

THE ECOLOGY AND CULTURE OF WATER

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Two free resources that drive all the biotic and abiotic processes that sustain all life on earth are water and light energy. Whatever our failings with energy, it is clear that our relationship with water is in trouble. Aquifers are dewatering. Our rivers run warm and sluggish or not at all when it is not raining and run over their banks and away when it is. Cities throughout the country are running out of water and grabbing desperately for shares of water in the Columbia River and the Great Lakes.

Yet, every half inch of rain on a thousand square foot roof provides about 310 gallons of useable water, nearly all of which in our current doctrine is turned to hot filth and piped away to our rivers and lakes.

All places and all living things can be defined by the way they handle water. People's relationship with water is grounded in complex interactions with local biological and mineral resources. The entire surficial environment of the earth: geology, soil, topography, flora, and fauna is mediated by water. All living things develop in an aqueous medium in their own genetically defined ways.

As a society, we are becoming increasingly aware that the earth's resources are not limitless. It is less understood, however, that the ability for the earth's natural ecosystems to mitigate the changes we impose and still be able to continue functioning indefinitely, is also limited. Jean Prior (1991) discusses this concept clearly: "People may modify the land to suit their purposes but it is wise to remember that the land must be used in accordance with its capacities as established by geologic history and expressed in landscape shapes and underlying deposits, including groundwater and mineral resources." As Thomas Ferril once said, "We have rearranged the rivers at our pleasure, as one might rearrange the apples in a bowl."

Although vitally important to all life systems, water remains one of the more misunderstood and mismanaged resources on earth. When we are unaware of, ignore, or are wasteful in our relationship to the interaction of water with other natural resources, water can be transformed from a vital resource into a troublesome waste product and potentially a powerful source of destruction—even as it leaves the people of the place where it fell bereft.

People of our culture have become functionally detached from an understanding of how the natural world around us works, unaware of its realities, and unmindful of its capacities. Inasmuch as we have lost touch with the importance of a sustainable cultural relationship with land and water, we have largely forsaken the human relationship with the natural environment and there for threatened our own very well-being..

Our technologies permit us to extract resources from distant places and import them at great expense, which allows us to defer accountability for our behavior insofar as our limited resources are concerned. This curious capacity to deflect or defer accountability for our own failed relationships with land and water seems to be born of a belief that there are no real rules in nature. It is as if one simply can push the start-over button with impunity because science has reworked the algorithms of nature and provided us with an upgrade.

Short of inexorable geologic change, the extent to which we mismanage natural systems is the extent to which these systems become more dysfunctional. Science can no more rearrange the laws of nature than engineers can make water compressible. Our hubris in the mismanagement of water is a primary factor in this increasing level of ecosystem dysfunction.

The range of adverse impacts associated with an inattentiveness to our relationship of water in built and natural environments is profound. Many natural disasters such as floods, landslides, erosion, and other changes, including loss of biodiversity, aquifer depletion and climate change can be traced to our failure to understand the ecology of water.

The purpose of this essay is to examine current problems associated with our relationship to land and water and to suggest that there are creative and economically crucial solutions. Understanding the human relationship to the interaction of water with the geology, soils, topography, flora, and fauna unique to a place is a first step by which a culture can learn to live in a stable harmony with the earth, one which will assure that the next generations will have as many choices and opportunities for *life, liberty, and the pursuit of happiness* as we have had.

The focus will be on the ecology of water within the physical context of the Chicago region and the Midwest.

While the basic principles evaluated here are adaptable to other geographic contexts, the specific applications of solutions will vary. The very first thing we must do, however, is discover the immutable laws of water that, if obeyed, can lead us to a secure and sustained living and promise amongst great beauty and fecundity.

Nature's Water Laws

When precipitation falls from the sky it is oblivious to local regulations and engineering dogma as to where it lands. Each square inch of the earth's surface was custodian in some way to the waters that fall on it. In our area, each square inch accommodated a column of water about 40 inches high every year, or about 0.16 gallons, which is about the volume that is evaporated each year. Aside from the fact that water is non-compressible, there are specific hydrologic circumstances that pertain throughout the glaciated regions of the upper Midwest. If the 0.16 gallons is translocated to the next square inch, then the latter must accommodate 0.32 gallons. Our historic natural wetlands and aquatic systems, including lakes, streams, and rivers were formed from direct precipitation in combination with groundwater discharge. In our biome, aquifer recharge occurred throughout the entire surficial landscape upon which rain water fell; no natural wetlands were formed from surface water runoff.

Historically, water infiltrated the prairies and woodland through soils well endowed with soil organic carbon, the legacy of deeply rooted grasses and sedges. This infiltration set up a flow-net relationship below the surface that is governed by the topography and the nature of the underlying till, outwash, or lake deposits. According to Richardson, Wilding, and Daniels (1992), there are four kinds of water movement dominant in soil development in the glaciated Midwest:

- 1) recharge, or water movement to the water table
- 2) flow-through, or lateral groundwater movement
- 3) discharge, or movement from the water table either to or near the soil surface
- 4) stagnation, or slow water movement creating water table mounds.

The glacial geology of the upper Midwest is characterized prevalingly by limestone or dolomitic bedrock, overlain by gravels, sands, silts, and clays derived from such bedrock. When water moves through these substrates, carbonates can dissolve in the slow moving groundwater, and the discharge will tend to be rich in bicarbonate ions. Bicarbonate-rich water that discharges through upward movement due to evapotranspiration potentials will precipitate carbonates near the soil surface, whereas water that discharges near the water table, such as in seeps and fens, will remain both bicarbonate-rich and isothermic. Either form of groundwater discharge

provides a surface habitat that is virtually stable in its physicochemical and hydrologic properties.

Although water in local wetlands varied enormously with regard to the mixture of groundwater discharge and direct precipitation, most of our more than 700 native wetland plant species are adapted to the stable habitats created by the blend of groundwater discharge and precipitation. Most of these species are denizens of either slightly acidic or circumneutral conditions. Also, most of our soil organisms are ectothermic and cannot endure stochastic and rapid temperature changes. When the rhizosphere soils have sustained levels of soil moisture, because of the specific heat of water, the connection of the soil environment to the thermal mass of the earth is congenial to ectothermic life. When soil moisture is sustained, salubrious levels of organic carbon are maintained, the presence of which, in sustained or accumulating amounts, assures nutrient retention, appropriate pH levels, and soil permeability.

According to Swink and Wilhelm (1994), there are five basic types of wetlands in the region of southern Lake Michigan. These wetlands can be classified generally as aquatic, marsh, fen, bog and swamp. Unfortunately, few of these wetland habitats remain intact today and few people are aware of their inherent biodiversity or their ineffable beauty. To help the reader appreciate the diversity of our local wetland habitats and the varied roles of water distribution in their formation and sustenance, the major community types are described below. Note that surface runoff water, other than clean spring snow melt, is not a significant factor in healthy wetland systems. The extent to which surface runoff waters become diverted to natural wetlands is the extent to which they degrade through loss of biodiversity.

Aquatic plant communities are occasional throughout the region. They formed in potholes and in lacustrine plains where there was little or no discharge. Aquatic communities are sustained by waters from a surrounding watershed greater than that provided by rain over their surfaces. Generally, these excess waters filter down through vegetated ambient ground into the underlying soil until they reach impervious material, and exit by way of springs, rills, or seeps. Along our major streams, aquatic plant communities developed in alluvial sloughs and ponds derived from surface melt or tributary streams. Depending upon the groundwater contribution, aquatic waters ranged from hard to soft, or else they consisted of still-flowing alluvial waters.

Marsh plant communities generally occur along the transition between aquatic communities and drier communities, or in large flats that are regularly inundated by shallow surface waters for much of the growing season. Marshes are best developed locally in the lake plain, in lacustrine flats, and along the lower reaches of the Des Plaines and Kankakee rivers. The sedge meadow,

a community with affinities to fens and wet prairies, develops in large, shallow, lacustrine flats, and is dominated by sedge hummocks. The kinds of surface waters suitable for marshes are those received directly from rain, or as a combination of rain and the essentially clean overflow from streams fed prevalingly by base flow or snow melt.

Fens are wetland communities that occur in areas where the glacial formations are such that bicarbonate-rich ground water discharges at a constant rate and temperature along the slopes of kames, eskers, moraines, river bluffs, or even dunes, or in flats associated with these formations, provided the material through which the waters traveled is rich in carbonates. Depending on the circumstances, fens can occur where marl is at or near the surface or where peats are constantly bathed in minerotrophic ground water. Such areas can be wooded or open. Many fens are generally found on open prairie slopes, and commonly produce constantly flowing rills discharging over the surface. Related to these hillside fens are the wooded seeps that occur sporadically on steep bluffs. In those fens that become peatier, there is a tendency for cation exchange to damp off, causing circumneutral or even acidic conditions, which can occur in the flat, black-soil prairies and in certain morainic depressions. A critical reality here is that even 1 gallon per minute flowing from a year-round rill is the equivalent of about 525,000 gallons per year—half the annual rainfall on one acre. The health and well-being of our discharge wetlands is hostage to the extent to which our land-use practices sustain appropriate levels of infiltration in the groundwater shed of the wetland.

