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ECOSYSTEM RESTORATION IN THE OUACHITA NATIONAL FOREST: EVALUATING THE PRAGMATISM OF PRE-EUROPEAN SETTLEMENT BENCHMARKS

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ABSTRACT OF DISSERTATION

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A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Arts and Sciences
at the University of Kentucky

By
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Lexington, Kentucky

Director: Dr. Jonathan Phillips, Professor of Geography

Lexington, Kentucky

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ECOSYSTEM RESTORATION IN THE OUACHITA NATIONAL FOREST:
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This paper looks at the intersections of nature and culture through a study of forest ecosystem restoration efforts in the Ouachita National Forest (Arkansas and Oklahoma). Ecosystem restoration goals are often informed by a pre-European settlement (PES) condition, with an implicit (and occasionally explicit) assertion that such conditions are both more natural than and preferable to the contemporary state. In many cases resuming pre-suppression fire regimes remains a key mechanism for achieving this restored condition. This study's three main objectives include: (1) determining how PES benchmarks arose in restoration thought, (2) examining how the choice to use a PES benchmark is influenced by culture, and (3) evaluating the pragmatism of including a PES benchmark in restoration projects.

The issues of the naturalness of PES conditions, along with the cultural implications of adopting a PES benchmark, are critically examined against the backdrop of historic legacies of fire suppression and paleoecological change. Normative balance-of-nature ideas are discussed in light of their influence on natural resource management paradigms. Linkages are drawn between PES conditions and forest health. Evidence supporting the ecological resilience associated with PES vegetation communities is considered alongside the anticipation of future forcing factors. The idea that restored forests represent an ecological archetype is addressed. Finally, an alternative explanation concerning the tendency of ecosystem restoration efforts to converge on a single historic reference condition – a point of equifinality – is weighed against notions of: (1) anthropic degradation, (2) a regional optimum, and (3) a socially-constructed yearning for a frontier ideal.

Because of the unique convergence between historical human activities and natural processes, contemporary culture has conceived of the PES time period as a sort of frontier ideal. The creation of PES benchmarks appears to be an unintentional consequence of attempts to restore forest health rigorously defined by biometric standards. This study offers, to restoration thinking, a framework for critically evaluating

the inclusion of historic reference conditions and a means of responding to criticism surrounding their use. This study's findings rest on evidence gathered from paleoecological and historical biogeography data, interviews, archival materials, cultural landscape interpretation, landscape and nature-based art, and complexity theory.

KEYWORDS: Ecosystem Restoration, Forest Health, Historic Reference Conditions, Pre-European Settlement Benchmarks, Social-Construction of Nature

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To Chelsey

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1.0 Introduction

The United States Department of Agriculture (USDA) Forest Service is investing a significant amount of economic resources, time, and expertise in the restoration of native plant communities and ecosystems throughout the southern United States (Brockway et al. 2005; Huebschmann et al. 2005; USDA 2005, 2006; Van Lear et al. 2005). Additionally, financial and technical support is being offered to federal and state agencies, conservation groups, and private land owners as public interest in restoration increases (Alavalapati et al. 2002; The Nature Conservancy 2003). These expenditures come in response to the historical degradation of terrestrial ecosystems (Outcalt 2000; Trani-Griep 2002) and the loss of native plant communities (Owen 2002) throughout the South. In the Ouachita National Forest (ONF) of west-central Arkansas and southeastern Oklahoma (Figure 1) a similar effort, focused on restoration of the shortleaf pine-bluestem grass (*Pinus echinata-Andropogon arctatus*) woodland ecosystem, began mounting in the early 1990s (Bukenhofer and Hedrick 1997; Hedrick et al. In Press; Henderson and Hedrick 1991). This activity was indicative of the agency's shift in institutional philosophy from an economically-sustained yield management style to one more oriented towards ecological sustainability (Curran 1994; Maser 1991; Mohai 1995; Robertson 2004). This philosophical shift has been accompanied by a corresponding move towards process/condition oriented management techniques, including the use of prescribed fire.

Because the vast majority of old-growth forests in the South were cut during the late 19th and early 20th centuries, restoration efforts are often based on a pre-European settlement[1] (PES) condition, rather than existing old-growth forests, as characteristically is done in the Western United States. In the ONF this development has resulted in the renewal of historically prevalent pine-bluestem woodlands. Ecosystem restoration projects, including those underway in the ONF, are often based on PES conditions, with an implicit (and occasionally explicit) assertion that such conditions are both more natural than and preferable to the contemporary state. In many cases resuming pre-suppression fire regimes remain a key mechanism for achieving this objective. Today, the practice of suppressing natural fire regimes is being replaced, albeit according to strict social, legal, and biological constraints, by efforts to restore "natural" fire regimes. Considerable evidence exists supporting the ecosystem services (e.g., endangered species protection, biodiversity, recreation, etc.) associated with PES communities. However, the issues of the "naturalness" of these conditions, along with the cultural, historical, and political aspects and implications of adopting a PES ecosystem restoration benchmark have not been critically examined. This study's three main objectives include: (1) determining how the PES benchmark arose in restoration thought, (2) examining how the choice to use a PES benchmark is influenced by culture, and (3) evaluating the pragmatism of including a PES benchmark in restoration projects.

[1] Throughout this study the term pre-European settlement refers to the time period, in which the first written records describing the Ouachita Mountain region were recorded, beginning in 1542 with Hernando Desoto's arrival in the Interior Highlands and ending in the mid-19th century with the completion of the General Land Office's witness tree survey.

There has been a call for the further integration of research in the social sciences with natural resource management issues (Cordell 1997; Endter-Wada et al. 1998; Jordan 2000; McIntyre and Hobbs 1999). This research agenda follows on the heels of an increase in the amount of conflict between resource managers, local communities, public-use groups, and private interests (Lueck and Michael 2003; Maguire and Albright 2005). Additional studies have addressed a range of topics, including the value of ecological integrity in society (Norton 1995), and the role of ecologists in the formation of public policy (Norton 1998). Likewise, human (Bryant and Wilson 1998; Williams and Patterson 1996), environmental (Zimmerer 1994), and physical (Phillips 2004a) geographers have either given attention to or made calls for synthetic and integrative approaches to understanding the human dimensions of environmental change.

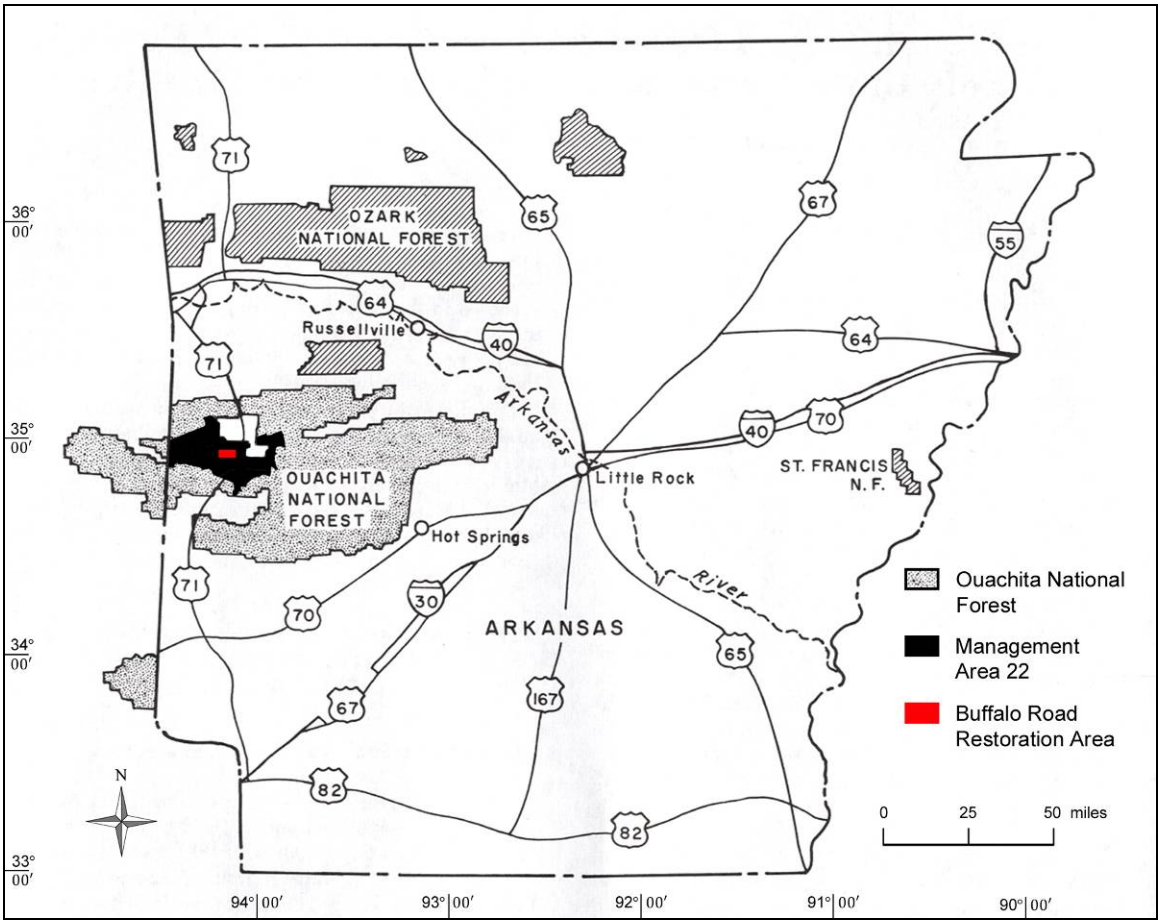

Figure 1. Location map of Ouachita National Forest [additions mine] (reproduced from Strausberg and Hough 1997, 2)

As a locus of scientific principles and cultural values, the practice of ecosystem restoration rests tentatively upon its own set of underlying ideas and assumptions. From a robust body of scientific literature, the culture of restoration draws on both well-entrenched equilibrium based theory and ideas rooted in nonlinear dynamics (Gersmehl 1976; Phillips 2004b). Although a gradual shift in the dominant explanatory framework surrounding ecosystem restoration should be noted, it would be a miscalculation to locate

it as either an applied field or area of theoretical inquiry, solely in the domain of nonlinear dynamics. In fact, it was the sense of some Forest Service personnel whom I spoke with throughout this study that the practice of ecosystem restoration remains firmly rooted in equilibrium-based theory. This discrepancy in explanatory frameworks adopted by different groups within the culture of restoration represents a paradigm shift in the way forest ecosystems are researched versus how they are actively managed. Common among most scientific and managerial paradigm shifts is the emergence of new concepts that serve to advance the paradigmatic agenda (Kuhn 1962). One such concept employed in the service of ecosystem restoration projects are benchmarks based on forest conditions which are thought to have existed prior to European settlement.

Although work in the field of environmental history has served to debunk the myth of pristine pre-Columbian landscapes in the Americas (Bowden 1992; Cronon 1983; Denevan 1992; Dilsaver and Colton 1992; Doolittle 1992; Kay and Simmons 2002; Sluyter 1999; Whitney 1994), scant attention has been paid to the importance and function of PES benchmarks as they have increasingly been integrated into ecological restoration projects (Helford 1999; Swetnam et al. 1999). As such, this study systematically examines the correspondence – often an uneasy one – between historic reference conditions associated with the time period prior to European settlement and ongoing efforts to restore the ONF's once prevalent pine-bluestem woodlands. Clarifying exactly how ongoing restoration efforts in the ONF came to be associated with PES conditions is a key element of this examination. Tracing the co-evolution of ideas working within the culture of restoration (e.g., balance of nature and nature of balance) with the adaptive management strategies they come into dialog with (e.g., fire suppression and prescribed burning, etc.) will help illuminate the influential role that normative conceptions of nature play in formulating adequate responses to maintaining forest health and integrity. Ultimately, investigating how PES conditions function within the agency, both conceptually and related to individuals who are directly involved with on-the-ground restoration efforts, will aid in an evaluation of the pragmatism of using a PES benchmark.

Pre-European settlement benchmarks have been criticized by some for their supposed invalidity as a historically vacuous and socially-constructed conception of nature (Helford 2000; Oelschlaeger 1991). In addition, historical biogeography and paleoecology studies often indicate that PES conditions are at least partly attributable to human agency, and that vegetation communities at any point in time are a historically contingent snapshot of more-or-less continuous environmental changes (Foster et al. 2002; Foti and Glenn 1991; Guyette and Dey 2002, 2000; Guyette and Spetich 2003). In the Ouachita-Ozark Mountain region, for example, Guyette and Dey (2002, 2000) and Guyette and Spetich (2003) have shown the effects of anthropogenic disturbances, such as fire, on the evolution of local vegetation communities. By writing more complete historical accounts of human induced environmental change, however, historical ecologists have, perhaps inadvertently, provided critics of restoration a means of challenging the notion that PES conditions are natural, and that any single preferred natural condition even exists. Such critiques have given rise to two additional assumptions which threaten to unnecessarily hinder the ability of resource managers' to convey the tangible benefits that are a product of existing restoration projects: (1) that PES benchmarks as social narratives are fallible constructs playing a privileged role in

determining *which* nature is restored as opposed to a host of other ecological factors and socio-economic considerations, and (2) that the legitimacy of restoration projects presumably based on PES conditions should be brought into question.

This research begins with the premise that although PES benchmarks may remain, in part, a socially-constructed idea, this finding need not diminish the value of restoration work. As an idea that circulates within the culture of restoration, PES benchmarks have received insufficient attention, especially considering the pivotal role they play in environmental discourse. As disputes over ecological restoration, and consequently PES benchmarks, enter local debates and the policy arena, a more thorough understanding of how this idea has evolved within the culture of restoration is needed. A systematic evaluation of the idea's function should take precedence over uninformed opinions about its appropriateness as an objective for resource management. This will help pave the way for either the qualified inclusion or dismissal of PES benchmarks from future restoration efforts. The implications that arise from allowing one account to enter the policy arena over another are substantial. Valuable environmental work in jeopardy of being retracted or discontinued deserves, at a minimum, that the use of historic reference conditions be reassessed according to foreseeable changes in regional climatic variability. This research is, therefore, an attempt to bring new questions to bear on an issue which natural resource managers and society at large continue to grapple with: *the practicality and appropriateness of employing historically informed benchmarks*. This study offers, to restoration thinking, a framework for critically evaluating the inclusion of historic reference conditions and a means of responding to criticism surrounding their use.

The extended inquiry that follows may be understood, in brief, as a syllogism of sorts: If statements (a) and (b) hold true, then so follows the validity of (c). Similarly, concerning our examination of the agency's restoration of pine-bluestem woodlands in the ONF, an equivalent statement would proceed as follows: (a) stable and healthy forests in disturbance mediated ecosystems include the presence of fire, (b) PES conditions are fire maintained; therefore, (c) PES communities are stable and healthy. Accordingly, fire is needed to restore stability[2] in the ONF. Of course, the emergence of this logic within the agency has come at much expense, both economic and social, and required first that a substantial body of research be compiled alongside a mending of tattered ties within the local conservation community. The ONF was no stranger to public controversy in the 1980s and early 90s, and some of these issues will be taken up later in this chapter. However, the true point of departure for this study long precedes the agency's more

[2] A general definition of *stability* is the tendency of a system (in this case ecosystem or landscape) to remain in a more-or-less consistent state or condition; to experience minimal change. *Instability* occurs when a system is vulnerable to, or experiencing, rapid or extensive change. Alternatively, *dynamical stability* refers to a system that is stable following a perturbation or disturbance, and is able to asymptotically approach its pre-disturbance state. *Dynamical instability* indicates a system which is vulnerable to minor variations in initial conditions or minor perturbations or disturbances. Rather than a return toward the pre-disturbance state, the effects of minor initial variations or disturbances tend to persist and grow over time. Accordingly, equilibria may be stable or unstable in this sense. The term *resilience* is defined as the ability of a system to recover from disturbance. Whereas, *resistance* means the extent to which a system is vulnerable to disturbance, or able to absorb disturbance with minimal effects.

recent dealings with environmental problems (e.g., catastrophic wildfires, epizootic insect and fungal pathogen outbreaks, etc.) – many of which are not uncommon in the American West and increasingly throughout the South. We must return to a time nearly 20,000 years BP with an eye for tracing climatic variability coupled with sweeping changes in the composition of plant communities – what Delcourt and Delcourt (1991) presciently called a "paleoecological perspective" – to properly account for present-day conditions in the ONF. It is against this historical backdrop of sea change in environmental conditions in the Interior Highlands that we may continue charting the agency's course ahead along a line of most ecological resilience.

1.1 History of Forest Service Management in the Ouachita National Forest

> "Locomotion should be slow, the slower the better; and should be often interrupted by leisurely halts to sit on vantage points and stop at question marks." – Carl Sauer (1956, 296)

USDA Forest Service tenure in the Ouachita National Forest[3] began in 1907 with the designation of forest reserves as "national forests" (Strausburg and Hough 1997). The lands had formerly been transferred in 1905 from the U.S. Department of the Interior to the USDA shortly before the formation of the Forest Service later that year. As Chief of the USDA Forest Service in 1906, Gifford Pinchot was instrumental in initiating the early planning stages of what would eventually become the ONF. On June 11, 1906 Congress passed the Forest Homestead Act making agricultural lands available for entry within forest reserves. Through a series of presidential proclamations the ONF steadily grew in size from 1907-09 following President Theodore Roosevelt's addition of reserved public domain lands to the agency's existing holdings. Initially propelled by the need to respond to impending problems brought on by agricultural land use, the agency's early viewpoint in the ONF and elsewhere was on protecting watersheds. The Forest Homestead Act helped to achieve this by bringing degraded agricultural lands under agency control. Much of this degradation occurred on higher elevation lands that had been over-cut in preparation for crop cultivation. This removal of vegetative cover combined with steep slopes created substantial downstream problems involving flooding due to increased sedimentation and siltation. The protection of sensitive watersheds became a focal point upon which the early emphasis on developing National Forests was centered. Most of the country's eastern National Forest lands, and to an extent the ONF, were created by acquiring private lands after the aforementioned initial cut had been made – often hastily. Cut-and-run or abusive exploitation as it was called was almost invariably followed by devastating wildfires that further increased the land's vulnerability to erosion by dramatically changing runoff characteristics. In its first fifty years of existence, therefore, the agency remained devoted to the arduous task of reforesting and protecting sensitive watersheds (Strausburg and Hough 1997).

Providing the forest enough time to regenerate (especially on degraded uplands in the arid western U.S. where recovery is slower) took considerable time and remained the

[3] The major points of the following historical narrative were gleaned from USDA General Technical Report SO-121, The Ouachita and Ozark-St. Francis National Forests: A History of the Lands and USDA Forest Service Tenure (Strausburg and Hough 1997), and interviews conducted with agency personnel and NGO scientists.

agency's primary focus until the mid-20th century. Following this initial period of recovery, industry renewed its interest in harvesting the substantial timber resource then present. Also helping to fuel the impending resource speculation were concentrated efforts under the Eisenhower administration to manipulate the allowable timber cut on National Forests as a way of affecting home prices. Building and growing the national economy, at times, took precedence over maintaining environmental integrity. In 1960 the Multiple-Use Sustained Yield Act was passed as part of an effort to allow and encourage other uses of National Forests. By the late 1960s a shift began in the agency's management paradigm. The prevailing sentiment that timber harvesting was an important but complementary part of broader resource management objectives was supplanted by the idea that National Forests should be managed in the most efficient way possible. Concurrent with this development was a rise in private industrial forests around the ONF and elsewhere throughout the country. The private timber industry was beginning to discover the efficiencies associated with clear-cutting and pine-plantation management. Succumbing to political-economic pressure reflecting the desires of interest groups, the Forest Service followed suit, thereby changing its management paradigm to resemble that of the private timber industry. The controversial practices of clear-cutting and plantation management increasingly became standard operating procedure. Any stands that could support plantation management were being converted into industrial forests (Strausburg and Hough 1997).

Many of the current concerns of environmental groups and citizens living near the ONF are legacies of these earlier circumstances, and are associated with specific economic oriented management practices that the agency has since left behind. According to Resource Professional 3, a long-time resident of Scott County, Arkansas, whose property is surrounded on three sides by National Forest land:

> The conditions when I grew up in the 50s and 60s were different from the way they are now, but of course that was a second growth forest. All that forest had been cut over so the trees were less stocking, younger, shortleaf. I'm talking about on the Forest Service land. In the 60s the Forest Service actually went to intensive silviculture, which kind of concerned me a little bit. They were doing clear-cutting at the time, and this coincided in the early 70s with Weyerhaeuser purchasing a million acres in Western Arkansas…. Weyerhaeuser was clear-cutting and thinning seventy thousand acres a year, so I think there was some copycat going on with the Forest Service. They started to do some of the same things. I went to forestry school in the late 60s and graduated in '71, and so my bias was that the Forest Service should not be clear-cutting and thinning like Weyerhaeuser…. (Resource Professional 3 6-28-2007)

Fire suppression served as a critical component of the intensive silviculture regime adopted by the Forest Service over previous decades. In an effort to maximize wood fiber production in industrial plantations fire was precluded by design. An alternative strategy had been implemented before turning toward planting and clear-cutting as the primary management approach: Larger, more-valuable trees were selectively cut, thus opening up the canopy enough to allow natural tree regeneration. However, in the absence of an active fire regime, regeneration came more slowly than anticipated, prompting resource managers to seriously consider plantation type management. Even age stands of economically valuable loblolly pine fit more seamlessly into the emerging economically-sustained yield management paradigm. Consequently, overstocked pine-

plantations prevailed in the ONF, and wholesale changes in the natural system were set in motion. Fire suppression was aggressively pursued under the agency's endorsement of the Smokey the Bear campaign, and a new era of environmental misunderstanding threatened to steer the Forest Service off course (Strausburg and Hough 1997).

The spring of 1970 saw the inaugural celebration of Earth Day followed by the steady rise of the environmental movement. The social milieu surrounding agency public relations during the 70s and 80s became increasingly contentious. In 1976 the National Forest Management Act was passed. This created a lawsuit and appeals process that required the agency to allow public participation in the development of new Forest Service management programs. Conflict over resource management in the ONF became ever more common, and polemical mudslinging was often followed by litigation and numerous appeals. Ultimately, lines were drawn between economic and environmental concerns, and any hopes of forming a consensus on how best to move the ONF forward seemed dashed. However, a turning point came that would help to lift the bleak circumstances that had come to characterize the two previous decades. In 1990 Senator David Pryor, and Forest Service Chief Dale Robertson held an informal, yet remarkably significant, meeting amidst the ONF's sprawling woods. News of the meeting captured immediate interest, drawing the attention of both the local press corps and foresters throughout the region. However, it was not until Senator Pryor pulled Chief Robertson aside from the trailing entourage, for what has been called the *walk in the woods*, that the full gravity of his message became evident. Senator Pryor informed the Chief that there was to be no more clear-cutting or economically-sustained yield management of any kind on the ONF. Whether driven by duty or solidarity, Chief Robertson concurred with Senator Pryor and a new horizon for the ONF started slowly coming into view (Strausburg and Hough 1997).

The renowned *walk in the woods* stands as a pivotal moment in the history of management practices in the ONF. Shortly thereafter the Southern Research Station in Hot Springs was "directed by the Chief to provide scientific support for a shift in management philosophy away from clear-cutting and planting, and toward even-aged and uneven-aged high-forest reproduction cutting methods that rely on natural regeneration" (Guldin 2004, 8). The explicit prohibition of *all* clear-cutting was atypical of standing orders given at nearly any National Forest in the country at that time, and set a unique precedent that other forests would eventually follow in the future. At the time Senator Pryor's mandate was delivered the ONF had reached the point of being totally devoted to clear-cutting plantation management. Although a significant portion of the ONF had the capability of being managed this way, many of the same areas that fell under this designation exhibited exceptional recreation value. Moreover, the environmental constituency that valued the forest for recreational activities, and others, posed an insurmountable obstacle to anyone interested in pursuing such a project. As if compelled by habit, the response that followed involved a proposal to return to standard, non-plantation type management. Fortunately, clearer heads prevailed, recognizing the unique opportunity afforded the ONF at that time. ONF leadership, exercising keen foresight, turned an attentive ear to individuals within the agency expressing alternative ideas about the path future forest management could potentially take (Strausburg and Hough 1997).

What emerged was a new form of management rooted in notions of restoring native ecosystems and plant communities that existed prior to the wholesale changes in the environment that followed European settlement. More importantly, such a management paradigm could help the agency accomplish many of its species and vegetation community management goals under the Threatened and Endangered Species Act (1973) while enabling timber production to continue. However, before the ceremonial lighting of drip torches could take place, and the busy buzz of chainsaws return to the ONF, officials decided to think long and hard about the ecosystem health and ultimately old growth[4] conditions they were intending to restore (Martin 1991). In September of 1990 their collective efforts culminated in a conference on *Restoration of Old Growth Forests in the Interior Highlands of Arkansas and Oklahoma* held at the Winrock International Institute for Agricultural Development in Morrilton, Arkansas. The conference enjoyed an impressive level of intra- and interagency support within the conservation community – something almost entirely absent from ONF activities during the late 1980s. A somewhat disparate group of independent scholars, academic researchers, and environmental groups, including the Arkansas Natural Heritage Commission, the Oklahoma Natural Heritage Inventory, and the Ozark-St. Francis National Forests, joined representative from the ONF to discuss their thoughts and findings on old-growth conditions that once persisted throughout the region. The wealth of information coming out of this round table discussion was published the following year in the official conference proceedings (Henderson and Hedrick 1991). With a revamped set of marching orders in hand, the agency was ready to embark on its maiden voyage toward restoring environmental health and harvesting the seeds of mutual understanding between all parties invested in the ONF's future well-being.

