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"...identifying, designating, managing and restoring the best remaining examples of natural communities and geological sites encompassing the full spectrum of Missouri's natural heritage"

Editor's Note

40 Years of Missouri Natural Areas

Resting behind me in my office cubicle is a tattered black wooden frame with two fading pages, turning yellow through time. The forty year old documents represent the original Memorandum of Agreement between the Missouri Department of Conservation and the Missouri Department of Natural Resources for the Coordination of a State Natural Areas Program signed by respective department directors on April 20, 1977. To commemorate the fortieth anniversary of the establishment of the program, this edition of the Missouri Natural Areas Newsletter reflects on the history and the future of our state's precious designated natural areas. We invited former Natural Areas Committee members and leading ecologists to present their thoughts on how the natural areas program has developed through the past forty years. Some of the articles are philosophical, expressing the need for better protection of these areas for the sustainability of our natural heritage. Most recognize the growth of the program through the years as natural area designation shifted away from small vignettes to large-scale landscapes for the purposes of viability.

The first three articles take a long view and are written by giants in the fields of ecology and botany: Doug Ladd of The Nature Conservancy, Paul Nelson, author of *The Terrestrial Natural Communities of Missouri*, and Justin Thomas, the Science Director for NatureCITE, the Center for Integrative Taxonomy and Ecology. Ladd and Nelson served on the Missouri Natural Areas Committee (MoNAC) in some capacity for over 35 years and discuss the threats to natural systems and the need for greater protection. Thomas is widely recognized as a leading botanist and ecologist in the Midwest and here he presents his thoughts on the importance of stability in our management of natural areas. In the early days of the program, natural area experts tended towards a "hands off" management approach; through time and thoughtful discussion, it grew ever more evident that active ecosystem management is crucial to the

Esteemed wildlife artist Charles Schwartz illustrated the Jack-in-the-pulpit as the emblem of the Missouri Natural Areas Program. Today, this woodland wildflower graces all natural area boundary signs.

Photo by Allison J. Vaughn

sustainability of biodiversity. With ever-burgeoning threats pressing at the borders of our best remaining examples of our natural communities, now more than ever should we stand by the guiding principles of the natural areas program, to employ sound science in our decision-making and managment.

We are honored that so many natural area experts and scientists penned articles for this 40TH Anniversary edition. Also in this issue, read about contributions to the program from other partners, the Mark Twain National Forest and the L-A-D Foundation. Sadly, in 2017 we also saw the passing of two longtime MoNAC members, the legendary geologist Jerry Vineyard and Bill T. Crawford, the founder of the MDC Natural Areas Program. Both are remembered here for their contributions to the program and to the greater conservation community.

The concepts outlined in this edition should lead to healthy discussion as we strive to preserve and protect Missouri's natural heritage into the future. Many years ago, with the robust beginning of active ecosystem management through prescribed fire, natural area experts conducted workshops, seminars, and fieldtrips to discuss and develop best management practices. Decades have passed and today we are met with new threats, new concepts and new faces in the field of conservation. While the agency missions of MoNAC partners differ from one another, the mission of the natural areas program remains strongly based in sound science as we strive to conserve and sustain Missouri's best remaining natural communities and geologic features. Thoughtful discourse and reflection on our past will hopefully lead us into the future with a robust land conservation and management ethic.

— Allison J. Vaughn, editor

Allison Vaughn is the Natural Areas Coordinator with the Missouri Department of Natural Resources.

Contact: allison.vaughn@dnr.mo.gov

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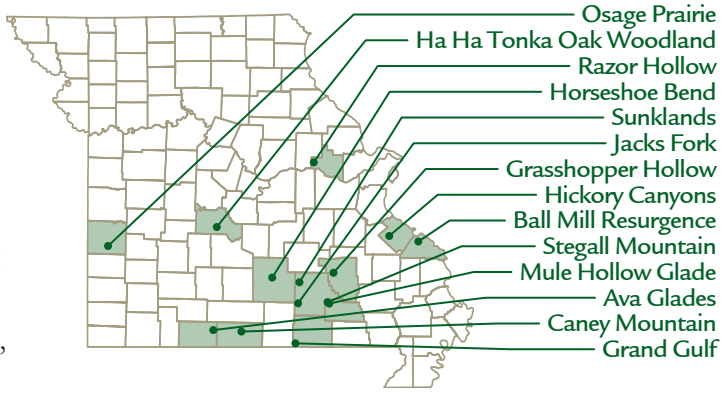
NATURAL AREAS FEATURED IN THIS ISSUE



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The Missouri Natural Areas Newsletter is an annual journal published by the Missouri Natural Areas Committee, whose mission is identifying, designating, managing and restoring the best remaining examples of natural communities and geological sites encompassing the full spectrum of Missouri's natural heritage. The Missouri Natural Areas Committee consists of the Missouri Department of Natural Resources, the Missouri Department of Conservation, the U.S. Forest Service, the U.S. Fish and Wildlife Service, the National Park Service and the Nature Conservancy.

Why Natural Areas?

By Douglas Ladd

Perspectives on Natural Areas Conservation

In the following three essays, veteran field ecologists Douglas Ladd, Paul W. Nelson and Justin Thomas share their thoughts on designated natural areas and natural community conservation in the 21st century.

Introduction

Missouri's Natural Areas system showcases some of the best of our state's natural heritage, with a legacy of on-the-ground results. Considered a model for other states, the program is based on dispassionate scientific criteria and robust administrative collaboration towards explicit common goals.

Some critics have recently suggested such programs are outdated or doomed to ultimate failure. Supporting arguments for this position are often cast in light of drastic impacts (climate change, invasives, fragmentation) from which the systems will not recover, or, perversely, on glib predictions of ultimate resiliency. Another view posits the inevitability of functional ecosystems of some type to develop regardless of impacts, minimizing the importance of natural area conservation. There is also an increasingly utilitarian and simplistic view of nature as something to be curated and supported to the extent that it is a direct provider of immediate (typically economically quantifiable) services to benefit humans.

These fads in contemporary thought result in perceptions that conservation of natural areas is not essential. In this view, natural areas programs are regarded as noble but doomed efforts, or as an ineffective use of resources, or as an antiquated, somewhat quaint approach not suited for the magnitude and scope of ecological stresses in the modern world. Another criticism is that natural areas programs preserve static, historical artifacts of little relevance in a changing world.

Discussions about conservation and natural areas occur within a global society that is increasingly disconnected from the natural world, focused on technology, and collectively ever less cognizant of human dependence on healthy, functional ecosystems for our quality of life. There is a real danger that our gadget-focused society increasingly views ecosystem health, including natural areas, as irrelevant or something that can be quickly repaired by modern technology if and when needed.

Here I discuss why natural areas are more than ever critically relevant to both ecosystems and human society. We'll explore some problems with our current thinking about natural areas, and how we can re-think key concepts to ensure a vibrant, viable, and broadly supported system of natural areas.

Importance of Natural Areas

As a species chronically encumbered with a strong focus on the present, we humans tend to lose sight of the extreme recency of North America's modern biological landscape. Barring some brief and ill-fated Norse attempts at colonization, Euro-settlement and its still unspooling ecological consequences began a mere 27,000 weeks ago. Here in the Midwest, large-scale impacts commenced less than 10,000 weeks ago. Having grown up with them, we take for granted the draconian habitat losses and alterations of the continent's natural landscape. In a genetic and evolutionary sense, these ecological concussions occurred mere moments ago. Our native systems and their component biota are still reeling from a series of impacts that have no antecedents in their evolutionary history.

Each taxon of our native biota represents a genetic algorithm for success, building on countless previous evolutionary tests, and reflecting millions to billions of years of adaptation and selection for the unique combination of conditions and processes at a specific locus on Earth. In the interactive self-replicating arrays that constituted our post-glacial natural systems, this biota encompasses the astounding diversity and collective power and adaptability of life itself. Only by sustaining representative examples of these original systems can we sustain this ancient legacy of biological resources and their cumulative genetic knowledge.

Without this, we doom the planet and our society to permanent loss, or at the least, millions of years of diminished potential and opportunity. This is a foundational reaffirmation of the importance of natural areas. Only in a landscape with robust natural areas, properly configured and stewarded, do we have an opportunity to sustain irreplaceable functional representations of the biological fabric that defines place and culture. Ancestors of this biota initially rendered the planet habitable for aerobic life, and its modern expression provides a panoply of attributes enhancing human society and quality of life. As part of an integrated conservation ethos, natural areas contain the collective biotic libraries and patterns for system function and resiliency in all its expressions.

A current focus on 'novel ecosystems' and their inevitability and role in the Anthropocene is based largely on poorly defined criteria or theorizations unconstrained by reality. Novel combinations of biota are common in the modern landscape, consisting of biotic assemblages that have never occurred previously, but to consider them functional ecosystems is a stretch. These may indeed be the start of future functional, stable ecosystems, but only through millennia of evolutionary and ecological cycles. Current examples are unstable, unpredictable, tend to change rapidly, have little resiliency, impaired ecological function (and consequent limited ecological services), and depressed biodiversity as compared with their native congeners. Given what we know about succession and evolutionary biology, most of these systems are destined to fail as diverse, resilient, or stable entities. Maintaining the highest functioning aspects of our landscapes and communities requires maintaining the diverse biological fabric providing this, of which natural areas are the most critical component.

Beyond this compelling biological need for natural areas are equally compelling human needs. As recent products of the four billion year history of life on earth, humans have been a part of nature in the most visceral sense since their origin. Recent studies increasingly reinforce the link between personal connections to nature and human health, quality of life and even mortality rates. We depend on healthy ecosystems for a multitude of benefits and essential needs ranging from food production, pollinators, climate mitigation, soil productivity, erosion and flood control, and clean water to recreation and aesthetics. Natural areas are an essential component of a spectrum of landscape conditions enabling this. Natural areas also contribute to a profound cultural connection to place and history, serving as a living legacy to regional and local character, culture, and heritage. They are a lens to our humanity.

Challenges with Current Approaches to Natural Areas

While our current natural areas system has created an invaluable foundation, I believe there are problems with our approach to natural areas and conservation. Here I discuss four issues that must be addressed to sustain an effective natural areas program and conservation framework: 1) resiliency fallacies and the decline of organismal expertise; 2) rigid models and preconceptions; 3) counterproductive time frames and endpoints; and 4) successional myths.

1. Resiliency fallacies and the decline of organismal biology

Several recent articles[1] propose that natural systems are highly resilient and self-recoverable, and the futility of sustaining historic systems in the face of overwhelming climate change and other factors. This line of thinking holds that, because nature is enduringly resilient, too much angst and effort is expended in counterproductive attempts at conservation of "historic" systems such as natural areas. Such efforts are often characterized as misguided attempts to retain static artifacts of the past. Supporting examples typically involve heart-warming cases emphasizing rapid recovery and adaptability of specific organisms — almost invariably invertebrates with fast life cycles.

I think perceptions of resiliency are inversely related to the level of biological knowledge of the system, which tends to be directly linked to levels of organismal and field familiarity with specific natural systems and their biota. It is easy for a theoretician — seeing the natural world as an un-

1 e.g., Kareiva, P. and E, Fuller. 2016. Beyond resilience: how to better prepare for the profound disruption of the Anthropocene. Global Policy 7 (suppl. S1): 107-118.

differentiated green blur — to blithely pontificate on nature's resiliency or the superfluousness of maintaining intact site and process legacies. Thus, perceptions of ecosystem irreplaceability and significance of native diversity are directly linked to a deep understanding of the biota comprising these systems.

This highlights another critical issue: the expungement of field-based organismal biology from contemporary education, and perceptions of its irrelevance in the modern world. As our educational and research institutions increasingly focus on mathematical models and molecular technologies, we risk losing a critical knowledge base essential to human well-being. This knowledge in its subtleties and complexities requires an interactive human learning tradition rendering it extremely fragile — once lost it is not easily regained.[2] As we cumulatively lose ever more people who can identify and understand the complexities and interrelationships of living things in their environment, we lose the ability to appreciate, or even distinguish, the value and function of healthy, diverse systems versus anemic and unpredictable replacements. Without these insights, one green blur simply replaces another, and by the time the losses of diversity and function are finally comprehended, it is too late.

