River in Oregon.
– Matt Wills

Nectar, containing up to 70 percent water, is a hummingbird's primary food source.
– Phong Nguyen

Clockwise from left:
A major tributary of the Rogue River, Evans Creek is a salmon stronghold.
– Scott Wright, Dec. 2013 winner

A heron stands undaunted by the rushing Pa'rus River, or Virgin River, in Utah. – Renee Bryant, April 2014 winner

The morning mist and sun highlights the beauty of South Falls in Oregon's Silver Falls State Park.
– Wendi Qiu, May 2014 winner

A 50-mile tributary of the Deschutes River in Oregon, White River drains a scenic mountainous area of the Columbia Plateau on the east side of the Cascade Range.
– Kevin Cowley, Mar. 2014 winner

Short and swift, Paradise River runs through a meadow on Mt. Rainier in Washington state.
– Jeremy Bauer, Feb. 2014 winner

Burney Falls is a beautiful 129-foot centerpiece of the McArthur-Burney Falls State Park in California.
– Don Jacobson, Jan. 2014 winner

Photo of the Month Contest

The Freshwater Trust and Pro Photo Supply have launched a monthly photo contest. Whether it's a beauty shot of your favorite water spot or an active photo of you recreating, submit your freshwater photos and enter to win. Each month, a photo will be selected and featured on The Freshwater Trust homepage for one month and will be eligible for inclusion in this Blue Prints photo section. The winning photographer will also win a $25 gift card from Pro Photo Supply.

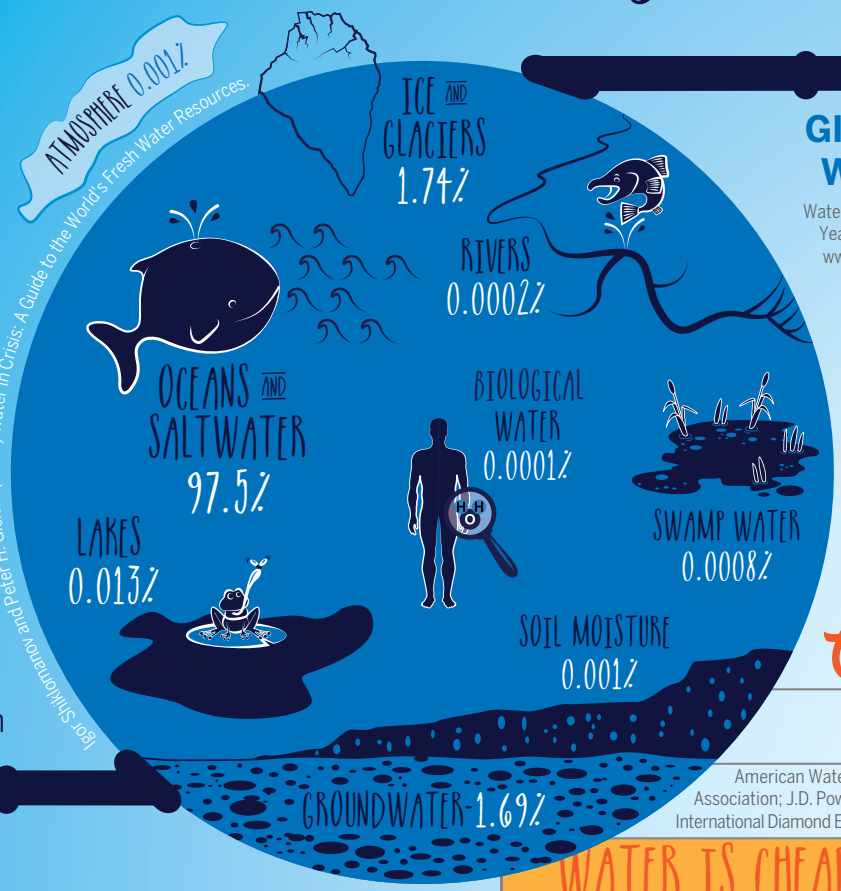
For more information and contest rules, see our homepage footer at: www.thefreshwatertrust.org.