1.2 Ecosystem Restoration and Forest Health in the Ouachita National Forest

> "Though I do not believe that a plant will spring up where no seed has been, I have great faith in a seed. Convince me that you have a seed there, and I am prepared to expect wonders."
> – Henry David Thoreau (1993, xii)

A new management framework for the ONF Forest Plan was formulated in 1991. Much of the detail surrounding the type of approach the agency would take towards devising broader management objectives for the forest at large were inspired by existing restoration efforts underway in Management Area 22 (Figure 2) – an area which serves as the centerpiece of this study and a topic that will be addressed in greater detail under a discussion of the Buffalo Road driving tour. The primary focus of Formal Amendment 22 to the Forest Plan was derived from the role Management Area 22 played in the

[4] Use of the term "old growth" in this context is meant to broadly encompass several major forest types that existed prior to wholesale changes in forest structure and composition taking place, often as a result of livestock grazing and logging at the turn-of-the-century. Pine-bluestem woodland, unique in terms of its association with a set of active disturbance regimes, is only one of several forest types to fall under the old growth category. Although pre-European settlement conditions across the Interior Highlands included old growth stands, and therefore pine-bluestem, the term PES conditions more generally refers to the ever-changing nature of historic ecosystems, prior to increased fire suppression.

creation of new management areas[5] designated for forest ecosystem restoration. This mandate provided the agency the prerequisite lands and necessary political support to begin implementing restoration projects elsewhere across the ONF. As restoration efforts mounted, following the ONF's passage of its new Forest Plan, PES conditions became evermore associated with the ongoing projects. No policy had ever been made or statement issued by the agency concerning an intentional plan to coordinate restoration

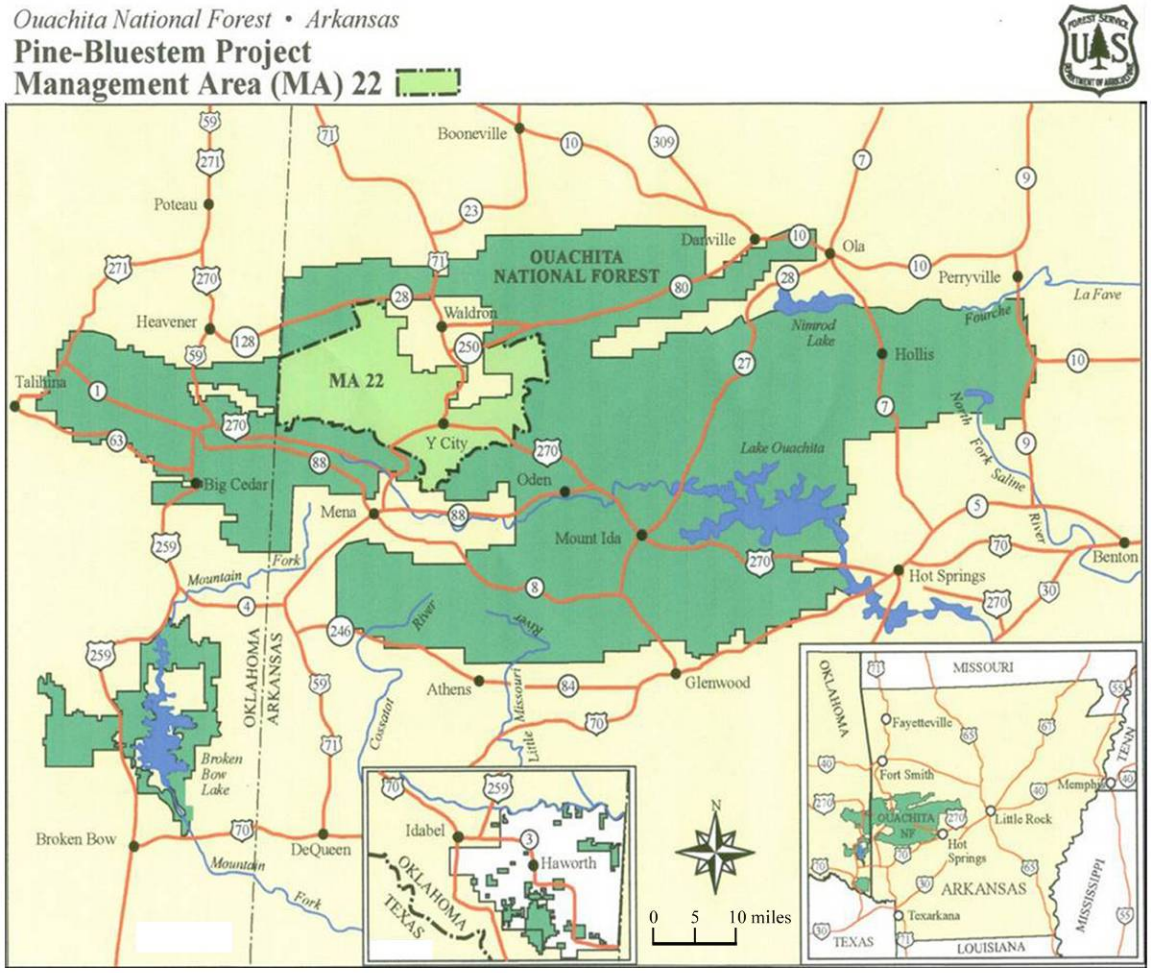

Figure 2. Map showing location of Management Area 22, where much of the current pine-bluestem restoration work is being conducted [additions mine] (reproduced courtesy of USDA Forest Service)

[5] U.S. Forest Service management areas are formally designated National Forest lands managed in such a way as to emphasize the promotion of specific resource values and ecological services. The ONF's Revised Land and Resource Management Plan (USDA 2005) provides for the creation of management areas designated for wilderness and wildlife conservation; scenic, watchable wildlife, and botanical areas; recreational use; seed orchard areas; water and riparian community management; habitat diversity areas; semi-primitive areas; wild and scenic river corridors; old growth restoration; and shortleaf pine-bluestem ecosystem and red-cockaded woodpecker habitat renewal.

targets, goals, or management objectives with PES conditions – much less an officially sanctioned benchmark. The aforementioned Old Growth Conference may have reflected a moment of punctuated evolution in the development of a somewhat ephemeral concept. Yet the close correspondence of PES conditions with a specific set of environmental parameters utilized by restoration scientists was not the product of any coordinated effort or conscious decision being made. Nevertheless, environmental groups and agency personnel alike tended to seize onto the benchmark. As Environmental Scientist 3 with the Forest Service remarked:

> Lots of managers presume the PES condition is what we're working towards. Therefore, consensus may be easily achieved, however, only through lack of thought. Consensus within the agency can form quite quickly and then be reinforced by the public. Many different groups, including both those who are in favor *and* critical of the PES condition, begin to think it's the common sense choice. (Environmental Scientist 3 9-18-2007)

Perhaps any good-hearted attempts at collectively rallying around such a unifying concept should have come as no surprise. After all, consensus had been in short supply during previous decades. The desire to make-things-right stood as a reasonable response to the agency's not-forgotten drift through troubled waters. Was the PES benchmark not the swift gale needed to move along restoration efforts in the ONF? The stated goal of the Forest Service is to manage the land in such a way as to maintain (or, in this case, restore) greater environmental integrity. However, the most desirable environmental condition aimed for does not *necessarily* correlate with a specific time period – something the PES benchmark seemed to do by definition. Those in favor of utilizing PES conditions, including the agency's use of prescribed fire to maintain them, sought to bolster their efforts at restoring environmental integrity by moving the incipient projects forward. Other groups, opposed to the periodic use of fire as a management tool, latched onto the benchmark drawing attention to its inconsistency with existing Forest Service policy. Those who were especially interested in merely debunking the myth of the PES benchmark, by pointing out that it is a historically contingent snapshot of more-or-less continuous environmental change, strongly protested the concept's association with ecosystem restoration projects. The most vocal of these critics was the Ouachita Watch League, a local citizens' organization with a keen interest in influencing ONF forest management plans (Norman 1990). Most important was the way critics of restoration managed to impede, in more concrete ways, the agency's path toward achieving its objective to maintain environmental integrity. By attempting to cast doubt upon the theoretical grounds which restoration efforts were *presumably* based, they succeeded in minimizing the capability of resource managers to identify and communicate the tangible benefits associated with restoration work. Numerous studies conducted both inside and outside of the agency had repeatedly confirmed the environmental services (both social and ecological) associated with ongoing restoration efforts (Liechty 2004, 2005; Seifert 2004; Thill 2005; USDA 2006). Yet, for critics the PES benchmark served as a theoretical straw man, affording them the opportunity to cast an eye of skepticism upon the agency's endeavors. The ONF's insipient restoration projects risked being pulled into a growing quagmire of anxious confusion over their relative merit. Despite its scientifically validated potential to do good environmental deeds, local critics of restoration appeared bent on re-conceiving the use of PES conditions as part of an

advertent effort to employ a historic benchmark – a static portrayal of an ever changing nature.

What accounts for the benchmark's fairly organic rise to prominence in the thinking of restoration scientists? Answering this question will help achieve the first of this study's three main objectives. The ONF was certainly in the forefront of using PES conditions as an informal, yet progressively constitutive, part of restoration activities. They were also widely known throughout the country for their innovative approach to addressing environmental problems using a strong admixture of field based research and adaptive management strategies. Much of their effectiveness grew out of partnerships within the agency like the one fostered between ONF management personnel and scientists at the Forest Service's Southern Research Station. But, once again, no effort to develop the benchmark was ever spearheaded by either branch of the Forest Service, nor was it the advertent brainchild of anyone peripherally involved with the agency. To what could the concepts increased presence be attributed?

Some of the PES benchmark's ascendancy may be owed to interregional variation in forest types that the agency inherited in the early-20th century. The vast majority of old-growth forests in Arkansas and Oklahoma were cut prior to and immediately following the Forest Service taking tenure in 1907. This was especially true of the pine-hardwood old-growth forest that once occupied the Ouachita Mountains. Compared with the forests of the Pacific Northwest, which have historically retained and continue to preserve a significant portion of their old-growth trees, the valuable stands of virgin pine that formerly attracted northern timber barons to the Interior Highlands have long since disappeared. In fairness, old growth stands of the Pacific Northwest escaped liquidation due in part to an abundance of longer lived species and their position in less accessible terrain. Nevertheless, Pinchot's men arrived in the Ouachitas only to find a forested landscape that had been dramatically impacted by the saws and mule trains that came before them. Often the gnarled stumps and silted streams they encountered were only a vague reminder of the antediluvian woodlands the Ouachita Mountains were thought to have once bore. In 1991 on the eve of the previously discussed Old-Growth Conference, forest conditions were even more greatly characterized by a predominance of second-growth component. Accordingly, the presence of an old-growth exemplar to refer to as a way of clarifying what the vast expanse of second growth stands might conceivably return to someday was not easily found. A modest number of old-growth stands remained scattered across the predominantly second-growth forests of west-central Arkansas and southeast Oklahoma. However, they by no means existed in the quantities needed to make it the archetypal centerpiece of an emerging paradigm shift in forest management philosophy.

If not the trees, then what might one turn to as a way of establishing a better understanding of how restoration efforts should proceed? Perhaps the next best thing to examining an old-growth stand would be to determine what forest conditions were like immediately prior to European settlement (Foti and Glenn 1991). By turning to the earliest days of first contact between European explorers and the New World would we not greatly improve our understanding of historic environmental conditions in the Interior Highlands? Even an analysis of forest conditions sometime after the moment of discovery, prior to the initiation of wholesale changes in the environment, could render a useful description around which a forest archetype might be constructed. The time period

between Hernando Desoto's first encounters in the New World and the conclusion of the General Land Office's witness tree surveys marks the last series of common reference points available for drawing conclusions. From the latest point in this series onward human environmental impacts began to accelerate and intensify, with early 20th century agriculture playing a pivotal role in the degradation of eastern forests. The degraded state that the ONF was left in following the 1970s and 80s prompted, understandably so, the agency's forward thinkers who were involved with the Old-Growth Conference to examine historic reference conditions out of a growing concern over forest health. Managing for forest health, after all, might have a significant impact on bringing greater integrity to the environment – a primary goal of the Forest Service.

Today, rising concerns over declining forest health in the ONF are certainly not unwarranted. Despite ongoing debates over how exactly the term should be defined. Increased tree mortality throughout the region is causing some to question what linkages might exist between forest management practices over the past century, contemporary forest health issues, and a tenuous capability to adequately respond to such pressures. Resource Professional 2 with the Arkansas chapter of The Nature Conservancy, a group actively involved in efforts to reduce fuel loads in and around the ONF, offers a sobering picture of the current predicament:

> What we were seeing over the last twenty years or so, even what we're seeing currently in the forest where restoration is [occurring]…is that those areas are coming to a time when the ecosystems themselves are forced into pretty big changes. Over the last two or three years on the Ozark and part of the Ouachita something like 1.2 million acres of oak trees have died just in a two or three year span. This was really noticeable, and I think that's happening in many places in the country right now. So a lot of people are thinking about what this means when you start seeing that kind of turnover. I think it's just a result of the forests we have now are a result of the management that went on in the early 1900s, and now we're kind of reaping the harvest of that in one way or another. (Resource Professional 2 6-18-2007)

Much of the aforementioned widespread tree mortality is occurring as result of epizootic insect infestations and pathogen outbreaks. Additionally, catastrophic wildfires pose an imminent threat throughout much of the American West and increasingly in the South. The ONF has been fortunate in this regard, but it is not necessarily because the forest there is in any better condition than elsewhere. In the early to mid-90s devastating forest fires destroyed a significant number of homes and claimed many human lives in the western United States, causing many to reassess how unhealthy the nation's forests had grown over the past century. As a result, the concept of health became a central idea around which debates surrounding America's forests were framed. However, the term forest health is a hotly contested idea that has come to mean different things to different people (Belaoussoff and Kevan 1998; DellaSala et al. 1995; Kolb et al. 1994; McLaughlin and Percy 1999; Patel et al. 1999; Rapport et al. 1998; Rapport 1998; Rieman et al. 2000; Ross et al. 1997; Starkey and Guldin 1999; The Nature Conservancy 2000; Thomas and Huke 1996; Tiedemann et al. 2000). The term forest health has been marshaled in defense of a variety of projects; some of which have competing interests. According to DellaSala et al. (1995, 355), "under the guise of promoting forest health, the 104th Congress is aggressively pursuing an agenda that is antithetical to many fundamental forest, fish, and wildlife management principles." A major point of

contention, in debates over the relative merit of the forest health concept, is the assertion that clear-cutting can replace the use of prescribed fire as a management technique for restoring forest health. Staunch critics of this idea have voiced their opinion otherwise:

> Advocates of intensive forest health management claim that clearcutting and other logging activities such as uneven-aged management simulate natural disturbances like fire…. At local scales, an individual clearcut may superficially resemble a stand-replacement fire of equal area in terms of the effects on vegetation structure. Clearcutting activities, however, have taken place over temporal and spatial scales far greater than pre-European settlement disturbances…. Unlike fire, intensive or persistent logging can substantially deplete important nutrients, minerals, and elements that have been sequestered and retained in the biomass through centuries of decomposition and recycling.... Such nutrient degradation associated with logging should not be confused with a carbon cycling argument used by the federal agencies to justify the forest health emergency. (DellaSala et al. 1995, 351)

The argument over forest health became entangled in a series of points and counter-points over how exactly biophysical processes were impacted by different management techniques. The ensuing controversy over the reduction of fuel loads became a dispute over the decision of whether to use fire or logging activities toward mitigating against future catastrophes. In response to the possibility that periodic burning might become a permanent fixture, many people expressed distaste for the future use of prescribed fire as a primary means of managing fuel loads. Tiedemann et al. (2000), among others, held the belief that:

> Management aimed at returning forests to an open, seral condition should be carefully evaluated from the perspective of all the key resources and values. Can objectives for producing wood fiber, as well as goals for wildlife habitat, biodiversity, soil protection, and water and air quality be simultaneously met? We think the answer is yes. But, our thinking must go beyond factors governing how a given controlled burn will affect the forest stand, the accumulated fuel load, and protecting life and property. (Tiedemann et al. 2000, 3)

Therefore, a distinction is drawn between the two primary objectives – long term vs. short term – of intensive forest health management. The first proposal focuses primarily on the affects of logging on biophysical processes, while the second proposal emphasizes the potential impacts of prescribed fire on key resources and values. Both views of forest health support a reduction of fuel loads to decrease the future likelihood that intense forest crown fires would devastate property and life. However, they diverge dramatically in relation to the amount of emphasis they place on recovering ecosystem processes. Rapport et al. (1998a) emphasize an alternative approach to the aforementioned problem by introducing a protocol for landscape health that accounts for both the biophysical processes and societal goals impacting intensively managed forests. The intended goals of their project are stated as such:

> Integrating societal goals and biophysical processes requires identification of ecological services to be sustained within a given landscape. It also requires the proper choice of temporal and spatial scales. Societal values are based upon inter-generational concerns at regional scales (e.g. soil and ground water quality). Assessing the health and integrity of the

> environment at the landscape scale over a period of decades best integrates societal values with underlying biophysical processes. (Rapport 1998a, 1)

Notable is the emphasis placed on landscape health, rather than solely on forest health. This emphasis on managing forest health at the landscape scale is related to an associated concept know as 'historic ranges of variability' (HRV) which advances the idea that "the composition, structure, and seral age of forests must be returned to HRV, which is determined by comparing current distributions to predicted historical levels at watershed scales" (DellaSala et al. 1995, 352). A primary tenet of HRV is that "such an approach may be useful in certain situations for reestablishing historic species composition and fire regimes" (DellaSala et al. 1995, 352). Likewise, HRV has been commonly associated with "restoration activities that consider regional as well as watershed levels of rare habitat types and those activities that allow sufficient time for recovery of ecosystem processes" (DellaSala et al. 1995, 352). The use of the HRV in conjunction with intensive landscape health management techniques indicates a more integrative approach to managing for forest health. It moves beyond earlier ideas concerning forest health that were built around a rather dichotomous understanding of the benefits and expenses involved with restoring pre-suppression fire regimes – property, life, and societal values vs. biophysical processes.

Although Guldin's (1999, 143) outline of the study design for landscape scale research in the ONF makes no mention of the HRV concept, the program was conceived of "as a way to deal with questions about forest management that cannot be answered at a stand-level scale, but that can be answered in the context of a watershed that contains many stands." Important here is Guldin's allusion to a need for answering forest management questions at an appropriate scale. An operable unit of analysis for answering management questions about forest health lies at the landscape level; wherein, dendritic networks of forested watersheds become the focus of restoration efforts rather than stands or even individual trees. Resource Professional 1 with the Arkansas Natural Heritage Commission expresses a similar view of the role landscapes should play in formulating healthy forest initiatives:

> Forest health connotes, in many people's minds, individual tree health. That's where the administration is going with its Healthy Forest Initiative is healthy tree initiative. That's not necessarily a healthy forest or a healthy system. A healthy system has diseased and damaged members, components of the system, and they're a part of it…. That's been a big part of our inappropriate management in the past, just going along and removing those things and keeping the vigorous economically valuable trees in place. What we're going for is a much more realistic definition of forest health, that has to do with sustainability, that has to do with long term health, that has to do with health of the vast preponderance of the species – within it are they being sustained by this community and this forest. So yes we are definitely in our minds working toward healthy forests, and we think that an appropriate fire regime and an appropriate cutting regime can maintain over centuries that healthy landscape. (Resource Professional 1 6-19-2007)

The more expansive definition of forest health that is conveyed above emphasizes the importance of maintaining the entire suite of species and forest structure (e.g., snags, downed woody debris, etc.) associated with healthy forest conditions. Furthermore, the role of disturbance events and appropriate economic activities (two topics that will be

addressed in much greater detail later on) is acknowledged as an integral part of this management approach. It is the combination of these two regimes – disturbance and cutting – that holds the potential for sustaining long term forest health.

Similar to several of the other concepts addressed so far, "sustainability" is a rather slippery term. It has historically meant vastly different things to different people. Sustainable development carries with it a strong economic undertone and is certainly disagreeable within the conservation biology community. Wildlife biologists have seen the decimation of entire populations as a direct result of exploitative economic activities. How might we recover the sustainability concept, despite its obvious shortcomings, as a way of helping to bolster efforts at maintaining forest health? More important, how might we do this without weakening the overarching project of restoration? Callicott and Mumford (1997) call for the development of an ecological sustainability concept that will,

> …restrict our discussion to the ecological constraints on the ability to maintain various culturally selected economic activities. We propose that ecological sustainability, as a conservation concept, be understood to be the maintenance, in the same place at the same time, of two interactive 'things': culturally selected human economic activities and ecosystem health. The spatial scale of ecological sustainability can vary from the watershed to the biosphere. (Callicott and Mumford 1997, 34)

To forge a more realistic definition of sustainable forest health we must understand that economic activities can (and sometimes *should*) occur to enable the maintenance of healthy forest conditions. Indeed, human economic activity provides the financial stimulus needed for the ONF to implement restoration work. Which particular economic activities are selected by the culture of restoration and why these choices are made is discussed in chapter four. Forest management practices (or lack thereof) during the first half of the 20th century dictated that the economic activities selected often flourished at the expense of forest health. All too often, a portion of the profits from timber extraction were not reinvested in modified lands. This legacy of neglect characterized by periods of intensified exploitation has, in some areas, changed the land to such a great extent that restoration remains a viable but not easily achieved alternative to industrial silviculture. According to Environmental Scientist 3, "we start with the assumption that PES conditions are more desirable than modified areas. When there is an existing situation that is undesirable and we're thinking about how to fix a degraded state, a PES condition works in the role of problem solving as a logical goal to be working towards" (Environmental Scientist 3 9-18-2007). Similarly, Resource Professional 2 with The Nature Conservancy observes the benefits of using a PES benchmark to help guide restoration efforts:

> The benefits are that…it does give you some snapshots of what the forest was like pre-European, before it went through some pretty rapid change. We know what those changes were because we know that over one hundred years now that volumes of timber were taken out, parts of the land were settled, and then reforested. We know to a certain extent what those changes, what the kind of cascading changes, due to that history were…. So it gives you a way to think about the kinds of interventions you would do on the forest to achieve some kind of management objective. (Resource Professional 2 6-18-2007)

The rapid change, referred to here, came not only through active manipulation of the environment (e.g., timber extraction, etc.), but also as a product of disallowing certain biophysical processes to occur: natural fire regimes. As fire suppression became more common on lands formerly degraded by industrial forestry, and reforestation transformed large portions of the ONF into second-growth forest, many of the biophysical processes (e.g., biogeochemical cycling, etc.) ordinarily regulating old-growth systems were either drastically altered or brought to a sluggish halt. The natural fire regime that historically served to maintain system states at a quasi-stable equilibrium point was divorced from the landscape. The resulting forest was often perceived by society as a natural system internally regulated by homeostatic controls. Second-growth forest, mistaken to be an old-growth system, was thought poised in eternal balance atop a landscape afforded its own internal logic – a logic that could persist in the face of wholesale environmental changes and unforeseen trajectories. Agency intervention was lost in a widening chasm between a normative view of nature-in-balance and a social milieu promoting the forest as un-tethered from the need for active management. This relationship was further promulgated by the sway of public opinion as attempts were often made to reduce the allowable number of burn days on the ONF. Why should the agency try to adapt its management strategy to the changing environment when it is self-evident that nature most certainly can, and no doubt *will*, maintain a state of equilibrium on its own? The forest would be just fine without fire, so it was thought.

Conflicts over the conscious decision to either leave the forest alone or attempt to manage it in such a way as to achieve a more desirable condition – one of greater health and integrity – were closely tied to divergent ideas about how restoration efforts should reference the time period prior to European settlement. Should the PES time period be viewed as an environmental condition to be managed toward or a precise benchmark that can be achieved? The two are not the same. The former acknowledges the natural disturbance regimes that are so critically implicated in maintaining an underlying set of biophysical processes. The later infers a static condition uniquely exempt from the ever-changing biophysical processes that ultimately led to its production. The PES condition embraces an environmental calculus – a paleoecological perspective that acknowledges past and, therefore, future changes in species composition due to climatic variability – counter-balanced by the need for adaptive forest management strategies. The PES benchmark promotes the conflation of a historically contingent snapshot with normative ideas on the balance-of-nature. The mismatch of ideas emerging out of views of *PES as benchmark* or *PES as condition* has tangible consequences for the way environmental resources are perceived and managed. We have yet to fully understand both the origins and impact of normative balance-of-nature ideas in the agency and across the culture of restoration. As restoration efforts and the historic reference conditions they, in part, rely on attract further criticism such an understanding will be needed. Future attempts at devising management objectives aimed at restoring health and integrity to historically degraded ecosystems need not be marginalized by such criticism. Perhaps the most imposing impediment facing the advancement of restoration projects lies not in dealings external to the agency. Conflict over the PES benchmark is reflective of a more fundamental concern related to pedagogical inconsistencies within the culture of restoration. How successful the agency is in navigating between the conflicting ideas that

have surfaced around the PES benchmark will help determine the longevity of their efforts.