Bog conditions can begin to develop as the cation exchange capacity damps off further and peats develop. Commonly, the peatland floats on a minerotrophic head of water. The deeper roots are thus exposed to calcareous or circumneutral conditions, and the shallower roots are imbedded in the upper sphagnum mat, usually in a more acidic environment. In large basins or in areas where the influence of minerotrophic waters is insignificant, acid bogs can develop. Related to the acid bog, often in sand flats or basins, are floating sedge mats that rise and fall with the surface groundwater water table.

Swamps are wetlands characterized by trees growing in large flats or basins that are poorly drained; most of the water leaves through evapotranspiration. They can occur in the backwaters of large, slow-moving rivers, such as the Kankakee, or in wet sandy flats in the Kankakee Sand Section south of the Valparaiso Moraine. They can also occur on moraines in wet depressions. North of the Valparaiso Moraine, in the lake plain, they are best developed locally in the large flats behind the high dunes, where lies one of the richest and most complicated forested systems in our region. It is characterized by a complex hydrology and is interspersed by gentle rises,

shallow depressions, and hummocks, and consists of an inseparable commingling of wooded fen, bog, and mesic forest.

It is important to understand that the clear line of demarcation (edge) we often search for and identify between upland and wetland habitats in contemporary landscapes is of far less importance in the natural landscape, where the wetland/upland distinction is highly undifferentiated. Such concepts as wetland edge are more artifacts of a regulatory mandate than observable manifestations in a natural landscape, and create the impression among our people that “wetlands” are separate entities from “uplands.”

Also a casualty of politics and regulation is the characterization of **prairies** as non-wetland. From the standpoint of redox and soil physics, the mollisols, or prairie soils, are hydric, which is why, on the Wisconsin till plain, black soils accumulated over the last eras of the Holocene. To have characterized them as such would have been so unacceptable to the “development” community as to have rendered the application of the Section 404 of the Clean Water Act unenforceable. Yet, historically, it was the deeply rooted bunch grasses of these systems that provided the permeability of the silty clay loams that allowed rainwater to infiltrate the landscape and sustain our surface water resources in the form of lakes, streams, and rivers through the constant flow of groundwater discharge. Dominated by regularly burned bunch grasses, these systems also provided a significant daily movement of condensation water into the soil at night, which is one way in which great rivers such as the Fox, DesPlaines, and Kankakee were able to sustain stable base flows of clean water.

Regional Hydrology

In natural areas, the primary recharge occurs in upland to mesic habitats, and discharge can occur anywhere along the spectrum from higher to lower gradients, depending on the relationship of geology, soils, surface and groundwater gradients, and other factors. Imagine the ecological attributes of a landscape mediated by a combination of flora, fauna, soils, and geology, such that groundwater was the dominant form of hydrology, as once occurred throughout most of Illinois and the upper Midwest.

At the time of European settlement, the Illinois River, draining more than one half of the land within the state of Illinois, was virtually still-flowing, with little perceivable discharge into the Mississippi River. According to Barrows (1910), the average fall between Hennepin and Pekin, a distance of 55.8 miles, is 0.82 inches per mile.

“The Illinois is a river of relatively insignificant volume. Its natural low-water discharge is but a small fraction of that of the upper

Mississippi and Ohio rivers. The nearly level channel and the small volume result in a very sluggish river, which has been described as a stream that more nearly resembles the Great Lakes than an ordinary river, and again as one that partakes more of the nature of an estuary than of a river."

Consider these accounts of the now beleaguered Illinois River, once one of the most beautiful and biologically fecund rivers in North America.

"The placid Illinois traverses this territory in a southwestern direction, nearly 400 miles . . . Unlike the other great rivers of the western country, its current is mild and unbroken by rapids, meandering at leisure through one of the finest countries in the world . . . upwards of 400 yards wide at its mouth . . . The banks of the Illinois are generally high. The bed of the river being a white marble, or clay, or sand, the waters are remarkably clear. It abounds with beautiful islands, . . . It passes through one lake, two hundred and ten miles from its mouth, which is twenty miles in length, and three or four miles in breadth, called Illinois Lake [Lake Peoria]." (Brown 1817).

"The Illinois river . . . presents to the eye a smooth and sluggish current, bordered on each side by an exuberant growth of aquatic plants, which, in some places, reach nearly across the channel. We soon found the water tepid and unpalatable, and oftentimes filled with decomposed vegetation . . . There is perhaps no stream in America whose current offers so little resistance in the ascent . . . Both banks are bordered by a dense forest of cottonwood, sycamore, and other species common to the best western bottom-lands. Of the fertility of the soil, no person of the least observation can for a moment doubt . . ." (Schoolcraft 1821).

"We have seen nothing like this river that we enter, as regards its fertility of soil, its prairies and woods; its cattle, elk, deer, wildcats, bustards, swans, ducks, parroquets, and even beaver. There are many small lakes and rivers. That on which we sailed is wide, deep and still, for 65 leagues. In the spring and during part of the summer there is only one portage of half a league." (Thwaites 1900, from Jacques Marquette, around 1674).

It is also significant that this portion of the continent, referred to by Transeau (1935) as the "Prairie Peninsula," lies within a physiographic region where the ratio of rainfall to potential evaporation ranges from 0.6:1 to 1:1. In contrast, in regions where the ratios are greater than 1:1, the tendency is for mesophytic forest to develop. Therefore, when Barrows did his study in 1910, of the approximately 37 inches of rainfall that fell annually across northeast and central Illinois, very little was discharged as surface runoff into the Illinois River. Instead, water either percolated into the aquifers, discharged slowly and evenly to seepage areas and fens, or evapotranspired. Simple arithmetic tells us that a balanced system receiving a given amount of precipitation per year cannot continue indefinitely to evapotranspire the same amount and lose an additional amount to runoff without a considerable increase in dryness—unless there is something remarkable about the

physiognomy of the vegetation, which there is in the form of native bunch grasses and sedges.

While the phenomenon is not widely studied in the temperate zone, it is quite clear empirically that atmospheric moisture, even during "drought" periods, can condense overnight on bunch grass culms and bleed inexorably into the soil, even when the soil surface itself appears dry (Wilhelm 2008). This is probably one reason that prairie plants burgeon and thrive after June 15th, while shallow-rooted wefts of lawn languish.

Weaver and Noll (1935) documented the absorption capabilities of prairie ecosystems and their unique relationship of water, vegetation, and soils, during their grassland studies. According to their findings, "The porosity of . . . moist grassland soil into which the water sinks is impressive. It accounts for the fact that on fully vegetated lands practically no erosion occurs except, possibly during storms of unusual violence, and even then erosion is seldom serious."

In a study involving interceptometers in Nebraska, they noted that eleven rainfall events over a year resulted in the loss of about 1% of the total rainfall from a prairie dominated by *Andropogon scoparius* (little bluestem grass) and with a slope of five degrees. A wheat field under the same conditions lost more than seven times that percentage of water volume, and a fallow field lost more than nine times that of the prairie, or 10.2% of the rain that fell—this at a time when our soils were in much better shape, as abused as they had been.

Such observations are further supported by a study at Iowa State University (Bharati 1996), where, based on eight sampling measurements, a five-year-old planting of *Panicum virgatum* (switch grass) exhibited the capacity to infiltrate, on average, more than 7.5 inches of rainfall per hour; an adjacent row crop on the same soil infiltrated 2 inches per hour.

Water in the Contemporary Landscape

If we wish to influence water infiltration positively, improve water quality, reduce flooding, and restore terrestrial and aquatic habitats, the intricate surface and groundwater relationships of our natural hydrology must be understood and incorporated into planning and land use. It is essential that practitioners responsible for all forms of land use—architects, landscape architects, engineers, planners, developers, contractors, agricultural producers, and government regulators—consider the natural hydrologic patterns not only of the site, but also of the surrounding area or watershed.

Embedded in the conventional doctrine of COLLECT, CONVEY, and DISCHARGE, rainwater is considered a nuisance and inculcated into the cultural psyche as "stormwater." Stormwater, as such, has become a

“management” consideration in nearly every development project. Traditionally, in America, water has been viewed either as a burden, source of contagion, or as a purely utilitarian commodity. Particularly since the Clean Water Act of 1972, professionals have been trained to collect and convey surface waters as a waste product, as quickly and efficiently as the law will allow, from the site in question to areas remote from their purview, presumably to be dealt with by somebody else. They analyze, design, and construct storm drainage and detention systems that attempt to mitigate, through temporary confinement, site and regional impacts of surface water-generated storm flows.

It is rare, however, for these evaluations to consider the natural hydrologic character of the area, or the hydrologic context in which the site and surrounding natural systems formed over geologic time: time measured not by decades or lifetimes, but by thousands of years of system development. These processes were imbedded together seamlessly across the entire watershed. The floristic and faunistic elements of these systems evolved their very nature with the human cultures that depended on them and were compelled to steward their inhabitancy in perpetuity.