Water Availability + Use

If
1 GALLON
=
All the water on Earth

Than
1 TBSP
would equal all the freshwater on Earth

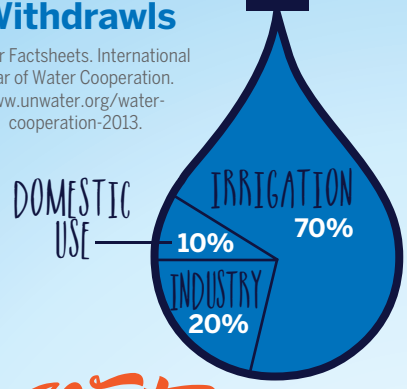
Igor Shiklomanov. (1999.) State Hydrological Institute.



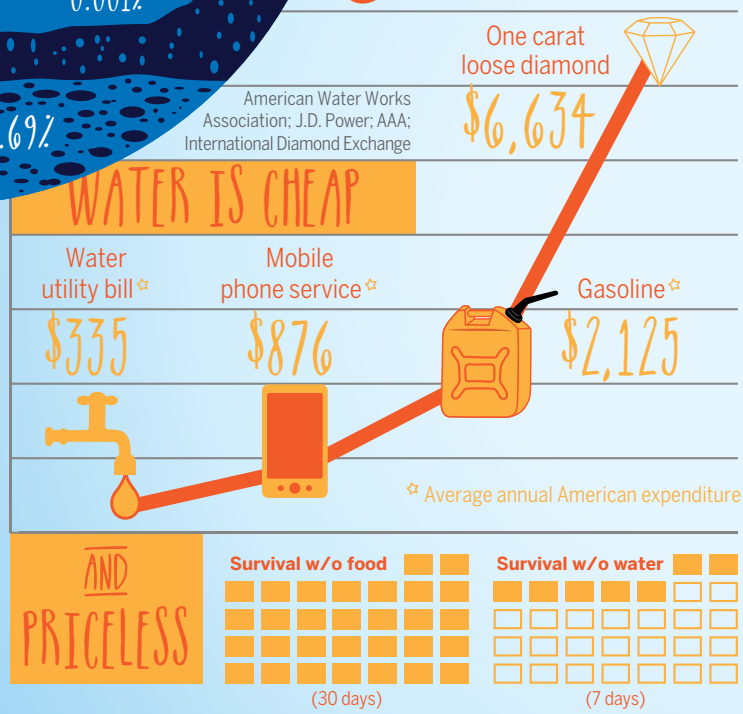
Igor Shiklomanov and Peter H. Gleick. (1993.) Water in Crisis: A Guide to the World's Fresh Water Resources.

Global Water Withdrawls

Water Factsheets. International Year of Water Cooperation. www.unwater.org/water-cooperation-2013.



Water Economics



Dina Spector. Here's How Many Days A Person Can Survive Without Water. www.businessinsider.com/how-many-days-can-you-survive-without-water-2014-5

10%
of homes have leaks that waste
90 GALLONS
or more per day.

WaterSense, www.epa.gov

Annual water leaks from U.S. homes can exceed
1,000,000,000,000
(ONE TRILLION)
gallons of water.
That's equal to the combined water use of
LOS ANGELES + CHICAGO + MIAMI

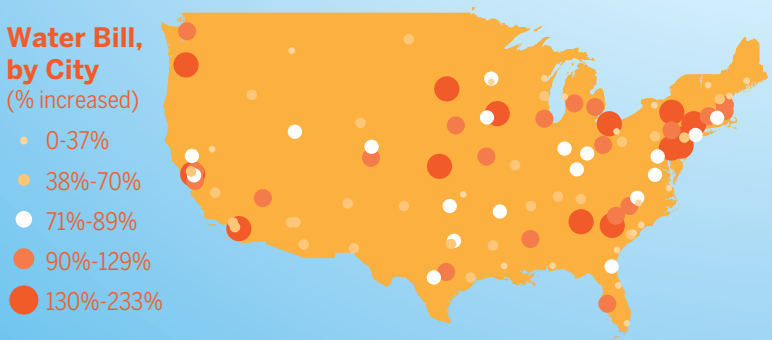
WaterSense, www.epa.gov

The average household's leaks can account for more than
10,000 GALLONS
of water wasted every year, or the amount of water needed to wash

270
LOADS OF LAUNDRY

WaterSense, www.epa.gov

Survey of 100 municipalities found in the past 12 years, at least
ONE IN FOUR RESIDENTIAL WATER BILLS HAVE DOUBLED



Black & Veatch, Raftelis Financial Consultants and USA TODAY research of municipal water data; Energy Information Administration, Bureau of Labor Statistics, and USA TODAY research.