Chapter 2. Methods

2.0 Intellectual Contributions and Preliminary Research

This research makes several intellectual contributions to the body of academic work it builds upon by: (1) expanding our understanding of the role PES benchmarks play in the culture of restoration, (2) clarifying the role PES benchmarks play in current Forest Service ecosystem restoration projects, and (3) more fully synthesizing and critically examining the issues of the naturalness of restored ecological conditions and the cultural, historical, and political aspects and implications of adopting a PES ecosystem restoration goal. Although the conflicts associated with adopting restoration benchmarks have been mentioned in passing or given preliminary assessment, systematic empirical work which offers insight on the reasoning behind the continued use of PES benchmarks has not been done. This research project is an attempt to fill this gap in the literature.

This research also contributes to the larger project of further integrating social science research with natural resource management issues. More directly related to the discipline of geography are the contributions this study will make toward finding synthetic and integrative approaches to understanding the human dimensions of environmental change. Indeed, the interdisciplinary underpinnings of my dissertation reflect Zimmerer's (1994, 118) belief that "human geography seems especially well-positioned for probing the multi-faceted ideas of the 'new ecology.'" The broader impacts of this research involve making contributions in the area of Forest Service policy by: (1) helping forest managers to determine the overall merit or practicality of PES benchmarks as an informant of current and future ecosystem restoration efforts, and (2) assisting individuals or groups who are interested in conservation issues to negotiate between the sometimes polemical positions associated with ecological restoration controversies. This includes the interests of forest managers in identifying and communicating the tangible benefits associated with restoration projects that are informed by PES conditions. Ultimately, it is believed that the dissemination of this study's findings will help bolster the Forest Service's commitment to managing our National Forests for greater integrity.

Preliminary research was conducted in the summer of 2006. This consisted of a trip to Hot Springs, Arkansas where initial contact was made with Forest Service personnel at the Southern Research Station (SRS) and Ouachita National Forest Supervisor's Office (SO). All individuals expressed a willingness to assist me with this research in the form of interviews and access to archival materials. A team leader at the ONF SO spent a generous amount of time answering my preliminary questions directed at learning more about the agency's experiences, interests, and expectations in conducting ecosystem restoration. The role PES benchmarks play in restoration efforts was discussed during my exchange with all Forest Service personnel. Their association with restoration projects throughout the Southern Region was agreed upon to be a relatively contentious issue and a subject worthy of further investigation. Time spent at the ONF also afforded me the opportunity to visit the Buffalo Road restoration area (Management Area 22). This preliminary work allowed me to establish key contacts necessary for carrying out the proposed research and fostered a greater understanding of and familiarity with the subject matter.

Justification for my choice of research site was based on several factors, including the use of a PES benchmark. Second was the desire to choose a study area which collectively encompassed a diversity of endangered species, ranging over avian, reptilian, and amphibious classes. How biological differences between species (e.g., use of habitat, range, abundance, etc.) may or may not create novel boundary conditions across the research site was of interest here. Third was the deliberate selection of a relatively large National Forest compared with others in the Southern Region. This element of areal size is often accompanied by more expansive efforts at ecosystem restoration, more extensive boundaries around restoration patches, and larger populations of endangered species. Fourth are the interrelated issues of population growth, urban encroachment, and non-industrial private forests, all of which have a direct bearing on the development of each boundary's distinct conditions. Along with the ONF, the surrounding environs of many other National Forests throughout the Southern Region have experienced punctuated urban growth over the past several decades (Wear 2002). This is especially true of Apalachicola National Forest in Florida. This general trend toward urbanization alongside the historical exploitation of the Interior Highlands' shortleaf pine and Gulf Coast Region's longleaf pine districts underscores the pressing need to restore habitat for a number of endangered species. Future research could potentially draw on Apalachicola National Forest's compatibility with this study. An important aspect of agency-wide mandates to manage National Forests in a restoration framework, is the leading role taken by the ONF as a USDA Forest Service research prototype for ecosystem restoration. Much of the cutting-edge work done on restoration of eastern old-growth conditions continues to be done in the ONF. Ultimately, the ONF was chosen for the above factors, and the interest and support of established contacts in pursuing the proposed research. The environmental characteristics of the study area are outlined in historical context in chapter 3.

Current restoration plans in the ONF call for the eventual restoration of approximately 200,000 ac of public forest land to PES conditions (USDA 2006). A substantial amount of this activity is currently underway in Pine-bluestem Project Management Area 22. This area contains my research site along the Buffalo Road restoration area driving tour. Project Management Area 22 is part of the greater 8 million ac Ouachita Mountain physiographic region, of which the Ouachita National Forest encompasses 1.7 million ac in west-central Arkansas and southeastern Oklahoma (Bukenhofer and Hedrick 1997). The Ouachita Mountains are oriented in an east to west direction, with their highest elevations reaching 2,700 ft and lowest dropping to 500 ft. Historic fire intervals throughout the region averaged 10 years or less, while today they have lengthened to anywhere from 40 to 1,200 years. This has resulted in significant changes in forest structure and composition of the ONF, resulting in a loss of habitat and either extirpation or endangerment of many native plants and animals (Masters and Engle 1994; Masters and Waymire 2000; Masters et al. 1995; Masters et al. 1996; Neal and Montague 1991). A more detailed description of the Buffalo Road research site is presented in chapter 5.

2.1 Methodology

This research uses a three-part **mixed methods approach** (Cloke et al. 2004; Creswell 2003; Kitchin and Tate 2000; Marshall and Rossman 1989), consisting of face-to-face **semi-structured interviews** (King 1994), **archival research** (Demeritt 1994; Forster 1994; Hanlon 2001; Holdsworth 1997; Kurtz 2001), and the **interpretation of landscape and nature-based art** (Andrew 2000; Cosgrove 1984, 1985, 1989; Daniels 1992, 2004; Gandy 1997; Harris 1999; Mitchell 1992, 1995; Olwig 1996; Schama 1995; Wallach 2002). This strategy gave me the dual advantage of focusing a predominant portion of the total research time on: (a) discussing issues germane to restoration with Forest Service officials, resource managers, and scientists as a means of answering interview questions and (b) collecting archival sources to construct an accurate account of the historical contingencies affecting the research site. This research is designed around a single case study (Hartley 1994). By incorporating my interpretation of restored forest landscapes with interview responses and archival documents this study uses a method of data analysis associated with **grounded theory** (Charmaz 2004; Strauss and Corbin 1998), including the individual analysis techniques of editing, open coding, and code maps. The term editing refers to a technique in which lengthy quotes from interview transcripts are reduced to their most elemental sentences, covering a given topic. The term open coding refers to the process of assigning thematic designations to text excerpts from interview transcriptions. The dominant themes that emerge from these designations are then listed in free-form. Next, overlapping ideas and interconnections between thematic categories are mapped by drawing a visual network of lines, arrows, and conceptual bridges between them. From this code map well defined thematic categories are grouped together to serve as sub-chapters, which form the basis of individual chapters. Once arranged in sequential order these sub-chapters and chapters form a general narrative structure to which the paper may adhere.

The final discussion of my findings is based on a synthesis of transcribed interview responses, archival sources, and landscape and nature-based art. The use of a heuristic metaphor, the ultra-reductionist art of Piet Mondrian, is employed in conjunction with the final synthesis to illustrate parallels between the formation of an aesthetic of optimal complexity and the reemergence of a rigorously defined forest archetype (Cosgrove 1990; Johnson 1981; Lakoff and Johnson 1980; Miall 1982). Aside from a shared subject matter, trees, Mondrian's nonrepresentational or non-objective work serves as fertile ground for a more theoretically inclined conversation on the human perception and value of natural environments (Nordstrom 1990; Patel et al. 1999). This final move, along with the empirical evidence laid out in previous chapters, strikes at the heart of my **primary research question**: *Are PES benchmarks representative of socially-constructed ecosystem restoration goals and/or informed attention to social, cultural, and historical meanings associated with pre-European settlement conditions?* This research attempts to etch out some of the hazy contours of human-environment interaction that historically occurred and continue to take place across the Interior Highlands. My **secondary research questions** are largely concerned with the PES benchmark's relation to historic legacies of environmental change both as a result of synoptic conditions and human agency, and the culture of restoration's current understanding of this change. Restoration efforts consistently tend to utilize a historic reference condition associated with the PES

time period. *Is this equifinality coincidental, a function of utilizing the most recent common reference condition relative to anthropic degradation? Is the benchmark perceived as a regional optimum of some sort that may have happened to exist, merely by chance, from the early-18th to mid-19th century, or perhaps a socially-constructed yearning for a frontier ideal?*

This study's **methodological orientation** supports, first, the idea that the external physical world, however removed from the immediacy of direct experience, is potentially examinable through rudimentary human perception and novel means, such as scientific instrumentation. I support the idea that a physical world of which we *can* know something about in absolute terms *does* exist. Second is the idea that, aside from the substantial gains in knowledge provided by scientific research, the rich texture of human culture approaches, to varying degrees, these same truths by affording us brief glimpses into the reality of our physical surroundings. My orientation stands in stark contrast to the various critical historiographies exploring the role of visuality in Western thought towards reproducing power relations (Bryson 1983; Harraway 1988, 1991; Rose 1992; Rose et al. 1997). This study is grounded in the idea that culture and the capacity to transform our environs has risen, in part, as a coping mechanism for the advanced intelligence of *Homo sapiens sapiens* to successfully deal with instability in nature (Tuan 1971). However, this does not preclude the notion that culture is moving towards a more accurate understanding of the world in which human consciousness arose. The history of humanity's collective wayfaring includes the ebb and flow of coevolutionary processes between culture and environment. Neither is entirely self-determining, but rather each serves to shape the other through a discursive relationship between mind (self) and world (Wilson 1998). The various metaphysics discussed in this study are illustrative of both the hindered and more factual cosmologies historically devised by culture. Appreciating how they affect the pursuit of scientific knowledge, and success or failure of societies in carving out harmonious life-ways with nature, underpins the ethical empiricism implicit in this study. How this study is situated within the discipline, and more broadly the history of geographic thought, is worked out through a discussion of landscape as an episteme for scientific knowledge and environmental perception. In the concluding remarks of chapter 5, I argue for the recovery of a universalist notion of truth in nature that neither minimizes the presence of dynamic system processes, nor obscures the instrumentalist role of humans in steering the course of environmental change.

2.2 Interviews

Qualitative methods have been used for quite some time in research focusing on the management of natural resources (Bliss and Martin 1989; Fischer 2000; Weeks and Packard 1997). Semi-structured interviews offer an effective means of exploring the role institutional knowledge plays within an organization (Cassell and Symon 1994). In the context of the Forest Service, this knowledge includes goals or benchmarks that are applied, documented, and referred to among Forest Service personnel. My interview questions are directed at understanding how this particular idea, the PES benchmark, arose in the minds of environmental scientists, forest managers, resource professionals, and others within the culture of restoration. Knowledge concerning the role that PES benchmarks play in restoration efforts and their importance relative to a host of

management issues assisted me in answering my primary and secondary research questions. The following questions/discussion points were asked of all interviewees:

1. How have forest ecosystem restoration projects come to be informed by historic reference conditions associated with the time prior to European settlement? How did the PES benchmark arise?
2. Share with me your understanding of how PES benchmarks fit into the current philosophy of the Forest Service.
3. What are the benefits of using a PES benchmark to inform restoration projects? What are the drawbacks?
4. What role do PES benchmarks play in forming consensus among resource managers?
5. What role do PES benchmarks play in supporting societal values and restoring environmental functions?
6. How does the PES benchmark relate to attempts at restoring and maintaining forest health?
7. What role do PES benchmarks play in attempting to anticipate and mitigate against future environmental conditions?
8. What kind of role do you think PES benchmarks will play in future restoration efforts? Why will it play that specified role?

Which specific questions were emphasized in each interview varied depending on how familiar the interviewee was with a particular issue. For example, a question addressing the importance forest health-concepts have in restoration efforts was asked of environmental scientists. Alternatively, questions addressing the possible role PES benchmarks have in forming consensus among agency personnel were emphasized with forest managers. There were a total of nine interviewees, including four environmental scientists and two forest managers with the USDA Forest Service, and three resource professionals with the Arkansas Natural Heritage Commission, The Nature Conservancy, and the private forest resource industry. The questions asked of personnel at the Southern Research Station, ONF Supervisor's Office (Hot Springs, AR), and Ranger District Office (Mena Ranger District) were informed by an understanding that separate branches of the agency have come to research, manage, and ultimately view the National Forests in different ways. The primary reason behind my selection of interviewees was based on the idea that agency and non-governmental organization scientists, managers, and professionals, who were intimately familiar with local restoration efforts, would be best equipped to answer my research questions. Another important consideration was the need to compile a roster of interviewees whose range of topical interests and scientific backgrounds could collectively speak to the broad array of concerns associated with pine-bluestem restoration. This included selecting personnel who had both formal scientific training, and personal experience or a familiarity with the management side of agency operations. Lastly, the non-governmental organization and private forest industry resource professionals, themselves forestry scientists as well, it was thought would bring an outside-the-agency perspective to my interview responses.

All research subjects are classified as one of three types: Environmental Scientist, Forest Manager, or Resource Professional. Throughout the paper each research subject is

referred to using these labels and assigned an identification number (e.g. Environmental Scientist 1, Forest Manager 2, Resource Professional 3). Below is a general description of each type, including the professional affiliations, scientific backgrounds, and topical interests of its members:

Environmental Scientist

All research subjects of this type have a professional affiliation with the USDA Forest Service. Their scientific backgrounds are in the fields of wildlife biology, fluvial geomorphology, ecology, forestry, and anthropology. The list of topical interests associated with this group includes avian and reptilian habitat conservation, erosion processes, channel morphology, silviculture, and restoration of old-growth forests.

Forest Manager

All research subjects of this type have a professional affiliation with the USDA Forest Service. Their scientific backgrounds are in the fields of ecology and forestry. The list of topical interests associated with this group includes native plants and animals protection, and ecosystem ecology and restoration.

Resource Professional

Research subjects of this type have a professional affiliation with the Arkansas Natural Heritage Commission, The Nature Conservancy, or the private forest resource industry. Their scientific backgrounds are in the fields of ecology and forestry. The list of topical interests associated with this group includes natural lands preservation, disturbance ecology, sustainable forestry, and forest health.

The agency's management of National Forests is guided by specific mandates that are determined by institutional policy – the formation of which is heavily influenced by public input (e.g., Multiple Use-Sustained Yield Act 1960; Threatened and Endangered Species Act 1973; National Forest Management Act 1976, etc.) (USDA 2006, 2005, 2002, 1999). Public input, at times, diverges sharply from agency directives regardless of their basis in rigorous research and sound judgment aimed at maintaining the integrity of National Forest lands. Alternatively, Forest Service research abides by its own paradigmatic agenda largely concerned with the advancement of ecological science for both basic and applied purposes. Some of the difficulty, in evaluating the relative influence that public input should have on forest management decisions, lies in fundamental differences between how survey results are interpreted versus how scientific research findings are analyzed. Investigating the use of PES benchmarks serves as a springboard for addressing questions related to the influence of intra-agency differences between scientific and managerial paradigms.

2.3 Archival Research

The Forest Service publishes a wide variety of documents to serve the agency's mission on research, management, and education. Among these documents are research articles, general technical reports, planning documents, maps, and community education pamphlets, all of which are of interest to this project. The information they provide is specific to the ONF's local dealings with non-industrial private forest owners, the timber industry, and conservation groups. This information helped me understand how specific social, economic, and ecological factors figure in the advancement of restoration projects. Many of these factors tie in with the literature on forest management issues, which form the basis of chapter 5. The agency archive which houses the aforementioned documents is located in the Southern Research Station and open to the public. Here, my use of the term archive is broadly conceived to include any place where documentary sources, published by the Forest Service or related to its internal operations, are maintained for public distribution or made available upon special request. Additional archival sources, contributing to this study, include letters and correspondence between agency personnel and federal officials, and local or regional newspaper articles and press releases. These documents are located in ONF Supervisor's Office files, and were made accessible at the discretion of the team leader, whom I had previously contacted. These files and the Southern Research Station publications represent the primary sources of my archival research, which was conducted during the preliminary research stage.

Archival research supports my intention to use grounded theory in guiding this study, where the researcher makes adaptive responses by adjusting their initial line of inquiry to accommodate new information as it is encountered in the field (Charmaz 2004; Strauss and Corbin 1998). This approach helped direct and lend flexibility to the semi-structured interviews as preliminary findings from archival research informed and altered the way questions were framed. This allowed the interview to remain open while preventing critical issues unique to my case study from going un-addressed during the course of the interview. My choice of which archival material to review was based on several criteria. The first of these included sorting through the content of sources to evaluate its pertinence relative to previously established literature categories, which served as the basis for my chapter headings. These categories included: (a) culture of restoration, (b) ecosystem change, and (c) forest management issues. A second consideration was the need to narrow the focus of my reading around topics of immediate interest to my research topic. The agency publishes a vast amount of scientific literature. Only by prioritizing my literature search and thus reading was I able to remain focused on answering my primary and secondary research questions, concerning the nature and use of PES benchmarks. Lastly, as a matter of gathering a functional understanding of the various scientific and management issues facing restoration efforts, I initially read from sources that provided a general background. Only after gathering a broad understanding of the concepts and ideas related to restoration did I delve into the more technical, scientific studies, addressing paleoecology and ecosystem ecology.

2.31 Data Analysis

The data analysis approach used in this study is largely concerned with "teasing out the wider meanings" of concepts and ideas (Kitchin and Tate 2000, 225). Techniques of analysis based on grounded theory were employed (Cloke et al. 2004; King 1994; Kitchin and Tate 2000). A basic concern of grounded theory is the contextualization of source materials, so that they are not analyzed in isolation from an understanding of the professional or social conditions in which they were produced. Just as agency documents are created within the constraints of an institutional framework, interviews take place with a cognizance on the part of interviewer and interviewee of the relative cost and benefits of sharing information, which often intertwines with their professional life. What is not said is often as important as what is.

After the tape recorded semi-structured interviews had been transcribed, grounded theory techniques were used to analyze the data. These techniques included: open coding used for an initial sorting of data, and code maps used to find interrelations among codes and extrapolate emergent themes within and between data sources (Cloke et al. 2004). This process of finding emerging themes in data as a way of interpreting the wider meanings of ideas ultimately seeks to arrive at a more catholic understanding of how PES benchmarks operate in an agency such as the Forest Service. The content of my transcriptions was organized around broad themes. These broad themes were eventually divided further into sub-themes, which served as the section headings within each chapter.

The analysis of agency documents required the use of another technique commonly associated with the grounded theory approach: editing. According to Miller and Crabtree (1992, 20), this technique of analysis "is termed editing because the interpreter enters the text much like an editor searching for meaningful segments, cutting, pasting and rearranging until the reduced summary reveals the interpretive truth in the text." Of course, the 'interpretive truth' that official documents convey lies not merely in what the text explicitly states, but rises out of a synthesis of meanings between documentary sources and the thoughts and knowledge expressed by Forest Service personnel concerning ecosystem restoration initiatives and the agency's broader goals.

Neither the archival or semi-structured interview data sources may be analyzed entirely independent of each other. To remain reflexive in the research process requires that documents are read with an awareness that their contents provide the reader only a limited depiction, and thus partial understanding, of the broader meanings of ideas and the importance they hold in society (Forster 1994). The occasional reference to PES conditions in agency literature is tempered by a noticeable lack of language which portrays the condition as a benchmark. Such an omission is telling of the reluctance, on the part of restoration experts, to overemphasize the relative importance of the concept in restoration projects, despite the inordinate amount of attention they have gained in environmental discourse. How exactly PES conditions have been misappropriated as a benchmark or target to be aimed at are addressed in greater detail throughout the later sections of this study.

2.4 Landscape Art, Visual Metaphor, and Truth

Landscape has a long and varied history in geography as an organizing principle for studying the human and physical characteristics of the earth surface (Sauer 1969 [1925]), as an areal unit in spatial science (Hartshorne 1939), and as a methodological technique developed within specific historical contexts under the auspice of powerful elites (Daniels 1993). Evolution of the landscape idea in Western traditions has been traced in detail by several scholars (Cosgrove 1985; Harris 1999; Olwig 1996). A particular rubric of cultural landscape research which this project draws from is the study of landscape and nature-based art (Andrew 2000; Bryant 1974; Cosgrove 1984, 1989; Daniels 1992, 1993, 2004; Gandy 1997; Schama 1987, 1995; Silver 1983; Wallach 2002). The following material on cultural landscape relates to my methodological approach in terms of one's purchase in the idea that landscape and nature-based art may potentially reveal something true about our physical surroundings; thereby altering our environmental perception. Strongly implicated in this discussion of artwork and environmental perception is the field of aesthetics, and an associated concern with visual metaphors (Foster 1998). All of these topics will figure centrally in my later discussion of the pictorial work of Dutch artist Piet Mondrian. However, first I provide several examples of how landscape art, and descriptive passages in general, have fashioned popular conceptions of nature throughout early American history.

Wallach (2002) addressed the stylistic evolution of landscape painter Thomas Cole, whose *oeuvre* included a series of pieces centered on the Catskill River's industrializing landscape. This segment of Cole's work depicted the "anti-pastoral" scene of a diminishing American wilderness, of which deforestation was increasingly a common occurrence. The artist's work conveyed simultaneously the virtue and vice of American expansionism, and informed its viewing constituency of the coming era of industrial modernization. The contrasting views of American wilderness held by early settlers and those of later arrivals illustrate well the two dominant perspectives embraced early in the nation's history. For William Bradford, a Puritan leader who arrived on the Mayflower in 1620, the New England wilderness evoked an eminence of danger where fear, depravation, and suffering could be found (Nash 1967). The terror of an impenetrable façade divided man from nature. In the later half of the century, an alternative account of the New World arises as John Fenwick's (1675) *The Description of a Happy Continent* is published. In contrast to Bradford's earlier description, the American wilderness was characterized by employing an altogether different metaphor. Drawing from the "paradise regained" allegory of Persian linguistic origin, Sir Walter Raleigh wrote home of Virginia as an "abundant garden." The emergence of these two metaphors relates the American wilderness, on the one hand, to a gardenesque landscape to be warmly embraced, and the other, a hideous expanse that repelled human intrusion. Throughout the 19th century both of these opposing views persisted as the English and American literati increasingly refined their expressions of each. However, the negative doctrine associated with nature's imposition of an artificial veil between man and environment was slowly eroded by works depicting a positive doctrine; wherein, nature was viewed as a source of truth, strength, and virtue. The national mindset was liberated by a reunification between community and wilderness as landscape painting challenged

previous notions of an inherent conflict between nature and society (Boorstin 1965; Bryant 1974; Lewis 1975; Nash 1967; Webb 1956).

As the positive doctrine prevailed, a romantic movement in which the picturesque garden metaphor was fully embraced began to unfold. These sentiments were carried throughout the 19th century; thereby, prompting eastern urbanites to contemplate and insert into the national discussion a growing need for wilderness preservation. In 1859 Henry David Thoreau saw fit the establishment of a park system in the state of Massachusetts, which was followed shortly thereafter by the provision of a federal grant in 1864 (to the State of California, under the direction of Frederick Law Olmstead) for the preservation of Yosemite Valley. The use of visual metaphors throughout early American history indicates stark differences in the three primary views of the natural world that gained a foothold in the national psyche. The first of these depicts nature as sublime or literally "in the image of god." According to Boorstin (1965) this view qualified as a "figment of optimism" within our continental myth. Second, there existed a utopian view of nature; wherein, the land was a possession of the people which stood to be altered and improved upon. This was the dominant view embraced by early pioneers, who after moving westward through Appalachia began exploiting the vast timber resources of the Ohio Valley – a wilderness they knew very little about on the eve of its removal. The popular belief that the forest was anathema to the settler's existence was indicative of this utopian view of nature. Third, and perhaps most important in the development of a national wilderness preservation movement was an Acadian view of nature. According to the Acadian ethic, man's rightful place on earth was to live within nature and draw from it strength.