Every tract of land, no matter how large or small, is affected by and interacts with water. We are often frustrated by the fact that precipitation falls everywhere, not just in wetlands or in places designated for water detention by engineers and ecologists. Precipitation in the Chicago area amounts to about 37 inches, or about one million gallons of non-compressible fluid per acre per year. When it falls, two things can happen. It can infiltrate the soil and become an asset to local life, or it can run off, leave where it fell in deficit, and become a liability to life and property downstream.

Site development generally results in an increase of impervious surfaces associated with the construction of buildings, roadways, parking lots, and sidewalks. Even landscape systems, particularly those areas dominated by a typical turf grass lawn, can generate significant volumes of dirty, super-heated surface water runoff. Nearly all of the intercepted water is collected and shunted away from the site, in accordance with local ordinance, carrying with it all dissolved and undissolved drugs and applications typically used for turf grass enhancement.

Most contemporary development sites contain an extensive, costly storm sewer network. Such networks quickly convey large portions of every precipitation event, and discharge its flow into the now mandatory detention basin, where its focused energy is released into the nearest stream corridor, or possibly into a larger storm sewer system. Victor Hugo once observed that “The sewer is the conscience of the city.” One has to wonder about the quality of our conscience insofar as it relates to the health and security of our children. Have

we forgotten about what our friend and colleague, John Todd, once wrote? that “Tomorrow is our permanent address.”

Discharged surface water carries with it sediments, greases, oils, in our climate, salts, from roadways and parking lots, and excess fertilizers and pesticides from conventional lawn care. Other areas have no detention at all; runoff is encouraged to flow uncontrolled and untreated into area sewers or drainage ways. In all cases, most of it, detained or otherwise, is passed downstream to somebody else, about whom we evidently must care little.

Much of the water falling on the ambient landscape is no longer able to infiltrate into the ground, where it once provided a constant source of groundwater seepage to sustain a stable stream hydrology, even during periods of prolonged drought. Instead of a stable watershed and associated groundwater hydrology, most systems are now dominated by erratic surface water hydrology. Waterways experience rapid fluctuations in stream-flow velocity and volume, generated almost completely in response to surface water discharges. The force of these combined stormwater flows is focused on terrestrial and aquatic ecosystems, with their inherent soils, fauna, and flora, formed with a completely different type of hydrology. The erosive and destructive power of this shift in hydrology is impressive.

A whole new language of hydrology has emerged in connection with the doctrine of COLLECT, CONVEY and DISCHARGE that makes it difficult to appreciate land and water for the critical resources they are. Words like drainage, ditch, runoff, conveyance, detention, release rate, and water quality run the dialog. Hydrologic aspects of water mismanagement, such as growing season floods and concerns over well depth to water sources, are emblematic of the unlinked consequences of treating water as a pariah instead of as a resource and a blessing.

Drainage ditches are gouged into the landscape where no surface drainage existed before. The collective runoff acts to carve out existing streams and rivers, which results in deeply incised stream banks subject to constant erosion and sedimentation at rates not seen since the glaciers receded. The loss of infiltration and groundwater recharge in the surrounding watershed, coupled with the depression of normal water levels in the stream system, combine to lower the regional water table, and starve the stream during periods of rainlessness.

This unbalanced arithmetic shows up, among other places, in the chronic depletion of our aquifers and the perception that we experience drought. Problematic as this is, is the general impression that our aquifers are bottomless evidently leads engineers and regulators to acquiesce to the notion that we can run half to three quarters or more of our rain, filthy and hot, to a neighbor

downstream, evaporation as much as falls, potentially, and continue to balance the equation.

On the opposite extreme, intense periods of rainfall, once mediated by a landscape highly capable of absorbing and using the water as a resource, now regularly result in flash floods in areas that were not historically subject to flooding. The economic, environmental, and cultural impacts of flooding are significant, and often catastrophic. This contemporary doctrine has converted our once beautiful streams and rivers into deeply incised storm sewer systems.

The instability of stream flow, coupled with degraded water quality, make it difficult for aquatic life to adjust. Desirable species of fish, birds, and other aquatic organisms must struggle for survival in a stream system that may experience virtual or complete desiccation during dry periods and that exhibit increased water temperature and altered water chemistry. Habitat availability becomes critically limiting to most native species. The lands from which the waters were conveyed away downstream are bereft of the water that had fallen upon it and encumbered by an ever more serious loss of the soil and nutrients necessary to sustain stable life there.

Whole sections of stream bank become overgrown with dense stands of trees and shrubs, effectively shading out the deep-rooted perennial forbs and grasses that are necessary to stabilize the soil layer. With the loss of a deep-rooted cover to secure the soil, the bare ground becomes increasingly exposed to erosive forces, resulting in accelerated streambank erosion. A new industry, streambank bio-engineering, has emerged to deal with this phenomenon. Unfortunately, most solutions are doomed to long-term failure unless we find intelligent ways of dealing also with the root cause: mismanaged water.

We have forgotten that floodplains, as we know them today, are not a natural phenomenon, but an engineering term created to describe a zone of flood-prone land that can change just as rapidly as the next upstream development. With each passing generation the culture becomes more distant from reality. Its words take on new meanings in accordance with the real experience of the young.

"River." What image does the word evoke? No longer can our children visualize a placid stream of steady clean flow, flanked by meadows bedecked by flowers, flush with birds and turtles. They picture instead a long channel, with steep muddy banks, that surges with brown roiling water after the rains, and during the "droughts," a scarcely wet ditch with shallow pools of gulping carp, discarded appliances, and abandoned grocery carts.

The Plight of Wetlands

Our society's failure to comprehend and synthesize natural hydrologic processes into all forms of land use is epitomized by our management and definition of what are called in our language, at first colloquial, then jurisdictional, "wetlands." Wetlands are even further defined by the "three criteria" in the 1987 edition of the "wetlands delineation manual," as promulgated by the U. S. Army Corps of Engineers (U.S.A.C.E. 1987). If a landscape does not have hydric soil, evidence of hydrology, and a "dominance" by "wetland" plants, it is not a wetland. Notwithstanding the fact that the mollisols were omitted from the technical list of hydric soils for political purposes, the silliness of these categories has been discussed by Wilhelm (1992), but the mere idea that wetland can be delineated reinforces the notion that they are singular components of our landscape and can be addressed as such.

It is a common misconception that these so-called wetland systems throughout our region rely on surface water hydrology for sustenance. Some practitioners even have fallen into the belief that they are stormwater driven—that water, irrespective of its flux or quality is the operative agent. Most modern wetland literature asserts that the basic value of wetlands is related to their ability to provide "functions and values," namely flood storage, aquifer recharge, "wildlife habitat," and to serve as "nature's kidney" with respect to "cleansing and filtering" stormwater pollutants. Tactical considerations such as "denitrification, biomass production, and flow retardation" are couched wholly in the extent to which these defined systems to "meet the needs of society."

These jurisdictionally delineated systems are treated as if there were something fundamental about the needs and any and all societies, at any given point in time, that relates to the ontogeny, stability, and continuation of earth's ecosystems. There is an enormous body of literature that articulates these issues, well summarized by Kusler (2004).

It is these beliefs and the doctrine of FUNCTIONS and VALUES that are most directly responsible for the degradation or outright destruction of our remnant wetland habitats. This singular approach is also partly responsible for the poor performance of most wetland mitigation efforts. Imagine requiring our kidneys and livers constantly to store and filter a random suite of toxicants. This problem occurs only because we have failed to learn how to recognize and receive rainwater as the blessing and resource that it is, turning it instead into a destabilizing force to be dealt with elsewhere. Indeed, rain has become something little more than a nuisance that ruins the weekend golf game or picnic on the patio.

We are aware of no scientific evidence to suggest that naturally occurring remnant or recreated wetland habitats

located throughout this region benefit from direct surface water discharge and inundation. To the contrary, there is overwhelming scientific evidence that illustrates that surface water inundation of wetland habitats will result directly in their degradation. Research indicates that changes in water quality, water quantity, and physico-chemistry can significantly impact the function and sustainability of wetland systems.

The U.S.E.P.A. publication *Natural Wetlands and Urban Stormwater: Potential Impacts and Management* (1993), summarizes research findings that describe stormwater impacts to wetland habitats. According to this document, changes in vegetative community structure, productivity, water quality, and hydrology are inseparable. Changes in vegetative community structure appear to be correlated with the time of year, water depth changes, and frequency and duration of inundation experienced in the wetland from excess stormwater discharge (Azous 1991; Cooke 1991; Stockdale 1991; U.S.E.P.A. 1985). Changes in water quality (chemistry and sediment loading) have the potential to affect the vegetative community structure and productivity, thereby reducing the availability of plant species preferred by fish, mammals, birds and amphibians for food and shelter (Lloyd-Evans 1989; Mitsch and Gosselink 1986; Weller 1987).

Wetland plant species are generally specific in their requirements for germination, and many are sensitive to flooding. Horner (1988) found that emergent zones of palustrine wetlands receiving urban runoff in the Pacific Northwest were dominated by the opportunistic non-native *Phalaris arundinacea* (reed canary grass), whereas unimpacted wetland plant communities were composed of a more diverse group of native species.

