Learning From Nature

Landscape Architecture and Park Design Fundamentals

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LEARNING FROM NATURE

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Nature is really good at making places for multiple organisms to live in harmony for long periods of time. Think about it, at the time of European settlement, Nature had created a home for thousands of flora and fauna to occupy the prairies for thousands of years. And while at an individual level all things may not have been harmonious, at a large enough scale it was. Even today, hundreds of years after much of the prairie has been plowed over and turned into lawn, roads, buildings and more, even the most rudimentary ecologist will find Nature has found a place for hundreds of different species living in your neighborhood. (That's not even counting the stuff in our guts, ears, noses, etc. I'm just talking about the stuff you could see with your naked eye.) Doug Tallamy in his book, Bringing Nature Home (2007), estimated that a healthy white oak can support more than 500 different species of organisms. By contrast, we as design professionals sometimes struggle to create places that won't fall apart in a few decades. As design professionals, it's not unrealistic to expect our work to be replaced in a few decades. Before you huff at this notion, think how long it takes for a community to redo a park, or how fast office parks and campuses change. A place must be REALLY special to last more than fifty years or so. Why is it Nature always plans for centuries? How is it Nature always 'beats the house odds' and creates places with long-lasting capabilities? More to the point, what can the design professionals learn from Nature in order to create places that last?

This isn't a Nature is good; humans are bad rant. While some may hold that view, I don't. We are part of Nature. I think there is a lot we can learn from Nature that will help us be better design professionals. So what are Nature's rules and how do they impact the built structures and places we've created? Can we borrow Nature's rules to benefit how we design? I think we can.

Human beings are primary change engineers[1] (PCE's). We aren't the only PCE's[2], but as PCE's go we might be about the best at re-engineering our environments to fit our specific needs in pretty short order. Unfortunately, much of what we make lacks lasting power. Heck, we don't even think of design in that way, at least not anymore. No sane design professional has the audacity to declare today they are designing a new, *fill in the blank*, to last a thousand years! That wasn't always true. In the past, the Incas, Mayans, Egyptians, Babylonians, and the English Crown, to name a few (and certainly not the only

[1] Primary change engineers, are ecosystem engineers that are capable of autogenic, capable of changing their surroundings via their own physical structures (such as root systems, or leaves) and allogenic, capable of changing their surroundings through mechanical or other means, ecosystem engineering. Jones et al. (1994), defined six factors that determined the scale of an ecosystem engineer, they are as follows:

1. The anticipated amount of activity that can be accomplished within the organism's lifetime;
2. The population density of the organism;
3. The spatial distribution of the organism;
4. The duration that an organism has occupied a region;
5. The type, formation, and permanency of construction, artifacts, and impacts and their durability in the absence of the engineer;
6. The number and type of resources that are directly and indirectly controlled by the engineering activity.

[2] Humans aren't the only primary change engineers, many organisms are PCE's, for elephants have been known to rearrange whole landscapes in days, ants build mounds, gophers dig holes, wasps build nests. The classic example is the beaver, who constructs a physical structure that alters in negative and positive ways, an entire ecosystem.

examples) all envisioned unending dynasties literally housed in structures expected to last equally long (i.e. forever). But they haven't and they didn't. Nature, however, left to her own devices, has very little trouble building long lasting places for organisms[3]. Nature can play the long game better than us, because very early in time she established some key rules that everything, and I mean EVERYTHING must follow. As designers of spaces built in Nature, it's in our best interest to understand her rules.

Before considering some of Nature's rules, we need to first establish a truism. Nature always wins. She made the game, heck she made the deck of cards we use to play the game so, you either play by her rules, or you get kicked off the gameboard. When we don't pay attention to Nature's rules we pay for it. Ignoring or overcoming nature costs us a lot of money, energy[4], and in the worst cases can lead to disasters and death.

Let's make sure this first point is well understood, it is the prime axiom to understand the relationship between the structures and places we humans design and build and Nature: Nature Always Wins. No design by any human is worth the paper its drawn on if the designer doesn't understand this most primary of truths. And to be fair, most designers do understand this, at least implicitly if not overtly. I suspect most design professionals have never thought of their work in this way but, all design is governed by this truth.