A broad range of material produced by the English and American literati echoed an Acadian view of nature, including Nash's (1967) influential essay *Wilderness Preserved*. From Audubon's berating of "greedy mills" that threatened the future of American forests, to Washington Irving's lament of a disappearing wilderness, artists and writers alike contested the pervasive utilitarianism seen about them. It was this spreading contrarianism that served as impetus for some of the first organized efforts in wilderness preservation. Conceiving of what might save America's natural wealth from the axe blade of industrial progress, American landscape painter and ethnologist George Catlin wrote (in Nash 1967, 101): "What a beautiful and thrilling specimen for America to preserve and hold up to the view of her refined citizens and the world, in future ages! A *nation's park*, containing man and beast, in all the wild[ness] and freshness of their nature's beauty!" The wilderness preservation movement would eventually rely less on romantic notions of a reverently held natural wealth. Specific land allotments would be presented instead as "natural curiosities" in the service of promoting a National Park system, and legislated for preservation under the guise of "useless land" in relation to agricultural use. This tactic proved effective and much of the national park system, including Yellowstone National Park, was officially protected. The brief history of dominant themes in American environmental perception outlined above is not exclusive to the inception of a National Park system. Indeed, the same confluence of ideas would later be incorporated into the conservationist movement and influence the ideas of, among others, Gifford Pinchot who was instrumental in establishing national forests.

Revised readings of landscape painting and literary descriptions, have attempted to map the various discourses which "endow them with often complex cultural power"

(Daniels 1992, 433). Daniels' focus on the "duplicity of landscape" sought to reveal its ideological nature by interpreting the English countryside as a material consequence of the continued legacy of class conflict and political strain (Daniels 1992, 1993). Scholarship in this vein seeks to uncover the politicization of images by contextualizing their historical production. Not only is landscape painting understood to visually catalog prevalent historical themes, including westward expansion of the American frontier; it also plays an active role in reproducing dominant views of nature by shaping public discourse.

While the impregnation of landscape painting with political meaning has often served the ideological aspirations of critical geographies, others remain less inclined to reduce culture to a product determined solely by economic relations. This work is informed by Cosgrove's (1984, 57) assertion to the contrary that "culture as ideology must be broadened to incorporate culture as an active force in the reproduction and change of social relations." Two decades later, Cosgrove's observations continue to inform a similar concern over geography's tendency to bankrupt the landscape idea of its more traditional meanings. The perceived importance of the traditional Sauerian landscape idea has been diminished by its contemporary use as a disciplinary arena for battling over ideological conceptions of a hyper-politicized nature. Rather than being grounded in ideas of culture as an "active force", landscape has increasingly been treated as a postmodern tableau for the *a fortiori* unfolding of capitalist relations (Harris 1999).

Olwig aimed to assail the "disciplinary dematerialization" of landscape by recovering the "substantive depth of meaning of landscape and its implications for our understanding of society/nature relations" and acknowledging its importance "as a place of human habitation and environmental interaction" (Olwig 1996, 630). This view of the landscape idea resonates with an earlier human-land tradition in American cultural geography devoted to the study of cultural development in relation to "geognostic factors" such as vegetation. This early focus on human-environment interaction was of interest to cultural geographers because of the "creative land-shaping process" which traditional practices (e.g., silvi-*culture*, viti-*culture*, etc.) brought to the earth surface. The genealogical origins of their ideas can be traced back to German romanticism, and drew additional insights from natural philosophy (Olwig 1996, 643). In his seminal work, *Morphology of Landscape*, Sauer asserts that "geography is based on the reality of the union of physical and cultural elements of the landscape" (Sauer 1969 [1925], 325). Sauer's definition of landscape remains open to the possibility of a unified study of physical and cultural phenomena; therefore, admonishing any essentialist misstep to assign one category absolute primacy over the other. J.B. Jackson echoed a similar interest in the acknowledgement of our human presence in the materiality of landscape. However, Jackson extended this idea beyond Sauer's initial vision to account for the aesthetics of landscape as a consequent of human intervention in nature:

> The longer I look at landscapes and seek to understand them, the more convinced I am that their beauty is not simply an aspect but their very essence and that their beauty derives from the human presence. For far too long we have told ourselves that the beauty of a landscape was the expression of some transcendent law: the conformity to certain esthetic principles or the conformity to certain biological or ecological laws. (Jackson 1984, xii)

By interjecting the topic of aesthetics into the discussion, Jackson brings to the forefront an additional usage of the landscape idea as a medium through which the tensions and complications of human environmental perception may be worked out. Trans-scientific concerns were not foreign to the earlier work of Sauer, who in an earmarked section of his original *Morphology*, "emphasized the continued importance of the aesthetic quality of the landscape picture, Landschaftsbild" (Olwig 1996, 644). Many of these concerns were taken up by students of the Berkeley school of geography and adapted to suit their own areas of study, including Tuan's (1972 [1961]) work on environmental perception. Gandy (1997) revisited the topic of landscape aesthetics by examining "the romantic attachment to various forms of aesthetic autonomy as a means to promote universalist conceptions of nature that obscure the historicity of environmental change" (Gandy 1997, 638). Likewise, Cosgrove recognized the landscape genre's close association with the morphological method in geography, and the inherent difficulty of representing process and change in landscape art:

> Like other area concepts in geography, region or *pays*, landscape has been closely associated in geography with the morphological method. Morphology is the study of constituent forms, their isolation, analysis and recomposition into a synthetic whole. When applied to the visible forms of a delimited area of land this is termed *chorology*. The result of a landscape chorology is a static pattern or picture whose internal relations and constituent forms are understood, but which lacks process or change…. The idea of change, or process, is very difficult to incorporate into landscape painting…. But one of the consistent purposes of landscape painting has been to present an image of order and proportioned control, to suppress evidence of tension and conflict between social groups and within human relations in the environment. (Cosgrove 1985, 57-58)

For Gandy (1997) the above concerns are closely related to questions concerning the presence of an "autonomous aesthetic" that is liberated from the ideological power of environmental discourse. This aesthetic would reveal a truth that transcends the limitations of any one representational form, and stand up to the rancor against a technological fix of nature. Locating an autonomous aesthetic in nature further supports my earlier claim concerning the epistemic quality of landscape. The idea that landscape art and landscapes in general can tell us something factual about the world is part of a larger discussion, concerning the ontological distinction between fact and value. Accordingly, Gandy states:

> The notion of some kind of aesthetic autonomy features prominently in a series of on-going debates concerning various kinds of truth in philosophy, the natural sciences, and the arts. A principal theme here is the capacity of art not to disclose 'truth' through the mimesis of 'higher' orders of truth revealed by the physical and mathematical sciences, but to reveal aspects of reality that would otherwise be overlooked…. The romantic tradition has consistently afforded art a privileged status as a means to access primordial and universalist sources of meaning that shape human existence. This dimension underlies the ideological implications of nature-based art…. (Gandy 1997, 638)

In my later discussion on the pictorial work of Dutch symbolist Piet Mondrian, I argue that the artist's ultra-reductionist rendering of organic structures achieves an autonomous aesthetic, which accounts for the process and change inherent in the natural

systems that constitute landscape. Furthermore, when considered alongside paleoecological date presented in chapter 3, I show that Mondrian's visual metaphor of optimal complexity supports an aesthetic that underscores the human presence in nature. This presence extends from historical accounts of Indigenous environmental modification, to present-day efforts, through the use of mechanical intervention, to restore nature and thus our relationship with it to a former state. An idea common to the environmental ethic shared by all interviewees was a strong belief in the potential for scientific research and education, if so allowed, to inform sound forest management practices and guide the evolution of appropriate institutional forms. They viewed restoration, but not necessarily the PES benchmark, to be the reasonable outcome of the agency's past legacy of industrial silviculture. However, they also found virtue in the belief that *their* era of scientific discovery might pass on to others a forest in better ecological condition than was given to them. They value indigenous knowledge, yet appreciate the necessity of modern technology for executing the timely recovery of historic forest structures. In chapter 5 I discuss the practice of prescribing fire and its implication in the coevolution of agency culture and ecological inheritance, followed by a section on the creation of an ecological archetype. The ecological expression of this archetype is elaborated upon in my discussion of the visual aesthetic of Mondrian's neo-plastic art. The melding of art and science has a strong presence in the syncretic traditions of Western culture. According to Cosgrove:

> In the later sixteenth century-immediately preceding the Scientific Revolution, and in the closing decades of the twentieth century-following the scientific and intellectual contributions of relativity and psychoanalysis, there have been serious attempts to collapse Modernist distinctions between spirit and matter, humans and nature, subject and object, *poesis* [moral order in nature] and *techne* [the ubiquity of machines and technology]. In both cases understanding is constituted neither in solely operational, nor entirely speculative terms, but rather through the construction of metaphor and image by individuals actively embracing the materiality of the world, recognizing the necessity of mechanical intervention in transforming nature, but refusing to be ruled by the materialist and mechanical vision of Modernism. Metaphor and image are conceived not as surface representations of a deeper truth but as a creative intervention in making truth. In each case, the place of humans in nature and their manipulation of the natural world, primary geographical issues, are central to the debate. [additions mine](Cosgrove 1990, 345)

Rooted in Renaissance environmentalism, the collapse of the distinction between *poesis* and *techne* helped form the basis of a modern green ethic. Cosgrove's observations lend further historical context to my closing discussion in chapter 5, concerning the role of restoration in transforming nature, and how nature-based art can serve as a metaphor for the underlying processes that govern its destruction and renewal. In the next chapter I trace the contours of ecosystem change in the Interior Highlands by reviewing paleoecological data associated with the hypsithermal interval of the mid-Holocene interglacial. This is followed by the proposition of two developmental pathways that possibly contributed to the assembly of pine-bluestem woodlands. The paleoecological portion of this study is potentially repeatable elsewhere in forests exhibiting similar sets of disturbance regimes and system processes.

Chapter 3. Paleoecological Change and Developmental Pathways

Paleoecological data indicates that long term changes in structure and composition of the Interior Highlands' forest ecosystems came as a result of shifting climatic conditions. Forest conditions prior to European settlement were also characterized by an active set of natural and anthropogenic disturbance regimes. How this combination of synoptic controls and human-environment interaction has come together to shape the region's landscape is the next topic of discussion. By tracing the patterns of ecological change across the Holocene, we may better understand what is meant by an old-growth condition, such as pine-bluestem woodlands, in the ONF.

3.0 Ecosystem Change

Various calls have been made by geographers to pursue research that accounts for the presence of nonequilibrium landscapes in the context of conservation (Zimmerer 2000), while further integrating a range of ideas more commonly associated with "new ecology"[6] (Zimmerer 1994). Although such work – often found under the sub-disciplinary heading nature/society – holds great potential for illuminating the dynamic, dialectical relationship between humans and the environment, too often the ecological issues are not fully articulated.

During the past several decades, the idea that a single, self-maintaining, stable equilibrium ecosystem state is the rule has been challenged by a growing number of studies of environmental change, path dependence, and multiple successional pathways (e.g., Foster and Tilman 2000; Gersmehl 1976; Illius and O'Connor 1999; Miles et al. 2001; Mitchell and Csillag 2001; Robertson and Augspurger 1999; Tausch et al. 1993; Wilson and Agnew 1992). As environmental conditions which depart from traditional models have been verified and documented, the idea that unstable multi- or non-equilibrium ecosystem states are just as likely to exist as any other has been more widely adopted (e.g., DeAngelis 1986; DeAngelis and Waterhouse 1987; Huggett 1998; Klötzli 1998; Mailly et al. 2000; Perry 2002; Phillips 2004b, 1999; Usher 2001). Gersmehl's (1976) examination of nutrient movement rules, mineral budgets, and transfer pathways in open-system, fire-dependent ecosystems, for example, sheds light on the critical role pre-suppression fire regimes played in PES landscapes, and continue to play in contemporary multi- or non-equilibrium restoration landscapes. Concerning the compartmentalization of forest ecosystems' nutrient cycles, Gersmehl (1976, 228) explains how "a common ecological role of fire is to return minerals from the biomass or standing litter to the soil. Fire suppression changes the internal transfer rules, and the equilibrium tends toward a new equilibrium."

As fire suppression policies on National Forest lands have been relaxed and the principles of "new ecology" become manifest in Forest Service management, fire has

[6] "New ecology" is a term primarily found in the academic literature and used by cultural ecologists to refer to the set of ideas on divergent plant succession coming out of the 1970s and 80s. Ecosystem ecologists within the USDA Forest Service more commonly refer to these ideas in association with the "post-Clementsian" school of thought on disturbance ecologies and forest dynamics. In this study the two terms, new ecology and post-Clementsian, are used interchangeably.

increasingly been "treated as a periodic factor necessary to maintain equilibrium, rather than as a source of non- or dis-equilibrium" (Phillips 2004b, 370). This transition is evident in both the agency's adoption of let-burn policies and its active use of fire as a technique for maintaining certain biotic communities. Subjecting forest lands to human-induced disturbances, either intentionally through management techniques or subsequent to public use (e.g., campfire ignitions, moderate- to high-impact recreational use, etc.) may precipitate vastly different conditions than those brought on by pre-suppression fire regimes, however. Zimmerer (1994, 116) contrasts the two, noting that "many human-induced ecological disturbances, for instance, differ from natural ones in frequency, magnitude, and degree. Comparisons between natural and human disturbances also raise far-reaching research questions for environmental conservation." Furthermore, oftentimes multi- or non-equilibrium landscapes are simultaneously impacted by both human-induced and naturally-occurring disturbances, making management directed at achieving any particular desired outcome or within designated limits of acceptable change a challenge. Perry (2002) illustrates the open-ended character of ecosystems:

> …from a nonequilibrium perspective, ecological systems are considered to be open and controlled by both extrinsic and intrinsic factors. Furthermore, nonequilibrium systems lack a stable equilibrium point and are not deterministic, with stochastic events such as disturbance being regarded as integral components of the system. (Perry 2002, 344)

Human-induced disturbances add to the list of extrinsic factors impacting systems that must be managed for. Yet, overcoming the uncertainty associated with forecasting trajectories of open, multi- or non-equilibrium ecosystems is not solely related to controlling for extrinsic factors. A certain amount of the dynamic behavior they exhibit is often attributable to intrinsic factors, with multiple successional pathways and path dependence possible outcomes. Despite the return of pre-suppression fire regimes little can be said, with much certainty, about what particular species composition will prevail at a given locale. DeAngelis (1986), among others (Gersmehl 1976; Perry 2002; Tausch et al. 1993; Wilson and Agnew 1992), has abandoned the idea that stages of succession necessarily ascend toward a specified climax community:

> Succession does not always lead to an approximately stable steady state, but can involve cycles in which a state that is '*earlier*' than the theoretical climax is perpetuated by recurrent fires or other disturbances. Apparently, fire plays a major role in maintaining certain species and associations. (DeAngelis 1986, 231)

Disturbances may be understood here to function instead as events which reset a given community back to some earlier stage or alter its trajectory altogether; therefore, challenging a traditional Clementsian model of succession. This process points to a characteristic common to nearly all ecosystems, "that intricate relationships exist, involving many multilink pathways among individuals and species" (DeAngelis 1986, 233). Taken in its broader spatial context, Perry (2002, 341) observes that, "the landscape may be viewed as a collection of patches undergoing successional change, each at different points in successional time, reflecting their varied disturbance histories." Finally, Phillips (1999) expressed a world view – at least as it relates to environmental change and stability – based on the principles of earth surface systems:

> Even at the broadest scales, earth surface systems – indeed, the earth system – cannot be viewed as proceeding along a particular developmental pathway, either toward ever-increasing diversity or toward any stable end-state. There are multiple possible pathways and many possible destinations. (Phillips 1999, 145)

With so many possible pathways, could it be that the rise of historic reference conditions during the later part of the 20th century grew out of the agency's shift in institutional philosophy – now centered on ecological sustainability – and the concurrent emergence of a new scientific paradigm? The PES benchmark grew, in part, out of the recognition that Native American's maintained historic forest conditions in a quasi-stable equilibrium state through an active fire regime. Prior to that, the perception of desirable forest conditions dictated that fire was increasingly treated as an unnatural or unnecessary component of ecosystem change. What role do PES benchmarks play in attempting to mediate, if only cosmetically so, between these two developments? Or even more broadly, do ecosystem restoration projects and the consistency in which they tend to converge on a PES and/or old-growth state indicate something else at work than merely practical ideas for advancing a particular agenda? Is this equifinality coincidental, a function of utilizing the most recent common reference condition relative to anthropic degradation? Is the benchmark perceived as a regional optimum of some sort that may have happened to exist, merely by chance, from the early-18th to mid-19th century, or perhaps a socially-constructed yearning for a frontier ideal? Before these provocative questions can be fully confronted, the primary question of this study must be addressed: *Are PES benchmarks representative of socially-constructed ecosystem restoration goals and/or informed attention to social, cultural, and historical meanings associated with pre-European settlement conditions?*

Of perhaps more relevance to this project, and its goal of interrogating PES benchmarks, is the apparent contradiction between a somewhat static, even uniformitarian view of nature implied by the use of historic benchmarks, and the prevalence of multi- or non-equilibrium ecosystem states. In short, historically-informed PES benchmarks reference historically-contingent conditions which may or may not represent stable equilibrium states. This point has further complicated any efforts to rely on historical descriptions of forest composition and structure toward establishing restoration objectives. Forest Service personnel argue that no single point in time should be referenced, but rather attention paid to a broad continuum of ecological change throughout the Quaternary. Historically contingent snapshots of continuously changing species composition offer little explanation of the driving factors, both anthropogenic and natural, behind ecosystem assembly. Alternatively, the Holocene offers several key insights into the role of humans in modifying their environment amidst shifting climatic conditions. More than simply an epistemological question concerning our understanding of historic forest conditions, the above distinction influences present-day environmental perception and the formation of policy.

The studies on ecosystem change and stability referred to above, and others, have fostered greater (though far from complete) acceptance and a better understanding of nonequilibrium ecosystem dynamics (Stone and Ezrati 1996). Moreover, they have done much to alter existing paradigms of reductionist science, while proliferating an alternative explanatory framework. This framework is flexible in both its scale and scope of

application; therefore, being amenable to an array of earth surface systems. Some studies have explicitly considered nonequilibrium phenomena as they relate to restoring degraded ecosystems (e.g., Suding et al. 2004), while others urge us to move from theory to practice in the ways multi- or non-equilibrium landscapes are managed (e.g., Usher 2001). Phillips (2004b, 370) maintains that "the concept and practice of ecosystem restoration…is often linked to the idea of a 'natural,' equilibrium ecosystem which can be maintained in a steady state." Previously, DeAngelis (1986, 242) urged us to steer away from the presumption that "the ecosystem functions like a servomechanism or organism, with goal direction toward particular set points." Harris et al. (2006, 170) point out the additional complication of ecological restoration in the context of impending global climate change, noting that "the usefulness of historical ecological system conditions as targets and references must be set against the likelihood that restoring these historic ecosystems is unlikely to be easy, or even possible, in the changed biophysical conditions of the future." However difficult restoring historic conditions may prove to be, the active restoration of forest ecosystems remains a primary activity of the Forest Service. Perhaps tracing past changes in plant community species composition will help determine if PES conditions are indeed a useful part of ONF restoration projects.

3.1 Post-Pleistocene Change in Species Composition

A number of studies have used a wide range of methods to trace the changing species composition of the ONF prior to European settlement (Bragg 2002; Devall and Rudis 1991; Foti and Glenn 1991; Fryar 1991; Masters et al. 1995; Smith and Neal 1991; Tucker 1991). Delcourt and Delcourt's (1991) study of the Interior Highlands gives us greater insight concerning post-Pleistocene changes in the region's species composition. The authors use paleoecological data spanning the last 20,000 years from seven studies. The two sites most relevant to the ONF are Ferndale Bog and Natural Lake. Both are located in southeastern Oklahoma along the most western portion of the Ouachita Mountains. Pollen analysis is provided for Ferndale Bog, a small spring-fed peat bog perched atop a sandstone ridge. The record of vegetation history at Ferndale Bog covers the entire Holocene interglacial interval, and has an 11,800 year old basal radiocarbon date (Delcourt and Delcourt 1991, 17-18). The pollen analysis diagram shown in Figure (3) characterizes post-Pleistocene vegetation change in the Ouachita Mountains of southeastern Oklahoma, with a pronounced change in plant community composition occurring around 4,000 BP including a rapid increase in pine species. The authors' results are based on radiocarbon-dated records derived from spores, fossil pollen grains, and plant macrofossils recovered from "karst sinkhole lakes, bogs, oxbow lakes, and springs within stream terraces" (Delcourt and Delcourt 1991, 15). Their analysis of the southeastern US draws on additional data gathered from sites distributed across a range of physiographic regions.

The beginning of the aforementioned 20 ka period marks the maximum extent of the Wisconsin Glaciation (Figure 4). Although glaciers never migrated further south than central Missouri and Illinois, the associated climate change had a significant impact on the plant communities of the Interior Highlands. At the height of glacial encroachment spruce forests dominated the Arkansas landscape, including both uplands and lowlands. A diverse suite of other species were present, but were restricted to their ideal habitats.

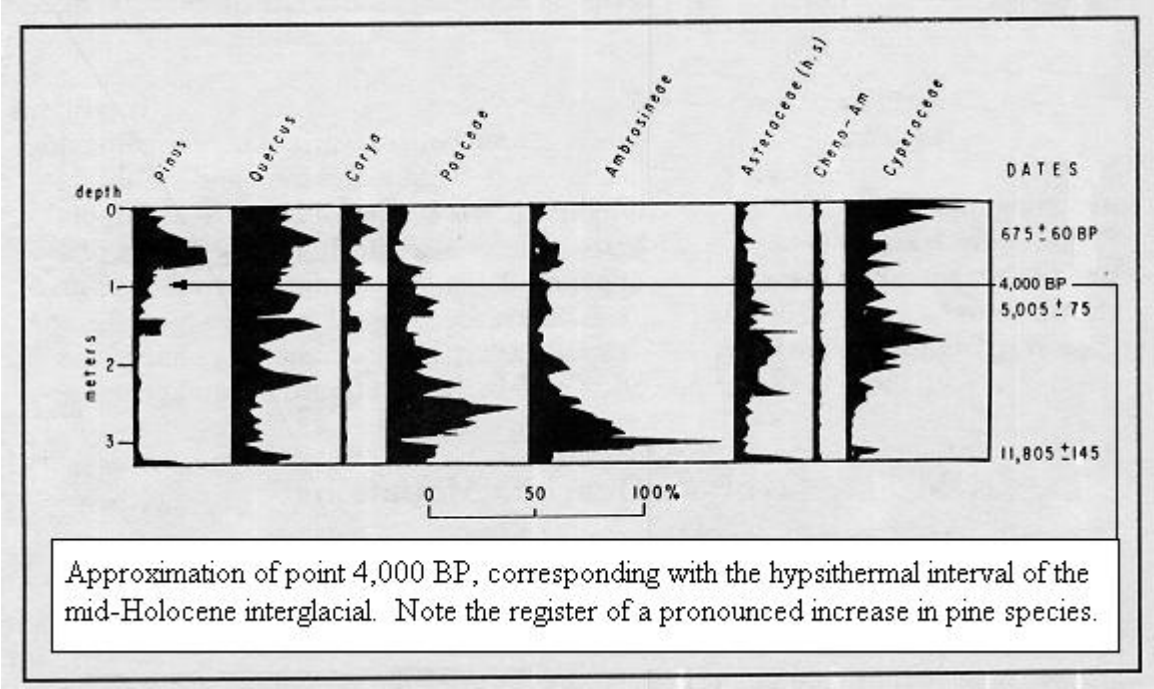

Figure 3. Pollen analysis diagram for Ferndale Bog paleoecological site [text additions mine] (reproduced from Bryant and Holloway, 1985 in Delcourt and Delcourt 1991, 24)

Oak, hickory, and a limited number of pines were relegated to warmer microclimates (southern pines do not register in the pollen profile until the later part of the Holocene). Eventually, the spruce forests that typified the glacial maximum were slowly supplanted by jack pine, followed by northern pines (Delcourt and Delcourt 1987; Wright 1981).

About 12,000 BP a general warming trend resulted in the establishment of prairie in eastern Oklahoma (Delcourt and Delcourt 1991). This easterly migrating prairie acted as a "phytogeographic barrier" to the westward movement of eastern deciduous forest and dispersal of boreal conifers in the north (Delcourt and Delcourt 1991, 15). The pollen analysis diagram (Figure 3) shows "high pollen percentages of grass (Poaceae), ragweed (Ambrosineae), and other herbs in the aster family (high-spine Asteraceae), along with pollen of chenopods (Chen-Am), in the earliest sediments" (Delcourt and Delcourt 1991, 23). These findings are consistent with the earlier assertion that prairie vegetation arrived with the transition into Holocene climatic conditions. Furthermore, Bryant and Holloway (1985 in Delcourt and Delcourt 1991, 23) "suggest that late-glacial replacement of coniferous woodland by grassland in the western Ouachita Mountains implies that the higher elevations of the eastern Ouachita Mountains were probably an effective migration corridor for boreal coniferous trees and other boreal plant species, at least locally, during the late-glacial interval." Pollen analysis shows an abundance of grasses persisting until approximately 5,005 BP, diminishing fairly rapidly thereafter with sedges (Cyperaceae) being the only exception.