A compelling rebuttal for Pollyannas trumpeting the overwhelming resilience of nature is captured in a single observation: the loss of virtually all the fertile, deep-soil tallgrass prairies in the Midwest, and our frustrating inability to restore anything resembling their original biodiversity and function despite more than a half century of increasingly successful restoration projects.

2. Rigid models and preconceptions

Superficial thinking about resiliency and replaceability of natural systems combined with the constraints of traditional ecological classification systems also ignores the uniquity of nature and our knowledge limits. We derive explicit structural models of how healthy natural systems "should" appear and function, despite appalling lack of knowledge of their organismal composition or pre-Eurosettlement structure and function. We develop broad categorizations of necessity, but these obscure real differences, and are further constrained by limits of our language and taxonomic concepts. Managing towards these preconceived outcomes risks system degradation and diversity losses.

Every spot on the Earth is measurably unique in terms of physical conditions, biotic history, and process regimes. This uniquity is reflected in the biota which, as discussed previously, reflect thousands of generations of adaptation to and selection for the ability to thrive under the unique combination of specific biotic and abiotic conditions that characterize each locus on Earth. The ancient Roman concept of genius loci, or Spirit of the Place, should be explicitly recognized and accommodated in our natural areas and land management, lest we degrade and impoverish our ecosystems in a headlong rush to derive universal models or 'exportable' management and restoration prescriptions.

Part of this is recognizing that ecological and taxonomic classification systems and hierarchies are models — useful tools but coarse and incapable of fully reflecting ecological reality. We must always be attuned to the actual system and its vagaries, lest we cause harm in slavish devotion to models and preconceptions. There is a danger of irreplaceable losses and impoverishment of the wondrous diversity of our natural systems if we don't acknowledge the limits of our classifications and language, and the complexity of nature, both at the genetic level within organisms, even of the same 'species,' and within the systems which these organisms comprise.

3. Counterproductive time frames and endpoints

Natural systems are not accommodated by human timelines or the compartmentalized goals driving today's society. This has fundamentally skewed our connections with the natural world, reinforced — albeit with the best of intentions — by those of us working in conservation. We have created the impression that natural areas can be

2 This is compellingly described in David Ehrenfeld's classic essay, *Vanishing Knowledge* in the March 1996 issue of Harper's magazine.

managed by implementing various time-delimited projects with specific outcomes and short-term goals. In the process, we have lost the ongoing human interventionist connectivity that shaped nature from the end of the last glacial period to Euro-settlement.

This ongoing, interventionist tradition is essential to ecosystem health and biotic diversity. Natural area managers, and all citizens, should embrace this ongoing stewardship responsibility and sacred privilege of interaction to sustain the unique biological systems that characterize each locus on Earth and shape human history, culture, and economy. There is no end game in conservation, but rather an enduring, interactive, carefully configured interventionist relationship necessary to sustain natural systems. This may dismay philosophical purists schooled in humans as despoilers of nature, but in reality is an empowering opportunity to achieve essential reconnections.

A related issue impeding our appreciation and management of natural areas is the enduring myth that natural systems are infinitely dynamic. As demonstrated by millions of examples in the contemporary landscape, natural systems are far from stochastic or infinitely dynamic, but terribly fragile and sensitive to perturbations to which there is no antecedent in their organismal lineage. Today, this fragility is exploited by a host of non-native biota adapted to these novel perturbations, permanently reducing system diversity, function and resilience.

Management protocols based on meeting other organizational priorities, or aimed at "diversifying" management for its own sake risks permanent and irreplaceable damage. Management of natural areas should be configured to maximize system resilience and diversity, emphasizing the most sensitive biota in the context of functional systems. This is the only enduring measure of ecological success.

We must adopt an ecological model of constrained dynamism, and zealously sustain or emulate process regimes within the range to which the system is accustomed, thus allowing opportunity for change and adaptation to occur on evolutionary time scales. Constellations of native biota remain functional and viable only where site history, landscape context, and process regimes have remained within the constrained range to which the biota of the system has collective genetic memory through thousands of years of selection and adaptation. Often, this limited range of dynamism must be further constrained by the realities of the current environment, with abnormal and unprecedented levels of habitat fragmentation, invasive species, and altered process regimes.

The goal is not to create a static, rigid artifact of the past, but to use the enlightening knowledge of original site context, biota, and processes to sustain the most resilient and adaptable system, with the best chance of adaptability in the face of daunting changes facing the planet today.

4. Successional Myths

One problem that has beset our concept of natural areas throughout the tenure of the program in Missouri, as well as elsewhere, is a simplistic and flawed concept of succession based on classical ecological theory.

This classic model of ecological succession, a repeating predictable sequence of seral stages, devolved from the pioneering work of Henry Chandler Cowles in the Indiana Dunes in the late 19TH century. Cowles' astute observations of processes, dynamism, and vegetation patterns were conceptually perverted by Frederic Clements into a more rigidly deterministic model focused on a pre-ordained end state that continues to influence thinking about succession.

By failing to recognize that succession in pre-Eurosettlement North America is nothing like contemporary successional sequences and patterns, we subconsciously assume that 'succession' of disturbed states implies system recovery, culminating in a return to a high-quality prairie, woodland, glade or other natural community. Reality differs starkly: contemporary successional seres, in our fragmented landscapes with drastically altered process regimes and abundant non-native species adapted to these ecologically novel perturbations, do not resemble the original successional patterns that prevailed for millennia after the last glacial period.

Even the successional patterns of a century ago, although severely altered, more closely resembled the original post-glacial successional patterns, as evidenced by what seem to us today to be astound-

ing levels of resilience and recovery in severely impacted systems from the early and mid-1900's. Examples include the rich and diverse suite of conservative native species associated with some old artificial ponds, none of which colonize modern pond constructions, or the passive recovery to prairie of some previously cropped lands from that era. When the surrounding landscape was imbued with sufficient diversity and connectivity, there were pathways for at least partial system recovery. Such is not the case today.

This misinterpretation of succession as a single unchanging process afflicts not only ecological theory and practice, but also more applied fields. For instance, wildlife biologists, foresters, and land mangers frequently refer to 'early successional' habitat and its importance in holistic management concepts, despite lack of guaranteed system recoverability. In the contemporary landscape, this all-too-often results in irreparable impacts, including recruitment of invasive species, biodiversity loss — particularly among the most sensitive and least replaceable elements of the system — and ultimate declines in system function and resiliency. Our misinterpretation of contemporary ecological succession has seduced us into believing that systems regularly cycle through depressed levels of organismal diversity, despite the lack of data for local terrestrial systems depauperizing themselves as part of an intact synecological cycle.

Prairie managers in particular should take note, lest we succumb to the successional fallacy of "calendar prairie" as merely a charismatic phase of a fungible grassland complex, rather than the remnant healthy expressions of a largely degraded system. While this concept may apply in the more resilient grassland systems on the Great Plains, it is not applicable in the wetter, more fertile eastern tallgrass biome. I find it interesting that we appropriately never refer to other highly diverse communities as "calendar glades" or "calendar fens," but instead regard occurrences with depressed diversity and floristic expression as degraded.

Re-visioning a Future for Nature and People Through Natural Areas

Fortunately, we live in a state that had the foresight to lay a sound conservation foundation, an essential part of which is an exemplary natural areas system. As the threats matrix of our world intensifies, natural area management must be focused on managing to sustain site integrity, process regimes, biodiversity, and landscape context.

To remain relevant, sustainable, and diverse, natural areas must be fully integrated into the social and cultural fabric, with a stewardship ethos that exemplifies the enduring and ongoing connections between humans and nature that are essential to both. This human reconnection with nature must transcend socio-cultural and economic divisions and suffuse the fabric of humanity. We can succeed only when all people relate to and take pride in this relationship, which in turn requires an ecological and conceptual continuum of ongoing conservation actions extending from small native garden and green space programs in the most urban environments to large-scale habitat conservation and natural area initiatives.

Only when our natural world is treated spatially and temporally as a whole, one that has an ongoing need for human actions, will we enable conditions for long term success. Ensuring this will require a new relationship with our natural environment — not one of strictly budget-driven immediate pragmatics, but instead a human relationship and understanding of the natural world akin to that of a loving family, based on enduring interaction, stewardship, and appreciation.

Natural areas will never be static, and in today's world of increasing stresses and impacts, it is sad but inevitable that many will undergo declines in diversity and function. Only by dedicated efforts to sustain our natural systems and their ecological context and processes will we maximize diversity and resilience, maximizing the potential for successful adaptation. These are the most irreplaceable aspects of our natural heritage, and a critical part of sustaining the healthy, functional natural systems on which humanity ultimately depends — the most important legacy we can provide to future generations.

Douglas Ladd is Director of Conservation for The Nature Conservancy

Contact: PO Box 440400, St. Louis, MO 63144

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Will Missouri's Natural Areas Endure Landscape Transformation?

By Paul W. Nelson

"The genetic memory of complex ecosystems that has evolved over millennia does not adapt well to changing management styles, varied objectives, nor different organizational philosophies." Adopted from Dr. Gerould Wilhelm, Conservation Design Forum

Introduction

For the past 100 years, Missouri state parks have provided a permanent refuge for high quality natural communities. For this reason, over 40 years ago, I chose to study the flora of Johnson's Shut-Ins State Park for my master's thesis. In 1978, girded with my passion for natural history, I became the first Natural Areas Coordinator for the Missouri Department of Natural Resources, and subsequently served on the Natural Areas Committee (MoNAC) for 33 years. In the 2016 issue of the *Missouri Natural Areas Newsletter*, MoNAC announced that 2017 represents the 40th anniversary of the founding of the Missouri Natural Areas Committee. At the time of publication, MoNAC had collectively designated 185 natural areas totaling over 87,700 acres. The newsletter further mentions that natural area managers and owners continue to face problems associated with an increasing human population.

This article assumes that newsletter readers understand and accept that natural areas are defined as "biological communities or geologic sites that preserve and are managed to perpetuate the natural character, diversity, and ecological processes of Missouri's native landscapes." For managers and natural area owners, a specified range of relevant ecological management prescriptions commensurate with certain natural community types is required to retain their healthy, vibrant qualities. However, the constant pressing forces of homogenization challenge us to assure the retention of these qualities and characteristic biodiversity. More troubling are the myths and misconceptions surrounding the ability of ecosystems to adapt, adjust and resist these changes. Fickleness of bias, philosophy, multiple and conflicting management objectives, indifference, personal aspirations, budgetary problems and other exigencies all compound the need for a one-science approach to applying the best range of management prescriptions that preserve natural area qualities.

We live in the Homogecene Era

Our world is immersed in an irreversible period of mass species extinction. The Millennium Ecosystem Assessment (www.millenniumassessment.org) findings reveal that, since the creation of the Missouri Natural Areas Program, we have lost more biodiversity worldwide than in all previous human history. Numerous scientific studies show that many plant and animal species are declining because of human activities, and are being replaced by a much smaller number of expanding species that thrive in human-altered environments. The result is a homogenized biosphere with lower diversity at regional and global scales. A quick literature review for the topic "Biotic Homogenization" reveals over 100,000 article links. Forty years ago, natural area managers and professionals had not learned of this term. Biotic homogenization occurs when native, localized ecosystems are diluted by widespread exotic or weedy native species. This results in vegetation composed of a few dominant exotic or weedy native species that displace the natural vegetation that once defined a stable natural community. Vegetative distinctiveness gradually dissolves, giving way to biological species flatness.

A few examples

Park-like savannas once covered six million acres in Missouri. Now reduced to a few thousand acres, our remaining natural savannas cannot exist without deliberate management. Tall fescue, smooth brome, a host of native weedy plant species and relict non-regenerating post, bur and white oak trees sparsely occupy former savanna grasslands. Abandoned, there's virtually no place,

no classic example of any location in Missouri where a former savanna coalesces the diverse plant species that characterized this once widespread natural community. The best remaining example of true savanna in Missouri exists at Spring Creek Ranch Natural Area, a sweeping landscape actively managed with regular fire, exotic species control, and woody species removal. Active management is integral to maintaining this landscape. If abandoned, or left unmanaged, no predictable 'successional' order of plant species exists. The biodiversity trajectory, determined by variations in the savanna's history of grazing, haying, cropland and other uses, does not readily accrue species richness once damaged. For example, one scenario includes the presence of cool season exotics on now-depleted and eroded soil followed by the invasion of Eastern red cedar, black locust, persimmon, autumn olive, Bradford pear, Siberian elm and white poplar.