Ehrenfeld and Schneider (1990) discuss the relationship between stormwater discharge and changes in plant community composition. They found a reduction in indigenous wetland species and an increase in the colonization of exotic species due to changes in hydrology, water quality, or both. Van der Valk (1991) noted that wetland species may have limited ability to migrate in the face of persistently raised water levels; many species can spread only through vegetative methods under such conditions. The result may be lowered plant diversity in the wetland-to-upland gradient. This is evident in many remnant wetland systems, where the lower gradient zones subjected to longer periods of surface water inundation have exhibited more substantial degradation than the edges of the wetland.

Studies have been conducted to evaluate hydro-period impacts on individual species. Stockdale (1991) found that *Typha* spp. (cattails) survive well under fluctuating conditions, and that *Phalaris arundinacea* (reed canary grass) has a wide tolerance to water level fluctuations,

though it does not survive long periods of inundation during the growing season.

In contrast, *Carex* spp. (sedges) are highly specific with regard to hydrologic preferences. According to Frederickson (1982), modifying natural wetlands with impoundments may result in radically different hydrologic regimes that are not ecologically sound. The introduction of stormwater runoff or water level control objectives, causing hydrological disturbances in impounded wetlands, could result in the development of stressful habitat conditions.

Changes in the pH of water associated with management practices or the introduction of stormwater also can have an effect on the biota in impounded systems. Most organisms are adapted to function within particular pH ranges, and abrupt or substantial variations in pH can have adverse effects on aquatic life, usually in the form of reduced productivity and increased mortality (Newton 1989).

Urban stormwater can vary significantly in pH, so the variable nature of stormwater inflow could result in abrupt changes in pH in an impoundment. Since only a few species can adapt to conditions of changing salinity, pH, temperature, and dissolved oxygen, low species richness could result (Devoe and Baughman 1986). Given the predisposition of most native species to either ombrotrophic or minerotrophic conditions (Swink and Wilhelm 1994), wetlands dominated by waters with fluctuating physico-chemistry, temperature, and volumes are much diminished in species richness.

Another point to be considered is that the environment least capable of handling excess water is a wetland habitat that is already saturated. This is often the case in detention and wetland mitigation projects that involve the excavation and creation of emergent and shallow water marshland habitats that rely primarily on surface water hydrology for sustenance. Except perhaps for marshes filled pre-jurisdictionally or illegally, the creation of such habitats is not an appropriate form of mitigation—if there is an appropriate form of mitigation.

A principal reason why wetland restoration fail and remnant systems decline is that signal truths about habitats are as ignored by textbook ecologists as much as water is ignored by engineers. If one accepts the tenet that plants and animals grow in habitats to which they are adapted, then he must accept the corollary: if the habitat changes, the inhabitants change. Of the 500 or so wetland plants native to each of our counties, many have been sown in wetland restorations, yet rarely are any of them recruited and sustain. Although there are nearly as many reasons as there are species, an overarching reason for their frustrating absence is that scarcely a handful can endure the degraded quality and flashy nature of surface waters.

Consequently, a wide range of factors must be evaluated to determine effective restoration or water management strategies for any specific project or site. The solution must be one that renders the hydrologic condition more stable, and reduces runoff waters to a level that fosters ecosystem stability.

These findings, which are supported by many other studies, help to shape an understanding of the types of impacts and wetland degradation that are occurring in varying degrees to nearly all the remnant or created wetland systems throughout our region, particularly those that are most directly exposed to rural or urban stormwater runoff. Changes in surrounding land use and vegetative cover have altered the natural hydrology of our wetlands from habitats formed and sustained almost completely by groundwater discharge and direct precipitation, to wetland systems almost totally dominated by surface water hydrology.

As a result of these changes, increased runoff exposes surrounding wetland systems to periodic, repeated inundation. With accelerated erosion, surface water flows carry sediments that are then deposited within the wetland, altering the chemistry, temperature, nutrient cycling, root zone, germination conditions, and other critical growth factors.

The combination of excess ponded water and sedimentation result in the obliteration of the more conservative native wetland species, those plants with strict physiological parameters that constitute complex systems. The high diversity of species that favor isothermic, groundwater-fed alkaline conditions and a very specific hydrological regime yield to a few weeds such as *Phalaris arundinacea* (reed canary grass), *Typha* spp. (cattails), *Phragmites australis* (common reed), *Lythrum salicaria* (purple loosestrife), and a handful of other ruderal species.

This default weed flora is tolerant of direct surface water inundation, rapid fluctuations in water levels, poor water quality, and sedimentation. The tremendous biodiversity, system stability, and biological function of our region's natural wetland habitats are lost.

The “Outdoor Rug” Phenomenon

A trademark of nearly every cultural landscape across the country is the turf grass lawn. This application is emblematic of the complete disconnect with history, place, local authenticity, topography, geology, and even ambient programming, much less an interest in local amenities such as groundwater and native plants and animals. The mass-graded site and “award winning” building and landscape occupy a clean slate, but without even the slate.

The infrastructural aesthetic held by our people and enforced by ordinance is dictated by the lawn. It implies a landscape that requires regular watering, yet can never be wet, that must at once be short, yet lives on fertilizer. The landscape is essentially designed to divest itself of water and resources, the two input components it needs most. This is the legacy of a cultural attempt to create a water-loving landscape that cannot abide water.

To achieve this designed “look,” the topsoil typically mass-graded away, the underlying clay is compacted. The forlorn topsoil is unceremoniously pushed to the side, run over a thousand times until it is compacted and rendered lifeless, referred to thereafter as “dirt.” Bedecked by a few hardy agricultural weeds it lies there in repose until it can be sold off again under the more marketable cognomen, “soil,” minus the several inches of gratuitous veneer that is saved eventually to soften the interface between the clay and flatbed truck loads of sod.

After all the stormwater infrastructure is buried, the exposed clay, which had been colored green on the landscape architects plan, along with thin graphic renderings of people walking happily amongst lollipop trees, a thin layer of sod is rolled out over it. Such sod commonly consists of Kentucky blue grass, *Poa pratensis*, which is not native to Kentucky or even the Americas. This sod, unconnected to water and nutrients but vulnerable to daily temperature changes because of the loss of continuity to the thermal mass of the earth, becomes little more than the supposed-to-be-green background layer on the landscape architects drawing.

In the typical context, the root system is but a few inches deep, and the whole layer represents little more than an outdoor rug with a worn-out floor pad. Because water cannot penetrate the clay floor and the shallow root system will die if it sits in water, the “floor” is tilted at no less than a 1% slope, often a requirement in local ordinances. More expensive or elaborate designs will include bumps or berms placed artistically throughout the landscape, and storm drains situated cleverly so that water will drain quickly from the site, discharging into detention basins at all due deliberate speed.

Current fashion makes it important to maintain the height of the Kentucky blue grass as low as is physiologically possible and still have something that looks like a green rug. This requires virtually constant mowing, lest grass blades here or there get taller than others. Mowing, of itself, might be relatively harmless if it did not use fossil fuel in unremediated internal combustion engines. For every gallon of gas burned, about 15 pounds of various oxides (mostly carbon dioxide, and other worse things), which the ecosystem of the earth has not seen since the Paleozoic (200 million years ago), are produced and given over to our atmosphere.

Since it is culturally important to grow Kentucky blue grass short, it must be fertilized regularly, which makes it grow fast, so that it must be mowed often. Inasmuch as no other living things are allowed in the lawn, the full aesthetic requires the application of as much broad-leaf herbicide and pesticide as the landscape maintenance budget will permit. When it rains, water quickly saturates the rug, inducing runoff that begins its course down the slope, carrying with it herbicides, extra fertilizer, and anything else that had been added to the lawn, including goose poop.

To control the flow into local streams, engineers and designers of such landscapes have fashioned huge holes in the ground, placed tactically to receive such waters and any toxicants, pollutants, or unused nutrients. There, the uncompressible, critical life resource, water languishes, its volume and any dissolved or suspended components to be metered into the nearest stream. Water from such landscapes throughout the watershed accumulates in massive storm surges, filling the rivers with filthy water, eventually passing it along the Mississippi River to the Gulf of Mexico. The resulting floods are blamed on the rain by evening news.

This regular movement of huge volumes of dirty water into the estuarine regions of the Mississippi River delta is contributing to a catastrophic decline in the productivity of the spawning grounds of the Gulf of Mexico. Meanwhile, having sent our rainwater downstream, we no longer have the water to recharge our landscapes. Since water continues to evaporate and transpire, our landscapes are soon dry and sear, often within hours of the last rain.

The solution, inevitably, has been to install expensive irrigation networks to mine water from deep within the ground, a supply that is the largess of a landscape far away that still infiltrates and stores water in net amounts—but nowhere able to keep up with our withdrawal rate. Deep “cones of depression” develop and the groundwater flownet system becomes chaotic. Meanwhile, unsuspecting government-trusting Americans are buying 30-year “adjustable rate mortgages” in areas with half that many years left in the assumed to be bottomless aquifer.