Rule 1: Preservation of Essence

Nature values places and systems that are capable of change over time without a material loss in essence. Think of a prairie over hundreds of years, the species composition of the prairie would have been dynamic, but the function and essence was consistent over the long haul. Human beings also tend to value places and systems that are capable of change without a loss in essence. Imagine that really cool old house you've passed on your drive to work that needs a little bit of work to make it a great house. If someone were to come along and sink some money into that house and keep it a house it typically (not always) retains more value to us as a culture, than if someone comes in and sinks the same amount of money into the house and make it a swanky restaurant. In fifteen years, as a culture we are more likely to justify raising the house that has been converted to a swanky restaurant to make way for a new building than it would be if it's still a great house. All things being equal and the house as home or restaurant was in good shape, we are more likely to accept raising the house that became a restaurant because it lost its essence. It might be a really nice restaurant but it's not a home – its essence – and it's much harder to undo the house as a restaurant and make it home again than it would be to put up something new. Even if that new thing was another house or condo.

A prairie that becomes a savanna, and savanna a woods, has lost its essence. It's no longer a prairie, now it's woods. Fortunately, Nature has a way to stop the progression from prairie to woods (or it did until human settlement largely suppressed the technique[5]). Prairies are grasslands, and most grasslands are

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[3] Hey, you object, what about the asteroid that killed the dinosaurs? Or maybe you just object, if Nature is so good at this how come we don't have dinosaurs, or dodo, or whatever your favorite objection will be. First, my response is there's only so much we can tackle in the brief space allocated to this essay. But you are right, Nature didn't do a very good job ensuring the dinosaurs are still around. But in the context of Rule No. 2, below I'd also suggest any one organism is a pretty low investment. But I'll also note, this essay is about highlighting generalizations. A simple rule of philosophy is to base a rule on generalizations not exceptions.

[4] In today's world, often money is a unit of energy, we constantly balance our ability to purchase energy sources: food, fuel, or electricity, or indirectly purchasing energy such as labor, cab fare, or even eating out.

[5] In the United States today we have much more woods today than was historically present, largely due to the suppression of fire for settlement purposes. Estimates of the amount of prairie in the United States varies, but

maintained by fire[6]. In the United States, grasslands historically dominated most of the land area that that wasn't occupied with water. As we all know water has a tendency to frustrate the spread of fire. The neat thing is, fire benefited from the prairies[7] and the prairies benefitted from the fire.

Fire needs dry fuel and lots of it with a lot of surface area for maximum spread. The prairies of the central US would have been perfect for this, vegetation and fuel located low to the ground allowed fire to spread with maximum speed, minimal heat loss to the atmosphere, and comprised of tremendous surface area (a whole bunch of vertical surfaces, even more dense than would be found in a woods). But prairie, in turn benefited from fire. In addition to suppressing many woody vegetation species that might have otherwise dominated the system, the prairie benefited from the cleaning; the charred, blackened soil warmed faster in the spring and allowed plants to sprout sooner; and burning forced plants to invest a lot of energy in deep root systems[8] that pushed prairie species to deep subsoil water reserves, permitting prairie species to thrive drought and desiccation. Furthermore, the heat from fires was needed for the seeds of some species to split and germinate. A pretty cool ying and yang relationship. It was a back and forth, fire shaped the look of the prairies and prairies were an ideal fuel source for fire, they fit each other.

How could this rule apply to us? First, let's think about a 'what-if' scenario: Imagine a concrete or asphalt that responded to routine traffic with improved stability and longevity; it didn't crumble or erode over time but got stronger while remaining pliable enough that it could be moved or even removed if desired. (What does that even look like, and how is that possible? I have no idea. But if we aren't asking the question, we'll never try to achieve it.)