A similar scenario exists in our woodland and forest natural communities, where the threat of a new suite of exotic species is particularly high. Especially in increasingly urbanizing areas, the spread of bush honeysuckle is insidious and rapid. The plant's allelopathic toxicity is laying waste to a once diverse assemblage of woodland/forest wildflowers, while also inhibiting tree regeneration. The savanna equivalents of tolerant plant species that gradually spread into these urban, fire-deprived bush honeysuckle woodlands include English ivy, periwinkle, wintercreeper, burning bush and multiflora rose. Certain well-managed natural areas continue to prove somewhat resilient

Bush honeysuckle *(Lonicera maackii)* is spreading rapidly throughout urban areas, roadsides, and towns and into adjacent forests and woodlands causing severe ecological damage, altering community structure, and reducing the presence of conservative plant species. As shown in this photo, its widespread telltale green understory presence is revealed during autumn leaf off.

Photo by Paul W. Nelson

to these effects, largely due to their remoteness, lack of urbanization, lack of invasive species, and continuation of the fire regime. The 2,995-acre Ha Ha Tonka Oak Woodland Natural Area remains a premier landscape showcasing over 30 years of prescribed fire. However, even places like this are under threat of development sprawl, deer overpopulation, and interruption of natural processes.

The transformation of what remains of native vegetation continues

Landscape transformation is the near complete replacement and/or dismantling of the ancient plant and animal associations we describe as natural communities. Remnant high quality areas remain, but most are far removed from their historical character. This transformation is an inevitable, insidious force that, without a constant deliberate commitment to management, will cause the last remaining areas of temperate native vegetation to lose species and genetic diversity. The effects will be delayed in the Ozarks, but no remnant natural landscape is immune from the consequences of the ever-pressing forces of homogenization.

The following are the primary drivers of homogenization; this list is by no means all-inclusive. Many permutations of these damaging causal agents have negative domino effects on natural communities.

Resource Exploitation Upon Settlement

Early settlers built their small towns and homes in locations where they could extract wood, grow crops and livestock, mine minerals and make a living. Timber became the raw material for buildings, homes, barns, fueling steamboats and trains, furniture and firewood. In the late 1700's, the first lumber merchant Ebenezer Mudgett sparked the American Revolution over the King of England's timber laws, which initiated the Great Cut that swept across North America. Only a few small areas of Missouri contain fragments of virgin trees following the logging era.

At the same time, huge numbers of Eurasian livestock roamed and multiplied freely. Open rangelands devoid of fences allowed livestock to severely overgraze nearly all accessible natural communities. Missouri's vast natural landscape suffered decades of soil erosion as rains eroded vast quantities of gravel, sand and silt into streams and rivers. Poor farming practices added to the soil erosion problem. Even as late as the 1980's, Missouri was ranked 3RD in the U.S. for soil erosion and loss.

The fur trade opened the North American wilderness. Hunters and ranchers nearly eliminated large predators and herbivores from the top of the food chain. The passenger pigeon and Carolina parakeet are forever exterminated. Invented in 1713, Flamsteed's star chart opened the world to safer trade and commerce by sea, which opened the door to the transport of exotic plants and wildlife.

The Industrial Revolution

Beginning with the invention of the cotton gin in 1794, machines increasingly replaced human muscle in an explosion of factories worldwide, and steam engines drove rapid transport of commodities. In 1852, the train transformed a nation where people traveled further in a day than previously in a lifetime; the railroad opened wilderness to the most rapid expansion the world had ever seen. Undeveloped land rapidly divides into homes, roads, cropland, pasture, factories, mines, reservoirs, hospitals, stores, fuel stations and much more. Fragmented lands augment and facilitate the forces of homogenization.

Urbanization

Dr. Volker Radeloff and colleagues (2009) compiled spatially-detailed housing growth data from 1940 to 2000, and quantified growth for each wilderness area, national park, and national forest in the conterminous United States. Their findings show that housing development may severely limit the ability of protected areas to function as a modern "Noah's Ark." Between 1940 and 2000, 28 million housing units were built within 50 km of protected areas. Housing growth rates during the 1990s within 1 km of protected areas (20% per decade) outpaced the national average (13%). The Missouri Resources Assessment Partnership has used Landsat imagery from 1972 through 2000 to quantify the amount of urban change that has occurred in several metropolitan areas (figure 1).

Invasive species

Virtually every residence, workplace, city roadside, public building, park visitor center and more,

are subject to the old-world culture of designing and manicuring matrices of lawn carpets and gardens. Humans chose from hundreds of cultivars from catalogues or plant nurseries to plant. Today's population densities and work locations force modern homes into subdivisions and high-rise apartments. Global transport brings an unlimited supply of exotic plant species used to beautify housing developments. These plants, coupled with many other non-native plant species used for agriculture, wildlife and other purposes, are the foundation of a grim landscape experiment. People across the globe transport thousands of exotic species, exposing them to the now-degraded ecosystems of North America. Having adapted and evolved in the presence of old world cultures, many plant (and animal) species out-compete native species, thereby replacing them in vast uncontrollable numbers.

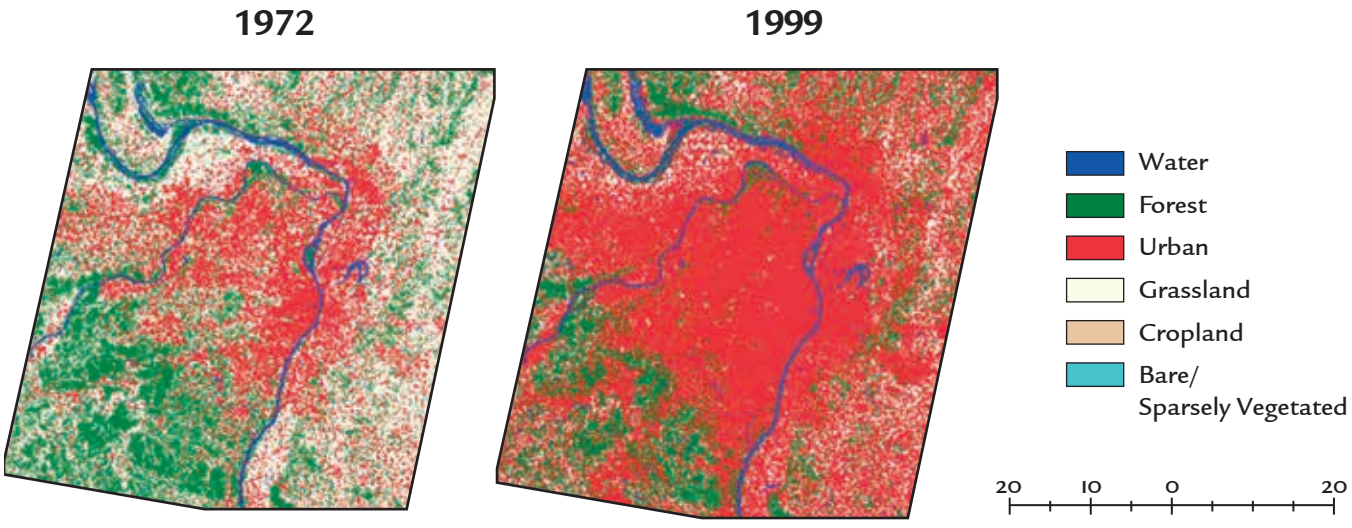
In September, 2017, I reviewed a list of 140 invasive plant species that threaten Missouri's ecosystems and biodiversity. This timely review is part of the Missouri Invasive Plant Species Task Force. In 1963, Dr. Julian Steyermark in his landmark *Flora of Missouri* recorded over 500 non-native plant species known to multiply and spread in Missouri. This number increased to over 900 with the revision of *Steyermark's Flora of Missouri* by George Yatskievych in 2013. The list of invasive plant species continues to grow.

Steyermark (1963) recorded bush honeysuckle in but a few Missouri counties in the 1950s. Today, society recognizes its menacing prevalence in virtually every county. This insidious shrub, killer of forest diversity, dominates cities and small towns. Spreading like mold on a petri dish, it is joined by autumn olive, oriental bittersweet, Japanese honeysuckle, rose of Sharon, Japanese privet and English ivy. Is this the ultimate transformed future urban forest?

The Trophic Cascade Effect

Missouri's historic native ecosystems evolved in response to an unbroken vegetated landscape of elk, bison and deer, preyed upon by wolves, mountain lions, and black bears. Today, elk and bison are confined to a few small refuges in Missouri, while only a scattering of mountain lions and bears occur. This disruption of a trophic level in the predator-prey food chain is known to cause cascade effects that ripple through the food chain. Trophic cascade describes the indirect control that a top predator exerts on species at lower, nonadjacent trophic levels. In a trophic cascade, ecological processes and consequences initiated by a change at the top of the food chain work their way down to lower trophic levels and eventually rebalance the ecological relationships of numerous species. A notable example of this top-down ecological interaction was observed in Yellowstone National Park. In the 1920s, the local extinction of the park's population of gray wolves (*Canis lupus*) through

Figure 1. Urban change in St. Louis from 1972 to 1999 using Landsat imagery (Lancos 2003)



hunting caused an increase in the elk population. This lead to a drastic drop in the abundance of numerous plants eaten by the elk with many species reduced to negligible numbers. In 1995, the reintroduction of the wolves dramatically reversed this trend, slashing the number of elk and increasing plant diversity.

Likewise, studies of the trophic cascade effect of wolf populations on white-tailed deer directly correlate areas high in wolf numbers to increased healthy populations of sensitive plant species (Callan, *et al.* 2013). Fifty years ago, seeing a white-tailed deer may have been a rare sight in Missouri. Bringing back white-tailed deer is certainly a great conservation success story, but the numbers of deer in eastern North America have surpassed a critical tipping point. Negative impacts caused by deer overbrowsing are widely published throughout North America, beginning with the works of Aldo Leopold. Roger Anderson (1997) concludes that removal of predator control from white-tailed deer populations invites ecological disasters by permitting excessive resource consumption to the detriment of whole communities of organisms. Thomas R. Rooney and colleagues (2004) correlate the loss of plant species richness in 62 upland Wisconsin forests with excessive deer browse. In Missouri, the Department of Natural Resources monitors the effects of deer browse using exclosures and winter twig browse surveys. The constant press of deer over browsing is steadily reducing populations of conservative plant species to the point of elimination. The Missouri Extension Service information on Missouri deer population dynamics discusses the effects that too many deer have on the biological carrying capacity of deer. Their data show that the historic number of white-tailed deer was estimated at 700,000. Today that estimate is 1.4 million.