This contrived “living” rug phenomenon has led to a curious infrastructural aesthetic: few other living things are acceptable on the rug. Only certain shrubs, planted in artistic groupings of 5s and 7s, and even-sized, lollipop-shaped trees planted in rows are allowed. Expensive plantings include huge clumps of mulch placed in small rings at the bases of the trees and shrubs the trick the plants to growing roots into the mulch, only to be stranded high and dry when the mulch has oxidized away.

Trees growing in clay holes on bumps commonly do not live long, partly because the holes have either too much or too little water in them. In order to forestall the mortality of ill-fated trees planted out of place, a new industry has developed to provide underdrainage for the clay holes.

The relevant point here is that such trees and shrubs are not really alive in the sense that they are members of a community and participate in the annual replication and stability of that community. These plants are more like concentration camp victims, growing there until they die and replaced by the warden. They have no children adapted to the habitat by time-honored genetic experience and able to adjust to the subtle vicissitudes of changing times at the rates at which mountains rise and fall. Such landscapes are without the capacity to make themselves new again with each passing year. Our landscapes, just like our public-owned corporations, are designed without a tomorrow—their only purpose to accommodate the urges of the moment.

Other than mowing, fertilizing, and pesticing, the only human involvement in such a landscape consists of workers who replace dead trees. Such landscapes are largely devoid of other living things as well, save, perhaps, gaggles of sedentary urban geese that have lost the capacity to migrate, . . . but not the capacity for other bodily functions.

Considering the sterility and lifelessness of our contemporary landscapes, one could get the impression that our culture regards the outdoors as little more than living rooms to be designed only with attention to the vagaries and vicissitudes of the design aesthetic of its day. The people of the culture no longer can see that there really is such a thing as an outdoors, or that it matters. Nevertheless, water remains a real thing, a noncompressible item that flows downhill. The more of it there is, the greater the volume; the greater the volume, the greater the potential flow energy. The greater the energy, the more resources it can carry with it. Water is one of the few resources that winds up on the top of the hill free, as a result of evaporation and condensation, rain, dew, or snow. Other resources, such as nutrients and soil, are less easily restored to the top of the hill. For them, the energy required is not sunlight energy, which mediates water restoration, but some other energy source, and, on the scale of the human lifetime, usually one that involves money and labor.

Water flowing downhill and carrying resources with it leaves the top of the hill bereft of resources, and renders the bottom of the hill surfeited with them. The same force that brings water free to the top of the hill enforces evaporation potentials such that, in the Chicago area, about one million gallons of water are evaporated from each acre per year, which is approximately the amount that falls annually. The first principle of our contemporary culture seems to be: get as much water out of sight as fast

as the law will allow. Depending on local ordinances, the rate of disposal can vary, but all of it must leave. Just how the downstream neighbors handle it is their problem—but everyone demands access to what little is left in the aquifers. As the water begins to run out government politicians are suppose to “do something about,” since it was the [insert current president] administration that did this to us.

It is not sufficient, once the liabilities associated with the contemporary aesthetic are understood, simply to stop all the mowing, watering, fertilizing, and pesticing, and “let nature take its course.” This contemporary landscape has nowhere near the stability or biodiversity to coalesce into a self-sustaining, self-replicating ecosystem. If current human involvement were simply to disappear, the landscape would not succeed into some pre-Columbian Eden. Rather, if the Kentucky blue grass were to go unmowed, a few other weeds like bull thistle and dandelion would flourish along with the grass for a few years, eventually giving way to weedy shrubs and trees, such as buckthorn, box elder, Amur honeysuckle, and black locust. Over time, the few ground cover weeds would be shaded out, soil would erode, and the roots of the trees and shrubs would become exposed and begin to topple. There would be few butterflies, birds, or anything else, other than perhaps some roving gangs of starlings feeding on box elder bugs. All the while, water, soil, and other resources will run downhill, polluting the rivers and putrefying the seas.

It should be noted that the authors are not opposed to the use of turf grass lawns altogether. There are many useful applications for turf grass, so long as they are designed in a context that nurtures the rain that falls upon them. We are opposed, however, to the contemporary mores that demand we default the entire outdoor landscape to turf grass, particularly when other landscape treatments are available that are far more ecologically and economically sensible.

What would be so wrong, so unattractive, so heretical to look out upon, indeed, walk within, a landscape inhabited by a profusion of native grasses and sedges, replete with comely perennials and colorful butterflies, infused with flowering shrubs, and dominated here and there by groves of trees—trees with futures? Would it be so radical to propose that trees be free to grow branches in whatever manner the habitat permits, and to grow broad, expansive root systems with a diversely populated rhizosphere rich in water and mycorrhizal fungi? Would we be so unable to countenance clean streams and rivers that flourish with fish and mussels and abound with birds? What would be so wrong with assuring that our children and theirs have access to clean water forever after? Or is our own reflection in the pond so endearing to us and our cupidity so entrenched that we find it acceptable to let our children and theirs shift for themselves?

The Agricultural Dilemma

Water in nearby agricultural lands is disposed of just as foolishly. Prairie lands, with their deep roots and water-holding root systems, once stored net amounts of fixed carbon each year in the creation of deep black soils. Very little water ran off the surface of the land. Most of the water either transpired through the living tissues of hundreds of different species of plants or seeped at a constant rate into the groundwater, only to discharge finally in fens and springs far from where it fell. The richness and fertility of Midwestern soils owes its properties to the hydrology of the grasslands, where subterranean reduction exceeded oxidation.

Weaver and Noll (1935), scientists embedded in a culture chastened by the “dust bowl” and world-wide economic depression, described the erosive effects of tillage on prairie soils.

. . . on bared or sparsely vegetated slopes both run-off and erosion may occur after relatively light showers. It soon becomes clear that the most important factor tending to decrease erosion in non-tilled lands is the maintenance of a plant cover.

The quantities of water lost during torrential rains even from small areas are impressive and naturally lead to calculations of the amounts running off from whole hillsides, the total amount of soil removed, the effects of this run-off in forming gullies and ditches, and of the sediment finally silting up the fertile lowlands. The water is lost to ground storage; the deepening of gullies and ditches lowers the water table, which results in a constant tendency of the water in the upper layers to sink to lower levels. The habitat is gradually changed. The hard, compact, poor absorbing surface left after severe erosion is always impressive. That the water holding capacity is reduced is not difficult to understand. . . . erosion can be held largely accountable for disastrous floods, on the one hand, and drought on the other.

Had we exhibited a little perspicacity, these lesson could have been learned a half century earlier. Our misbehavior in the landscape, and awareness of it, is hardly a new phenomenon. Amos Sawyer (1874) noted that:

During the last twenty years our climate [in Illinois] has been slowly but surely changing from wet to dry. . . . But the most important agent [of this change]—one that is yet to produce greater mischief—seems to have escaped [our] attention: it is the aqueous. The chemical and mechanical effects of this agency are constantly at work, and the result is plainly visible in the deepening of the channel of all our small streams. [It] is hard at work night and day, summer and winter, overcoming every obstacle placed by nature or man to impede its progress. The work marked out for it to do is no less than the complete drainage of the ponds and lakes of our prairies: and so surely as the world stands, so surely will the task be accomplished. . . . Every little streamlet has its miniature Niagara Falls: but, unlike their giant relation, they are making visible progress every year, and are consequently (strange as the language may seem) more instructive. The “hard-pan,” which only yields after repeated blows from the sturdy laborer’s pick, and grinds off its steel

at the rate of two inches per day, crumbles and gives way under the combined agency of frost and water: the largest trees in the forest yield to the conquering element. . . . Every little streamlet is bringing its bed down to a level with its parent stream, and the merry rippling of their little cascades greets the ear on every side, and tells you in language not to be misunderstood that they will in time accomplish the work allotted them to perform the thorough drainage of the land through which they pass.

Illinois's topsoil, once fertile beyond imagination, now chokes the last of life from the Illinois River. Demissie and Bhowmik (1987) note that the average depth of Lake Peoria in 1903 was 8.0 feet, but by 1985 it was no more than 2.6 feet deep. Ironically, the Corps of Engineers has spent and continues to spend millions to sustain a 9-foot barge canal down the middle of it.

The huge fishery along the Illinois, which, in 1908, at its peak yielded 24 million pounds of fish, by 1964 yielded only 1.5 million pounds (Emge *et al.* 1974). The mussel-fishing industry, once huge, no longer exists. The reasons for this decline are many and complex, and Illinois biologists have been writing about the effects of man on the Illinois River for many years (Bellrose *et al.* 1979; Mills, Starrett and Bellrose 1966; Starrett 1972).

For the first half of the last century, the Peoria lake filled at a rate of about 0.05 foot per year, which was too fast to sustain a diversity of life forms. From 1965 to 1975 it was filling at a rate five times that, and from 1975 to 1985 the Lake Peoria section of the Illinois River was gagging on 0.12 foot of agricultural sediment per year.