Following this time period when grasses tended to dominate the vegetation record, there was a steady rise in the presence of southern pine, oak, and hickory (Pinus, Quercus, and Carya respectively). According to Delcourt and Delcourt (1991, 24) the "establishment of oak-hickory-pine forest in southeastern Oklahoma thus occurred after

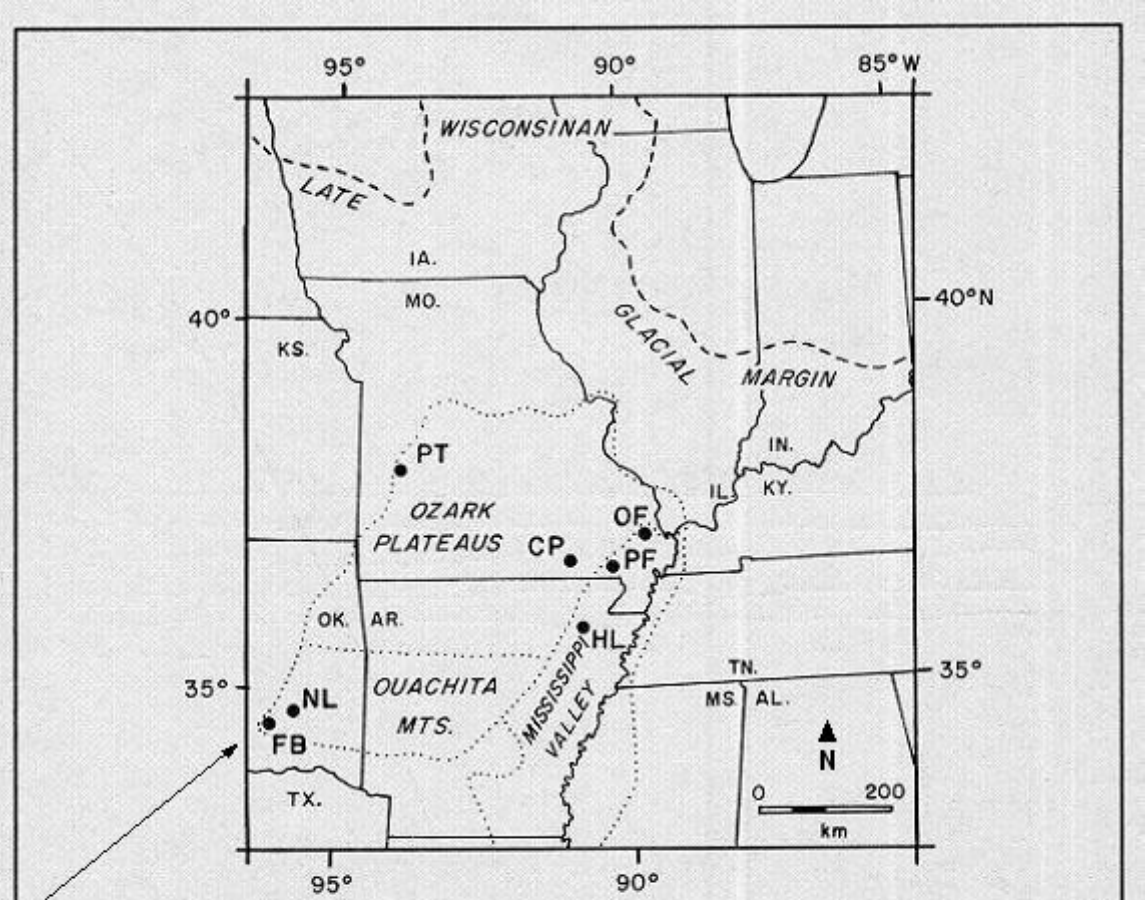

Figure 4. Location map of radiocarbon-dated paleoecological sites [text additions mine] (reproduced from Delcourt and Delcourt 1991, 17)

the peak of warm, dry climatic conditions that marked the hypsithermal interval of the mid-Holocene interglacial." Eventually, the oak, hickory, pine forests, that were once restricted to warmer sites, became a much more prominent feature across the landscape. The hypsithermal interval, occurring approximately 4,000 BP, indicates that an important shift in climatic conditions preceded a pronounced change in plant community composition. Resource Professional 1 with the Arkansas Natural Heritage Commission reiterates this point concerning the correlation between climate change and plant community dynamics:

> As the climate ameliorated five thousand years ago [leading up to the hypsithermal] that sequence of shifts took place back in the other direction so that prairie came back through the state, overgrew those areas that had been desert in the past, and became established…. Once prairie flora are established they can be maintained even in the face of dramatically changed

> climate through frequent fire…. My emphasis here is prairie, but you find many of those prairie species in the ground layer of the woodlands and savannas of the [Arkansas and Oklahoma] uplands, and they got established in the same way and got maintained in the same way. [additions mine](Resource Professional 1 6-19-2007)

Drawing from an existing seed bank, this climate driven reestablishment of prairie species was accompanied by the migration of shortleaf pine into the Interior Highlands. Shortleaf pine's ecological tolerance to a wide range of edaphic and synoptic conditions provided it a competitive advantage over other species. This allowed shortleaf to move into southeastern Oklahoma, northern Arkansas, and southeastern Missouri during the hypsithermal interval's increasingly dry conditions. Many of the species associated with old-growth conditions in Arkansas that persist today came as a product of the hypsithermal, at a time when emerging plant communities were forming in response to climatic change (a general warming trend) associated with the late-Holocene (Delcourt and Delcourt 1991).

This change in species composition is part of a more-or-less continuous pattern of biotic change that has gradually unfolded over geologic timescales. The transition from woodlands to prairie and vice versa illustrates a close association between these two community types. Under slightly altered conditions (e.g., soil characteristics, moisture and fire regimes, etc.) basal areas have increased and decreased, surging and retracting in accordance with the availability of resources (Resource Professional 1 6-19-2007). Plant communities have graded all the way from treeless grassland with a scattering of forbs, to open, park-like savannas, to closed forests devoid of any remaining herbaceous ground cover. Discussing this morphology in species composition, Delcourt and Delcourt (1991, 16) state "the presettlement old-growth forests of the Interior Highlands thus consisted of newly formed plant communities that were still in the process of change in response to changing late-Holocene climate." An increase in the dispersal of southern pines continued into the late-Holocene, thus populating the southern Ouachita Mountains with shortleaf pine (Delcourt and Delcourt 1991, 26). Assembly of the pine-bluestem woodland ecosystem came as a product of these sweeping environmental conditions and the region's unique set of disturbance regimes. This finding, that the emerging newly formed plant communities of the late-Holocene are, at least partly, attributable to synoptic conditions, raises questions concerning the relative impact of anthropogenic fire. Did burning by Native Americans – associated with the woodland period's eastern agricultural complex – contribute significantly to the assembly of the Interior Highlands' pine-bluestem woodlands (Delcourt et al. 1998; Foster et al. 2002; Gremillion 2003)?

3.2 Disturbance Regimes

> "We find ourselves in a world that is already planted, but is also still being planted as at first. We say of some plants that they grow in wet places. The truth may be that their seeds are scattered almost everywhere, but in these places only do they succeed."
> – Henry David Thoreau (1993, 101)

Hernando de Soto's expeditionary crew reached present-day Arkansas on June 18, 1541. The group ascended the Arkansas River to an area immediately south of contemporary Little Rock where they spent the following winter. Sometime in early

1542 they are thought to have entered the Interior Highlands, visiting present-day Hot Springs along the way (Albornoz 1986). A local mural painted on the edifice of Hot Springs' Rodeway Inn depicts De Soto's arrival at the *Valley of the Vapors* (Figure 5). In it is shown an Indian village (presumably Caddo; Williams 1974) with the iron clad explorer standing on one leg; the other leg bent, resting atop a large rock. Standing before him, with his back turned to the viewer, is a local tribesman clutching a wooden staff. Each man faces the other as if to make his acquaintance. In the middle ground runs a swift flowing river, flanked on its far side by the forested slope of a distant mountain – its verdant cover only suggestive of forest conditions present on the eve of European settlement.

Figure 5. Mural depicting Hernando de Soto's arrival at *Valley of the Vapors* on September 16th, 1541 [Hot Springs, Arkansas] (photo by author)

This historicized moment of first contact would only be posthumously retold. Shortly thereafter the party descended the Ouachita River, arriving at its confluence with the larger Mississippi, where De Soto passed away on May 21, 1542 (Albornoz 1986). However much the mural's portrayal of discovery in the New World may be rooted in myth, its title is not entirely without historical basis. Aside from its obvious connotations with the nearby hot springs, *Valley of the Vapors* possibly makes reference to an atmospheric phenomenon common, more then than now, throughout the Ouachita Mountains: haze. According to William Dunbar, while traveling through western Arkansas in 1804 he observed a "smokey [sic] or misty" quality of the air (Rowland 1930). This appearance he owed to "the common practice [sic] of the Indians and Hunters, of firing the woods, planes [sic] or savannah; the flames often extending themselves some hundred miles, before the fire is extinguished…" (Rowland 1930). Moreover, Dunbar noted:

> When a piece of ground has once got into this state, in an Indian country, it can have no opportunity of re-producing timber, it being an invariable practice to set fire to the dry grass in the fall or winter, to obtain the advantage of attracting game when the young tender grass begins to spring: this destroys [sic] the young timber, and the prairie annually gains upon the woodland. It is probable that the immense plains known to exist in America, may owe their origin to this custom. (Dunbar 1807)

The bluestem grass that is so much a part of contemporary restoration efforts served a practical need in the human ecology of indigenous people. The community composition achieved through a regime of frequent, low intensity fires provided a range of ecological services; from abundant mast harvests, to a seasonal supply of edible berries, to a forest teeming with wild game (Gremillian 2003; Krech 1999; Scarry 2003). Grazing bison and elk were a common element of the Interior Highlands' landscape. Indeed, numerous locations in present-day western Arkansas and southeastern Oklahoma incorporate the terms buffalo, elk, and prairie into their place names: Buffalo Creek, Buffalo River, Elkhorn Tavern, and Prairie Cemetery are only a few. The evidence extends beyond mere markers in the landscape however. Anthropogenic fire was an important and perhaps historically underappreciated factor, contributing to the assembly of native plant communities during the hypsithermal (Guyette and Dey 2000; Guyette and Dey 2002; Guyette and Spetich 2003; Guyette et al. 2002; Hammett 2000; Keeley 2002; Williams 2002). The fall or winter burning described by Dunbar has been corroborated by ecologists through an examination of the fire record:

> The really important thing that we need to think about in those terms is that people were here four to five thousand years ago. We now understand, and began in the 1980s to really understand, that people were actively and intentionally manipulating their environment for those four to five thousand years. We know that in eastern Arkansas, and some cases in the highlands, that they were actually clearing land, growing crops, and having major influences on relatively small areas…. The major influence that they could have over the broad landscape was through fire. It did not take many ignitions to burn a large area of land, so it didn't take many people to burn a large area of land. (Resource Professional 1 6-19-2007)

Previously, Delcourt and Delcourt (1991) established the influence of broad scale climate change on the development of regional species compositions. Yet, climatic conditions alone do not account for the inter-dispersed migration of prairie species into the Interior Highlands. Climate determines, in part, the moisture regime of a region; thereby, placing a natural constraint on whether land is dry enough to burn or not. It was not, however, the sole determining factor of how active a fire regime existed. Lighting strikes contribute significantly to the production of wildfires, but human ignitions are an equally important part of the disturbance regime puzzle (Foti and Glenn 1991). Neither climate nor human agency can be said to have maintained the pre-European settlement landscape alone. The truth lies somewhere in the middle, where historical human-environment interactions produced somewhat of a quasi-natural fire regime. Furthermore, we know that Native Americans applied the tool of fire to the pre-European landscape, but did there exist a reciprocal relationship between regional weather patterns and anthropogenic fire? The emergence of some type of land surface-atmosphere feedback pattern between long-term anthropogenic disturbance regimes and atmospheric processes is only speculation. Nevertheless, possible interactions involving particulate matter from forest fires as condensation nuclei for ice formation and cumulonimbus cloud seeding remains an interesting hypothesis. A possible connection between the two may help explain how the historic maintenance of disturbance regimes perpetuated ecological conditions that were uniquely suited to and increasingly stable across a particular region.

Pine-bluestem woodlands, for example, exhibited a high degree of persistence across the Interior Highlands during the relatively warm and dry hypsithermal interval, approximately 4,000 BP, in part, due to shortleaf pine's wide ecological amplitude. This fact does not detract from our current understanding that pine-bluestem woodlands existed historically only in conjunction with anthropogenic fire. Natural disturbances alone were insufficient it seems to have maintained pine-bluestem across the landscape with any regularity. Commenting on this process of intentionally creating stable forest conditions, Bates observes that "sometimes a sort of artificial stability is achieved through human action, as with the pine woods of our southern states. These seem stable enough, but they are maintained only through periodic fires which kill the oaks and other broad-leaved trees that otherwise would eventually replace the pines…" (Bates 1960, 116-117). Living in such an intermediary zone as the Interior Highlands – situated between the central plains and the eastern deciduous forest – offered its inhabitants an exceptional mix of resources. Firing the woodlands came as a reasonable cultural adaptation for Indigenous people who had occupied the Ouachita Mountains physiographic region for thousands of years.

To fully understand how they may have manipulated their environment we must first examine the complex interactions unfolding between human and natural systems. Each of the following two historical scenarios posits one possible developmental pathway associated with the pre-European settlement landscape. The first outcome results from an active set of disturbance regimes independent of any human impact on the environment. The second outcome accounts for the influence of cultural practices on maintaining forest conditions favorable to human inhabitation. This human-environment interaction may have produced a regional optimum unique to the Interior Highlands during the mid-Holocene. The previously discussed climatologic backdrop affords us a moving window through which cultural practices may be examined relative to ecological change.

3.21 First Pathway: Ice, Wind, and Fire

The Interior Highlands of Arkansas and Oklahoma are subject to a variety of weather related disturbance events. Some of what has contributed to the Interior Highlands' dynamism is its geographic orientation and position within the continent. The east-west running Ouachita Mountains are situated in close proximity to a convergence zone where warm, moist southerly air out of the Gulf of Mexico collides with westerly flowing cool, dry air. As the northern jet stream dips into the southern plains squall lines are organized over the Interior Highlands, thereby, setting off the convective updrafts necessary for cumulonimbus cloud formation (Schaefer and Day 1981). These cumulonimbus clouds compose the single and multi-cell storm systems that originate over the central plains and are eventually carried into the Ouachita Mountains. Wafted along by these storms are numerous seeds and pollen granules. Drawing from the Central Plains species pool, waves of genetic material are seasonally deposited in the Interior Highlands. The grass (Poaceae) pollen, ragweed (Ambrosineae), herbs of the aster family (high-spine Asteraceae), and chenopod (Chen-Am) pollen, previously discussed, arrived in the uplands by way of these westerly winds. Deposited high along ridgetops, amidst the dispersal corridors used by southern pines, the botanical building blocks of the pine-bluestem ecosystem have been placed. Over a century ago Thoreau discussed a similar emergence of fireweed some distance from its original source in disturbed woodlands:

> There are enough of these seeds in the air always ready to fall on and vegetate in such places. They may have been blown *into* the woods and settled there, when there was a lull, in the fall before the woods were cut or, for aught I know, preserved their vitality in the soil there for many years. Perhaps, moreover, these seeds are fitted to escape or resist fire, or even the wind which the fire creates may lift them again out of harm's way. (Thoreau 1993, 88-89)

The historic assembly of pine-bluestem woodlands in the Ouachita Mountains relied on a similar coupling of wind and fire. The former served as a dispersal mechanism, while the later acted as a natural control on the establishment of native plant communities and an impetus for further dispersal. Although burning today's forest will not result in the creation of prairie, prescribed-fire will allow the ecological expression of a diverse suite of relict species at a time when, much like the hypsithermal, warm, dry conditions favor an active fire regime. Aside from their potential to disperse seeds, intense storms function in yet another way. They provide the necessary ingredients for maintaining a highly active set of natural disturbance regimes. Often associated with the cumulonimbus formation are its fearsome offspring, the tornado and thunderstorm. According to Pretor-Pinney (2006, 49) "it is estimated that some forty thousand thunderstorms occur around the world each day. At the heart of every one is a Cumulonimbus cloud – often many of them." Each of these atmospheric phenomena has exacted its own lasting influence on the forest. Windfalls, broken limbs, and lightning ignited wildfires shaped the pre-European landscape and continue to impact the present-day ONF (Figure 6) (Dunham and Cameron 2000; Skatter and Kucera 2000; Spatz and Bruechert 2000).

Figure 6. Evidence of natural disturbance regime shaping pedological and ecological memory at tornado blow-down site [Ouachita National Forest, Arkansas] (photo by author)

One historic account by a hunter and traveler in western Arkansas noted that "storms are frequent in Arkansas, and occasionally hurricanes [tornados], which will sweep a distance of a mile in width and several miles in length, leveling everything in their path. After a time blackberries, thorns, and creepers, grow…over the heaps of fallen trees" (Gersteacker 1856). Likewise, Forest Manager 2 with the ONF draws similarities between historic reference conditions, like those described by Gersteacker, and contemporary disturbance events:

> Looking at these kinds of things that are still happening and gleaning what we can from the past, we know that disturbances of all kinds, of various kinds, were extremely important to the dynamics of these ecosystems. They took place, the stochastic pattern. We had at the end of the year 2000, December 2000, the largest impact from an ice storm in history, that we know of…. We don't know what happened pre-European settlement in the way of devastating ice storms. We do know that even if it occurs every two hundred years it's an important part of the ecosystem. I carry around this picture of all kinds of disturbances affecting the Ouachita – wind storms on average probably replacing the canopy about half a percent on average per year; maybe as high as two percent, but it varies. (Forest Manager 2 6-26-2007)

By examining the stochastic patterns occurring throughout history, we are able to better understand the ecological role of disturbance events in maintaining forest equilibrium. Ice storms are common in the continental mid-latitudes. However, a forest that has been dramatically altered following many consecutive generations of fire suppression is ill prepared to withstand such perturbations. As a thick blanket of ice lowers over the forest, its burdensome weight begins snapping tree limbs. As little as 1 cm of ice is often enough to trigger widespread changes in forest structure (Smith 2000; Smith and Shortle 2003; Travis and Meentemeyer 1991). Similar to how excess fuel accumulations help contribute to devastating wildfires, present-day overstocked second-growth forests are a tremendous liability under such stressful conditions. Rather than each tree supporting its own weight overlapping limbs tend to freight a neighboring tree's ice load. Had a regime of frequent fire maintained the forest in an open seral condition such impacts would be negligible. The idea that fire is economically wasteful and counterproductive to maximizing wood fiber – combined with the common misconception that ecological change is unnatural or even harmful – supported the aggressive pursuit of fire-suppression over previous decades. Today, the closed forest conditions fostered by decadal fire-suppression are inconsistent with efforts at bolstering ecosystem resilience in the ONF. The consistency and rate of change, in part, determine the ecosystem's resilience. This maxim of ecological change is reflected in the ONF's more recent adoption of let burn policies. However, the approval to let wildfires burn – barring a loss of life or salvageable property – would not have come without first acquiring knowledge of how ecosystems have changed historically:

> I think looking at what was here in the past helps us think about what a disturbance driven set of ecosystems we have here. Of course, we can still see it today. We still have frequent blow-downs from tornados and straight-line winds. We have southern pine-beetle and its outbreaks that we generally control, but you can imagine how they might have behaved in the past…and the same for the most part with wildfires. Although, we saw last year a hint of how wildfire may have behaved pre-settlement. We had one of our episodic really dry years, and we had some of the biggest wildfires on record…. They occurred in areas where we had not been doing much prescribed burning or any other kind of management for some time except custodial. They were rugged areas. We had lots of lightning ignitions and we've had several that went over five thousand acres. I think the largest was probably nine thousand. (Forest Manager 2 6-26-2007)

Lightning ignitions are an integral component of the system. The wildfires they create represent chance events that have been increasingly prohibited by society. As fire suppression gained greater support over the last century, the stochastic patterns were disrupted by human modification in the form of "non-chance events" (Forest Manager 1 6-26-2007). Natural processes were prohibited from occurring; thereby, bring about wholesale changes in the environment. Rather than the landscape exhibiting a shifting mosaic – an ecological patchwork of "varied disturbance histories" (Perry 2002, 341) – its uniformity of second growth forest reflected resource managers' and society's belief in a *theoretical* climax community.

3.22 Second Pathway: Human Ignition

More recent thinking on the importance of landscape heterogeneity and habitat connectivity highlights the role of disturbance events in maintaining healthy and stable ecosystems (Azevedo et al. 2000; Lovett et al. 2005). This idea was understood well by Native Americans. Over a span of several thousand years they skillfully harnessed the tool of fire to create desired environmental conditions (Foti and Glenn 1991). However important an active set of natural disturbance regimes were in shaping the Interior Highlands, anthropogenic fire remained a key factor in the maintenance of native plant communities, including pine-bluestem. Native Americans no doubt witnessed the beneficial conditions created following lightning ignitions; thereby, growing to recognize their own capability to modify the land accordingly. Denevan and others (Lentz 2000; Cronon 1983; Rostlund 1957) have suggested indigenous people of the western hemisphere bore a greater impact on pre-Columbian wilderness than was previously thought:

> But was the landscape encountered in the sixteenth century primarily pristine, virgin, a wilderness, nearly empty of people, or was it a humanized landscape, with the imprint of Native Americans being dramatic and persistent? The former still seems to be the more common view, but the latter may be more accurate. The pristine view is to a large extent an invention of nineteenth-century romanticist and primitive writers…. (Denevan 1992, 369)

The pristine view of a mythic nature may have been an invention of sorts, but how significant were the environmental impacts of Native Americans? As the climate ameliorated, conditions became dry enough for Native Americans to implement a regime of frequent fire. The practice of setting the woodlands ablaze occurred within a landscape that already exhibited its own set of natural disturbance regimes. Lightning ignitions in Arkansas peak in late summer, beginning around July or August and continuing into September (Guyette and Spetich 2003). According to Resource Professional 1, conventional logic suggests that late summer is "when it's dry enough and when you get big convection of air that creates thunderstorms, so that on the edge of a thunderstorm you can get lightning set fires that hit a dry enough landscape that they can burn large acreage" (Resource Professional 1 6-19-2007). However, a discrepancy exists in the historical literature between when lighting and lightning set fires took place in Arkansas and anthropogenic fires occurred (Guyette and Dey 2000; Guyette et al. 2002; Guyette and Spetich 2003). Native Americans set fires in October and November when conditions remained dry enough to carry the fire, yet a decline in temperature prevented the escalation of hotter, more catastrophic wildfires. The fire regime maintained by Native Americans occurred more frequently and was implemented later in the season (Resource Professional 1 6-19-2007). A fundamental difference between these two scenarios is the degree to which ecological disturbances are attribute to either human agency or natural processes internal to the earth system. In the first scenario, late summer storms alone provide the impetus needed to maintain an active fire regime. While in the second scenario, Native Americans' fall burning of the woodlands figures centrally in the creation of a healthy and stable environment:

> First, we had this massive climate change. That's got to have many lessons as we're involved in new climate change today. After that climate change, as the communities reassembled and the species began to find their niches to survive, thrive, or not, people were affecting the landscape through fire. So, whether we have a romantic notion of a landscape without people or not is irrelevant. The species and communities that were here two hundred years ago, that are trying to be here today, evolved under some extent of manipulation by people, and we've just got to recognize that. We've got to realize also that [past manipulation] is a totally different sort of manipulation than we're talking about today, and it's not because of any romantic notion of the Indians. [addition mine](Resource Professional 1 6-19-2007)

Although the frequent burning of pine-bluestem woodlands by Native Americans was persistent as Denevan suggested, its affect on the Ouachita landscape was by no means as dramatic as the environmental impacts that followed European settlement. Native Americans did not possess the technology available to modern society. They were far less capable of exceeding the threshold of a natural system's stability parameters – defined here in relation to theoretical literature on non-linear dynamics (Bodin and Wiman 2007). They could direct the system in one direction or another, shifting it to some degree, but the modifications they made invariably fell within the limits of the system (Pyne 1982; Pyne et al. 1996). This realization, that the imprint of Native Americans was persistent but less dramatic than present-day modification, does not detract from the idea that pine-bluestem woodlands were primarily a product of long term cultural activities, unfolding against a backdrop of shifting synoptic conditions. Whether set by humans or lightning, fires would not burn until the moisture regime allowed them to do so. Yet, forest fires that occurred historically in early fall, following peak lightning season, are most often attributed to human ignitions. Understanding which causal event should be attributed to either system illustrates the complexity of human-environment interactions, and demonstrates the difficulty of parsing the historical influence of one progenitor apart from the other.