Water for Food

Milk
600 GALLONS

Hamburger
634 GALLONS

Apple
18.5 GALLONS

Coffee
36 GALLONS

Steak
1,857 GALLONS

Cheese
599 GALLONS

Beer
20 GALLONS

Corn
108 GALLONS

Arjen Hoekstra and Ashok Chapagain. (2008.) Globalization of Water: Sharing the Planet's Freshwater Resources.

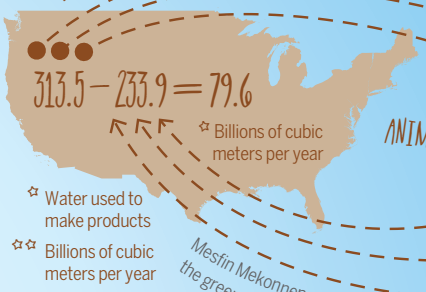
Kevin Hall, Juen Guo, Michael Dore and Carson Chow. The Progressive Increase of Food Waste in America and Its Environmental Impact. (2009.) www.plosone.org

Food waste in the U.S. accounts for

1/4

of **all freshwater consumption**

The United States is the **3rd largest net exporter** of virtual water*



313.5 − 233.9 = 79.6

* Billions of cubic meters per year

36.9** ANIMAL PRODUCTS 26**

251.9** CROP PRODUCTS 158.7**

24.7** INDUSTRIAL PRODUCTS 50.2**

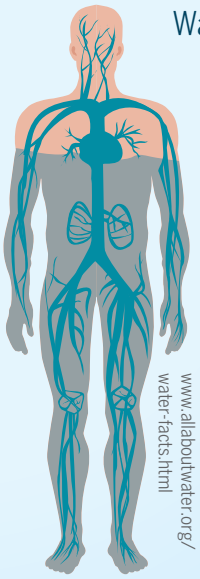
* Water used to make products

** Billions of cubic meters per year

Mesfin Mekonnen and Arjen Hoekstra. (2011.) National water footprint accounts: the green, blue and grey water footprint of production and consumption.

79.6 BILLION CUBIC METERS PER YEAR EXPORTED

Water for Drinking



Water makes up about

70%

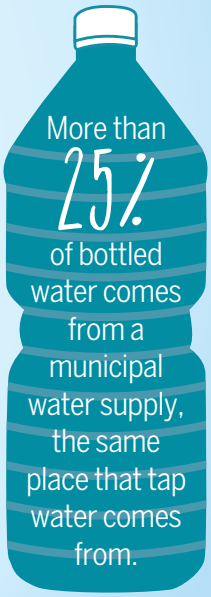
of an adult's body

If you're feeling thirsty, you've already lost

1%

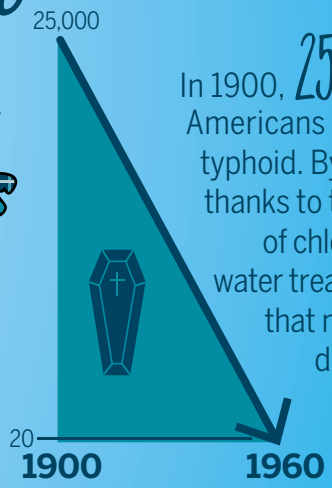
of your total water amount

www.allaboutwater.org/water-facts.html



More than 25% of bottled water comes from a municipal water supply, the same place that tap water comes from.

In 1832, the first municipal water filtration works opened **in Paisley, Scotland**



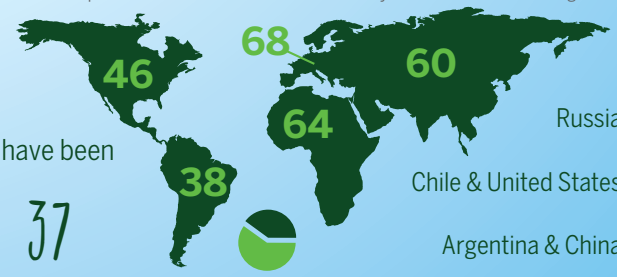
In 1900, 25,000 Americans died of typhoid. By 1960, thanks to the use of chlorine in water treatment, that number dropped to 20