A more pedantic example of how we might apply Rule 1 could be: while the annals of design history are rife with examples of structures and places that 'borrowed' from other regions more common was to create structures and places based on the resources available to the designers at that time. If your region was rich with timber resources, you designed and built with wood. Whereas if your region was a desert, you designed with sand and stone. For example, the brick used in many of the historic buildings in Milwaukee, Wisconsin is called cream-city brick, it's the native color of the clay harvested from the Menomonee River and western shores of Lake Michigan. And it's the color of the clay that was used to make the bricks that gives the older buildings in the region a distinct color. In fact, many of the structures or places we value most for their historical significance are of the place. They have a look, a material that defines the region.

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most historical ecologists agree that prairies were found across the United States. All historical ecologists agree we have significantly less prairie today than existed even 50 years ago.

[6] Drought or low rainfall is another way to encourage graminoid (grass) dominance in the absence of fire.

[7] Prior to European settlement, fires dominated the landscape of the United States. So many acres were burned annually by lightning strikes, or started by First Nation's people, that when European settlers began suppressing fires in the US the reduction of carbon in the atmosphere from fires cooled the planet. This led to an event called the Mini Ice Age. And it wasn't just prairies that burned. Many ecosystems in the US thrive on fire (Anderson, 2002).

[8] We often think trees, they are big, have the deepest root systems. The idea that a trees branch structure is mirrored below ground is simply not true. While the spread of a tree's crown may approximate the spread of its roots (even this isn't really true, under good growing conditions root spread can easily exceed crown spread), most trees tend have pretty shallow roots. Many prairie species have much, much deeper roots. Where trees might linger in the 2-3' depth range, many prairie species set roots in the 8-10' depth range. This is why prairies or native grasslands in general tend to be much larger carbon sinks than forests. It's also why the central United States has been one of, if not the most, successful agricultural regions in the world.

Today building material resources are global but designing highways, buildings, parks, and homes that are ***of the place*** is still the best practice in most cases. The idea of, **of the place**, might seem easily applied to structures or landscape, but does it make sense for other design professions? How would a highway **of the place** in Colorado differ from one in Florida? As design professionals, we focus on the primary objective of making highways safe, and we tend not to think of highway design of the place, but we should. And the challenge here isn't about the vegetation on the shoulder of the road or stormwater control for a highway, I'm talking about the means and materials. If every road looks like every road everywhere else, we probably aren't doing a good enough job of designing of the place. Enough said. On to rule number two.

Rule 2: Expect a High ROI

Generally speaking, the more Nature has invested in an object or system, the more value it expects to get from its investment in terms of how long it lasts or how it supports the other parts of a system. To put it another way, Nature doesn't typically invest a lot of energy into an object or place unless it expects that investment to result in high returns across the board. This is true for individual structures, like a mountain or tree, or systems like a prairie or forests. Nature builds objects and systems to withstand change.[9] Here's the funny part about this though, change is the investment. This doesn't make sense, I know, let me explain.

As we discussed earlier, Nature wants objects and systems to resist change.[10] The more Nature invests in an object or system the longer it expects that something to resist change. Think of a mountain. Nature put a whole lot of energy into raising the mountain and invested a lot of mineral resources into the rocks and stones of that mountain. That mountain, is a mineral bank. After building the bank, Nature then meters out the minerals through erosive techniques over a period of time. Even though the mountain, as a whole, is durable to most forms of violent impacts over the long turn. Even when a mountain is hit by tornados, hurricanes or even subsequent volcanos most of the mineral bank remains intact. It might break into pieces, but it is rarely vaporized into its constituent parts. The investment to create the mountain was a huge change investment (tectonic lift, or volcanic energy), or to put it another way it was a massive energy investment. And the ongoing maintenance investment is small change (erosion), a lower energy investment. The mountain is more durable because the initial investment was very energy costly. But the maintenance investment (erosion) is long and typically requires a lot less energy.