Loss of historical processes, especially landscape fire and natural water flow

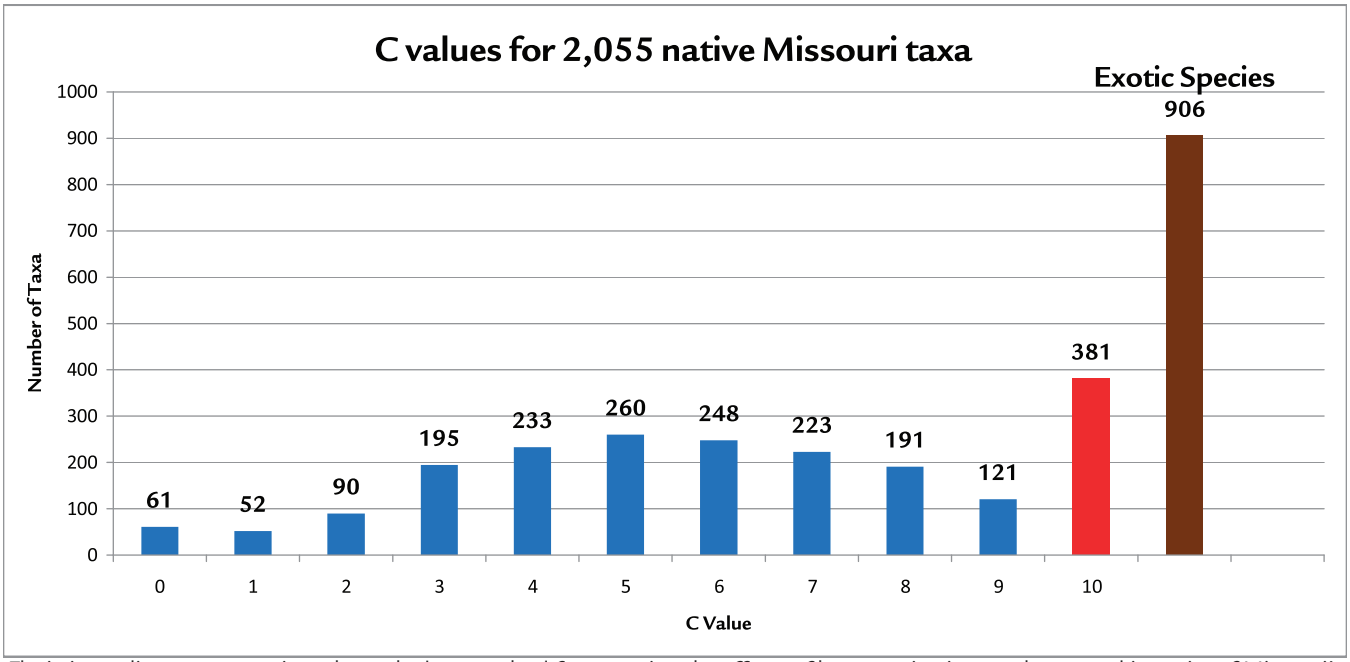
An estimated 80% of Missouri's historic vegetation was fire-mediated. Visits to Prairie State Park, Helton Prairie, Glade Top Trail in the Ava Glades Natural Area, Taum Sauk Mountain State Park, Grasshopper Hollow Natural Area and other fire-managed landscapes clearly point to the significant role that fire plays in restoring and maintaining viable conservative or habitat-specialist plant species, and the associated diverse array of wildlife, particularly invertebrate species. But the cessation of fire across the entire landscape, compounded with deer overbrowsing, accelerates the environmental impacts of homogenization.

Advancing urban sprawl makes it increasingly difficult to emulate historic fire regimes. Weakened by decades of open range overgrazing and fire suppression, what remains of fire-adapted sensitive plant species (royal catchfly, Mead's milkweed, prairie white-fringed and grass pink orchids to name a few) continue to decline, and in some instances barely holding on in small, protected refugia.

Historically major rivers such as the Missouri provided annual cycles of flooding across a wide floodplain that sustained riverine wetlands. A shifting mosaic of newly created marshes and bottomland prairies varied with others shifting towards more mesic conditions with slow sediment accrual over time. Today nearly all of our major riverine floodplains suffer from a wide variety of hydrological alterations such that current wetland hydrology has deviated significantly from historic conditions that had unique cycles of flooding and soil saturation that developed over millenia. These hydrological alterations including channelization, levees and drainage ditches in concert with watershed issues leading to increased sedimentation in places have stressed some natural areas beyond repair. For example, Cordgrass Prairie Natural Area was removed from the natural areas system because of irreversible hydrologic problems that shifted a diverse bottomland prairie to a sediment laden willow thicket.

How do we monitor and measure this transformation?

To find and designate high quality natural areas, field ecologists use a quality ranking system to locate the best examples of various natural communities. As defined in Nelson (2010), those qualities included high numbers of conservative plant species widely dispersed throughout the community. Scientists must base a sound natural areas program on the best available science with the protection of ecosystem biodiversity as its



Floristic quality assessment is perhaps the best method for assessing the effects of homogenization on the natural integrity of Missouri's native vegetation. The system relies on conservative rankings of 0 to 10 assigned to each native species. Species having a ranking of 7-10 are considered conservative with a high fidelity to intact natural areas. Likewise these species can be indicators of the negative effects of homogenization factors. Roughly one half of Missouri's 2000 native plant species are conservative elements.

primary driver. Ladd and Thomas (2015) capture the essence of the value for the Floristic Quality Assessment (FQA) for purposes of determining the degree to which the health of natural communities (and systems) maintain themselves under appropriate management practices. The utility of FQA in natural areas work is over 40 years in the making, and is employed by at least 25 other states. The assignment of Coefficients of Conservatism values to plant species is an excellent approach to assessing trends in how species that are least capable of maintaining viability are doing, and in explaining why certain high C-value plants decrease across the land.

Over 900 native plant species have conservatism values greater than 6; this is nearly 50% of all the known native plant species in Missouri. Homogenization disturbance factors further reduce and transform our native remnant landscapes to simplified dominance by a few generalist species. Fully transformed vegetation does not readily accrue conservative plant species, and any trained botanist can see this while driving from St. Louis to Kansas City where roadside vegetation is dominated by weedy generalists and exotic species.

Myths and Misconceptions of Natural Community Management

Natural plant succession, migration, realignment, recovery and resilience—all are erroneous ecological assumptions that threaten the fundamental character of high quality natural communities. Historically, these ecological behaviors operated to change ecological patterns over long periods of space and time. However, our contemporary landscape is now dominated by the causal factors of homogenization.

Some ecologists believe that ecosystems will migrate in response to climate change. Faced with the consequences of climate change, prairies and grasslands will migrate toward the East coast (National Geographic, 2008); post oak and shortleaf pine will migrate north; glades and savannas will do the same, and new orders of plant assemblages will follow. Homogenization barriers prevent these historic changes from happening in the Midwest. Nowhere on the landscape will one witness conservative (as well as many generalist) plant species migrating or coalescing anywhere removed from where they presently occur. And these conservative plants represent nearly 50% of our native flora.

Old school concepts of ecology taught us that

damaged or destroyed ecosystems will recover or 'succeed' to some approximation of their former condition. For example, Dr. Julian Steyermark's *Natural Plant Associations and Succession in the Ozarks of Missouri* (1940) postulated that open woodlands dominated by our Ozark woodland flora were succeeding to "true forest" due to a wetter, more humid climate. Fire studies later taught us that historical fires maintained our woodlands' open, grass-dominated character and diversity. Rather than 'succeeding' to forest, these once open and diverse woodlands and glades abruptly degraded to lands with a depauperate understory and out-of-context tree canopy following early settlement resource exploitation. Others proclaimed that, by leaving nature to its own devices, vegetation and wildlife would recover from the consequences of the Great Cut, 100 years of open range grazing, mining, and cropland abandonment. The US Forest Service management philosophy adopted the approach that future ecological conditions across National Forests should integrate modern human values and that "adaptive management" would result in new, resilient assemblages of vegetation.

When left untouched, no aspect of our contemporary altered landscape will recover the diverse assemblage of native plants and animals uniquely associated with historical, self-replicating natural communities. Transformation effects continue to press all remaining areas of natural vegetation, thus reducing their quality. Long-term vegetation monitoring, floristic quality indexing, ecosystem assessments, natural features inventories, and threats studies are revealing something entirely different. This profound difference must reshape our thinking about the future of restorable, but diminishing, ecosystems. There is no scientific basis for supporting the idea that varying management practices and fire suppression will result in the coalescing of new plant associations that will assure plant and animal species viability. It is also a myth to assume that we can assert experimental management practices on what little remains of highly diverse assemblages of conservative plant species. Closely allied to this myth is the notion that two landowners can manage equally similar fire-adapted natural communities—one with and one without the use of fire. Some believe, without proof of data, that the consequences of such out-of-character management will contribute its own unique biodiversity.

Which plant species occupy and colonize abandoned landscapes are determined by the land's use and condition at abandonment. What happens after, in the absence of native plant propagules and the pressures of homogenization, is subject to multiple pathways—all almost always a mix of weedy exotic species winners. The more than half of all Missouri native plant species with a conservative value of 6 or more almost never colonize such areas.

Our monitoring should be directed at measuring trends in conservative species with emphasis in tracking whether management actions favor agreed-on desired conditions.

Management contributions to homogenization

Forty years of natural areas management is sufficient time to look back and assess whether our actions were beneficial or detrimental to maintaining the viability of plant and animal species found within natural areas. We are left with impressions of success, and failure. I mention impressions because not all natural areas are subject to the rigors of ecological science. Not all owners have the resources necessary to engage in the types of appropriate research from which to understand, predict and then achieve the right set of desired ecological conditions. When we do, respective agency ecologists sometimes disagree on the management issues and thus the right course of action.

Unfortunately, strong disagreements on the methods by which we should monitor, research and evaluate whether certain management actions improve or damage the attributes of healthy ecosystems can divide otherwise unified efforts to do what is best for biodiversity. We often disagree on what the desired condition or management objectives should be. Ecologists often fail to adequately test theories or use the most relevant methodologies and analysis. Instead, land managing agencies are attracted to new approaches, only to abandon them in timelines that hinder comparison of long-term data (Belovsky et al. 2004). We are reminded that these differences often lead to management actions that do not favor adaptations of ancient genetic diversity.

Disagreement on management questions can translate into management practices or styles to which ancient genetic memory of ecosystems do not adapt well. Ever-changing staff aspire to

make a difference in the world. Those aspirations depend on one's history, education, experiences, work ethic, political preference, beliefs, the environment in which they live, hobbies, and biases. We all wonder what the management style of the next new natural area manager might be, whether in a state park, conservation area, Nature Conservancy area, federal property or the new owner of private lands. The wonderment arises simply because as natural area specialists we have experienced changes in management style. Agency decentralization and reorganization requires effective advocacy skills on the behalf of Missouri Natural Areas. Fortunately, we can influence the selection in the hiring process. The manager that has great passion for ecological management, coupled with the ability and desire to carry out the best prescriptions, often translates into vibrant, high quality natural landscapes.

Conclusion

Human actions are fundamentally—and to a significant extent, irreversibly—altering the diversity of life on Earth, and most of these changes represent a loss of biodiversity. The factors of homogenization changing and threatening natural areas and other lands containing remnant biodiversity will continue to grow. Society can do little to alter continuing growth trends and their development patterns. Conservation leaders must plan for the consequences of homogenization. Biodiversity must be a high priority on their list among conservation, preservation, recreation or other multiple use purposes.

Keeping in mind the huge list of management styles, human resistance factors, lack of resources and shifting priorities, an irrefutable precept is that the trajectory of change for natural area biodiversity can follow many different and undesirable pathways. Nature does not adapt well, nor is resilient to, missing critical management prescriptions. Homogenization can quickly drive damaged natural communities to turnstile tipping points of no return. We are finding that the genetic diversity of ancient ecosystems truly does not adapt well when their boundaries are surrounded in a dystopian sea of transforming landscapes. With this transformation comes a management dilemma.

To maintain natural biodiversity and species viability, management appropriate to the natural community in question must be deliberate, precise, and based on sound ecological science. Missouri's natural diversity is best assured only through the continued dedicated commitment of resources to care for natural areas and other places of ecological importance. Managers must unify to identify the management and science issues, and to reach consensus on solutions. Given 40 years of tested natural areas management, managers and administrators need to convene workshops and conferences to identify pressing issues, share management successes and failures, and seek information to quickly predict present and future ecological conditions. ❧

Paul W. Nelson served as the Director of the Natural History Program for Missouri State Parks and as Forest Ecologist for the Mark Twain National Forest.

Contact: pnelson@chjv.org

References:

Anderson, R.C. 1997. Native pests: the impacts of deer in highly fragmented habitats. Pp. 117–134 in M.W. Schwartz (ed.). Conservation in highly fragmented landscapes. Chapman and Hall, New York.

Belovsky, G.E., D.B. Botkin, T.A. Crowl, K.W. Cummins, J.F. Franklin, M.L. Hunter, A. Joern, D.B. Lindenmayer, J.A. MacMahon, C.R. Margules, J. M. Scott. 2004. Ten Suggestions to Strengthen the Science of Ecology, *BioScience*, Volume 54, Issue 4, Pages 345–351

Callan, R., N.P. Nibbelink, T.P. Rooney, J.E. Wiedenhoeft, and A.P. Wydeven. 2013. Recolonizing wolves trigger a trophic cascade in Wisconsin (USA), Journal of Ecology, 2013, 101, 837–845.