U.S. Environmental Protection Agency. (2013, December). Water Trivia Facts. water.epa.gov/learn/kids/drinkingwater/water_trivia_facts.cfm

Water Cooperation

276 **river basins that cross an international border** (a.k.a. transboundary river basin) + 200 aquifers not included

Water Cooperation 2013. Fact sheet: Transboundary Waters. www.unwater.org



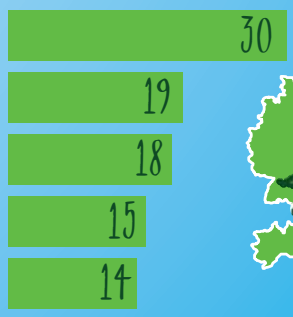
Since 1947 there have been

300 **International water agreements**

37 **Conflicts between states over water**

60% **transboundary river basins have no cooperative management plan**

Most Transboundary River Basins in a Country



Danube River Basin is the "most shared" transboundary river basin in the world.

18 COUNTRIES

UNESCO. Water e-Newsletter: Water Cooperation. www.unesco.org/new/en/natural-sciences/environment/water/water-cooperation-2013/Water_e-Newsletter

The Freshwater Trust® UPDATES

The Freshwater Trust continues to implement large-scale habitat and flow projects to preserve and restore our freshwater ecosystems in the Pacific Northwest. Here are some highlights of another record year.

From top:
Habitat Director Mark McCollister (holding award), along with representatives from U.S. Forest Service and Bureau of Land Management, received the Oregon State Land Board Award from Oregon Secretary of State Kate Brown (left).
– The Freshwater Trust

The lower reaches of the Applegate River provide important migratory and rearing habitat for summer and winter steelhead, fall Chinook and coho. Riparian restoration on side channels enhances refuge habitat that is essential during high flows and generates productive foraging habitat during spring and summer months.
– The Freshwater Trust

Once again, The Freshwater Trust has been selected to manage Pacific Power Blue Sky Habitat Fund, a program supported through customers of Pacific Power. Under the guidance of The Freshwater Trust, four projects were recently selected to receive these funds to restore habitat for the benefit of native fish. More than $100,000 from the Blue Sky Habitat program will be directed to projects in Oregon's Rogue, Illinois, Bear Creek and Clackamas watersheds in 2014.

The Oregon Department of Environmental Quality recently approved the Water Temperature Transaction Tool (W3T) that we use for estimating thermal benefits of instream flow transactions. This tool provides a standardized method of quantifying temperature reductions for credits, and is currently in use in our Rogue River projects, as well as being used to evaluate the ecological effectiveness of our flow trading programs in the John Day River Basin. W3T was developed by Watercourse Engineering, Farm Stream Solutions, Willamette Partnership and The Freshwater Trust with funding from the National Fish & Wildlife Foundation.

Tested last fall and early spring of this year, The Freshwater Trust's tablet-optimized data collection application — StreamBank Monitoring — has launched publicly. During the testing phase, we worked diligently to define the protocols for data collection and refined the user interface. StreamBank Monitoring is now being used by our partners from Eugene Water and Electric Board, McKenzie Watershed Council, Upper Willamette Soil and Water Conservation District and Lane Council of Governments.

Rogue Basin

The Freshwater Trust is expanding its scope in the Rogue River basin and the organization is frequently called on as a resource for the local restoration community. The Freshwater Trust has applied lessons learned from our experiences in the Rogue to facilitate basin-wide planning efforts and has held several trainings to increase habitat restoration capacity in the basin. To date, The Freshwater Trust has planted 30,000 native trees and shrubs on nearly 20 acres along the Rogue River and its tributaries. Approximately 10 more acres are planned for plant installation this year

The Freshwater Trust staff field test a new protocol assessing riparian function and a mobile data collection application in the Sandy River delta. This protocol and the mobile application is being used by the Eugene Water and Electric Board and partners in their riparian conservation and drinking source water protection program.
– The Freshwater Trust

under The Freshwater Trust's contract with the City of Medford. Further, The Freshwater Trust recently signed an agreement with the U.S. Bureau of Reclamation to improve coho salmon habitat in the basin by installing an additional 18 acres of riparian plants, constructing approximately 85 large wood structures and restoring 21 cubic feet per seconds of flow by 2020, primarily in the Bear Creek and Little Butte Creek tributaries of the Rogue River.