By contrast comparatively less energy is invested in growing a tree or a blade of grass, but their ongoing maintenance investment is higher. I'm not at all suggesting the investment in a mountain or a tree are equal[11], I'm saying the rate at which Nature turns over its investment is based on the level of initial investment. The rate of maintenance investment for mountain ranges is millennia to centuries; forests centuries to decades; and prairies decades to annual. The maintenance investment is based on the

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[9] This may sound like it contradicts the first rule Preservation of Essence. Remember I likened the rules of Nature to a game, well the best games have competing interests. The value and excitement comes in the competition of interests. In this case the first two rules have at the surface competing interests but the outcome is much more exciting.

[10] In Nature change, is any deviation in an object's or system's normal and desired state of affairs; such as wear, pressure, damage. The ability to resist change defines an object's or system's durability.

[11] Nature does apply the basic principle of accounting credits equal debits but the accounting at an ecosystem level is really complex.

energy need to develop the systems in whole and the rate at which it is expected to turn over and made anew.

But there is a second aspect to the anticipated ROI on the investment Nature makes in building something. When the object or system does eventually succumb to the change (i.e. when it erodes, decomposes, or turns over, etc.) its decomposed or eroded state provides the capital for the investment in a new object or system. Those minerals eroding out of the mineral bank of a mountain are being used to feed other types of systems or the development of a new system or object. They might collect along a mountain stream bank and providing the nutrients needed for growing a riparian habitat system. Or maybe those minerals wash all the way to an ocean and feeding a marine estuary. Either way the ROI is immediately recycled as capital into another system or, as in the case of forests and prairies it is invested on site in perpetuation of the existing system.[12]

The two pieces of the ROI work together. Nature doesn't typically invest in relatively low cost systems and then invest costly maintenance energy without still getting something for it. Using our examples, prairie is a pretty low-cost initial investment, but fires are pretty expensive maintenance investments. Nature gets more from the fire, than turning over the prairie. The maintenance investment cost of fire on a prairie, or in a forest for that matter, leads to locking up a LOT of carbon in the soil of the system. A net positive effect for Nature. To put it a differently, when Nature does invest in high cost (energy) maintenance it's getting a pretty good value for the investment.

By contrast we humans often over invest in the least valuable parts and under invest in the most valuable parts of the objects or systems we design. For example, in many developed parts of the world, we invest a lot of fuel and human energy mowing lawns[13]. Over the long-term lawn becomes one of if not the most expensive components of the built landscape. We over invest in lawn, assigning a larger portion of the built outdoor environment to it, because it's simple and low cost to install and really simple to maintain. But what do we gain from it? Aside from some neat aesthetic outcomes (and there are some really beautiful uses of lawn) or utilitarian needs (you need lawn for some types of uses, like soccer for example. No way around it, soccer in a forest, while interesting, is a completely different game) we don't gain much from it. Unless you are raising a grazing animal on it[14], lawn has zero nutritional value, it does little to absorb stormwater, and any carbon it absorbs is wasted on the inefficient engines used to power the mowers used to mow it. And then there is manufacturing and wasted labor applying chemicals to ensure a completely homogenous stand of vegetation (i.e. weed free lawn). Simply put we are investing way too much energy and money on something that provides very little ROI in almost all instances (unless you want to raise sheep, goats, beef, horses, etc). However, we'll under invest in the siding on our home because, hey vinyl is cheaper. Never mind it lacks the insulative value or durability of other materials. (Maybe that's not realistic example for most readers. It was a pretty big jump in potential cost differences). Let's use a different example, what is the nutritional value of the food you are eating? Of all the things to spend a little more of one's income on I've personally always felt a little more for better food stuff (the materials for making your own food, not eating out

[12] An ecologist once shared with me that it's as if Nature was stingy. Once Nature has invested in something it tries to eke out as much value as it can get from its investment.

[13] Those familiar with my work will know I don't care for the overuse and application of lawn. If I were to be honest this largely stems from the fact that I had to mow lawns to pay for college. Imagine how delighted I was to find out that lawns really are pretty bad for the planet. Stupid lawn mowing job!