3.3 Summary

The preceding section has traced the legacy of ecological change throughout the Quaternary. This natural history is tempered by the recognition that forest community species composition at any time is a historically contingent snapshot of continuous ecological change. The Interior Highlands are characterized by an active set of natural and anthropogenic disturbance regimes. Aside from shaping forest structure and maintaining natural plant communities, disturbance events serve to maintain quasi-stable system states amidst otherwise non- or multi-equilibrium conditions. This fact draws attention to the idea that steady-state equilibrium and theoretical climax communities are not necessarily the norm. Our current understanding indicates that pine-bluestem woodlands existed historically only in conjunction with anthropogenic fire. Natural disturbances alone were insufficient for maintaining pine-bluestem across the landscape with any regularity. The cultural adaptation of fire by Native Americans allowed them to work within the limits of the natural system toward achieving a more desirable state of ecological resilience by propagating a fire resistant forest type. Two developmental pathways were presented; each offering a survey of the various forces driving the assembly of pine-bluestem woodlands. In the first scenario the antediluvian forest

remains devoid of human imprint; subject only to three of nature's elemental forces: ice, wind, and fire. Human impact on the environment is neither dramatic nor persistent. The second scenario introduces human influence as a constitutive part of the forest's developmental pathway. However, human inputs once removed have a negligible affect on the long term function of natural systems. Cultural activities remain in isolation or temporarily engaged with the system upon which they impact. Humans are present and metaphysically more centralized with the natural world. The second outcome results from a perceptual reconfiguration concerning our relative position within the natural domain, or conversely nature's relative position within the cultural domain. This is tantamount to conceiving of humanity as either *part of* or *apart from* nature. Historical human-environment interaction indicates that Native Americans were cognizant of their potential to help steer the course of ecological change; even when faced with the proposition that multiple outcomes are an essential characteristic of disturbance mediated, nonequilibrium landscapes. Does contemporary society view nature as a detached entity, un-tethered from the need for active management? If so, do PES benchmarks signify an unconscious effort to brush aside the complications of multiple outcomes by focusing on a single, readily-defined state? Perhaps the persistence of normative balance-of-nature ideas in the culture of restoration reflects a profound misunderstanding concerning the centrality of humans in maintaining resilient environments both historically and today.

Chapter 4. Agency Culture and Ecological Education

Equilibrium based theories and metaphors are influenced by ideas circulating through the culture of restoration and society abroad. Normative balance-of-nature ideas were present during ecology's development as a unified field of inquiry, and continue to pervade modern scientific thought. In this chapter, the cultural origins of such ideas, their influence on educational pedagogy and professional training, and possible ties with present-day management paradigms are addressed. This will help to achieve this study's second main objective of examining how the choice to use a PES benchmark is influenced by a broadly conceived notion of culture. Lastly, the prospect of adopting an alternative, countervailing framework for forest management that draws from a naturalistic philosophy buttressed by indigenous knowledge is discussed.

4.0 Culture of Restoration

Research in the social sciences addressing ecological restoration has dealt with the topic, largely, in terms of its associated culture. The culture of forest ecosystem restoration includes local community members, restoration experts who are directly involved with implementing restoration projects, users of the national forests (e.g., hunters, all-terrain vehicle enthusiasts, etc.), Forest Service management and research personnel, and others. The multifaceted culture of restoration is comprised of its own systems of ideas, beliefs, and ethics (Elliot 1994); some of which at times are conflicting. At one end of the spectrum lie idealist views of ecological restoration, often warning of the moral limits inherent in such practices (Birch 1995; Katz 2002, 1996, 1995, 1992a, 1992b, 1991; Sylvan 1994). At the other end are pragmatic views of ecological restoration, touting the value of its application (Light 2006, 2005, 2002, 2000, 1996a, 1996b, 1996c, 1995; Light and Higgs 1997). Out of these two primary positions emerge a number of related issues; from efforts to uncover the rationale behind ecological restoration (Throop 1997), to understanding differences between fact and value in ecological restoration (Sagoff 1985), to measuring the quality of ecological restoration (Higgs 1997). Egan's (1990) history of ecological restoration and Gobster and Hull's (2000) compendium of contemporary thought on the culture of restoration illustrate well past and present trajectories in the field. A rubric that has, thus far, been under-addressed is the influence of normative balance-of-nature ideas on the culture of restoration.

Despite substantial evidence that nonequilibrium, multiple-equilibria,[7] and complex nonlinear dynamics are common in ecosystems (e.g., DeAngelis 1986; DeAngelis and

[7] In relation to restoration management, the above equilibrium concepts are defined in terms of how ecosystems respond to periodic disturbances, their dynamics as it is, rather than by the importation of mathematical or physics derived formalisms. Accordingly, equilibrium refers to "a steady-state, whereby small fluctuations may occur around a constant mean condition" (Phillips 2004, 370). Here, the constant mean condition in restoration management being the maintenance of pine-grass dominated ecosystems through a regime of frequent low intensity fire. The term multi-equilibria refers to a system characterized by more than one possible steady state around which a mean condition can be maintained. The ONF has historically experienced multi-equilibria system conditions as evidenced by a predominance of pine-hardwood, pine-grass woodland, and some speculate open-woodland native hardwood forest types.

Waterhouse 1987; Huggett 1998; Illius and O'Connor 1999; Klötzli 1998; Perry 2002; Phillips 2004b, 1999; Tausch et al. 1993), well-entrenched normative equilibrium-based theories remain an explanatory mainstay in classroom pedagogy, professional training (Sanderson 1990, *vii*), and ecosystem management and research (e.g., Bouwman 1989; Kronert et al. 2001; Middleton 2002; Muller 2000; Rickard et al. 1988). The persistence of the idea that biophysical systems (should) tend toward a normal, "natural" self-maintaining state of balance is common not only among laypersons, but also among scientists, engineers, and resource managers. Some systems indeed display stable steady-state behavior, and there is some inevitable inertia and persistence of well-entrenched equilibrium-based theories. However, both empirical and theoretical work over the past several decades has brought a greater recognition of nonequilibrium based theories that attempt to explain the behavior exhibited by various natural systems. Perry's (2002) critical review of equilibrium concepts in ecology and biogeography offers a concise account of the transition toward nonequilibrium ideas and growing importance of space over the last thirty years.

Concurrent with the shift toward nonequilibrium frameworks has been a growing awareness of the important influence that spatial heterogeneity and disturbance ecologies have on the function and stability of ecosystems. This relationship between non- and multiple-equilibria, and disturbance ecologies has raised far-reaching questions in the fields of environmental management and ecosystems restoration. Indeed, the practice of ecosystem restoration is fundamentally premised on the idea that a single equilibrium point can be maintained in perpetuity. For certain terrestrial ecosystems that are maintained by natural disturbance regimes (e.g., fire, wind, ice, etc.) another term of analysis has been devised in an effort to avoid the problematic assumptions associated with normative ideas concerning the balance-of-nature: stability. Although the term stability attempts to broaden our understanding of nonequilibrium conditions in ecosystems ecology, Pimm (1991) expressed some misgivings about its intended use:

> If ecologists speak more of ecological stability, perhaps we are just substituting one phrase for another. Balance or stability implies some restoration following disturbance. The phrases indicate that the stability arises from 'nature': ecological processes within populations, among the interactions between species in a community, and between the community and the physical environment. There is something unmistakably fuzzy about the terms stability and balance of nature as most ecologists use them (though, just because the terms are fuzzy, this does not mean that the underlying ideas are unimportant). (Pimm 1991, 4)

Although stopping short of an all out dismissal of the two concepts, Pimm does draw attention to the fuzzy quality of each term. Perhaps it is the incommensurability between the language we use to describe ecosystems and the complexity they exhibit that necessitates an alternative means of defining what they are and how they behave. Such strategies of definition carry important consequences for how society perceives the environment and their complicity with either existing or proposed management paradigms, including those centered on ecosystems restoration. Concepts such as equilibrium and stability often *are* used imprecisely, but they can be and sometimes are rigorously defined (e.g., dynamical stability, steady-state mass balance equilibrium, etc.). More (1996) brings the idea of fuzzy concepts to bear on ecosystem management practice:

> In a sense, the descriptions of ecosystem management in practice…can be considered attempts to define the prototype. While each may emphasize slightly different elements, they all can be seen as striving to approach an ideal prototype. In fact, when dealing with prototypic definitions, our primary concern should be the degree to which a particular example represents the prototype. Some will be closer than others. But what about the definition of the prototype itself? What captures its essence? …Are there corresponding individually necessary and jointly sufficient conditions that constitute the essence of ecosystem management? The answer is yes, [but] there needn't be. Many everyday concepts are fuzzy-set concepts with no clearcut center or prototype. [addition mine](More 1996, 21)

Forest ecosystems restoration in the ONF provides a salient example of how a fuzzy-set concept, the PES benchmark, is being applied in conjunction with existing environmental management tools (e.g., prescribed burning, selection logging, etc.). The "individually necessary and jointly sufficient conditions" (More 1996, 21) of ecosystem restoration are parlayed into their own fuzzy concept: the pre-European settlement landscape. Restoration experts may be concerned primarily with returning a process to the landscape, but the biophysical conditions (e.g., plant species composition, forest structure, etc.) this creates are provided a name because they are perceived in relation to their historical antecedents. The PES landscape is then taken to be a prototype, when in fact it is merely a fuzzy concept, the historical reference condition, upon which the project's center is subsequently found. There is a center, per se, to the project, but it is not necessarily declared by any intention to define a prototype. Fire remains the process necessary to achieve a PES condition, but the particular physical attributes (identified as the PES landscape) are approached to varying degrees in different locales. It is the flexibility of fuzzy-set concepts that allows the PES benchmark to be used across a fairly wide range of geographic locales, each with their own set of initial conditions. In this case, the process (fire) is the centerpiece of restoration efforts because it is perhaps the most efficient and cost effective means of arriving at the most desirable condition – a state of increased resilience that happens to correspond with a measurable composition and structure of vegetation. Restoration's interest in the dynamic nature of PES landscapes, despite the fuzzy or imprecise nature of a contested benchmark, may potentially supplant normative balance-of-nature theories. This is evident in restoration experts' focus on disturbance ecologies rather than attempting to define and recreate a historic prototype.

Offering a cautionary note about our penchant to project order onto various fields of inquiry as a result of unexamined procedures and pedagogical artifacts, Szymanski and Agnew state that,

> when a principle of order becomes well-established there is a tendency to keep 'discovering' it unless there exists some countervailing mechanism that facilitates skeptical questioning. Pressures come from various directions: traditions of data collection and manipulation, the demands of clarity in professional and classroom presentations requiring order rather than disorder, and the imperative to *explain* rather than merely *describe*. Whatever the specific pressures in operation, the 'self-fulfilling prophecy' will be a likely outcome. (Szymanski and Agnew 1981, 53)

This is especially true of environmental systems (e.g., fluvial, ecological, etc.) exhibiting complex non-linear dynamical behavior. Progress in the environmental sciences is often focused on the practice of model building in an effort to arrive at broad scale explanatory frameworks. As a result idiographic approaches, which aim to provide a description of the system at hand, are neglected in favor of generating approximations of system behavior. Characteristics that would otherwise account for the full complexity of natural systems, including historical human-environment interactions, are potentially lost in this process of simplification. Foundational principles are preempted by, as Szymanski and Agnew (1981, 53) suggest, "the imperative to *explain* rather than merely *describe*." Phillips discusses the inherent limitations of favoring one particular approach over others:

> Science is characterized by creative tension between a search for fundamental laws and generalities that are independent of place and time and the recognition—particularly in the earth and environmental sciences—that geography and history matter. The law-based, nomothetic approach (often, but not necessarily, reductionist) seeks explanation based on the application of laws and relationships that are valid everywhere and always. Particularities of place and time are not ignored, but they are treated as boundary conditions and are not a causal or necessary part of explanation. Alternative approaches, which may be termed idiographic, historical, or interpretive, seek explanation based on the particular details of site, situation, and history. General laws are acknowledged and utilized, but as constraints and context to the specific events, objects, or situations that are the basis of explanation. (Phillips 2004a, 39)

The extent to which geographical and historical particulars are set aside has a considerable affect on the advancement of knowledge. Deeming such details to be mere statistical noise, or perhaps even worse, simply discarded altogether may steer attention away from avenues of investigation that might otherwise be pursued. Put another way, how often is the outcome of our efforts a product of self-fulfillment? Ideally, the guiding principles of earth surface systems would direct, not dictate *a priori*, the pursuit of scientific knowledge. If pursuing a nomothetic approach means narrowing one's explanatory framework to encompass only normative equilibrium concepts, then equilibrium is all one will find because that is all one is looking for. As Szymanski and Agnew allude to above, what is needed to offset this tendency to find only order is a countervailing explanatory framework that accounts for nonequilibrium system conditions.

Normative equilibrium concepts have left their imprint on the applied fields of environmental management and engineering and continue to influence natural resource management, ecological restoration, and environmental impact mitigation. Engineers typically construct formal sets of procedures around (design) and operate under the general assumption (theory) that a single equilibrium state is both an achievable and desirable condition. At least two examples include civil engineering's fundamental concern with structural integrity and a related interest among materials scientists to understand how certain physical properties (e.g., harmonic resonance, etc.) determine a medium's suitability as a building material across a range of applications (e.g., aeronautical, bridge building, etc.). Indeed, the integrity of our built environment and ultimately the public's welfare is dependent upon such practices. However, when normative equilibrium concepts, so at home in the abodes of engineering, are directly

transferred to the environmental sciences their utility becomes a potential hindrance to ascertaining the full complexity of natural systems and adapt management practices accordingly. Characterizing this incompatibility of normative concepts between disciplines, Perry (2002, 344) states that "part of the problem with defining the concepts of equilibrium and stability has arisen from an inappropriate application of stability concepts derived from mathematics and physics; such concepts usually characterize simple dynamic systems." The ecological systems ordinarily dealt with by restoration experts are neither simple nor static. An important idea within the culture of restoration, that runs counter to our understanding of nature's dynamism, is the balance-of-nature. The cultural origins of this idea and its ties with existing conceptual frameworks for forest management are discussed next.

4.1 Balance-of-Nature

For many laypersons, scientists, engineers, and resource managers the idea that biophysical systems should tend toward a normal, "natural" self maintaining state of balance remains a common explanation for how natural systems ordinarily function. Indeed, supporting theories continue to pervade research and classroom pedagogy across the environmental sciences. However, the persistence and development of normative equilibrium concepts among laypersons and scientists may be attributable to the historic influence of metaphysical, trans-scientific factors as well. Perhaps a fundamental question at hand is: To what degree have social and cultural factors colored and continue to more-or-less maintain our casual impression, if not functional understanding, of how natural systems function?

Ecological theories have been reshaped, at times, into inaccurate explanatory frameworks due to the bias towards balance-of-nature thinking. Lovelock and Margulis' (1974; Lovelock 1988, 1979) Gaia Theory , for example, was initially based on the assumption that earth, itself a *super-organism* of sorts, maintains an aerobic environment – one that is conducive to sustaining human life – out of some natural tendency to maintain a single steady-state equilibrium. This view was long ago abandoned by the authors, but the term remained tied to its mythological origins. A classical view, concerning the Greek earth goddess for whom the theory was named, held that Gaia was "devoted to the management of the environment in her own collective interest" (Williams 1992, 481). Over time, the Gaia Theory – originally centered on biochemical processes – has been misappropriated as a metaphor that more closely parallels a neo-classical account, focusing on self-regulation. Contrary to its original message, the earth's biosphere, indeed the entire environment, is increasingly looked upon as a giant life support system that will prove resilient despite whatever perturbations, either human or naturally induced, are launched against it. Perhaps some of the theory's embellishment is owed to a persistence of ties between theology and modern scientific thought. Long before Gaia was ever popularized, a classical self-referential construction of balance, and the modern normative equilibrium concepts it continues to infuse scientific discourse with, began taking shape among 17th century theologians:

> The idea of a balance of nature emerged, but only implicitly, in antiquity. During the 17th century, with an increasing knowledge of natural history, the idea became a functional assumption, but within a theological rather than ecological context. In the 18th century

> Linnaeus defined the concept and attempted to make it the foundation of an ecological science. However, it remained tied to theology and was elaborated without critical examination. (Egerton 1973, 322)

Thus, Lovelock's essentially biochemical hypothesis, given an evocative name and coincidentally consistent with some popular and teleological notions of natural balance, took on metaphorical baggage which is nowhere explicit in the writings of Lovelock and his collaborators. Given the persistence of normative ideas of a balance-of-nature in the 21st century it appears that environmental science and engineering has yet to entirely divorce itself from such functional assumptions. Restoration activities are commonly carried out by sub-contracted personnel, whose formal training in fields of engineering, rather than ecology, further supports the importation of normative equilibrium based theories into management practices. Furthermore, an ongoing entrenchment of equilibrium notions stems, in large part, from the influence of nonscientific factors, which direct us to the role of culture in influencing popular and scientific environmental perception. The notion that ecosystems tend toward a single steady-state equilibrium state (as a normative concept, rather than as one possible developmental pathway) is an artifact rooted in the aforementioned origins of metaphysical thought. The persistence of such ideas in the face of contrary evidence may be, in part, related to a host of socio-cultural and psychological factors that have hereto been under-examined. Identifying fragmentary evidence of the cultural origins of balance-of-nature ideas is an important step toward understanding their effect on and translation into scientific metaphors and theories.

4.11 Classical World

The origins of normative equilibrium ideas lie partly in fields of cultural production such as music and the arts. Often expressed under the guises of symmetry, harmony, or composition, each term connotes a singular characteristic common among classical art forms: balance. The Greek Kouros and later Da Vinci's (1492) *Vitruvian Man* (Figure 7) attest well to an ancient western ideal relating bodily symmetry with the notion of anatomical perfection. The statuary nudes of Greek antiquity make similar claims to an enduring physical beauty, and suggest the structural equivalent to the analytical proportions of a perfect human body. Take, for example, Franz Gnaedinger's geometric description of a Greek masterwork, the statue *Poseidon from Cape Artemision*:

> Poseidon, standing upright on his left foot, arms raised, balances his body weight with his right leg and sights over his left hand, aiming a (now missing) trident at a far away target we can only guess at. The figure of this Greek god displays such composure, creates a wonderfully balanced effect, majestically at rest upon itself. How did the unknown master achieve this effect? First, he applied the famous contraposto: Poseidon extends his left arm and his right leg simultaneously, while bending his right arm and his left leg. Second, he used a principle I call self-reference: stretch out the left arm and you duplicate the line of the right upper arm; extend the right leg and you reach the left shoulder via the navel; prolong the left upper thigh and you reach the right shoulder via the navel again; extend the left lower thigh and you reach the left shoulder…. A large circle around the navel and touching the tip of the middle finger of the left hand seizes the right hand and the heel of the right foot while resting on the ground. (Gnaedinger, 1980-2002)

Depicted in this passage is a calisthenical technique or contraposto; the physical application of which achieves the effect of balance. Formally defined, contraposto is an association of two forces placed in opposition to one another. Here, it is the leverage provided by extending the left arm opposite the right leg. Poseidon's body, anatomically reminiscent of the Kouros, is "majestically at rest upon itself." However, this effect is less a product of some external calibration understood by the "unknown master" to help position the body in a state of perpetual balance than it is a consequence of the organizing principle put to work: self-reference. Rather than being *achieved*, as Gnaedinger suggests, balance is presumed an internal condition inherent to the body in motion. The author proceeds vicariously taking Poseidon, in contraposto, through a battery of callisthenic exercises – stretch, extend, prolong, seize, his body ultimately left resting on the ground. Each circular motion arrives at a predetermined point of reference; thereby, mimicking the linear progression of a closed system – each step following the next through a process of self-regulation *par excellence*. The animation of Poseidon's limbs towards drawing pitch circles relates his anatomical balance to the mechanistic workings of a geometric cosmology. As Poseidon's balanced anatomy operates so too does the cosmos we are instructed.

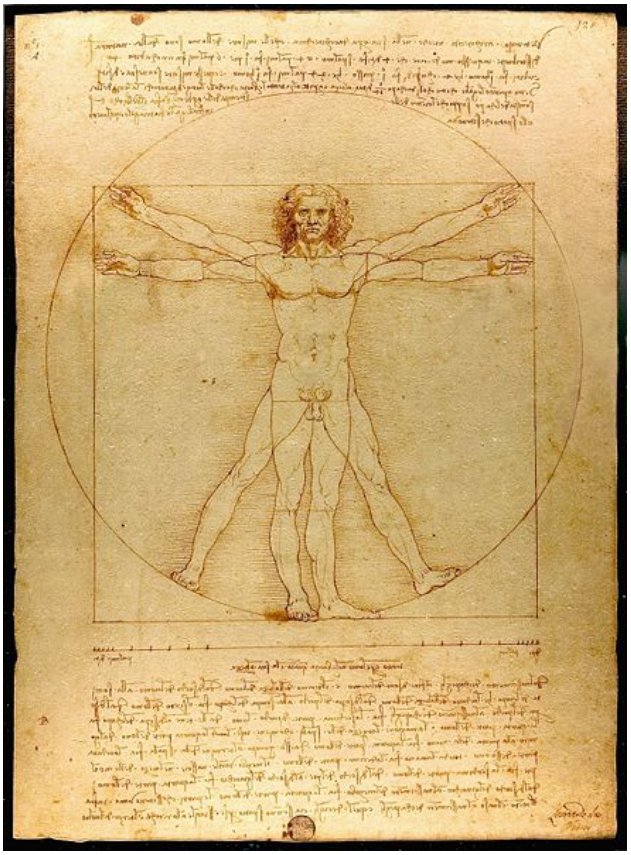

Figure 7. Leonardo Da Vinci (1492) illustration, *Vitruvian Man*, in contraposto depicting the idea of perfect anatomical symmetry and self-referential balance (photo courtesy of Luc Viatour GFDL/CC)

In Grecian society the symmetrical quality of facial characteristics was an absolute measure against which popular conceptions of beauty were made. Such a rendering of beauty vis-à-vis symmetry extended beyond overtly anatomical depictions of balance. For Greek artists the bodily form was at once expansive, embodying the exalted structure of a cosmological geometry, yet reducible to more truncated forms of artistry: namely pottery. The vase – an etymological derivative of the Latin *vas* meaning vessel, or by extension bodily vessel – was of special interest to Greek artists. Its amenability to exacting, as nearest possible, the bare essence of visual symmetry gave the vase elevated status as a preeminent type of artistic production. Each vase's profile offered a study in perfection; two opposing handles often protruding gracefully from either side, elegant in composition, balanced without imperfection. The primary importance of identifying the normative concepts of symmetry and balance in classical masterworks is to establish both their centrality in the cultural production of artistic forms, and the enduring appeal they hold in contemporary society. However, the larger question that remains is how might Poseidon's striking pose and the geometric cosmology it gives rise to potentially hinder the collective gathering of our sea legs in ecosystem management amidst turbulent environmental conditions? Is the far away target, to which his trident was lost, a mere reflection of the self-referential body that muddies our understanding of nature's complexity?

4.12 Harmonic Resonance

Anyone with a keen appreciation of music has certainly grown accustomed to hearing the term harmony used to describe the pleasing sound made by two or more voices or instruments. In mathematics, harmonic progression, harmonic mean, and harmonic analysis are common terms of reference. A more formal definition might be: the unifying structure of an orderly whole created by various arrangements, purposeful or otherwise. Harmony's vernacular usage refers to its importance in the field of musical composition where finding a composite tonal quality created by arranging consonant and dissonant chords is of utmost interest. Although varying in importance among different musical genres, harmony is characteristically a fundamental concept taught early on to musicians, while consummate artists may study the theoretical aspects of harmonic structure. To the uninitiated harmony may simply mean creating a balanced sound that is pleasing to the ear. Indeed, the phrase *to harmonize* carries with it the connotation of a purposeful layering of notes to achieve an agreeable sound. Yet somehow the details of a given harmonic arrangement's complexity often get lost in its agreeability. We may not possess a technical understanding of the innumerous ways in which harmony is created, but we certainly *know it when we hear it* and sometimes cringe when we don't.

Similar to other fields of cultural production, each having their own set of normative concepts subscribed to, harmony is ubiquitous throughout music and often left unquestioned as an integral component of standard musical composition. Of course, anyone who has listened, much less contributed artistically, to the performance of an atonal piece fully understands the existence of avant-garde styles which challenge the normative dimensions of what music should necessarily sound like. We grow accustomed over time to a particular set of harmonic tonal qualities. However, harmony

may be found, as balance is elsewhere in nature, to exist among multiple sets of conditions or arrangements. The musical principle of chord inversions offers a loose equivalent to the multiple-equilibria system states found in nature. Speaking on Rameau's historic move to disrupt the standardized methods of procedure in traditional musical composition, Shirlaw (1928) asks the question:

> How then does it come about that in the fourth, *g*-*c*, which is everywhere understood as the inversion of the fifth, *c*-*g*, the lower note of the inversion of chords, whereby he so enormously simplified the theory and practice of harmony, does not explain this to us. In dealing with inversion, Rameau's methods of procedure are to a large extent empirical. He says in effect: 'If in the major harmony *c*-*e*-*g* we place *c* an octave higher, we obtain the first inversion of the harmony, i.e., a chord of the sixth, *e*-*g*-*c*.' Rameau does not tell us what natural principle permits him to place the lowest note of this, or any other chord, an octave higher. It may thus be objected that although Rameau inverts chords, Nature does not, and Rameau's writings may be searched in vain for an answer to this objection. The answer is that in the fifth, *c*-*g*, this g may be not only fifth of c but may itself assume the rôle of fundamental. A glance at the harmonic series will make this plain…. (Shirlaw 1928, 116-117)

According to Shirlaw, however much this shifting of the *c* note an octave higher changes the composition's fundamental structure, through an inversion of chords, an alternative harmony is nevertheless found. As Rameau's theoretical work reveals, for the listener harmony remains perceptible whether "the lowest note of this, or any other chord, [is placed] an octave higher" (Shirlaw 1928, 116-117). We see that the floating *c* may be judiciously placed an octave higher, thus forcing the sound produced towards a somewhat slightly different tonal quality – one that is still pleasing – while maintaining the structural integrity and coherence of its underlying chord arrangement.