Sandy Basin

The Oregon State Land Board recently awarded The Freshwater Trust the 2013 Stream Project Award for our work on the Salmon River and Still Creek in the Sandy River Basin. The project was led by The Freshwater Trust, on behalf of the Sandy River Basin Partners, a coalition of government agencies, the local watershed council, private interests and non-profits dedicated to restoring Endangered Species Act-listed salmon and steelhead.

Snake Basin

Idaho Power Company has contracted with The Freshwater Trust to assist in the development of a large-scale watershed restoration program. This program will be presented to the Department of Environmental Quality in Oregon and Idaho to address the thermal load compliance related to the relicensing of the Hells Canyon Complex on the Snake River. After extensive analysis of water quality issues, a research project to test the effectiveness of narrowing and deepening the river channel near Marsing in Idaho is underway. Native riparian vegetation will be restored to stabilize banks, provide shade and reduce sediment loading to the river. Next year, the project will address best management practices for irrigation on area farms to reduce runoff. In total, the Snake River Stewardship Program is designed to decrease instream temperature, reduce aquatic vegetation, improve aquatic and riverbank habitat, and meet the objectives of the hydroelectric dam relicensing.

Klamath Basin

Stakeholders, agencies and PacifiCorp have collaborated to develop a framework to support water quality tracking, accounting and trading in the Klamath Basin. Based on The Freshwater Trust's experience with such programs in other basins, PacifiCorp contracted with The Trust for a 2014 pilot project to demonstrate the process of generating nutrient reductions to improve water quality in the Klamath Basin. The Freshwater Trust is currently recruiting a landowner in the Sprague River subbasin to construct ½-mile of livestock exclusion fencing and quantify the ensuing nutrient reductions instream. We will maintain and monitor the fencing, assess the pilot project and complete the certification and verification process with local administrators. Credits will then be transferred to PacifiCorp.

John Day Basin

Designated as the highest priority tributary on the highest priority reach of the John Day River,

The Freshwater Trust staff was recently invited to become an active partner in the Grande Ronde Basin planning process by working with a group of biologists to identify and solve issues impacting fish survivability in Catherine Creek.
– NarrativeLab

Reynolds Creek is home to summer steelhead and spring Chinook. This year, The Freshwater Trust contracted with two landowners to lease their excess irrigation water and leave it insteam to benefit wild fish. Although these are annual leases at this point, these two efforts will lead to ongoing projects that pursue better water management strategies. Indeed, a third water irrigator on Reynolds Creek has contacted us about an instream lease for next year.

We are also working with landowners in the lower John Day Basin to implement both habitat and flow restoration projects at the same site. In addition to significant and broad opportunities for habitat restoration, this project will restore up to 6 cubic feet per second of streamflow to a previously dry John Day tributary and increase flow in a critical reach of the mainstem John Day River.

Grande Ronde Basin

Last year saw a large leap forward in protecting insteam water in Catherine Creek, and even more progress is expected in 2014. The Freshwater Trust has signed three new long-term leases (15+ years), one short-term renewal and three new short-term leases. Many of these leases came unsolicited, demonstrating the importance of hiring local staff to work with local landowners on instream water leases.

Additionally, The Freshwater Trust and the City of La Grande Public Works Department have agreed to a 20-year lease of some of the City's restored water in the La Grande Reservoir on Beaver Creek, a tributary to the Grand Ronde River. This project will restore flow to the Upper Grande Ronde River.

To learn more about The Freshwater Trust
visit www.thefreshwatertrust.org

Like us on Facebook at facebook.com/thefreshwatertrust

Follow us on Twitter @fresH2Otrust

The Good Dirt on Keeping Our Rivers Clean

by Ann Sorensen

Rivers do matter. That's why we work hard to restore and protect them. But did you know that enhancing soil quality is a fundamental first step to cleaner water?

Improving the health of farmland soils might not jump to mind when we talk about water quality but in 1993, the National Academy of Sciences (NAS) published a 542-page report on *Soil and Water Quality: An Agenda for Agriculture* that showed that soil and water quality are inherently linked.

Soil is a living, dynamic system that is the interface between agriculture and the environment. It is the mediator between farming practices, agricultural chemicals and the environment.