The Heartland Water Resources Council estimates that by the year 2040, Lake Peoria will have vanished as a water body, leaving little more than a narrow and muddy navigation channel. Mike Platt, executive director of the council, sees a grim future, the lake having "turned into willow thickets and mudflats by 2016, swarming with mosquitoes, with only a narrow, muddy barge channel open for boating. Marinas will have become ghost towns. Waterfowl will have fled and fish will have declined. Property values will have plummeted. What will properties along the river be worth when (people) look out over willow thickets and mudflats?" (Peoria Journal Star, August 7, 1996).

Soil erosion and hydrologic alterations to the landscape associated with conventional tillage practices trigger other detrimental side effects. A recent SCS study (1990) concluded that, of the original average 18 inches of topsoil across the state of Iowa at the time of settlement, 10 have been lost to wind and water erosion, and that, of the remaining 8, half the tilth (related to soil organic carbon content) is gone. When soil loses tilth, it loses its organic matter, and therefore its ability to absorb water and hold nutrients. The corollary to lost water absorption is increased erosion, and therefore exaggerated divestment of erodible resources, which then

accumulate in somebody else's back yard in amounts too great to be useful, if not actually destructive. The long-term consequences on both the local and broader economy are frightening.

As the water in the soil is drained away, the reduction/oxidation relationships change dramatically. Whereas, once the prairies held their water and carbon was fixed beneath the surface in net amounts, annual row crop tillage now causes carbon to be oxidized more rapidly than it is fixed, a situation exacerbated by the constant drain of water through the tile systems and into the ditches. Consequently, during each growing season, carbon dioxide that was fixed and fossilized millenia ago is now released into the atmosphere in amounts greater than it is taken up, potentially contributing to the problem known as global climate change.

This net release of soil organic carbon (SOC) is not a minor concern. Recent studies on the amounts of carbon stored in the Conservation Reserve Program (CRP), in which deep-rooted native grasses are planted in some of the less productive or more erodible soils, have shown that nearly ten years of SOC storage can be oxidized within a single growing season after tillage. These amounts can be impressive, since land in CRP, over a broad geographic area, can gain an average of 0.5 tons of organic carbon/acre/year (Gebhart *et al.* 1994).

According to Wilhelm (2008) *The loss of tilth in our farmlands, particularly since the 1920's, has led to progressive needs to fertilize, herbicide, and irrigate. The costs of these "inputs" has drastically reduced the profit obtainable on a bushel of product, so the federal government, under the aegis of the protection of the "family farm," has instituted staggeringly high subsidies to assure that corn and soybean production, specifically in the Midwest, remain a stable enterprise, although by 2002, 80% of the subsidy was going to corporate agriculture.*

In 2002, the "Farm Bill" budgeted 190 billion dollars to be spent through 2012 on farm subsidies. "This bill is generous and will provide a safety net for farmers, and it will do so without encouraging overproduction and depressing prices," President Bush placated us the at a signing ceremony. "It will allow farmers and ranchers to plan and operate based on market realities, not government dictates."

The family farmer is so in debt on the purchases of huge farm equipment designed solely to produce massive quantities of corn and bean, the re-investment in any alternative crops or equipment is an untenable financial possibility.

Inasmuch as alternative crops are not feasible to produce, the huge supply of corn and bean produced keeps the prices down. More land is tilled annually to achieve the subsidy, and more of what is left of our topsoil is lost.

With the recent increases in oil prices the idea has taken hold that converting corn to ethanol to dilute the consumption of oil makes some kind of sense. It is said to be a "win win" program: we can reduce

the growth of oil consumption, even as we provide the "family farmer" a new market!

This headlong rush to "go yellow" has increased demand on corn, which has led to higher corn prices, an ostensible positive, albeit only for the short term. This hunger for corn production has stimulated the removal of more land from the Conservation Reserve Program (CRP). According to the USDA, about 2.5 million acres of CRP will be tilled in 2008, largely to capitalize on corn production. Not taking into account the fossil fuel inputs to corn and ethanol production, the increased tillage of our land just exaggerates the loss of soil organic carbon.

According to one analysis of USDA figures, by Philip Corzine, "farmers typically don't idle their top-producing land in the CRP program and a great deal of the acres in this program are in fact, much better off never being farmed. So even the "best land" coming out of CRP will likely be at the bottom on typical yields, regardless of what crop is being produced.

As we continue to pump drugs and subsidy into a senseless agricultural economy, the nation's life's blood, water, and natural amenities continue to bleed and gush downstream, local economies throughout their area of impact are destroyed and the health and well-being of our children and theirs are held hostage to the spawn of Narcissus. The same system imposes intense tax and regulatory burdens on entrepreneurs who are attempting to bring genuine family farming back to the purloined of and even into towns and cities where our citizens could have access to healthy food and clean water in perpetuity.

Misunderstandings in Natural Land Management

Water is even overlooked as a factor in the interpretation of natural areas. In a polemic on the management of remnant natural woodlands in Illinois, Wilhelm (1991) points to the hydrologic changes occurring deep within the shade of Midwestern woodland areas. Much of the change can be attributed to the cessation of annual fire, which was practiced by the native people for millennia before European settlement.

These observations were amplified by Wilhelm & Rericha (2007). Already . . . where shade has become the most extreme and herbaceous ground-layer the thinnest, the forest floor is open to sheet erosion. It is evident that the increasingly species-poor community of the [woods] no longer can hold water or soil. Recent and dramatic increases in the number, depth, and width of erosional ditches, though not yet quantified, are obvious to those who have been watching. It is yet to be determined just how much water is running off the slopes, but indirect evidence suggests that it is a significant percentage of the annual precipitation. . . . Because summer and fall vegetation on the forest floor of the [woods] is sparse, much annual precipitation sheet-flows toward ever deeper erosional ditches and carries with it soil, native

plant seeds, and diaspores. Tree buttresses are wholly exposed and some have been undercut by loss of soil. Many small maples are undercut and propped on their roots, 5 cm or so of soil having washed away since their germination 10-15 years ago. . . . Although woody mesophytes are the prevailing species at this time, simple arithmetic tells us that no balanced system receiving a given amount of rain per year can continue indefinitely to evapotranspire the same amount and lose an additional amount to runoff.

Indeed, as the water table lowers, these mesophytes will be less and less able to draw upon the deep ground water accumulated in the presettlement [period]. Droughts and episodic rainfall events inevitably begin to take their toll on a system that has become overstocked with phreatophytes [water-loving plants] and no longer has sufficient means for holding precipitation. The cumulative negative effects of such natural system collapses are now felt throughout the streams and rivers of the prairie province, ultimately to degrade and diminish estuaries of the Mississippi River delta region, spawning ground for many fishes of the Gulf of Mexico.

Hydrological impacts associated with shortsighted land management practices are not limited to the Midwest. Note the following citation:

The trees are large and noble in aspect and stand widely apart except in the highest parts of the plateau where the spruces predominate. Instead of dense thickets where we are shut in by impenetrable foliage, we can look far beyond and see the tree trunks vanishing away like an infinite colonnade. The ground is unobstructed and inviting. There is a constant succession of parks and glades--dreamy avenues of grass and flowers winding between sylvan walls, or spreading out in broad open meadows. From June until September there is a display of wildflowers which is quite beyond description. The valley sides and platforms above are resplendent with dense masses of scarlet, white, purple, and yellow. It is noteworthy that while the trees exhibit but few species the humbler plants present a very great number both of species and genera. . . .

Dutton (1887) wrote this in his physical geology report on the Grand Canyon district in Arizona. Since then, overgrazing and fire suppression have so depleted the Colorado River watershed of its capacity to absorb water that the dramatic topography is able to conduct massive amounts of precipitation rapidly to this once beautiful canyon. The immense flow energies and scouring capacity of the water have rendered the canyon little more than a deep and wondrous landscape, bereft of the verdure described by Dutton. The uplands, once blessed with the deep root systems of bunch grasses and many flowers, are now heavily eroded and largely defaulted to compacted soils, shallow-rooted Asian brome grasses, and sage-brushes.

Consider the plight of the western valleys and bays. Currently, stands of pine, juniper, or oak, undisciplined by

regular controlled burns, according to the custom of the native peoples, become ever more dense, and their leaves accumulate for years beneath them, unable to decompose as fast as they fall in the dry climate. The leaves shade away the ground cover vegetation, and therefore reduce the slopes' capacity to hold water.

Finally, when the winds are high and the humidities are low, the inevitable uncontrolled fire starts, with catastrophic results. The heat produced is tremendous, many trees are killed, the ground is laid bare, and life and property are lost. When the rains come, waters flow freely over the erodible exposed soils, and fill the streams with sedimen-filled, scouring, roiling waters that immediately debauch into the bays, befouling them as well. Soaked slopes without a stabilizing root architecture slip away, carrying everything upon them, including houses and roads. Such events inevitable are blamed on rain, Santa Ann Winds, global climate change, arsonist, the [insert current president] administration—just about anybody who is not us.

Imagine the coastal ranges and the Sierras of the western states, currently so bedeviled by catastrophic wildfires, mud slides, and water shortages, again replete with healthy pines, flower-rich slopes and chaparrals, and streams again filled with base flow waters. Today, people fear the fires and resent the mud slides, complain of water shortages, and decry the pollution of the bays, as if there were nothing that could be done about it.