Ladd, D. and J.R. Thomas. 2015. Ecological checklist of the Missouri flora for Floristic Quality Assessment. Phytoneuron 2015-12: 1–274. Published 12 February 2015. ISSN 2153 733X

Lanclos, M. M. and C. F. Blodgett. 2003. Urban change in St. Louis using Landsat imagery from 1972–1999. Missouri Resource Assessment Partnership, Columbia, Missouri.

McKinney, M.L., and J.L Lockwood. 1999. Biotic homogenization: a few winners replacing many losers in the next mass extinction. Trends in Ecological Evolution. Nov: 14 (11): 450–453

National Geographic Magazine. 2008. Special Report: Changing Climate. National Geographic Society, Washington, D.C.

Nelson, P.W. 2010. The Terrestrial Natural Communities of Missouri. The Missouri Natural Areas Committee, Jefferson City, Missouri, 550 pages.

Radeloff VC, Hammer RB, Stewart SI (2005) Rural and suburban sprawl in the US Midwest from 1940 to 2000 and its relation to forest fragmentation. Conserv Biol 19: 793–805.

Rogers, D. 2008. Shifts in Southern Wisconsin Forest Canopy and Understory Richness. Ecology 89(9) 2008.

Rooney, T.P., S.M. Wiegmann, D.A. Rogers and D.M. Waller. 2004. Biotic impoverishment and homogenization in unfragmented forest understory communities. Conserv Biol 18: 787–798.

Steyermark, J.A. 1940. Studies of the vegetation of Missouri—1. Natural plant associations and succession in the Ozarks of Missouri. Chicago Field Museum of Natural History, Botanical Series. 9:351–475.

Steyermark, J.A. 1963. Flora of Missouri. Iowa State University Press, Ames, Iowa.

Yatskievych, G. 2013. Steyermark's Flora of Missouri. Revised edition. Volume 3. Missouri Botanical Garden, St. Louis.

Photo by Justin Thomas

A severely destabilized Ozark woodland system likely resulting from a history of livestock overgrazing, early twentieth century spring burning, over harvesting of timber and, more recently, an intense summer arson fire. What is left is a soilless, depauperate landscape, an abundance of weedy and generalist species and little chance of recovery to a stable state that remotely resembles the original community.

Stable Communities Require Stable Management: Chaos Breeds Chaos

by Justin Thomas

"A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise."

— Aldo Leopold

The most important variable in the formation of natural communities is time. All quality natural communities, from glades to swamps, are defined by antiquity. Stability over deep ecological time underpins the very processes by which species evolve, coevolve, shift and accumulate into complex communities. It is this complexity, one borne of time, which separates natural communities from novel communities; ecological integrity from ecological inadequacy; reverence from condemnation.

Stability, as a function of time, is crucial to the formation and persistence of complex natural systems. The longer a system is stable, the more complex it can become. From soil microbes to

keystone predators, complex communities assemble into lattice-like frameworks of interwoven, interdependent processes relative to their stability and relative to time. Anything that destabilizes a system disrupts the delicate intricacy of this lattice, sending it into alternate, often simplified, states of stasis or reassembly. In terms of biological diversity and function, this is what we strive to avoid and why we seek to preserve.

But what of the "thousand natural shocks that flesh is heir to?" After all, nature isn't all rainbows and butterflies. Natural destabilization can come from numerous sources. Any given place on earth is subject to any number of natural catastrophes at seeming random intervals of time. Examples include severe droughts, conflagrations, hurricanes, floods, etc. — not to mention an occasional meteor impact. But typically these are locally rare events, and in all cases nature recovers and reestablishes ecological complexity via the life affirming qualities of stability, succession and natural selection. But it takes significant and relative quantities of time.

Space is another major player in the complexity of natural systems. Before modern humans so thoroughly fragmented the landscape, ecological complexity could reassemble faster and in more predictable ways because of the buffering effects of large scale spatial dynamics. Unrelenting, we brutish moderns continue to subject the earth's ecological complexity to our growing appetites. We are simultaneously robbing it of its size and complexity — and thus its stability — on a global scale. Prairies once analogous to oceans have been reduced to puddles, forests once unfathomably immense and ancient have been reduced to even-aged lots, and waterways once teeming with aquatic life are now choked with sediment and poisoned with an unholy chemical cocktail of toxicity. Heavy is the brow and the heart of the field ecologist.

So here we are lost in the immensity of time, cut off from the healing forces of spatial connectivity, watching those areas we can't protect sink farther into the bottomless mouth of human-in-

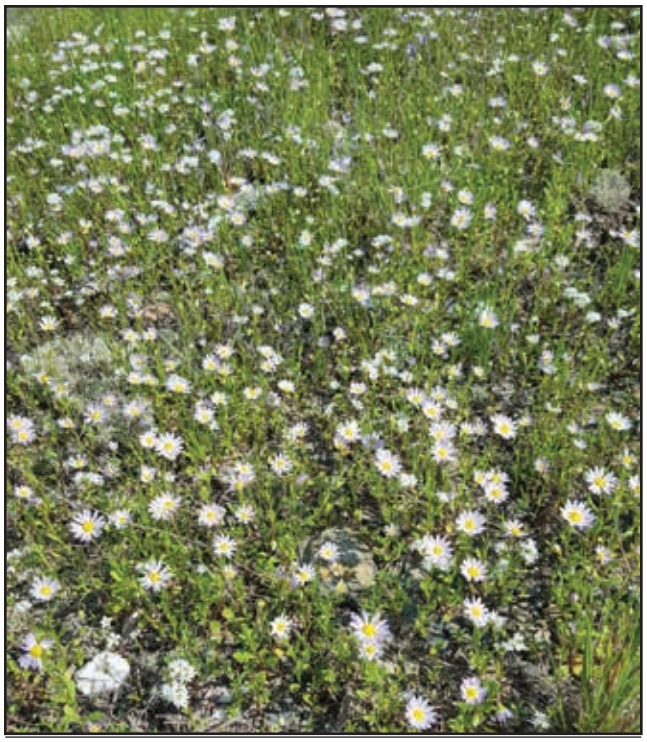
A stable, highly complex, woodland community with significant species richness, floristic quality and ecological function. Only an occasional, low intensity, dormant season fire is necessary to maintain this community. Intense or frequent fire, extensive grazing or rooting by animals or soil disturbance from logging activity could easily simplify/destabilize this community.

Photo by Justin Thomas

Photo by Justin Thomas

Communities that are extremely limited by nutrient and moisture availability like this severely degraded (simplified/disturbed) shale barren are especially sensitive. This example, Missouri's largest, has been completely denuded by ATV traffic.

Photo by Justin Thomas



Stable shale barren communities in Arkansas that still harbor ecological complexity are rich with conservative species such as *Astranthium ciliatum* (Western Daisy) and *Valerianella bushii* (Bush's Corn Salad).

duced degradation while desperately clinging to the few remnant natural areas that are legally protected, the sacred scraps of the natural heritage that once bedecked our state.

We are faced with the sobering fact that if we don't know precisely how to proceed we could lose everything remotely resembling natural integrity. This induces a sort of panic. This panic easily seeps into natural areas management. Examples include the prescription of non-dormant season fire, the application of intense grazing, and the aggressive chemical and mechanical removal of unwanted species — themselves often a response to poor management practices. Some sites, under the misguided philosophy of "heterogeneity in management," experience all of these in a given year. Obvious damage is often dismissed with the phrase "something will use it." These actions are often not based on tested and defendable science, but on knee-jerk reactions and an institutional culture that rewards or ignores assumptions. As guesstimates feed further guesstimates, the panic deepens and the accepted precepts of science and the advice of seasoned ecologists are regularly challenged or ignored. This leads to chaos and a lack of direction that overwhelms, frustrates and discourages the most steadfast practitioner of natural areas management. On the ground, sites become overburned, overgrazed, overharvested, trampled by heavy equipment and/or prematurely or inappropriately thinned. In essence, they become destabilized and simplified instead of stabilized and diversified. These results are antithetical to conservation and ecosystem management. This has become so rampant that in some circles there is a push to accept the degraded state of natural communities as more natural than clear examples of high ecological integrity. Clearly, even when intentions are pure, some management can do more harm than good.

The first step out of this dark labyrinth is to reinstate and communicate the simple truths, focusing on what we do know and admitting what we

do not. Quantifiable benchmarks for management based on ecological integrity and quality must be set at the site level and adhered to. These benchmarks should be established by reference sites and in such a way that monitoring results immediately feed back into management methodologies. We need to transcend speculation about what "used to happen" in natural systems and begin directly monitoring what does happen, in both the short term and the long term. This must be done at the species level; functional groups are meaningless. Once management is data based, the results need to be shared regularly for discussion and incorporation. Positive ground will be difficult to gain initially, but will come easier with practice. Only in an actively collaborative, science-based atmosphere in which the bar for ecological integrity is set at the highest level can we ensure the ecological stability, and thus continuity, of natural areas. Anything short of this is potentially damaging.

Justin Thomas is Science Director at NatureCITE
Contact: jthomas@botanytraining.com

Photo by Justin Thomas

Research botanists working hard to collect meaningful ecological data pertaining to site management.

Soil Health: The Unseen Foundation of Biodiversity

by Irene M. Unger, Ph.D.

As we celebrate 40 years of Missouri Natural Areas, undoubtedly many will think about the rare plants, animals and geological features protected by this valuable land protection system. The remnant prairies, old growth forests and woodlands, wetlands and caves, and their associated inhabitants provide inspiration as we strive to protect them and the biodiversity that they foster. Nevertheless, we may well be overlooking a key component: how often do we think about the soils that underlie and support these areas?

Soils are teeming with life: as many as 10,000 to 50,000 species of microorganisms may inhabit a single gram of soil. This unseen life provides us with many of the ecosystem services upon which we and other organisms rely, including clean water, the decomposition of organic matter, and nutrient cycling. Much like climate, soils help determine which plants flourish; in turn, these plants determine which animals thrive. Therefore, it is quite accurate to state that soils and geology are the foundation of the biodiversity we seek to preserve and protect in our Natural Areas. Thus, just as a wildlife manager may also be a plant ecologist because wildlife depends on plants for habitat and food, a landscape manager may also be a soil scientist for similar reasons.

While we know that different ecosystems (e.g., prairies vs. forests) support different microbial communities, much is yet to be learned about the relationship between the soil microbial community and the terrestrial plant community it underlies. For example, what is the pace and character of the succession of the soil microbial community in response to aboveground disturbances, including our restoration efforts? We know that in many ways, plant development drives animal succession. Even animals not necessarily tied to a particular set of plant species may be tied to the dominant

Photos by Irene M. Unger

Two Westminster College students assess soil color as a part of sampling for MO-DIRT (Missourians Doing Impact Research Together), a citizen science program looking at soil heath and how it is influenced by microclimate. Soil color can be used to estimate the organic content of the soil, an important component of soil health.

plant forms. In other words, it might not matter as much which trees are present, but rather that trees are present. What, then, is the role of the soil microbial community? Does the development of plants drive the succession of soil microbes or is it the other way around? We know the vital role soil microbes play and thus could argue that they are the driving force. However, we also know the soil microbial community changes in response to changes in the aboveground terrestrial community. As a terrestrial community transitions during the restoration process, the soil microbial community will transition with different groups (i.e., bacteria vs. fungi) responding in different ways. While some changes in the soil microbial community may come quickly with fluctuations in the aboveground community, there appears to be a lag-effect of decades or more before the soil microbial community of a restored prairie or forest resembles those of native remnants in our designated natural areas.

The soil microbial community is diverse and resourceful. It responds to changes — favorable or not — in its habitat, just like any other community. For example, we know that plowing or tilling affects soil structure by reducing the amount of macropores (i.e., large pores that drain freely by gravity). This in turn affects not only how water and the nutrients it carries moves through the soil (macropores allow for easy movement of air and water), but it also reduces habitat for soil microorganisms. Soil microbial community diversity is typically higher in natural systems, such as remnant prairies, than in those that have been plowed or managed for crop production. The deep and expansive rooting systems of the diverse perennial grasses and forbs in native prairies provide habitat and carbon-rich secretions, whereas the seasonal loss of aboveground materials provides other important nutrient molecules through plant litter. Similar resource additions are not provided by annual, monoculture cropping systems such as corn and soybean fields. Diversity begets diversity.