After sifting through decades of research, the highly qualified scientists and practitioners who wrote the NAS report concluded: "Protecting soil quality, like protecting air and water quality, should be a fundamental goal of national environmental policy."

Farmers know that soils are important. The largest recorded loss of farmland in the U.S. was during the Dust Bowl of the 1930s when more than 100 million acres were lost to drought and erosion in the Great Plains. More than 75 percent of the topsoil was blown away in many areas.

This prompted the U.S. Department of Agriculture to create the Soil Conservation Service — now the Natural Resources Conservation Service (NRCS) — to help farmers fight erosion and protect their soils. It took over a decade for farmers to rebuild the soils. By 1941, although much of the land was rehabilitated, some lands never recovered.

But memories faded quickly and many of the same mistakes were repeated during World War II when farmers again plowed up grasslands to plant wheat when grain prices rose. Indeed, the balance between protecting the environment while responding to markets that rarely pay for these activities is a continuing challenge for farmers.

That is why the NAS report focused on "win-win" scenarios that would maintain profitability for the farming operation while protecting the surrounding environment. Enhancing soil quality ended up on the top of that list.

The USDA NRCS recently launched a national campaign to raise awareness about soil quality and help farmers and landowners build "soil equity" for long-term returns. Their soil health materials eloquently and convincingly tell us why farmland soils are so important.

Factors of soil quality:
- Texture
- Depth
- Permeability
- Biological activity
- Capacity to store water & nutrients
- Organic matter

Soil quality threats:
- Erosion
- Salinization
- Compaction
- Acidification
- Loss of biological activity

High-quality soils prevent water pollution by:
- Resisting erosion
- Absorbing and partitioning rainfall
- Degrading/immobilizing agricultural chemicals, wastes, or other potential pollutants

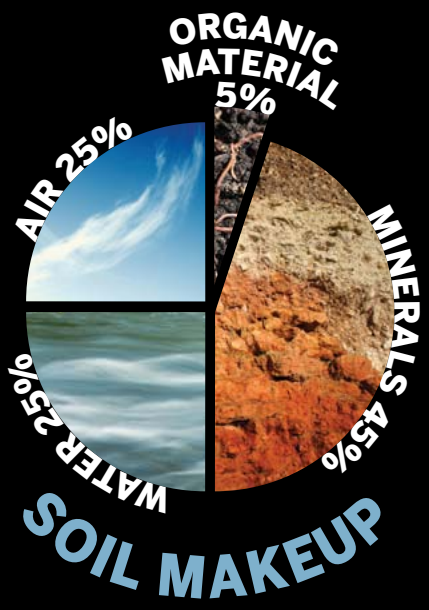
If soils are healthy, they help reduce production costs and improve profits for farmers. Healthy soils hold more water by binding it to organic matter so less water is lost to runoff and evaporation.

Most farmers can increase their soil organic matter in three to ten years by adopting conservation practices to achieve this goal. This means: keep soil covered, do not disturb it, use cover crops and rotate crops to feed it and develop a soil health management plan with the help of USDA NRCS.

Recommended practices include conservation crop rotation, cover crops, no till, mulching, nutrient management and integrated pest management. Side benefits include saving energy by using less fuel for tillage and maximizing nutrient cycling so less fertilizer is needed; saving water by increasing infiltration and water holding capacity as soil organic matter increases, reducing disease and pest problems and improving plant health.

These practices can make a dramatic difference. For example, American Farmland Trust is working with farmers to accelerate the adoption of cover crops and conservation cropping systems in Illinois. In fields with cover crops, we documented a 50 percent reduction in nitrate-nitrogen loss at the edge of field.

With more variable weather predicted for the future — cycling between the extremes of droughts and downpours — improving soil health is the best investment farmers can make.



Source: Physicalgeography.net

Ann Sorensen is the Research Director at the American Farmland Trust, the nation's leading conservation organization dedicated to protecting farmland, promoting sound farming practices and keeping farmers on the land. For more information on the policies and programs of the American Farmland Trust, visit www.farmland.org.

The Freshwater Trust®
65 SW Yamhill Street, Suite 200
Portland, OR 97204

ADDRESS SERVICE REQUESTED

NON-PROFIT
ORGANIZATION
U.S. POSTAGE
PAID
PORTLAND, OR
PERMIT NO. 4313