[14] Grazing animals are incredibly efficient lawn maintenance investments. Take it from someone with personal experience.

more) is worth the investment[15]. Buying better food might mean you have to save another year or two for that new mobile tablet but the benefits outweigh the wait. In the United States, our cost of food as a portion of our household expenses has been steadily decreasing (Barclay, 2015). To be sure this is in part because we have other household expenses that someone, say like Charles and Caroline Ingalls (Laura Ingalls Wilder's Pa and Ma), just didn't have in circa 1881. (Internet what?) But it isn't just that, the cost to produce and ship food has gone down. And we grow less of our own food (Putnam and Allshouse, 1994), probably because we don't have the time to grow it. Unfortunately, the way we lowered the cost of producing and shipping food wasn't simply in growing and trucking efficiencies, we also made the food less healthy. A lot has been written about this by many really good authors (Michael Pollan, Mark Schatzker, Nina Teicholz, to name just three) so I'll digress. Suffice it to say the generalization I made is true at the personal as well as the corporate or commercial levels, we can all readily think of examples where we invest too much in the things that burn out fast, and too little in the things that should last. The most important take home is, are we asking the question: are we making the right level of investment based on the expected ROI?

If we examine the other side of this coin, we have to admit we also have a hard time imagining how the 'waste streams' the decomposed or eroded pieces of the systems or objects we design can serve as investment capital in a new system or object. Recycling is one means of addressing this idea, and there are some really cool design hacks from shipping containers, and palettes, and repurposed this or that, but I'm also imagining a larger perspective. What are the possibilities at a planning level (think Smart-Cities)? Do we routinely examine the closed loop opportunities at a community planning or site planning level that covert traditional waste streams into downstream resources?

To be honest, in the design world, we've only just begun to scratch the surface in this regard. And while there has been a renaissance in how designers think about storm water, wind, and solar energy as untapped resources, there's more. As an example, what is the energy generating potential of stormwater? Recall that at one point in history water in flow was the most abundant most readily available source of energy in many parts of the temperate world. Today we have millions of gallons of water in flow following every storm.

3. Keep It Elegantly Simple

One of the ways that Nature balances rules one and two is by avoiding overdesigning objects or systems. That doesn't mean Nature is austere in its design, but it also isn't hubris. We are all really familiar with the amazing and inspiring beauty in Nature. But in Nature, where there is form (or color) there is function. Nature builds irreducibly complex systems. An irreducible complex system has all the form components needed to meet all the functional expectations without unnecessary accoutrement. The flip side is, if you remove any of the components from the form the object or system fails to function.

An example from the built world is the classic snap mouse trap. The snap mouse trap has all the pieces needed to do the job of catching mice. It doesn't need more than the basic pieces of a platform, spring, snap bar, latch, trigger. But it also doesn't function without any one of these pieces. There is some latitude in the size or form of the components on a mouse trap but the various components have to maintain a degree of balance. The diameter of the snap bar can vary some without over exerting

[15] This assumes one can meet the most basic needs of life for themselves and their families: Safety and Shelter. I know that for many, there is barely enough money for living. For many they buy the best food their budget can allow. That is an extremely sad condition and a topic that has been and should continue to be discussed. It's something we have to solve.

additional effect on the system as a whole. The platform could be longer or thicker to some degree without losing efficiency, but the system doesn't gain a lot by going overly large and loses function by going to small. However, if the snap bar exceeded the length of the platform the system wouldn't work. Or, if the spring was too loose to move the snap bar, the system wouldn't work. The mouse trap also won't work if all the components are the same. If a mouse trap were a pile of springs it won't catch mice. Lastly, adding to the mouse trap superfluous designs, say printing the platform with artistic swirls, or even the text, "Mouse Stand Here" with an arrow indicating where the mouse should stand, wouldn't make the trap more effective. And since printed text wouldn't make the trap more effective (i.e. the ROI would be zero, see rule number 2), unless mice learn to read[16], then why do it? Nature operates the same way accoutrement has meaning or it isn't necessary. [17]

Just like the snap mouse trap, Nature allows for some flexibility in the objects or systems it builds, but pushing the allowable variability too far causes a failure. Riparian systems (creeks, streams, rivers) are a balance of water, soil, air, vegetation, micro and macro organisms, minerals, and energy. We are well acquainted with what can happen when a riparian system has too much energy, destructive erosion. We also know what happens with too much soil, siltation. Adding unnecessary components to a riparian system, like a boat house or a dock might not impact the operational function of the system[18] but it also doesn't improve the system either – not from Nature's perspective.