We also know that other disturbances, including flooding, periodic fires, and logging, can affect the biodiversity of the soil microbial community. For example, the duration and the nature of a flood event (i.e., stagnant vs. flowing water) can result in changes in the abundance of different microbial groups, with some being favored and others diminished. These changes may impact soil nutrient cycling and, subsequently, in the ability of the terrestrial plant community to reestablish after a flood event.

Invasive species including garlic mustard (*Alliaria petiolata*) and sericea (*Lespedeza cuneata*) also alter the soil microbial community through their root secretions and litter contributions. For example, soil microbial community structure and function in the soils associated with the rooting zone of sericea differs from that of soils associated with native prairie vegetation. In a recent study, I partnered with other soil scientists to demonstrate that these invasive plants may continue to have an influence long after they are removed, particularly if their roots remain (top-killed only), or if these plant species are capable of producing chemicals that influence the germination, growth, survival and reproduction of other native plant species. We discovered that even though a restored or reconstructed prairie may resemble a remnant prairie on the surface, differences may remain in soil chemistry, structure and microbial community. As noted above, these differences may translate into reduced ecosystem services.

By protecting high quality functioning ecosystems, natural area managers are protecting more than the plant, animal, and geologic communities. While a primary objective is to preserve these visible components of natural areas, in protecting these areas, soil microbial communities and their vital ecosystem services are also preserved. The value of these ecosystem services must not be underestimated because they help to provide the foundation for the aboveground diversity. In addition, the protection and study of natural areas are vital to efforts to restore damaged ecosystems as they serve as reference condition landscapes towards which ecosystem restoration efforts aspire. As we celebrate 40 years of Missouri's natural areas, we celebrate both the seen and unseen biodiversity of these significant landscapes.

Irene M. Unger, Ph.D, is Associate Professor of Biology and Environmental Science; Environmental Science/Studies Program Coordinator; and Sustainability Coordinator at Westminster College
Contact: Irene.unger@westminster-mo.edu

Ava Glades Natural Area: A Glade Landscape on the Mark Twain National Forest

by Kyle Steele

Photo by Kyle Steele

Photo 1. A managed dolomite glade and woodland complex within Ava Glades NA. Note the bottlebrush blazing star (*Liatris mucronata*) in full bloom, a species primarily limited to the glades of the White River Hills. Also note the wooded crest above the glade at the top-right corner of the photo, developed from a Mississippian limestone remnant.

In October, 2016, the Missouri Natural Areas Committee unanimously approved the nomination for the Ava Glades Natural Area, a 5,251 acre tract of dolomite glades and woodlands located in the White River Hills region of the Ozark Highlands. The nomination of the Ava Glades NA represented the conclusion of a decade-long effort to identify the highest quality glade complexes that possessed the best potential for restoration on the Ava Ranger District of the Mark Twain National Forest. This new designation provides an unparalleled opportunity to connect Missourians with an iconic example of the globally unique White River Hills glade landscape and provides a level of commitment to preserve and protect this area for generations to come.

In the past 15 years, the Missouri Natural Areas Committee has actively sought to secure large-scale landscapes to capture theme gaps in the natural community system. In 2010, MoNAC delisted Hayden Bald Natural Area, a small 40-acre glade of marginal quality also located in the Ava Ranger District. Designated in 1984, Hayden Bald NA represented a small fraction of a greater landscape that stretches for thousands of acres across the region. The primary reasons for delisting Hayden Bald NA included the small size, the neighboring grazed private lands on all sides which prevented active management, and the lack of a defining landscape feature which could more likely be found on larger landscapes located elsewhere in the district.

Ava Glades NA represents an outstanding example of the modern, landscape-scale natural area concept, one designed to include enough land for proper ecological functioning. While Hayden Bald was, indeed, a dolomite glade, it did not represent the surrounding landscape features that make this region of the state significant as a source of rare and unique biological diversity. Ava Glades NA encompasses a mosaic of natural community types, including, but not limited to, a series of high quality dolomite glades, surrounding woodlands, and karst features. The glades serve as the natural area's centerpiece. Cotter dolomite underlies the glades, a substrate which is abnormally resistant to weathering and produces distinctive glade soils unlike most other areas in the Ozark Highlands. The glades here occur on all topographical aspects, including north slopes and ridgetops. This unique feature of ridgetop glades coined the term "baldknobbers," originally named for a group of vigilantes active in the late 19th century in this region, groups that would meet on the crest of these treeless, prairie-like knobs so as to spot any potential foes.

Many of the glades in the Ava Glades NA are capped with a mantle of younger, Mississippian-aged limestone material. Similar to monadnok landforms, the limestone caps on top of the dolomite are remnants of an old geologic surface — lost hills rising conspicuously above the local high elevation zone defined by the bald knobs. In some locations on the natural area, one can hike up a dolomite glade into a limestone glade and not even realize it. The dolomite produces massive boulders and is finer-grained, while the limestone is crumbly and contains many fossils (i.e., fossiliferous), and appears very different in comparison (See Photo 2). More commonly, these Mississippian landforms produce woodland natural communities, particularly in areas of thicker bedrock remnants. Much of the Glade Top Trail Scenic Byway

Photos by Kyle Steele

Photo 2. A chunk of freshly-exposed bedrock from the Pierson Formation from a limestone glade, less than ten feet in elevation above the contact with the Cotter dolomite and associated dolomite glade. At Ava Glades NA.

which traverses the natural area is located on the highest ridges along Mississippian-aged remnants as thick as 100 feet. In comparison to the Cotter dolomite, these limestone formations weather readily and produce very deep, leached woodland soils, soils that produce unique acidic and extremely cherty oak-pine and mixed oak woodlands (see Photo 3). The Cotter dolomite below, known for glade production, can also develop woodland soils, but these soils are less rocky, and generally not possessing more than 3 to 4 feet of clayey subsoil over the resistant bedrock. This close association of the limestone with the dolomite bedrock (high in calcium and magnesium) produces higher fertility, but the clayey residuum holds water so tightly that it is largely unavailable to plants. Good examples of these so-called "high base" woodlands house an impressive diversity of woodland and prairie flora and are typically dominated by short, stubby post oaks (*Quercus stellata*) in the overstory.

Ava Glades NA provides excellent access for recreational opportunity, as well. The Glade Top Trail Scenic Byway, portions of which were originally constructed by the Civilian Conservation Corps in the 1930s, courses the area for those unable to explore on foot. The ability to access Ava Glades NA by road expands the opportunity for all Missourians to experience and learn about this ecologically important and beautiful landscape. Along the Trail, there are several scenic overlooks. The most noteworthy are the Caney Mountain Picnic Area and the Arkansas View overlook. For those looking for adventure by foot, visit Three Sisters or McClurg glades which allow visitors to experience the glades up close.

Kyle Steele is Forest Ecologist for the Mark Twain National Forest
Contact: kylesteele@fs.fed.us

Photo 3. A landscape view from an opening in a dolomite woodland site above the glades, maintained in part by the Mark Twain National Forest for the enjoyment of observers driving the Glade Top Trail Scenic Byway. At Ava Glades Natural Area.

Photos by Kyle Steele

Photo by Greg Iffrig

The resurgence at Ball Mill Resurgence Natural Area.

L-A-D Foundation: A History of Work with Missouri Natural Areas

By Greg Iffrig, John Karel, and Susan Flader

Two decades before the establishment of the Missouri Natural Areas Committee (MoNAC), the Nature Conservancy, noted botanist Julian Steyermark, Leo Drey and others began organizing and working to protect important places in Missouri. Drey, who later established the L-A-D Foundation, began acquiring forested land in the Missouri Ozarks in 1951, just as the Conservancy was organizing its Missouri Chapter. In 1953, University of Missouri horticulturist Robert Nevins reviewed for the Nature Conservancy some potential nature preserves based on an earlier list compiled by Steyermark of 121 "Missouri Areas in Need of Protection." These early efforts envisioned a robust program of land protection.

In his report, Nevins highlighted an old-growth stand of white oak owned by the National Distillers Products Corporation; at the time, the Society of American Foresters (SAF) expressed interest in designating this area as a virgin type association for white oak in its own natural areas program, initiated in 1947. It was while fighting fire in 1953 when Drey learned National Distillers was liquidating its timber and intending to sell all of the company's Missouri land. After six months of negotiating, Drey acquired nearly 90,000 acres from Distillers, and by contract, arranged to protect that white oak stand above Satterfield Hollow in Shannon County from cutting (Flader 2008). Working with SAF, Drey and his staff arranged to protect 10 acres as an SAF Natural Area (Shanklin 1955). Named Current River Natural Area (NA), it was the first area of its kind in Missouri,

and among the first in the country. A second site on the forest, a 20-acre mixed stand with old-growth Eastern red cedar co-dominant in the canopy, was included in the SAF system in 1964 as Pioneer Natural Area (Lynch 1964).

Leo Drey established the L-A-D Foundation in 1962 as the organization established to carry on his life's work. Karel (2008) provides a more detailed account of L-A-D Foundation contributions to recognize natural areas in Missouri. Initially, the Foundation held title to lands located beyond Pioneer Forest and awarded grants to charitable organizations. In 1965, the Cooperative Wildlife Research Unit of the U.S. Fish and Wildlife Service at the University of Missouri-Columbia began a series of natural area surveys. Mary Alice Sherman, a graduate student, completed the first survey in central Missouri. In 1972 and 1973, the L-A-D Foundation provided funding to the University to assist its second natural area survey of six eastern Ozark counties, conducted by George Fadler. With funding from the Missouri State Inter-Agency Council for Outdoor Recreation, the University completed four other natural area surveys, each based on regional planning districts (RPD). Between 1972 and 1973, Larry Mechlin surveyed the Mark Twain RPD. In 1973 and 1974, Daniel Muser surveyed the Kaysinger Basin RPD, and from 1974 to 1975 John Karel surveyed the Southeast Missouri RPD. Finally, in 1978, Greg Iffrig surveyed the A.B.C.D. and Mid-America RPDs. Leo wished to expedite the statewide inventory, and so from 1974 to 1978 the L-A-D Foundation undertook its own natural areas survey in 67 remaining counties which were managed by Roger Pryor (1980). To complete the comprehensive effort, the Missouri Department of Natural Resources contracted Iffrig in 1979 to survey the last ten counties in northwestern Missouri.

The results of these surveys were made available to the agencies and organizations that were acquiring land at this time. Drey, working on behalf of the L-A-D Foundation, began acquiring specific high priority natural properties. In 1970, he donated the title to lands at the Narrows in Texas County, Grand Gulf in Oregon County, Clifty Creek in Maries County, and the well-known Cave Spring on the Current River in Shannon County to the L-A-D Foundation. Also in 1970, Drey donated easements to 35 miles of frontage along the Current and Jack's Fork Rivers in the Ozark National Scenic Riverways. In 1971, he added land to Clifty Creek and the Narrows. By 1972, the Foundation acquired Rocky Hollow in Monroe County, and Horseshoe Bend and Dripping Springs in Texas County. The Foundation acquired Hickory Canyons in Ste. Genevieve County and title to the scenic easement lands totaling an estimated 960 acres along the Current River in 1974. In 1977, the Foundation acquired additional land at Hickory Canyons, and in 1978 the Foundation acquired Ball Mill Resurgence in Perry County.

The Foundation initiated a land use agreement with the Missouri Department of Conservation in 1971 for the management of seven of these areas. That agreement constituted a lease and is periodically amended over the years as the Foundation acquires additional lands. The Foundation leases its Grand Gulf property in Oregon County to the Missouri Department of Natural Resources to be part of the Missouri state park system. Title to these properties remains with L-A-D, and the Foundation donates the leases while the state agencies manage the properties to make them available for compatible uses including research, stewardship, and appropriate outdoor recreation. In addition to holding Missouri natural area status, Rocky Hollow is also listed on the National Register of Historic Places and Grand Gulf is a designated National Natural Landmark.

Drey's interest in natural lands deserving protection continued throughout his active life. When Congress included a 44-mile long portion of Missouri's Eleven Point River as one of the eight original units of the Wild and Scenic Rivers System, its most significant feature, Greer Spring, remained in private ownership. With its pristine setting and nearly mile-long, spring branch canyon, it is the very heart of the Eleven Point. Greer Spring was owned by one family since 1920, and in 1987, when the 7,000-acre property was offered for sale to Anheuser-Busch Corporation to be used for bottling water, Drey was motivated to intervene. He persuaded Anheuser-Busch to abandon its bottled water idea and instead help him secure the property for the Mark Twain National Forest; they reduced its sale price to the US Forest Service, protected Greer Spring and Greer Mill, and added miles of river frontage and thousands of surrounding acres to the scenic river corridor.