The theory and practice of harmonization informs musicians of the shifting arrangements in which harmony or tonal balance may be located. How might a tracing of harmony's normative dimensions, to its metaphysical origin in the field of standardized musical composition, help us to understand the internal logic at work in various other fields of inquiry? Do we hear the same tonal balance no matter what harmonic arrangement is being played? Again concerning the upper octave upon which the floating *c* may be placed, Shirlaw notes that "the octave is necessary; if not actually present, it will nevertheless make its influence felt. Similarly with the fourth. It also has two aspects according to the position it occupies within the octave, and may form part of either an Authentic (ascending) or Plagal (descending) order…" (Shirlaw 1928, 117). Furthermore, "it is difficult for us, however, trained as our ears have been to appreciate the lower note of the fifth as the real fundamental note, to realise [sic] fully the downward, dependent effect of the descending order" (Shirlaw 1928, 117).

It is precisely a continued training of our ears, suggests Shirlaw – what Szymanski and Agnew (1981) might refer to as a countervailing influence – that is needed for us to identify the "downward dependent effect" contributing to the unifying structure of an orderly whole. Yet how much of this realization, as Shirlaw calls it, is lost to the inevitable inertia of listeners' belief, vis-à-vis perception, in a normative view of harmony: tonal balance being solely a product of a single arrangement (order) of chords. Fortunately, this point is not lost to the novice:

> No musical reader will have difficulty in understanding what has just been said, and as for the non-musical reader, it matters little whether he understands it or not, so long as he grasps the following simple fact – one that is, for the question in hand, of paramount importance. It is this: that in the order *g-c-g¹*, or other similar order, the highest sound may arise as the octave of the lowest, thereby bringing about a fifth of which *c* is not directly the fundamental. It is the reverse of the Authentic order *c-g-c*…. It is a remarkable order floating, as it were, in the air, without foundation or real fundamental note. (Shirlaw 1928, 118)

The remarkable order, spoken of here, may be understood as an alternative arrangement contributing to merely one of several possible states of tonal balance. A close variation of the same harmony – the complexity of which is often imperceptible to the untrained ear – may be played through a slight alteration of the harmonic series. Tonal balance remains, albeit under a choice set of conditions.

This brief foray into the metaphysical origins of normative equilibrium concepts offers the reader no unequivocal answers, and is perhaps only suggestive of the influence that culture may have on our construction of normative balance-of-nature ideas. However, it seems clear that a comprehensive explanation for the persistence of normative equilibrium concepts must take into account the influence of human cognition. The brief review above traces the origins of normative equilibrium ideas by establishing a historical basis for the enduring presence of balance-of-nature ideas across a range of fields and epochs; from the classical period of Greek art, to the theory and practice of harmony in early twentieth century musical composition. Each instance offers a purview into balance-of-nature ideas vis-à-vis the nature-of-balance itself, as both a socially-constructed *and* cognitively-derived conception of how biophysical systems function. This does not suggest a one-for-one exchange of ideas, between those originating in the cultural and scientific domains. The comparisons drawn are rather intended to emphasize culture's continual reinforcement of popular, often teleological, depictions of nature. Discussing this iterative engagement of cultural and scientific discourses throughout history, Cohen notes:

> Exploring the interaction between the creative scientific mind and the matrix of culture in which its owner and his ideas are imbedded, the historian of science studies not only the origins of scientific ideas and techniques of investigation, but the diffusion and influence of such ideas and techniques. (Cohen 1956, 151)

Intuitive theories that carry the cultural baggage of myth and metaphor may potentially bleed into scientific explanatory frameworks. The same can be said for Gaia. The theory's close association with its classical namesake, Gaia the Earth Goddess, increased the likelihood that parallels would be drawn between scientific principles (e.g., ecological resilience) and their closest cultural equivalents (e.g., aesthetic appreciation of symmetry and self-referential balance). Allegory and artistic form became less a representation of principles at work, and more a functional assemblage of elements operating in some organized fashion unto itself. Biochemical processes, which formerly served as the theory's scientific foundation, were supplanted by a loose equivalent – kinesthetic self regulation. Although balance-of-nature ideas are rarely, if ever, declared a functional assumption operating in the minds of scientists or laypeople, they nevertheless influence society's environmental perception. The preceding interpretation

offers two opposing accounts of the cultural origins from which equilibrium based theories may originate. The former account stresses an uncritical, self referential, classical conception of balance in the natural world. While the later focuses on a capacity to recognize multiple arrangements in which harmony may be found. Each origin indicates the starting point for an alternative tack on resource management. How normative balance-of-nature ideas have an affect on, and are translated into, scientific metaphors and equilibrium theories that populate the curriculum of ecological education is discussed next.

4.2 Ecological Education and Pedagogical Engineering

> "Every farm woodland, in addition to yielding lumber, fuel and posts, should provide its owner a liberal education. This crop of wisdom never fails, but it is not always harvested."
> – Aldo Leopold (1949, 73)

During the mid-20th century, Lucy Braun's (1950) theory of millennial legacies greatly influenced how environmental scientists' understood the assembly of ecosystems. Generally stated, the theory advanced the idea that the historic assemblage of plant communities was a product of millennial legacies of environmental stability. The composition of each plant community was thought to be the final result of a prolonged period of stable environmental conditions which consequently favored the success of one constitutive species over another. This idea was consistent with, and further supported, Clementsian models of ecological succession; wherein each plant community's species composition is thought to move inexorably toward a predetermined endpoint or climax state. Ecological stability – misperceived at the time to mean an unchanging, disturbance-free environment – was posited as the requisite condition driving biotic processes.

The re-colonization of the Ouachita Mountains by southern pines following the mid-Holocene interglacial is counterintuitive to the floristic relict model proposed by Lucy Braun and her contemporaries nearly half a century ago. Our current understanding of long-term forest history indicates that contemporary forest communities have not resided intact over millions of years. Instead, species compositions have been in continuous flux, varying in accordance with shifting climatic conditions. The previous chapter's discussion of paleoecological data on the Interior Highlands underscores this idea. Offering an alternative method for understanding long term changes in plant community composition, Delcourt and Delcourt (1991, 16) state, "interpreting the structure, composition, and dynamics of pre-settlement old-growth forests as a prelude to restoring some of their characteristics through management of present-day forests requires a long-term perspective on vegetation history that takes into account the development of forest communities on the time scale of millennia." A common element in both contemporary frameworks and Braun's legacy model is an understanding of species variation over extended time scales. However, missing from Braun's account is an acknowledgement of the important role an active set of disturbance regimes plays in maintaining certain forest ecosystems at a state of sub-climax.

Above and beyond its inherent significance, the dynamic stability associated with disturbance mediated ecosystems is of interest to resource managers attempting to maintain the integrity of publicly held lands. Recall that shortleaf pine, a fire tolerant

species and central component of the pine-bluestem ecosystem, is resilient amidst a wide range of edaphic conditions. This fact brought shortleaf pine to the forefront of restoration efforts, and prompted Guldin to voice concern over the need to reconsider the species' unique ecology in future management scenarios:

> Within the realm of the ecology of the shortleaf pine, the last decade has not been a fruitful period for promoting an enhanced understanding of the species. But society's pressure on the use of forests for non-timber resources will undoubtedly increase in the future, and these needs must be satisfied on an ever-decreasing forest land base. In the future, available forest land must be used efficiently, and in harmony with other uses. From this perspective, a new consideration of the ecology of shortleaf pine may be in order. (Guldin 1986, 31)

Managing for resilience in a multiple-use framework requires that the ecology of individual species be weighed against the particular set of needs managers are attempting to satisfy. The flexibility of a forest's constitutive parts may indeed help determine the long term persistence of the ecosystem. Increased societal pressure on using the ONF has prompted forest managers to place a greater value on shortleaf and the entire suite of species associated with pine-bluestem woodlands. This realization is promising, but remains inadequate when left divorced from an understanding of pine-bluestem's underlying fire ecology. Tangible efforts to restore PES communities have, at times, been hindered by gaps in the knowledge of agency personnel. There has been an increased awareness of fire's potential as an effective forest management tool. However, a more nuanced understanding of the intersection between disturbance ecologies and plant community dynamics has lagged behind. This limitation found its beginning in the formal education of professional foresters and has continued to receive support through agency training programs.

Often housed in land-grant institutions, initially founded on the goal of promoting education in the agricultural sciences and mechanical engineering, college forestry departments have, in some cases, remained insular by subscribing to a fairly narrow set of ideas on how forestry is best practiced (Environmental Scientist 2 5-05-2007). Coursework emphasizing the importance of fire regimes (either natural or prescribed), as a constitutive element of disturbance mediated forest ecosystems, has been less present historically in the curriculum of university forestry schools than today. Of the academic departments offering such coursework, sections on disturbance ecologies were more commonly taught in ecology courses than in silvicultural courses. Over the last several decades, legions of foresters have passed on this pedagogical artifact from university classrooms to the Forest Service. This transference of ideas has done much to influence agency culture; therefore, prompting resource managers to question how appropriate such pedagogy is for preparing agency personnel who are directly involved in the implementation of restoration projects. An understanding of the role that natural disturbance regimes, including fire, play in maintaining certain species compositions became more common in the later part of the 20th century. However, notions of Clementsian succession have continued to tint the content of college textbooks and maintain an enduring foothold in classroom pedagogy (Forest Manager 2 6-26-2007).

This mismatch of ideas has become increasingly evident in miscommunications between foresters in charge of implementing on-the-ground, adaptive management strategies (especially towards achieving vegetation management objectives) and

personnel in the research arm of the agency (Forest Manager 1 6-26-2007). The ONF has long since moved on from the traditional, economic-yield, pine plantation management paradigm that it once followed (Strausburg and Hough 1997). However, the knowledge base necessary to fully appreciate the importance of achieving restoration objectives has, at times, lagged behind the agency's technological capabilities. Prescribed burns are carried out by Forest Service personnel and contract labor, many of whom receive their formal training and prerequisite red-card certification at the Forest Service's training facility in Boise, Idaho. Professional training consists of field exercises and classroom instruction centered primarily on the practical aspects of igniting, monitoring, and controlling prescribed burns under various sets of circumstances (e.g., wind velocity, slope, fuel type, etc.). Strong emphasis is placed on preparing agency personnel and contract labor on the fundamentals needed for completing burn assignments according to agency protocol (e.g., safety, efficiency, etc.) (Environmental Scientist 2 5-05-2007). The immediate problems facing the agency's research scientists, including the effectiveness of prescribed burns toward achieving vegetation management goals, continue to be inadequately addressed. This miscommunication indicates, on a more fundamental level, qualitative differences in the ways forest ecosystems are researched versus how they are managed. Accordingly, Forest Manager 1 with the agency remarked:

> We just have not [applied] an adequate burning rotation, and we haven't [mastered] yet burning for effect. Part of this is internal…. The people in vegetation management, the people who work in my areas of responsibility; until they are held responsible for achieving objectives on the ground we're going to continue to have this. They're content to say 'I burned it. It's done!' [additions mine] (Forest Manager 1 6-26-2007)

An intellectual divergence between the research and management arms necessitated the creation of a conceptual apparatus designed to help reunite disparate branches of the agency around a common countervailing framework (Environmental Scientist 2 10-04-2007). The agency needed a heuristic device that could depict the environmental condition that came as a result of natural disturbance regimes, while informing management personnel of the biophysical processes at work behind such a visual representation. However, ideas can and often do take on a life all their own. The same logic directed at promoting a greater understanding of forest management objectives caused, perhaps inadvertently, a cross-section of people within the culture of restoration to re-conceptualize PES conditions as either a target or goal to be strived for by resource managers (Environmental Scientist 3 9-18-2007). Rather than merely parlaying the critical need to incorporate nonequilibrium principles germane to disturbance ecologies into restoration efforts, the process oriented framework they intended was supplanted by an emerging PES benchmark – a prototypical landscape inferring the stasis of an unchanging nature "majestically at rest upon itself." Reflecting upon the tendency of restoration advocates to pre-maturely seize hold of the PES benchmark, Environmental Scientist 3 stated, "sometimes it's latched onto too quickly and could create a spin-off problem downstream" (Environmental Scientist 3 10-04-2007).

Rather than bridging the intellectual divide, the PES benchmark threatened to further inundate restoration efforts under a rising deluge of misperception concerning the role of disturbance regimes in regulating multi- and nonequilibrium landscapes. Significant

advancements in basic research had been made. However, there existed an evolutionary lag time between the Forest Service's scientific branch and managerial arm which oversaw the implementation of restoration protocols. A loose association between the ONF's emerging management framework and pedagogical artifacts – rooted in normative balance-of-nature ideas – continued to impinge upon the culture of restoration. This supported the unwarranted assertion that the value of restoration efforts was as arbitrary as the imperfect conceptual apparatus upon which it was supposedly based. Even if everyone interested in restoring PES conditions was on board with advancing the agency's insipient projects, one problem remained – transforming the link between theory and praxis into a widely agreed upon and executable set of operational procedures. How either normative balance-of-nature ideas or multiple equilibria theories become manifest in forest management practices and ultimately initiate changes in land cover is discussed next.

4.3 Imbedded Ideas

Forest conditions fostered by traditional, economically oriented, silviculture regimes vary dramatically from the characteristics exhibited by disturbance mediated ecosystems. The overprinting or replacement of spatially variable disturbances and environmental controls with a single dominant management scheme must lead inevitably to a loss in natural variation of land cover. This natural variation is not merely a residual feature – reminiscent of the geologic monadnock – lying in isolation amidst an enveloping peneplain of structural uniformity. It is, rather, an animated landscape indicative of the underlying processes at work. For disturbance mediated ecosystems not to exhibit such variation would be antithetical to their very nature. This is why spatially fixed habitat reserves, while commendable for their role in protecting endangered and threatened species, remain an inadequate solution to the problems associate with widespread land cover/land use change. They fail to account for the shifting nature of an overall landscape mosaic – a quality only achievable in some landscapes through the periodic use of fire. Historical practices of fire suppression necessary for the maximization of wood fiber production brought about significant changes in forest structure and composition. Less flexible management approaches emphasizing cost efficiency were adopted. A forest once characterized by a shifting patchwork of uneven aged stands at different stages in their disturbance history gave way to even-aged plantations. As the culture of restoration attempts to return a portion of this natural variation to the landscape proposed benchmarks have been scrutinized in relation to past management practices:

> You run into challenges with forest management activities when they're being applied in what appears to be a widespread way without much site specific consideration. Clear-cutting was that case, herbicide use associated with clear-cutting was that case, and I'd argue that if we did nothing but single tree selection we would run into that same problem. That kind of language speaks to devising silvicultural prescriptions at the stand level that meet specific stand related goals rather than a cookbook approach to silviculture that has a generic standard prescription for every stand. That's one of the reasons I disagree with the argument about benchmarks as a target because that suggests that there's one standard goal to achieve. (Environmental Scientist 4 6-26-07)

Eschewing a focus on one standard goal for a natural system characterized by multiple outcomes highlights an important development: A growing awareness among restoration experts of a mismatch between the conceptual frameworks formerly used for devising management strategies and nonequilibrium concepts. A significant number of agency personnel initially latched onto the PES benchmark as a target for restoration efforts. This zeal for change in management regime prompted a desire to switch from intensive clear cutting toward a universal approach to restoration. However well intentioned this reflex was, it mirrored a tendency to exchange one generic silvicultural prescription for another. Some within the culture of restoration were tottering between two opposing yet strikingly similar approaches to forest management; both of which resorted to applying a single management scheme across the entire forest. Doing the same thing everywhere had previously produced ill consequences; therefore, readopting such a flawed logic promised similar results. At that time agency personnel affiliated with the aforementioned Old Growth Conference stepped forward in an effort to coordinate research findings on the ONF with emerging management protocols. Flexibility of approach and the capacity to employ adaptive management techniques were increasingly emphasized as necessary components of any strategy for managing the restoration of disturbance mediated ecosystems. According to Forest Manager 1 with the ONF:

> In disturbance mediated forests…the shifting mosaic is the only model that makes sense. Climax makes no sense at all; the idea that it goes to some sort of steady-state endpoint. You've got multiple possible outcomes based on chance. Then if naturally you've got multiple possible outcomes then what do you do? And the question becomes: What do you want? We've decided that *there* we want shortleaf bluestem. Well, that's say three hundred and fifty thousand acres. The other six hundred and fifty thousand acres of land that's dominated by [something other than] shortleaf pine is going to be managed in a different way. [addition mine] (Forest Manager 1 6-26-07)

The above calculus of natural variation seeks to discern the appropriate admixture of techniques (e.g., prescribed burns, selective thinning, herbicide use, natural biological controls, etc.) needed to express one of several ecological conditions. Effective vegetation management functions to maintain healthy forest conditions across transient resource management areas, including zones for threatened and endangered species. In keeping with an instrumentalist approach, the agency began formulating a forest management plan that was compatible with "the maintenance, in the same place at the same time, of two interactive 'things': culturally selected human economic activities and ecosystem health" (Callicott and Mumford 1997, 34). Past decades of clear-cutting made the simultaneous pursuit of economic activities and forest health objectives prohibitive. Emerging ideas on resource conservation and landscape mosaics now dictated that,

> most commodity extraction should take place within matrix areas…. Proper matrix design and management can enhance the compatibility of timber extraction with forest health objectives. Matrix areas would support some forms of timber extraction, including elements of the intensive forest health approach (e.g., thinning, extended rotations), provided these areas are managed to minimize edge effects…. (DellaSala et al. 1995, 354)

The implementation of proper matrix design does not occur in isolation from the enveloping culture which scientific ideas are imbedded. Normative balance-of-nature ideas under-gird the generic silvicultural prescriptions associated with industrial forestry. Alternatively, multiple equilibrium theories are implicated in stand level management activities, where site specificity is considered an important factor. The later framework embraces an idiographic, historical, or interpretive approach to forest management. The exceptional circumstances presented by disturbance mediated ecosystems led to a creative tension in the ONF. Previous management strategies were devised around the general assumption that climax communities are an inevitable, even predestined outcome of natural systems. Table (1) summarizes how equilibrium, multi-equilibrium, and non-equilibrium approaches to forest management would differ with respect to factors such as pathways of community development, the role of climax communities, and role of disturbances.

Table 1. Management approaches relative to forest dynamics

Management Approach	**Developmental Pathway**	**Climax Communities**	**Role of Disturbance**
Equilibrium without disturbance	Attempted suppression of fire and other disturbances	o Succession toward steady-state regional climax community	Retards progress toward climax
Multi-equilibrium with disturbance	Manipulation of fire and other disturbances to achieve desired state	o Multiple possible (sub-) climax communities o Disturbance regime manipulated to favor a particular community	Restoration and Maintenance tool
Nonequilibrium	Use of disturbances to steer development	o Climax concept irrelevant o Multiple possible successional pathways	Inherent part of ecosystem dynamics

Research has verified a close association between forest health and the multiple equilibrium states fostered by an active set of disturbance regimes. Fire had previously been treated as a boundary condition, rather than an integral process behind pine-bluestem development and a necessary component of its natural history. The influential role that indigenous people played in the maintenance of the Interior Highlands' native plant communities and ecosystems remained, if not lost, perhaps underappreciated. Historical interpretations of human-environment interaction have done much to alter our understanding of the region's changing biogeography. The shifting mosaic that is increasingly evident throughout the historic record became a central organizing principle for the management of old growth forest. Accordingly, Resource Professional 1 describes how old growth restoration and intensive forest health management come together on the ground:

> What that can mean is that the old-growth stand shifts over time. So that from the standpoint of creating and managing old-growth, we first do some economic chainsaw management intervention to get us to the old-growth condition, and manage it as old-growth for as long as it's practical to manage it for old-growth. Until it becomes beating our head against the wall to try to keep it in that condition because of whatever changes are going on. Then we let it shift states. We might even make it shift states. We might even cut and allow regeneration. It's shifted into this condition that's got some old pines, some old hardwoods, and a lot of younger hardwoods, and it's now in a situation that's not our desired condition. We go through and cut it and take whatever is available there. Let it reseed naturally…and we keep it in that fire maintained condition. Now it may be that we've gone to a young stand now, so that it may be a hundred years or more of economic chainsaw intervention in there to get it back to the old-growth condition that we're after. But we've shifted our old-growth somewhere else. We haven't lost the number of acres. (Resource Professional 1 6-26-07)

Economic chainsaw intervention is also ecological intervention. The initial input of energy to attract the system towards one particular steady state provides capital that is then reinvested in future restoration work. It is much easier to generate reinvestment capital through conditional involvement with resource economies than to pursue appropriation funds from the federal government. Only a small fraction of the restoration work completed thus far in the ONF would have occurred had the agency not devised an economically viable solution to the impending problem of declining forest health. These efforts mark a transition for the ONF towards a management paradigm that is centered on ecological sustainability, yet cognizant of the political-economic constraints placed upon it. Selection logging and extended rotations are the culturally selected human economic activities found most compatible with emerging forest health initiatives (Environmental Scientist 4 6-26-07).

Once adjustments in forest structure are initially made, perpetuating a fire maintained condition is easier. A dense herbaceous understory is established; therefore, higher stem counts increase the probability that low-intensity fires will be carried along the forest floor (Arthur et al. 1998). This is the same condition previously sought by Native Americans. However, PES Native Americans didn't contend with the wholesale changes in forest structure encountered by contemporary restoration experts. Present-day second growth forests, largely a product of fire suppression, are the ecological expression of an alternative state that historically occupied only a modest fraction of the heterogeneous landscape. Pines would prevail, for some time, as episodic dry spells altered the moisture regime and therefore fire's access to areas formerly exhibiting mesic conditions. Natural variation throughout the ONF's history was dependent, therefore, not on ecological climax, but on this oscillatory behavior.

4.4 Attractive Landscapes

Contemporary forest health initiatives call for a recovery of ecosystem processes to increase resilience at the watershed level. Likewise, adaptive management strategies that are closely aligned with the historic ranges of variability (HRV) concept aim to restore historic forest composition, structure, and seral age across multiple stands. Restoring health and resilience in forested watersheds has larger implications for landscape evolution as well. We understand that historic human-environment interactions have helped determine regional patterns of vegetation change; thereby, reformatting ecological

memory across the Interior Highlands. Therefore, it is increasingly evident that landscape evolution is influenced by a dynamic interplay between biophysical processes and human contingency, including the decision to maintain lower basal areas through a regime of frequent anthropogenic fire. Bracken and Wainwright discussed the developmental pathways associated with a fourfold arrangement of process and form:

> A fuller definition of geomorphological equilibrium is necessary because the nature of our studies requires us to investigate the co-evolution of process and form. It is thus possible to envisage a matrix of eventualities incorporating relationships which have stable process and stable form; stable process and unstable form; unstable process and stable form; and unstable process and unstable form. Where a particular landscape falls within this matrix is a function of the dominant landscape-forming processes, the historical trajectory of environmental drivers of those processes (dominantly tectonics, climate and vegetation) and any specific contingencies (e.g. extreme events and increasingly human activity). More extreme climate changes flip the state into a different set of dominant processes and thus a different position within the matrix. (Bracken and Wainwright 2006, 176)

Most important to this discussion are the historical trajectory of climate and vegetation, and the contingencies of natural and anthropogenic disturbance regimes. Present-day overstocked second growth stands suggest a landscape whose dominant processes are impacted by human contingency in ways much different than was historically the case. Over the long term, Native American agricultural practices shaped the land by maintaining decreased basal areas. This, in turn, established bio-feedback patterns between the forest type maintained and the future distribution of trees. Current research suggests that variation in levels of forest stocking potentially influences future forest densities by encouraging the establishment of trees in nutrient-rich microsites (Van Lear et al. 2000). Restoration efforts aimed at returning historic forest structure, composition, and seral age are, in one regard, attempting to overwrite the ecological and pedological memory installed by post-suppression basal areas. Therefore, prescribed fire (human contingency) is essentially an attempt to engineer the historical trajectory of environmental drivers (vegetation or Sauer's "geognostic factor"), which influence the dominant landscape-forming processes impacting forested watersheds.