Here's the take away. Does the design profession as a whole take a wholistic view of the work it develops to understand if it has all the parts or too many parts to function? There is a place for aesthetic expression – Nature does it too, but different than us Nature does it for a purpose. Aesthetic expression often leads to something called mutual satisfaction of the users. To be pedantic, it improves the quality of life for the organisms that experience the aesthetic expression. It helps birds mate, it attracts bees to the flowers, it warns humans to stay away from jellyfish, and so on. I love to paint, but my painting also has a purpose. It allows me to relax and it provides me with an opportunity to share what for me is an intimate part of me with those I gift my paintings to. I'm not sure if we were to look at the work we as designers develop, if we could honestly say it has all the right parts in the right balance and satisfies the users. Too often I think we tend to pursue aesthetic or functional purposes without finding ways to balance the two. Or to place in the context of rules 1 and 2 to ensure our built environment is of the place and provides a wholistic ROI.

A cautionary second example is need to follow the first example of applying this rule. We need to be pretty thoughtful about what we add or remove from the objects or systems (especially systems) Nature has built. To be honest, my example of the mouse trap belies the terrible complexities of natural systems. Objects and systems built by Nature have form and functional relationships at the macro to molecular levels. It's not hyperbolic speech to suggest there is no way for us to know or understand all of the relationships built into an object or system. I'm not advocating analysis paralysis. The point is simply look closely at what Nature has already built, it's a model for what we should build. We don't need superfluous, nonfunctional objects or systems in our built environment. And we should be really

[16] And if they could read, how long would it take a mouse that could read, and therefor reason, to figure out, this is a trap?!

[17] I'm inclined to say unlikely because at the time of writing I can't think of a form that doesn't have function in nature, but the scientist in me is reticent to make an absolute statement that it never happens. Nature is a big place.

[18] Actually, adding build spaces to a riparian system usually degrades the system. At a minimum it impacts the flow of the system and it often changes the vegetative cover, to name just two changes that are very common.

careful about pulling at the thread and unknitting Nature. We don't understand what we don't know, and there is a lot we just don't know. Does that mean we shouldn't interact with Nature? Not at all. But it also means the next time someone says, we don't have to worry about 'X', it will never harm Nature, our collective radars should sound.

Summary
Although humans have been altering their environs with ever increasing rapidity for centuries, we have rarely created objects or places that have the long-lasting power of those created by Nature. (Heck, we can't even socially organize ourselves effectively for more than a few centuries before new civilization paradigms and regimes circumvent previous organizational structures.) While we can certainly point to a few remnant objects or places more has been lost than preserved. Why is that? We certainly have the smarts for creating amazing structures, objects, and places.

For my own convenience, I grossly anthropomorphize Nature throughout this essay as if it were sentient and sovereign; the fact is Nature is neither. Nature is mindless. More importantly, it has no will, no purpose, it's not even a law or axiom of science. Nature is a convenient term and human definition describing everything that isn't under the direct and immediate control of human beings. Nature is the relationship between natural objects, entities, places and laws; it has no consciousness independently or collectively. It is a place, a realm, where the laws of physics, biological and chemical function, and natural laws operate without any governance other than the governances dictated by natural laws. It doesn't seem fair then that a mindless, nonentity we defined is better at making long-lasting objects and places than we are.

The essay highlights what we as designers all know, but often forget, to think about how Nature works and using Nature as a model for the design and built environment. If this all sounds like common sense, it is. Despite that it's surprising how often we ignore this simple rule of life. And to be honest with ourselves we've built a culture, a way of life, that depends on bucking Nature on a daily basis.

Good planning and design begins with understanding the rules of Nature and the opportunities to borrow from Nature in ways that benefit us and others.

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