Beginning in the 1980s, the L-A-D Foundation enlarged its board to include community leaders and professionals interested in natural areas, state parks, geology, forestry, conservation, and history. The Foundation began to strengthen its grant oppor-

tunity program, to consider the management and long-term stewardship of Foundation-owned natural areas, and to sustain conservative management of Pioneer Forest into the future. In 1995, Pioneer Forest began a program to select and designate forest reserves on Pioneer lands. These sites are protected in a similar fashion to natural areas. Initially, seven of these sites were designated for protection, but the number has grown to eleven. Then, in 1997, the L-A-D Foundation formally adopted natural area policy guidelines which recognized designations for protecting certain lands, including state natural areas, national natural landmarks, research natural areas, Pioneer Forest reserves, endangered species sites, riparian zones, and historic sites on lands it owned.

These actions served as preparations for Leo and Kay Drey's donation of most of the Pioneer Forest to the L-A-D Foundation in 2004. Pioneer Forest has undergone a remarkable half-century of restoration of an oak-hickory-pine forest landscape. Pioneer Forest continues its mission to demonstrate responsible, conservative forestry on most of its lands, but there are also significant areas withdrawn from commercial silviculture. For example, the forest now includes four designated Missouri natural areas: Current River NA, Pioneer NA, and the Triple Sink portion of Sunklands NA in Shannon County, and Lily Pond NA in Reynolds County.

After acquiring a narrow tract of old growth shortleaf pine in Shannon County from the Highway Department in 1996, the Foundation introduced prescribed fire for the first time in 2009. The goal remains to manage that tract and the adjoining acreage within a historically important shortleaf pine area on Pioneer Forest for its pine-oak woodland character. Subsequent adjustment of the management area increased its size. In 2011, the Foundation completed acquisition of an inholding critical to collaborative management of Jerktail Mountain and its extensive rhyolite glades, an 1,800-acre landscape along the Current River, now jointly managed by National Park Service and Pioneer Forest. In 2015, L-A-D Foundation formalized the designation of "ecological management areas" as part of a policy document. Each of these areas will be an ongoing source of information about the historic landscape character in Missouri and the Ozarks, while enhancing overall scientific and recreational values on L-A-D lands.

The Foundation has developed a consolidation policy and plans for Pioneer Forest and for each of its natural areas to help guide divesting small isolated tracts not essential to the forest, while adding lands important to successful long-term management. In 2005, to celebrate the 50th anniversary of the designation of the Current River NA, MoNAC approved its expansion from 10 acres to 265 acres. L-A-D has made significant recent additions at Hickory Canyons NA, added key bottomland acreage along the Big Piney River at Horseshoe Bend NA, and acquired important buffer for Ball Mill Resurgence NA in Perry County to include more stream frontage along Blue Spring Branch and watershed acreage in the surrounding karst landscape.

The L-A-D Foundation continues Leo Drey's lifetime commitment to the recognition, protection, and stewardship of natural areas in the Missouri landscape.

Greg Iffrig is Liaison to the L-A-D Foundation Board
Contact: greg.iffrig@ladfoundation.org

John Karel is Past President of the L-A-D Foundation
Contact: john.karel@ladfoundation.org

Susan Flader is the current President of the L-A-D Foundation
Contact: fladers@missouri.edu

References:

Fadler, G. 1973. A natural area survey of six eastern Ozark counties. University of Missouri-Columbia 98 p.

Flader, S.L. 2008. Missouri's Pioneer: A Half Century of Sustainable Forestry. Pages 9-40 in J. M. Guldin, G. F. Iffrig, and SL. Flader eds. *Pioneer Forest—A Half Century of Sustainable Uneven-Aged Forest Management in the Missouri Ozarks.* General Technical Report, SRS-108. Asheville, NC: USDA Forest Service, Southern Research Station. 123 p.

Karel, J.A. 2008. Natural areas protection and recreation opportunities on Pioneer Forest and other properties of the L-A-D Foundation. Pages 84-89 in J.M. Guldin, G.F. Iffrig, and S.L. Flader eds. *Pioneer Forest—A Half Century of Sustainable Uneven-Aged Forest Management in the Missouri Ozarks.* General Technical Report, SRS-108. Asheville, NC: USDA Forest Service, Southern Research Station. 123 p.

Lynch, D.W. 1964. Report of the Committee on Natural Areas. Journal of Forestry December, 1964: 916-918

Nevins, R. B. Not dated. Report of Missouri Natural Areas Survey. (Referred to in another document as being conducted in the summer of 1953). Submitted to Dr. Schery and Dr. Steyermark. 12 p.

Pryor, R.R. 1980. Natural Areas in Missouri—Report of the Missouri Natural Areas Survey. L-A-D Foundation, St. Louis, MO.

Schery, R. W. February 14, 1954. Letter to Robert B. Nevins. 2 p.

Shanklin, J.F. 1955. Current River Natural Area. Journal of Forestry 53(7): 532-536.

Shanklin, J.F. 1960. Society of American Foresters Natural Areas. Journal of Forestry 58(11): 905-917.

Sherman, M.A. 1965. An ecological survey of natural areas in central Missouri. M.A. thesis, University of Missouri-Columbia 65pp.

Steyermark, J.A. January 1954. Missouri areas in need of protection. 15 p.

Remembering the First Decade of the Missouri Natural Areas Program

by Rick Thom

I started work as the first Natural Areas Coordinator for the Missouri Department of Conservation (MDC) in January of 1978, a few months after the directors of MDC and the Missouri Department of Natural Resources (DNR) signed an agreement creating an interagency Missouri Natural Areas System. A committee of four representatives from each agency coordinated administration. The Missouri Natural Areas Committee (MoNAC) worked to define and build the statewide system. Paul Nelson, Greg Iffrig, and later Ken McCarty were my DNR counterparts. The first members of MoNAC included Allen Brohn, Bill Crawford, John Wylie and Bill Pflieger of MDC and John Karel, Fred Lafser, Glen Gessley and Jerry Vineyard of DNR. Although not required by the agreement, both agencies also created internal committees to broaden perspectives and support in selecting and designating future Missouri Natural Areas. MDC initiated a Natural Areas Program in 1970. MoNAC grandfathered all 50 MDC natural areas into the new natural areas system. Beginning in 1981, representatives from the Mark Twain National Forest and the Ozark National Scenic Riverways (National Park Service) attended MoNAC meetings. The Missouri Chapter of The Nature Conservancy followed suit in 1985 as an advisory role. This broadened participation extended the influence of the program to federal and private lands, and helped to make it a truly statewide, interagency program. The program coordinators worked within their agencies to strengthen the natural areas concept, and we worked closely with each other to coordinate meetings and field trips, shepherd nominations through the designation process, and recommend program goals to MoNAC.

We realized from the start that we needed a framework for fitting new areas into the system and to assure their wide distribution. We also needed field inventories of potential natural areas throughout the state, especially on public lands whose purpose was resource conservation. With a framework and inventory, we could identify gaps in the system and establish goals for the best possible range of natural communities and features representing Missouri's various geographies.

The first step was to create a geographical framework. In 1980, Jim H. Wilson, a colleague in MDC's Natural History Section, and I authored *The Natural Divisions of Missouri.* This regionalization divides Missouri into six major ecoregional divisions and 19 sections within those divisions. MoNAC used this as a reference for attaining geographic distribution of natural areas and DNR used the Natural Divisions to identify regional gaps in the state park system. Today, MoNAC uses a refinement of this system, the A*tlas of Missouri Ecoregions*, by Tim Nigh and Walter Schroeder (2002).

MoNAC also needed ecologically-based natural community classification systems. Paul Nelson stepped forward to conduct the extensive field research and organization for a terrestrial classification system and authored the monumental *Terrestrial Natural Communities of Missouri* in 1985. With the Nelson classification overlaying the Natural Divisions, MoNAC created a matrix which showed where each natural community was represented, as well as the many gaps in the natural areas system. This gave us specific goals for future work. MDC Fisheries biologist Bill Pflieger, author of *The Fishes of Missouri*, created an aquatic classification system in 1989. In that same year, DNR geologist Art Hebrank produced a geologic features classification system.

In 1980, MDC began a series of county level natural features inventories with a long-term goal of completing a comprehensive inventory of the state's natural features. Don Kurz, a veteran of the successful Illinois Natural Areas Inventory, led the first survey in St. Louis, Jefferson, Franklin and Washington Counties. His report in 1981 completed the first phase of the statewide comprehensive Missouri Natural Features Inventory. It took until 1995 to complete the report, but by

1991, twelve MDC inventory biologists had completed surveying 87 counties.

To use and retrieve all of the new information that the growing Natural Features Inventory and other projects were generating, DNR contracted with The Nature Conservancy to establish a Natural Heritage Database in Missouri. Later transferred to MDC, this database became Missouri's critical repository for locations of rare species and exemplary natural communities. MoNAC used this program to prioritize areas for natural area designation and for targeting acquisitions to expand and improve representation. The database also answered questions about the size and quality of designated natural areas compared to all known examples of those distinct natural communities.

MoNAC grappled with a number of important questions during early meetings and field trips. Among the most controversial topics involved the importance of area size, the best management practices, degree of tolerance of man-made intrusions and the types of compatible public use. Through the years, MoNAC members grew more acquainted and understanding of values and traditions of each agency. It became easier to discuss controversial issues and, usually, to reach a resolution. MoNAC and its strict criteria and process for designations provided a quality control for inclusion of new natural areas, as well as for declassifications of existing areas. The MoNAC agreement does not impinge on a member agency's control over lands under its jurisdiction, but MoNAC serves an important advisory role, providing further protection for natural areas from single agency decisions that might impact an area on its lands. The committee also serves an important role in advocacy for the protection and management of natural area quality lands throughout Missouri.

Some early discussion topics included the exact definition of a natural area. By the end of the 1970s, we agreed to the definition as it remains today: "Natural areas are biological communities or geological sites that preserve and are managed to perpetuate the natural character, diversity, and ecological processes of Missouri's native landscapes." It took us a while to get there. For example, does a 3 acre white oak stand constitute a sustainable natural area? Does the presence of rare species qualify an area? Should fire be used as a management tool in natural communities that are not grasslands? Should prescribed fire be allowed to extend into surrounding woodlands, or should it be confined to the grassy areas of the glade or prairie? Should we allow haying and cattle grazing on a prairie natural area? How about bison? Should we allow existing public uses, such as horse trails, and existing human disturbances such as ponds and roads, if that is necessary to create a larger area? Should natural area management tend towards preservation, a "hands off" approach to let nature take its course? Or should we actively manage natural areas involving interventions and manipulations in forest understory and canopy, hydrology, fire intensity and frequency? What is a true savanna and where does it fit in Missouri's presettlement landscapes? Are woodlands a natural community type? How significant a threat are invasive species to biodiversity? We debated these questions and many more, often in the context of a specific area's management or designation boundaries.

An important concept that is well accepted today maintains that larger natural areas that include a range of communities within a landscape are more viable than small, isolated areas that limit ecosystem management options and ecological function. The 3 acre white oak forest can better be managed as part of a larger forest matrix by allowing natural forces — or simulated natural forces — to reinforce the patchwork mosaic of natural communities that exist. We can't accurately predict what a 3 acre white oak stand will look like in 100 years, but we can predict that it will be different from its appearance today. And regardless of management regimes, we can't maintain a small stand of trees as natural area quality for 100 years. One fierce wind event could topple the canopy on the entire 3 acres at any moment. Long term viability became a theme in more modern natural area designations, as MoNAC began to encourage the designation of larger areas that better represent the heterogeneous matrix of Missouri's natural landscapes. While ecosystem changes may occur through time, the functioning landscape mosaic and ecological function should continue to represent the natural range of variability for the natural area.

Photos by Rcik Thom

In April 1983 Long Bald was suffering from fire suppression and eastern red cedar invasion as shown in this photo-monitoring image.