Attentiveness to the fire practices of the native people, the natural hydrology, and the local ecology could be incorporated generally into all manner of landscape designs to render a land rich in flowers, safe from uncontrolled fires, unsusceptible to mud slides, and nurturing to the major rivers and bays. As the awareness and correlative ethics of the people grew, so also would the health and safety of the land.

The Nature of Landscape Evolution

Impacts to historic biological systems, as a result of processes associated with European settlement, have occurred with a magnitude and rapidity without precedent in the history of the continent's biota. In plant communities, for example, there is a striking difference between areas inhabited by a full component of locally native species and those inhabited predominantly by weeds. The conservative systems contain native biodiversity that is suited to the processes, and they will exhibit long-term stability.

Weed communities, by comparison, are adapted either to catastrophic disturbance or the kinds of activities associated with traditional agricultural cultural landscapes. These weed communities contain neither the biodiversity nor the aggregate adaptive ability to coalesce into self-replicating, sustainable systems.

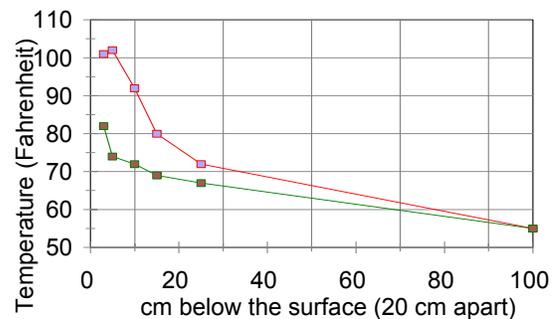
In our contemporary, fragmented landscapes, the conservative elements of our native systems, supplanted in place, have neither refuge, effective migration routes, nor the time to adapt or move. Rather, their populations are decimated time and time again until their local extirpation or ultimate extinction occurs. The destiny of many systems dominated by weeds is further destabilization, during which resources such as water, soil, and nutrients are often lost at rates faster than they are replaced. (Swink and Wilhelm 1994)

Wilhelm (2008) notes that *All native plants and most animals are ectothermic, and owe healthy metabolisms to their ability either to thermoregulate or grow in an environment where moisture and temperature levels are essentially stable. Just as endotherms, such as ourselves suffer from even a 1° Celsius (1.8° Fahrenheit) temperature change, so also do ectotherms. All enzyme systems are subject to van't Hoff's rule, so temperature changes of that sort can be quite disorienting for organisms.*

In our own studies (e.g. Wilhelm & Rericha 2007), we see the impact of SOC loss regularly on the diminished diversity and quality of remnant ecosystems. At a sandy prairie remnant in northwest Indiana, for example, where bunch grasses had been removed through mechanical disturbance, the sand was much hotter than the ambient temperature.

The sand in the nearby swards of bunch grass, mostly Andropogon scoparius, were quite cool, even in a zone 20 centimeters from the open disturbed sand. There were no nests of ants in the open sand, there were three species of native ant in the sward of Andropogon scoparius: Forelius pruinus, Aphaenogaster treatae, and Formica dolosa. This area is an Indiana Nature Preserve, known for its native fecundity and diversity, virtually none of which can endure such unmitigated hot summer sand. In the accompanying illustration, it can be seen that the soil temperature at the surface is twenty degrees warmer than in the clump of nearby Andropogon scoparius.

Soil Temperature in Sandy Prairie
in *Andropogon scoparius* (ambient = 70)



The phenomenon is generally the same, though somewhat less dramatic in our loamier soils, particularly those of agricultural character. As soil moisture drops below 50% or so, seasonal and even daily temperature ranges become more extreme, the pH rises (in

local soils), and biodiversity is much diminished. Studying it as intimately as we do, we can equate it to the earth's life zones as experiencing fever and chills.

Such conditions are not isolated. Less than 1% of Illinois' landscape is in remnant vegetation, the rest is largely in dewatered agriculture, pavement, lawn, or rooftop. The growing season for native species is about seven months. Soy beans and corn are about the only living thing over more than 80% of the state's surface area, but only for about 3 months. For the other 4, there is no photosynthesis, respiration, transpiration, condensation, reproduction, or any other evidence of life in our soils. They simply lie there, run off water when it rains, and become hot in the day and cold at night.

While we have no way of relating this phenomenon directly to "global warming," there is no question that the Mid-western climate is changing. We might also want to make a distinction between climate as climatologists see it and climate at the scale where most terrestrial organisms live, the boundary where heaven and earth meet—the several feet or so just above and just below the earth's surface. My suspicion is that the two climates are not unlinked.

It has become the mantra of the erudite and those "in the know" to proclaim that all these issues are not man's [person's] doing. Actually, all these "environmental issues," such as global temperature, floods, drought, and extinction, are natural and cyclical.

As Wilhlem (2008) points out, *over the last 300 years, for the first time in the history of the world, the human being abrogated an age old relationship with the living earth. Never before have significant masses of land been ditched, tiled, and so wholly dewatered. For the first time in the history of the world, the aquifers have been undergoing dewatering, with large cones of depression spreading across significant portions of continents. Never before has 99% of the biodiversity of the life zones of a continent been replaced by monocultures of commodity products.*

A cycle is something that continues to move in a progressive pattern, always to return to a previous circumstance. Cultural value changes seduced from exponential changes in tool production and use, through technological change, along with the widespread tendency to make commodities out of the necessities of life: food, water, and shelter, has resulted in the massive mining of critical resources. When mines run out, their supporting towns are abandoned; the people go elsewhere. The reader can ask himself what happens when nations mine away their water, soil, and biodiversity, replace them with drugs and manufactured items, and divest themselves of an interest in next generations in order to optimize apparent quarterly performance.

Restoring a Cultural Relationship with the Land and Water

What do we mean when we say we want to restore the landscape, or restore the health of the earth? What is it that needs to be restored? How do we know when the land is healthy? Such questions can be hard to answer

for a people who have become so distant and removed from the idea that their relationship with the earth is integral both to the long-term perpetuation of their culture and the renewability of the earth's living surface.

One way of approaching the answers to these questions in human societies, for example, is to regard a culture healthy so long as it continues to renew itself with each new generation of individuals and families. The health of a culture is dependent upon the behavior of the individuals within it.

Each individual is born with a unique combination of genes that the culture has never experienced before, and is born into a time and circumstance that has never been before or will be again. Individuals are reared in the ways of their people by the family within the culture, and draw strength and experience from the knowledge and wisdom of their elders.

With an eye toward tomorrow, these elders have tested the knowledge and wisdom of their forebears, made scarcely detectable modifications in response to their own experience with their people and their land, and passed it along to young ones. In this way, the health of the culture is assured, as the people, utterly respectful of the experience of the past, respond to the subtle vicissitudes of an ever changing earth, so that their culture might perpetuate itself and replicate the full potential of human experience with each passing year.

Take the metaphor of the Turtle Mother, as propagated by many of the native peoples of eastern North America. The elder tells the story, a care-worn hand touching the shoulder of the young one. "The earth is on the back of the turtle. So goes the turtle, goes to earth." The young one can see that if he befouls the waters wherein the turtle lives, so also he befouls his own world. If the turtle dies, so also the people die. The circle of life is broken, and the earth falls off the back of the turtle.

So it is with the ecosystems of the earth with which human cultures interact. The warp and weft of life and human culture on any remnant acre of the earth is unique to the earth. No other complex of genetic expressions has such an experience of the singular geological, historical, and climatic definition of a place as do the organisms that have long residency in it. With each passing season there is a propagation of young with genes that are at once nearly identical to those of their parents, yet manifesting combinations of genes that have never been before. With the inborn "experience" of long-time residency in their habitat, the next generation is at the same time equipped to accommodate subtle shifts in climate and the gradual changes brought on by mountains and seas rising and falling.

This co-evolution of life forms with the geological and meteorological transformations of the earth occurs at a

time scale that is inextricably linked with the regular cycles of the earth around the sun, and the time periods necessary for individuals of populations both to transmit the experience of the place to subsequent generations and yet to allow small genetic changes to satisfy subtly new conditions.

Rates of change in human cultures and ecosystems are buffered against catastrophic collapse by an internal diversity that works to protect the whole against the development of exaggerated, untested individual behaviors or genetic malformations. Without such protections, rapid, system-wide changes can cripple the system's ability to renew itself and conserve its local knowledge of the place.

The health of an ecosystem or a culture degrades in accordance with the degree to which it destabilizes or simplifies itself, and there comes a time when there is not enough diversity within the system, with either enough memory of the past or enough potential for the future, to continue. The evolution of a system so compromised ceases.

Establishing a sustainable relationship with the living earth requires the reintroduction of a capacity for change. Water out of place is a primary agent in both cultural and ecological instability; therefore, our relationship with water is related to our ability to sustain a culture and the culture's ability to sustain the living fabric of the earth.

The Challenge to Ourselves

We believe that sustainability is an overarching principle in all of our relationships with our land and water. To support the hydrologic cycle, ecosystem stability, and other critical natural processes, it is necessary to consider local, regional, or even global issues on land use of all sizes. In contrast to a sustainable approach, much of our contemporary infrastructure and conventional planning methodologies are products of a contrived visual aesthetic with little understanding, relationship, or grounding in the unique realities of place.

Such methodologies represent a cultural indifference to the function of natural systems, or even the energy required to maintain this infrastructure, much less any long-term consequences. This is especially true with respect to the dynamics of water. Site planning and development, as a whole, must evaluate local natural systems and integrate their essential aspects into problem solving techniques, such that design is based on historical patterns of terrain, water, and climate.

A primary obstacle facing sustainable planning and design is that no one profession has the depth of training and skills necessary to do it alone. Sustainability requires a multi-disciplinary approach. Traditional academic degrees and professional training lead us to believe we

have earned the competence to solve very specific types of problems. As David Orr (1995) points out: "The ideal of a broadly informed, renaissance mind has given way to the far smaller idea of the academic specialist."

To overcome this impediment, the challenge to planning and design professionals is to synthesize a broad spectrum of expertise. The leaders of future sustainable development must be able to facilitate a dialogue between environmental scientists, landscape architects, engineers, builders, planners, architects, local, state and national decision makers, and a public that expects quality of life to be supported by its environment. It is encouraging to see that the seeds of sustainable planning, design, and development are emerging from a variety of disciplines.

If we are to shift toward sustainability successfully, we must first address several basic shortcomings that are pervasive in the planning and design professions, including landscape architecture. Design professionals must learn to recognize the drawbacks associated with continued reliance on the standard default, an unwieldy combination of visual aesthetics.

"If it comes down to a decision between good design and the environment, I'll always opt for good design." Thus proclaimed a design practitioner in one of the professional design journals several years ago. This is a curious, disturbing statement, but unfortunately, it is a sentiment too commonly expressed among contemporary design professionals. How do the criteria for "good design" differ from those for "the environment"?

What is the controlling factor in aircraft design--performance and safety, or just aesthetics? Is not the performance of the land on which we live and depend just as important as the performance of a transportation vehicle? A safe, high-performance airplane is inherently attractive. So also would be a building and landscape well integrated into the place.

Sustainable design is more than artwork, and more than a painting or a piece of sculpture. It is the achievement of artistic goals within the parameters set by the chain of an unfolding past and future. Every form of development on the land, no matter how small, requires an understanding of the relationship between land use and its impact on water and other resources. The implications of this understanding must be disciplined by a cultural ethic that mandates a response that accommodates ecological and cultural stability.

Fellow humans have voices, and are subject to whims and temporal urges. They have faces and money. Too often it is easy to be seduced into believing that the exigencies of the day are paramount. Few people see the faces of plants and animals. Plants and animals have no money. Yet, attentiveness to the exigencies of their survival is

profoundly informative in regard to the requisite relationship we must develop with the living earth.

Building a sustainable relationship with the living earth requires that our actions be grounded in environmental realities. In a culture-driven society, this requires an ethic. Since the beginning of the Holocene, and perhaps for much of the Quaternary, an important component in the shaping of the landscape has been mankind. Human beings are governed not only by random interactions within the ecosystem, but by choice. Fundamental interactions such as predation, competition, and foraging are complicated by the fact that humans can decide how to act, often with no immediate ecological parameter coming to bear on this decision, other than a human ethic.

According to Leopold (1966), All ethics so far evolved rest upon a single premise: that the individual is a member of a community of individual parts. His instincts prompt him to compete for his place in the community, but his ethics prompt him also to cooperate. The land ethic simply enlarges the boundaries of the community to include soils, water, plants and animals, or collectively: the land. We can be ethical only in relation to something we can see, feel, understand, love and otherwise have faith in. A land ethic, then reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land.

The design of environments where humans and other organisms interact, where actions create reactions, where the future is built on an understanding and appreciation of the past, requires that good design and the environment be synonymous. Regardless of scale, the design of sustainable environments means facilitating human purposes in concert with natural processes.

Once we understand the realities of place, there are infinite opportunities for creative expression; true design freedom is possible only within these limits. Since every place is unique, every design will require new creativity, innovation, and technology. A new aesthetic, encompassing every aspect of infrastructure, will emerge as we become more successful at designing whole systems. This requires a design process based on the interconnection of natural systems, and an increased understanding of the relationship between an individual site, the surrounding region, and beyond. The products of such design will be both visually interesting and sustainable if they integrate basic physical and behavioral factors into the solution. (Patchett and Wilhelm 1995)

As our awareness of the reality of sustainability expands, the attributes of environmentally grounded design will be simply and clearly expressed, without hindrance to a formal and purely aesthetic design paradigm. As Orr (1995) contends, "When human artifacts and systems are

well designed, they are in harmony with the ecological patterns in which they are embedded. When poorly designed, they undermine those larger patterns, creating pollution, higher costs, and social stress."

In our opinion, if sustainability is to be achieved, it will require a collaboration of philosophy, science, ethics, and creativity. Water management is a key touchstone of sustainability. There is no other resource or form of energy, with the ability both to sustain or destroy, more powerful than water.

A principal reason why wetland restoration fail and remnant systems decline is that signal truths about habitats are as ignored by textbook ecologists as much as water is ignored by engineers. If one accepts the tenet that plants and animals grow in habitats to which they are adapted, then he must accept the corollary: if the habitat changes, the inhabitants change. Of the 500 or so wetland plants native to each of our counties, many have been sown in wetland restorations, yet rarely are any of them recruited and sustain. Although there are nearly as many reasons as there are species, an overarching reason for their frustrating absence is that scarcely a handful can endure the degraded quality and flashy nature of surface waters.

Summary

We were dismayed, although not surprised, to hear the conclusions of a recent report presented to the president of the United States by a so-called "flood expert," proclaiming that floods are a natural phenomenon, and that nothing can be done about them; that we can only plan ahead to save lives. To the contrary, floods, as we know them today, are not a "natural" phenomenon. In presettlement landscapes in the Midwest, the only substantial form of flooding generally occurred during the spring snow melt, when grounds were still frozen and incapable of absorbing the meltwater. It tended to create expansive, placid, still-flowing pools, quite a different form of hydrology from the snow melt dynamic in today's urban, suburban, and rural landscape, the volumes and characteristics much altered by numerous hydrologic and hydraulic modifications in the land.

Until our people can comprehend that the devastating floods of 1993 in the Mississippi River valley were not caused by an unusual and excessive amount of rainfall, but rather, by an unusual and excessive amount of rain falling on a landscape sorely needing water, but stripped of its capacity to absorb it, both droughts and floods will continue to become more frequent and catastrophic.

A principal cause of many of our water problems is directly related to the self-deception built into land use policies of all kinds. Many policies consist of agendas that are characterized by unrelated values and narrowly focused priorities. For example, local stormwater management

ordinances routinely focus on water quantity issues, because many voters live in flood-prone areas. Such ordinances reflect little understanding of water quality or the implications of how water is dispersed throughout the landscape, because few voters are aware of the ecology of water so long as it is not in their basement or inundating their roads.

Decisions made in such contexts may appear to be economically sound because they are supported in part by a series of federal, state, and local programs, but the long-term economic and ecological consequences of such actions are rarely recognized. A redirection in these programs that integrates sustainable economic and environmental objectives will give decision makers better choices and solutions.

Another barrier to sound policy is a lack of knowledge within the citizenry and their elected representatives regarding their environment and sustainable economic alternatives (DuPage County Environmental Commission 1993). No one factor will guide future sustainable land use and site development more than education. Making informed decisions is paramount to preserving the quality and quantity of the earth's resources.

A primary goal of sustainable design in building and site development should be, wherever possible, to retain water where it falls, treating the water as a resource, not discharging it as a waste product. This will require new design innovations throughout the urban and rural environment in the form of buildings that detain and use water, redesigned site drainage systems that replicate surrounding natural hydrological patterns, and the integration of landscape systems with agricultural crops that have specific water holding capabilities and are uniquely adapted to the region. Many of these ideas, in various forms, have already or are currently being introduced in a wide range of areas around the globe.

Since precipitation is universal, our relationship with water must be developed everywhere. Every form of land use, whether urban, suburban, rural, or otherwise, must be based upon a clear understanding of the relationships of water within the physical characteristics unique to each place. Whatever the context of human inhabitation or nature's hydrology, the manner in which water is incorporated into the design, development, and management of the land should be such that water does not act as a depletor of resources. It is our proposition that a sustained economy and culture are most assured if priority is given to developing new paradigms that incorporate water into our lives in ways that sustain life and nurture our precious resources.

Today, we divest ourselves of natural resources and sterilize our imaginations in regard to creating economic growth, jobs, and prosperity. Envision, instead, a new economy, defined by the extent to which we reinvest in

natural resources, as industrial, urban, residential, and agricultural North America is redesigned and rebuilt sustainably. Children who now are born into a world feeling that there is no hope for a sustained future can be enlisted into a cultural recovery program based on reality and a sense of tomorrow. Whatever their particular bent or special gift, their youthful energies, and natural openness toward tomorrow can be deployed within a new cultural ethic, one that engenders hope and a sense of self-worth in a world in which elders pass along wisdom, as well as knowledge.

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