June 1987 photo-plot after cedar thinning and one prescribed fire.

April 1997 photo-plot after five prescribed fires. Note there still are some cedars in the background needing to be thinned.

MDC designated the 3 acre white oak stand as Diggs Natural Area in 1971, among the first areas recognized as a natural area. In 1999, MDC recommended declassification of Diggs NA. The defining feature it represented — a dry-mesic loess/glacial till forest and woodland in the Outer Ozark Border ecological subsection — is now included in the 392 acre Razor Hollow Natural Area, a mosaic of representative natural communities. Another example is the 50 acre Caney Mountain Glade Natural Area in Ozark County, another early MDC natural area. After a comprehensive natural features inventory by MDC's Natural History Section and Wildlife Division in 1980, it became evident that the original natural area was not only small, but one of the poorest examples of glades on this conservation area. MoNAC agreed to declassify the original area, and to create a larger area on nearby Long Bald. Long Bald, like all of the glades at Caney Mountain Conservation Area at that time, was choked in Eastern red cedar and other trees to the extent that once-vast grasslands were separated by stands of trees with little glade vegetation present. Long Bald offered an outstanding opportunity for ecosystem restoration efforts to include cedar removal and prescribed fire. Cedar removal began in 1983 and MDC conducted the first burn in the spring of 1985. Glade vegetation exploded, with species flowering that had not been documented on the area in decades. In 1990, MoNAC voted to expand the natural area to include 1,330 acres of today's Caney Mountain Natural Area. The natural area encompasses glades, woodlands, dry-mesic forest, caves, and creeks in a true landscape mosaic, one characteristic of Ozark County. Not only does this natural area preserve multiple terrestrial and aquatic landscapes, but many uncommon and rare species exist here as well. During one of the inventories on Caney Mountain NA, a surveyor documented a blind crayfish in one of the area's caves. In 1998, Cave Biologist Bill Elliott determined that it was a new species, now named *Orconectes stygocaneyi*, the Caney Mountain Cave Crayfish. Caney Mountain NA remains the only known location for this species.

The expansion of small natural areas to include similar, landscape-scale areas continues to occur under MoNAC even today. Osage Prairie,

Mill Mountain, Sunklands, Burr Oak Basin, Mule Hollow Glade, and Danville Glades natural areas were all significantly expanded to include larger acreages. Rogers Creek NA is now part of Stegall Mountain NA. Hayden Bald NA on the Mark Twain National Forest joined the system in 1983, but was small and offered little opportunity for expansion, and was delisted. In 2016, the Mark Twain National Forest nominated the Ava Glades NA, 5,251 acres of quality glades and surrounding woodlands located along the U.S. Forest Service's Glade Top Trail near Ava, Missouri. Jam Up Cave NA, located on the Jack's Fork River and designated as a 143 acre natural area in 1980, was expanded in 1995 to encompass 966 acres called the Jack's Fork NA. In the past 40 years, MoNAC delisted several small natural areas of low quality, but never before they identified a better example of the natural communities represented in them or added as a new natural area.

It is satisfying to recall the details of the Missouri Natural Areas Program's first decade. Those of us involved in it believed we were doing something significant for the future benefit of Missourians and for the plants, animals, and ecosystems that inhabit Missouri. The program clearly protects and defends an important part of our state's natural heritage, and it is gratifying to see the larger conservation world using the techniques and the resources that we developed for the natural areas system for their own protective measures. The institution that was reinforced during that first decade has continued to thrive and to contribute to the greater conservation goals of the wider community. In retrospect, I hope that the 40TH anniversary is just a marker that will retreat into the past as the Missouri Natural Areas Program continues to flourish.

Rick Thom is former Natural Areas Coordinator, Natural History Division Chief, and Wildlife Diversity Chief for the Missouri Department of Conservation

Contact: rickthom@socket.net

Today Long Bald is a showcase of a restored glade/woodland complex in the expanded Caney Mountain Natural Area.

Photos by Susan Farrington

In Memoriam: Jerry Vineyard: Remembering a Pioneer

by Greg Iffrig

Jerry Vineyard grew up in Dixon, Missouri, where he explored the hills and hollows of Pulaski County. He held a lifelong interest in Missouri's karst landscapes. Those who enjoyed the pleasure of working with him recall his roadside and trailside interpretations of geology, and his amazing knowledge of the variety and order of our state's rock strata. Jerry Vineyard, 82, of Ozark, Missouri passed away on March 31, 2017.

Among cavers, Jerry was widely respected for his knowledge and understanding of Missouri's caves and springs. In 1958, in his early twenties, he published an article in the National Speleological Society Bulletin discussing the reservoir theory of spring flow. A few years later in 1963, he authored his Master's Thesis at the University of Missouri-Columbia detailing the origin and development of Cave Spring on the Current River. He had described and mapped the underground conduits which connected the spring to nearby deep water spring supply reservoirs. Jerry was certainly influenced by his descent into the largest of these reservoirs, Devil's Well, where he observed the erosive influence of water continuing to enlarge its underground dimensions. He returned to the site more than 50 years later to encourage present-day explorers with the Missouri Cave Research Foundation when they descended into Devil's Well in 2015.

Jerry Vineyard was a charter member of the Missouri Natural Areas Committee (MoNAC), participating in the organization of the committee in 1977, and then serving as its Chair from 1995 to 1998. By the time he retired from MoNAC, he had reviewed 122 nominations for Missouri Natural Areas. Rick Thom, another founding member of the committee and one of the early leaders protecting natural areas in Missouri, said "As a member of MoNAC, Jerry's quiet style, patience, professional competence, and skillful diplomacy helped to unite the agency members of the group and made MoNAC more effective."

During those early years, an ad hoc acquisitions committee of various non-profit and agency representatives met to discuss future acquisitions. Jerry encouraged Leo Drey to acquire Ball Mill Resurgence in Perry County in 1978. In 2007, as a member of the board of directors of the L-A-D Foundation, Jerry played a significant role in securing a $400,000 grant which allowed the foundation to begin modest expansion of its protected land in Perry County, the Missouri capital of karst.

Photo by Greg Iffrig

Jerry Vineyard

During his 40 year career with the Missouri Department of Natural Resources, Jerry co-authored two popular reference books of interest to natural areas practitioners, Geologic Wonders and Curiosities of Missouri and Springs of Missouri. While at MoDNR, Jerry encouraged the scientific study of caves and water resources and supervised Missouri's cave catalog. He co-founded and was a lifelong member of the Missouri Speleological Survey, and was the primary developer of the 1980 Missouri Cave Protection Act.

John Karel, former Director of Missouri State Parks and recently retired President of the L-A-D Foundation, remarked that "Jerry understood that the foundation of the most important outdoor places in Missouri were based on geology, and he inspired a generation of natural history professionals with his interest in and commitment to those resources." The L-A-D Foundation, Missouri Department of Conservation, and the Missouri Department of Natural Resources will honor Jerry with a bronze plaque to be placed at the entrance to Ball Mill Resurgence Natural Area.

Greg Iffrig is Liaison to the L-A-D Foundation Board.
Contact: greg.iffrig@ladfoundation.org

Honoring a Conservation Legacy: Bill T. Crawford

by Mike Leahy

2017 marks the 40TH anniversary of the inter-agency Missouri Natural Areas Program but the roots of today's Missouri Natural Areas System go back even further and Bill T. Crawford was the person who was there at the beginning.

Crawford was 17 in 1935 when he and his father attended the first meeting of the Conservation Federation of Missouri at the Tiger Hotel in Columbia in 1935. Crawford helped his dad campaign for the vote for the constitutional amendment that established the Missouri Conservation Commission and Department in 1937. A few years later in 1942, with a graduate degree from the University of Missouri, Crawford joined the Conservation Department (MDC).

Crawford headed the Department's Wildlife Research Section for 34 years. In 1966, Crawford, along with friend and MDC colleague Don Christisen, and other prairie enthusiasts helped form the Missouri Prairie Foundation. In the late 1960s, Crawford served as president of the North Central Section of The Wildlife Society; in that role he attended a Wildlife Society meeting in Madison when he learned about Wisconsin's state natural areas program, the first in the nation. Crawford brought the concept to Missouri and shared it with fellow MDC staff John Wylie (then-Assistant State Forester), Charlie Schwartz, Jim Keefe and Assistant Director Allen Brohn. This led to the creation of the first classification system for terrestrial and aquatic natural communities and the adoption by the Conservation Commission of a Natural Areas Policy in 1970. In 1971, the first Missouri Natural Areas were designated on lands owned or managed by MDC. The first MDC natural areas committee included Crawford, Charlie Schwartz, John Wylie, John Funk, Bob Wells, Jim Keefe and Allen Brohn.

The Design for Conservation and passage of the conservation sales tax in 1976 specifically promised an expanded Missouri Natural Areas System and Crawford helped with the formation of a new Natural History Section within MDC in 1977. Also in 1977, the Missouri Department of Natural Resources joined with MDC to form the inter-agency Missouri Natural Areas Program. Crawford served on the inaugural Missouri Natural Areas Committee.

Photo by Noppadol Paothong

Bill Crawford in 2015

Thanks to those early efforts by Crawford and others, today we have a robust Missouri Natural Areas System of 189 designated sites on over 92,000 acres. We also have a vibrant Missouri Prairie Foundation that has protected more than 4,000 acres of prairie and owns more than 3,000 acres of mainly remnant prairie in the state.

Crawford retired from MDC in 1983 and was awarded the prestigious Master Conservationist award from the Conservation Commission in 2010. In addition to his conservation pursuits, Crawford was active as a local historian in Columbia, Missouri, and instrumental in the establishment of the Boone County Historical Society at the Walters Boone County Museum.

Bill Crawford died on December 7, 2017, at the age of 99 years. His conservation legacy lives on.

Mike Leahy is Natural Areas Coordinator with the Missouri Department of Conservation

Contact: Michael.Leahy@mdc.mo.gov

Photo by Gwen Shirkey, The Nature Conservancy

The Nature Conservancy's Doug Ladd Retires

On October 18, 2017, the Missouri Natural Areas Committee gathered at Bass River Resort for the annual fall meeting. After the business meeting, we honored Doug Ladd with an original illustration by Paul Nelson of Missouri's natural divisions. After 37 years of regular involvement with the committee, Ladd is retiring from The Nature Conservancy and thus his position with MoNAC. Ladd writes a few parting words:

"My involvement with the Missouri Natural Areas Committee started when I began working for the Missouri Department of Natural Resources in 1980. My initial work involved various internal assessment and work groups within DNR, and around 1983, I presented a natural area nomination to the committee. When my tenure began with The Nature Conservancy in 1985, I became TNC's representative for MoNAC; at that time, TNC served as a non-voting, advisory role on the committee. Many years later, after considerable discussion, the committee included TNC as a full voting member. It has been one of the pleasures of my work to be a part of MoNAC for such a long period and play a small part in the evolution and continuing development of a successful and enduring program that directly benefits all Missourians while providing an enduring legacy of our natural heritage."

Ladd's passion and expertise as a premier ecologist will continue to benefit the greater conservation community for decades to come.

Allison Vaughn is the Natural Areas Coordinator with the Missouri Department of Natural Resources.

Contact: allison.vaughn@dnr.mo.gov

Calendar of Events

January 13, 2018 • 10am-11:30am
Winter Tree Identification
Shepherd of the Hills Conservation Area
Branson, Missouri
www.mdc.mo.gov

January 28–31, 2018
78th Midwest Fish and Wildlife Conference
Milwaukee, Wisconsin
www.midwestfw.org

January 31–February 2, 2018
Missouri Natural Resources Conference
Osage Beach, Missouri
www.mnrc.org

March 20–22, 2018
Missouri River Natural Resources Conference
Nebraska City, Nebraska
www.mrnrc2018.com

October 23–25, 2018
2018 Natural Areas Conference
University of Indiana in Bloomington
Bloomington, Indiana
naturalareas.org/conference

Erratum

In the 2016 Missouri Natural Areas Newsletter the species label on the image on p. 31 was incorrect. The correct species is rainbow darter (*Etheostoma caeruleum*). In addition, the images of hellbenders and sampling for them found on p. 9, 10, and 12 should have been credited to Jeff Briggler, Missouri Dept. of Conservation.