Under conditions of increased climatic variability there is greater likelihood that a more active disturbance regime will prevail as it did during the hypsithermal. A general warming trend would dictate that fire maintains a stronger presence in the landscape. In an effort to curb the potential for catastrophic events from occurring, land managers must respond to the need for more fire resistant stands, which are able to persist, to be installed prior to the onset of forcing factors. This management approach is akin to civil engineers' design of infrastructure in such a way as to mitigate against future impact scenarios. This is not to suggest that environmental managers should rely entirely on climatic forecasting, or neglect to identify the potential problems associated with narrowly defining desired future conditions. However, assessing risk relative to the idea that today's disturbances may occur with different frequencies in the future remains an important consideration. Could the present-day ONF withstand such an upward trend in the frequency and intensity of extreme events? Catastrophic levels of tree mortality due to declining forest health could exacerbate unstable geomorphic processes. A rapid deforestation of watersheds would certainly affect runoff characteristics; thereby,

increasing the erosion rates. Where the ONF will come to rest in this matrix of eventualities depends, in measure, on how well restoration efforts return stable forest conditions – defined here in terms of a given forest type's resilience or capability to persist amidst shifting synoptic factors – to at least a portion of the landscape:

> We can think of stability in a certain time frame and at a certain spatial scale. But at different time frames and at different spatial scales we can always define time frames and spatial scales that are not stable, and should not be stable. Everything changes…. Even with something like old-growth we're probably not going to have old-growth in existence at one particular stand forever…. But we need to have a certain percentage of old-growth in some kind of landscape. (Resource Professional 1 6-19-2007)

Along a similar line of thought, Forest Manager 1 remarked that "to have it everywhere would be as wrong as to have it nowhere…. Our job is making sure there's a *where*" (Forest Manager 1 6-26-07). Previous commitments to generic silvicultural prescriptions, applied in a widespread manner, emphasized the pursuit of economic activities over concerns about environmental health. A dwindling percentage of old growth stands and rise in fire suppression reflected the prevailing management paradigm and societal belief in the desirability of environmental stasis. An ecological science based upon such functional assumptions laid the groundwork for normative equilibrium theories to be translated into a fundamentally flawed yet guiding principle for forest management. Rather than the forest exhibiting the ecological expression of a multiple steady state system – a shifting mosaic of varying processes and forms – its uniformity of species composition inferred the presence of homeostatic controls. Notions of natural variation and oscillatory behavior, both consistent with multiple equilibrium based theories, were foreign to classical conceptions of the natural world. It became increasingly evident that the agency's use of a Clementsian model for devising forest management strategies was inconsistent with Bracken and Wainwright's (2006, 176) "fuller [hence idiographic] definition of geomorphological equilibrium." Nature was historically balanced not in spite of Native American influence; rather site specific ecologies and cultural practices had co-evolved so that, of the various process/form relationships available, those which were most conducive to stable conditions were coincidentally fostered.

What does this mean for the culture of restoration and its tendency to reference historic condition associated with the pre-settlement time period? An approach toward managing the environment that is mindful of our capacity to harmonize may help us learn to bend with nature's dynamism instead of acting as a bulkhead against it. This way we avoid the problems associate with, as Resource Professional 1 noted, "beating our head against the wall to try to keep it in that condition because of whatever changes are going on" (Resource Professional 1 6-26-07). This realization among forest managers has prompted a reassessment of how the agency chooses to position itself relative to the ecosystems being managed. According to Forest Manager 2, "we [will] position ourselves on the systems we live with to be most resilient in the face of those changes. And certainly doing nothing is probably not a good prescription for resilience" (Forest Manager 2 6-26-07).

Key is the idea of positioning oneself on the system rather than the other way around. The Interior Highlands' long legacy of anthropogenic fire suggests this distinction was

understood well by Native Americans. Indeed, they acted as though their lives depended upon it, which according to most historical accounts it in some senses did. Of course, much in the world has changed since then. America's forests have been carved through by roads and bound around by development, creating a fragmented landscape over which fire can no longer easily move. Understanding the logistics involved with restoring system process is a technical challenge. Perhaps a more difficult problem involves understanding how to encourage the prerequisite intellectual shift necessary for spurring environmental action. Will a spatial discontinuity similar to that which blockades nature's dynamism threaten to alienate humanity from the evolutionary hearthstone from which it arose? Neither a science disposed to reductionism, nor theonomous appeals to hope should guide our strategic vision for the adaptive management of a natural world fraught with contingency. Rather a naturalistic philosophy that seeks to un-tether present-day environmental dilemmas from an enduring theological context, similar to that which spawned 17th century balance-of-nature ideas, is called for. Toward this end, Rowe offers a reconfiguration of the prevailing view on environmental ethics:

> By extending the all-important life center beyond organisms and *Homo sapiens sapiens* to the ecosphere's creative, sustaining, enveloping matrix, the new metaphor would point away from the traditional anthropocentric-biocentric ethic whose unhealthy results are more and more evident worldwide. It would urge an ecocentric ethic in harmony with such realistic evolutionary/ecologic thoughts as: 'In the beginning was the world,' and, 'First the earth' – a cosmopolitan message that in these troubled times is neither inimical to a universal science nor to religion in its fundamental 'binding together' sense. (Rowe 2001, 146)

A greater acceptance of nonequilibrium theories would figure centrally in the adoption of such a worldview. Since assuming tenure in 1907 the Forest Service and agency culture have, through a process of trial and error, undergone a metamorphosis. Alongside this transformation a myriad of ecological changes occurred. In one sense the agency's management and research arms have co-evolved to the point where praxis and theory now mirror that of their indigenous predecessors. I have discussed some of the cultural factors underlying this historical mitosis of environmental perception. Classical concepts, originating outside the culture of restoration, serve as import for the creation of balance-of-nature ideas. These normative ideas are then translated into equilibrium based theories and metaphors which populate the pedagogy of ecological education and professional training. The prevailing paradigm is a reflection of whichever suite of ideas influence forest management practices. Taken to its final conclusion; these cultural ideas become literally imbedded in the landscape by dictating the imprint of ecological information on pedological memory. By changing historic ranges of variation in forest structure, composition, and seral age, both Native Americans and contemporary foresters have laid the groundwork for future developmental pathways in landscape evolution to occur. These observations resonate with an instrumentalist philosophy; wherein, ideas are considered plans for action. As principles of post-Clementsian ecology are increasingly adopted, the management approaches necessary for restoring system processes will gain further support. The PES benchmark arose in restoration thinking, in part, as a product of greater knowledge about paleoecological change across the Interior Highlands. This knowledge has served to challenge present-day balance-of-nature ideas and entrenched normative equilibrium based theories; thereby, altering the existing

natural resource management paradigm. The decision to return pre-suppression fire regimes to the contemporary landscape reflects this paradigm shift.

Chapter 5. Coevolution, Complexity, and Forest Archetype

In the preceding chapters several key topics relevant to forest ecosystem restoration have been addressed. These include: 1) the early history of USDA Forest Service tenure in the ONF, 2) the emergence and contestation of the forest health concept, 3) a summary of paleoecological change across the Interior Highlands of west-central Arkansas and southeastern Oklahoma, including two possible developmental pathways scenarios leading to the assembly of pine-bluestem woodlands, and 4) a general analysis of the influence of trans-scientific ideas on the culture of restoration, and their translation into scientific metaphors and equilibrium theories that populate the curriculum of ecological education. Lastly, a link was drawn between multi-equilibrium theories and vegetation management practices, and human contingency was brought to bear on historical processes of landscape evolution. The discussion has attempted thus far to trace the elements in human and natural history that have helped formulate the current stage of forest management. The ONF has arrived at its current position partly as a product of the coevolution between agency culture and the ecological armamentarium with which it was readily equipped.

In this chapter I weave together, more tightly, the loose factors of causation between culture and environment. A discussion of management issues offers a synthetic evaluation of how changes in forest complexity come into dialogue with the PES benchmark. This discussion assists in evaluating the pragmatism of including a PES benchmark in restoration projects, which is the third of this study's three main objectives. Here, I am concerned primarily with the *coevolution* of restoration culture and the biophysical landscape being managed. Drawing on the additional concepts of *inheritance* and *emergence*, my discussion focuses on how the forest and the agency responsible for managing it have each affected change in the other. Evaluating this process of coevolution helps to illustrate how culture and ecology mutually constitute the ONF's emerging scientific management paradigm. Lastly, the idea that pine-bluestem woodlands signify a sort of ecological archetype is developed through a discussion of the naturalistic and neo-plastic art of Dutch painter Piet Mondrian. His work provides a clear example of how human visual perception and artistic form can help us better understand the autonomous aesthetic of optimal complexity present in the Interior Highlands' disturbance mediated forests.

In the following sections I develop several contrasts between how the individual elements of restoration are viewed. By drawing these distinctions I hope to locate restoration, in its broader historical context, as a site of evolving scientific practices and cultural values. Cosgrove's insights outlined previously in chapter 3, concerning Renaissance environmentalism as an intellectual response to the epistemological conservatism of modernity, will help inform this discussion as well. Table (2) shows two restoration elements, fire and the PES benchmark, interpreted through the lens of Renaissance environmentalism, a topic previously discussed in section 2.4. The collapse of *techne* and *poesis* contributes to the formation of a modern green ethic characterized by several themes common throughout this study.

Table 2. Elements of restoration interpreted through Renaissance environmentalism

Techne →	**Modern Green Ethic**	**← Poesis**
Fire as ecosystem process	Awareness of and practical harnessing of anthropogenic-earth surface feedbacks	Fire as cultural adaptation
Fire as practical forest management tool	Belief in technological innovation as tenet of instrumentalist philosophy	Fire as artistic instrument
PES benchmark as "optimum" state for forest management goals (e.g., wildlife, endangered species, etc.)	Acknowledgment of human presence in the landscape and pragmatic role in "creative land-shaping"	PES benchmark as "optimum" state of brain stimulation
PES benchmark as socially-constructed frontier ideal	Acceptance of universalist notion of truth in nature	PES benchmark as expression of archetypal ideal

5.0 Forest Management Issues

Issues that figure centrally in the management of forest ecosystem restoration projects range across, and overlap, a diverse number of topics related to policy and law (Dana 1994-95; Granskog et al. 2002; Hagen and Hodges 2006; Overdevest and English 2004; Polasky and Doremus 1998; Ruhl 1998-99), industry and economics (Abt et al. 2002; Alavalapati et al. 2002; Bourland and Stroup 1996; Brown and Shogren 1998; Gresham 1986; Heubschmann et al. 2005, 2002; Innes et al. 1998; Kennedy et al. 1996; Restani and Marzluff 2001; USDA 1999; Wilcove and Chen 1998), endangered species (Gerber and Hatch 2001; Hoekstra et al. 2001; Male and Bean 2005; Tear et al. 1995; Van Lear et al. 2005; Wilcove et al. 1993), habitat conservation (Lueck and Michael 2003; Noss et al. 1997), property ownership (Argow 1996; Brunson et al. 1996; Campbell and Kittredge 1996; Thomas 2000; Walkingstick et al. 2001; Wicker 2002), and quality of life (Floyd et al. 1996; Gramann and Rudis 2004; Holmes 2002; Li et al. 2004; Ray-Barlow and Rudis 1999; Rideout 2003; Rudis et al. 1999; Vining 2002; Vining et al. 2000). Many of these issues either come as a result of, or are intensified by, increases in population near public forest lands (Frentz et al. 2004; Graham 2002). This is reflected in the considerable literature which addresses non-industrial private forests (NIPFs), endangered species, or a synthesis of the two topics. Indeed, attempts at restoring ecosystems by the Forest Service are often coupled with the recovery of endangered plant and animal species native to these renewed habitats (Heppell et al. 1994; Thill et al. 2005; USDA 2006, 1996; USFWS 2003; Wahlquist 1991). The primary importance of this literature is to gain an understanding of how such factors ultimately influence existing restoration projects, and provide a historical context that accounts for some of the constraints encountered by those directly involved in their implementation.

Aside from the more rhetorical function these issues serve in framing environmental discourse, are the *boundary conditions* they impose on the implementation of specific

restoration efforts. Present-day knowledge of PES conditions and indigenous practices has translated into a forest management concept known as *natural range of variability*. This concept is complemented by an additional term called *limits of acceptable change*. Together these ideas connote a framework for management that acknowledges long term changes in forest composition and structure, but remains cognizant of the limits beyond which ecosystem function tends to break down. Forest management plans for the ONF have not always made use of such concepts. This was evident during the 1980s and early 90s when the agency's silvicultural practices were harshly criticized by public watch groups. However, since the passage of a newly amended Forest Plan in 1991, these terms have helped define the ONF's management schema. They are more than mere institutional verbiage designed to put a new face on an old management stratagem. The above terms realign the culture of restoration and its attendant projects with the biophysical landscape that existed over a century ago – before an era of fire suppression virtually eliminated these ecological expressions from the Interior Highlands. Underlying this relationship between culture and environment is the problem of inheritance.

5.1 Coevolution and the Cultural Adaptation of Fire

The ONF's scientific management paradigm has developed over the last century, partly, as a product of the joint influence of existing agency culture and the forest environment inherited. Taken in its broadest context, the concept of inheritance serves as a useful way to understand how scientific knowledge of disturbance ecologies has helped shape agency culture and vice verse. The culture of restoration has maintained a flexible link to the ecosystems they inherited by way of an imperfect, yet ever-growing, knowledge of natural history. Paleoecological data and indigenous knowledge have greatly added to the culture's current understanding of the Interior Highlands' changing environs. Yet restoration efforts are partially hindered by an incomplete understanding of specific environmental drivers contributing to PES conditions. Some of these gaps in knowledge were previously alluded to in the discussion of large scale ungulate grazing. Because of their destructive capabilities, bison are not an element of the PES condition that the Forest Service is likely to attempt to restore. The reintroduction of elk would require extensive fencing, which remains economically and legally infeasible due to the widespread forest fragmentation caused by property ownership. As Environmental Scientist 4 remarked, "the social fabric of today's society has permeated the woodlands landscape" (Environmental Scientist 4 6-26-07). Therefore, prescribing a precise set of management techniques to accurately replicate the historic developmental pathway associated with pine-bluestem assembly remains, in some instances, prohibitive. Likewise, seasonal burning by Native Americans, a cultural practice transmitted from one generation to the next over the last several thousand years, is an environmental driver long since removed from the PES landscape. With the onset of European settlement, indigenous agricultural practices were slowly attenuated. Setting fire to the woodlands had repercussive effects outside the immediate croplands and hunting grounds. It gave expression to a regional optimum of sorts, in which human-environment interactions fostered the ecological expression of an otherwise partially dormant seed-bank. They learned to maximize a dynamic set of biophysical processes toward developing a forest

environment that best fit their needs. Their cultural adaptation of fire grew increasingly sophisticated as a result of generational refinements in understanding when and where to effectively use the tool of fire.

Neither culture nor environment alone had entirely governed late Quaternary ecological change. Rather both domains constituted the Interior Highlands' matrix of possible outcomes. Native American agriculture, including game harvesting, and the surrounding forest had coevolved as the acquisition of knowledge concerning local disturbance ecologies grew. Unaware of Clementsian principles and aided by analogical thought, which minimized the importance of sequential narrative (a basis of Braun's legacy theory), they more often toiled *with* the land than against it (see Cosgrove 1984; 1990 for more on the importance of analogical reasoning in Western intellectual traditions). This trend was reversed over the course of the 20th century as an agency culture and public focused on fire suppression succeeded in steering the course of ecological change down a different developmental pathway. During the mid-20th century (roughly 1940-70), neither the Forest Service nor Lucy Braun were privy to paleoecological data (derived from pollen record analysis), that would later provide insight concerning post-Pleistocene change in species composition. This gap in knowledge contributed to a continuance of the ONF's extraction oriented management philosophy, which was reinforced further by the aforesaid pedagogical artifacts rooted in metaphysical thought. By attempting to eradicated fire from the landscape, proponents of a nationwide campaign on altogether stopping forest fires threatened the devolution of an environmental precept passed down through paleoanthropic time.

For present-day resource managers there is unfortunately no internal biasing mechanism carried down through agency history, internally regulating the compatibility of culturally selected activities with the ecological outcomes they foster. They are not privy to Desoto's historicized moment of first contact in the *Valley of Vapors* more than four and a half centuries ago. Notions of returning to the historic era of one place or another come from an earnest desire to truly know how things were *way back when*. For resource managers this desire is accompanied by the hope that such knowledge will somehow shed light on, or better yet guide us through, the modern era of environmental mishaps. The restoration of pine-bluestem woodlands is an intentional step in that direction. Offering a somewhat unorthodox view of the potential for science to benefit from traditional forms of knowledge, Resource Professional 1 commented on the pine-bluestem ecosystem:

> That's such a dynamic system that the only way you can have that on the landscape from now on is to manage to get it that way, is to manage to keep it that way, through active intervention, but it's ecological intervention. It's what the Indians were doing, but it's informed by science that the Indians didn't have. But we've got to have the same sort of philosophical underpinnings that the Indians had. (Resource Professional 1 6-19-07)

Agency personnel continue today collectively reconstructing this ethic through the culture of restoration. As new empirical research is conducted and better data becomes available, environmental prescriptions are further refined. The prescriptive measures that guide them are derived through exhaustive efforts to accurately interpret the paleoecological record towards establishing an environmental baseline. From these scientific gains management protocols are proposed and appropriate techniques

implemented. It is not an infallible system. However, relative to other methods available science remains superior for its ability to rigorously test hypotheses, including those which draw from a natural history inclusive of human contingency.

How was the cultural adaptation of fire lost to begin with? Some early European settlers did indeed fire the woodlands, no doubt enjoying the same benefits that the Native Americans had. However, each successive generation, following European settlement, neglected the aforementioned syllogism by refuting its first premise: stable and healthy forests in disturbance mediated ecosystems include the presence of fire. What this fact points to is a fundamental difference in how settlers sought to meet their needs while attempting to survive along the frontier. For Native Americans the prescriptive custom of setting the woodlands ablaze was highly pragmatic in nature. They were attempting to create the most desired condition relative to their needs, which were largely defined by an eastern agricultural complex of hunters, gatherers, and small scale crop production. Following European settlement an optimal forest condition was redefined to meet the needs of a rapidly evolving frontier society. Over the following century the forest gave way to an altogether different ecological expression – one of decreased biodiversity and diminishing structural variation. First frontier society and then agency culture began to slowly grow apart from the forest that was inherited nearly one century ago.

In recent years the ONF has adjusted to this divergent evolution between agency culture and a changing forest environment by prescribing fire. By examining the fire record, land managers are given a better idea of historic fire return intervals. This allows the prescription of an appropriate burn regimen for achieving vegetation management objectives. Burn prescriptions manifest themselves through outward expressions, broadly analogous to extended phenotypes. In the case of pine-bluestem restoration this expression is ecological. Restoration projects are, in part, an organized effort to provide a place within the landscape mosaic where fuller expression of the region's total genetic inheritance can manifest itself. As Forest Manager 1 with the ONF succinctly put it, "our job is making sure there's a *where*," a place, for PES communities to succeed (Forest Manager 1 6-26-07). Pine-bluestem restoration is more than merely a recovery of native plant communities, however. It is an attempt to shorten the lag time between what was a rapidly evolving culture, listing towards the systemization of intensive silviculture, and a natural system whose regulatory processes had been increasingly suppressed. The connection between agency culture and forest environment today is slowly being ratcheted back together to resemble something more reminiscent of the historic relationship between Native Americans and the Interior Highlands. The restored pine-bluestem woodlands along the ONF's Buffalo Road driving tour, a topic addressed below, are symbolic of this philosophical reemergence. They are also illustrative of the changes that have occurred since a steady decline in this and other types of old-growth stands throughout the region.

5.2 Managing Life on the Edge

A widely (though hardly universally) accepted idea among environmental scientists is that ecosystems with a greater diversity of species are more resilient to environmental stress. This notion has caused forest managers to reassess pine-bluestem woodlands, a

relatively diverse community, in terms of their potential for long-term persistence. The structural uniformity of industrial plantations, exhibiting row upon row of planted loblolly pine, is visual shorthand for an exceedingly shallow gene pool ill equipped to withstand the stress of a rapidly changing environment. Industrial forests lie at one extreme end of the organizational spectrum, where rigid organic structure lends greater inelasticity to the ecosystem (Bodin and Wiman 2007). On the other end are unmanaged forests (hypothetically) unbound by human contingency and free to follow their own teleological course. Nearer the point midway between either condition are old-growth stands, including pine-bluestem and other pine-grass dominated forest types, characterized by structural contrast, that continually change in response to both natural and anthropogenic disturbance events. A heterogeneous landscape marbled with pine-bluestem woodlands is broadly analogous to a system situated at a point of flexibility and intermediate diversity otherwise referred to as the *edge of chaos* (Waldrop 1992). By operating in a restoration framework forest managers are attempting to maintain the forest, through a regime of frequent fire, somewhere near this theoretical edge; halfway between a state of maximal regimented order (i.e., diminishing biodiversity and structural variation) and the apparent disarray of an entirely unmanaged system. The term *limits of acceptable change* is a formal mandate for resource managers to maintain forest conditions within certain designated parameters. These limits are based on their *natural range of variation* resulting, in part, from historic system behavior, which across the ONF is primarily disturbance mediated. However, managing forest ecosystems toward greater resilience in the presence of potentially divergent multi-equilibrium conditions is further complicated by the influence of climatic change and variability. Broadly speaking, climate change causes us to reconsider how ecological restoration is practiced. The expected outcomes that previously guided management objectives must be reevaluated according to the changing biophysical conditions and ensuing environmental parameters that accompany climate change:

> The critical question facing us is to elaborate appropriate strategies and tactics for restoration as thus defined in a world of rapidly changing climate regimes, when in many cases relying on historical references makes less sense. Paradoxically, although specific historical references may be less useful as direct objectives, historical information documenting change may rise in importance in developing models for future ecosystem formations. It is our contention that we need to look outside of simple static species or community metrics to wider consideration of ecosystem functions and processes and that we must be realistic and pragmatic. (Harris et al. 2006, 172-173)

Adherence to overly prescriptive management schemes should be examined in relation to the persistence of normative equilibrium concepts among environmental scientists and laypeople alike. The implied shift from using historic reference conditions to information documenting historical change may have direct consequences on the use of PES benchmarks. An important point is that PES conditions were originally intended to reference the history of change in plant community composition, rather than to establish the historically contingent nature of vegetation at any given point in time. This includes the time period immediately before PES. Restoring environmental conditions to one previous static point in time assumes that broader climatic conditions were constant then; just as they are assumed by some to be today. Out of this flawed logic, inferring an

environmental stasis reminiscent of Braun's theory of millennial legacies, the contestable PES benchmark was wrongly conceived. Environmental scientists now know otherwise. Sweeping changes in plant community composition resulting from shifting climatic conditions were common over paleoecological time scales, and will no doubt continue well into the future. According to Harris et al. (2006, 170) a number of climatic changes are expected to occur over the next several decades, including "changes in weather patterns, increases in mean temperatures, changes in patterns of precipitation, increasing incidence of extreme climatic events, and increasing sea level." Moreover, Bodin and Wiman indicate that:

> …these manifestations might involve not only shifts in the long-term averages of meteorological parameters but also changes to the frequency distribution curves. These might broaden, in other cases might narrow, and in still other cases might become skewed, so that the frequency of anomalous weather events in some cases might decrease and in other cases might increase. In addition, the amplitude of parameter oscillations might change substantially. (Bodin and Wiman 2007, 542)

Such synoptic conditions are expected to have differential affects between regions. This means that disparate restoration efforts must respond to whatever unique suite of challenges their region happens to be presented with. The set of changes listed above is expected to alter species ranges due to differences in climatic tolerances. Therefore, attempting to coordinate regional climatic variables with individual species tolerances will be an important consideration in the future (Harris et al. 2006, 174). This regional coordination of climatic conditions with appropriate species compositions is an attempt to anticipate or extrapolate future change – something not easily done according to all of the scientists interviewed. Additionally, the agency's decision to intentionally position management activities relative to changing climatic conditions operates under the assumption that changes will occur at a rate and magnitude of manageable proportions. Climate change – whether human induced or not – could further complicate the capacity of ecosystems to adequately maintain certain community compositions due to the varying tolerances between individual plant species.

As regional climate patterns are potentially disrupted, areas typified by seasonal wet/dry cycles could experience prolonged periods of arid or mesic conditions. A shift in the average of meteorological parameters would inevitably alter natural disturbance regimes. Temperate zones that were formerly characterized by low-intensity ground fires would trend towards more arid conditions where historic fuel accumulations have the potential to become, a tinder box awaiting ignition (Langston 1995). Large crown-fires would be much more common; as would be an associated loss of property and life. Furthermore, according to Perry (2002, 349) the perturbations associated with single events could have "long-lasting effects" on vegetation. How these long-lasting effects will ultimately manifest themselves in forest ecosystems remains poorly understood. Commenting on Turner et al.'s (1993) thesis of catastrophic change brought about by ecological instability, Perry notes:

> If disturbances are sufficiently large and/or frequent, the landscape might not recover to the pre-perturbation trajectory. An alternative system trajectory may exist, and the disturbance

> could fundamentally change the nature of the system if certain components (species) cannot re-establish. (Perry 2002, 351)

There has been in recent years a rise in the number of large crown-fires affecting southern forests (Stanturf et al. 2002). However, a lack of catastrophic fires in the ONF has not come as the result of superior forest management. In reference to an increase in the size and intensity of fires occurring in Florida, Georgia, and farther West, Resource Professional 2 remarked: "We have not experienced those kind of catastrophes, you know, because we've been lucky, not because our forests are in any better condition necessarily than anybody else's" (Resource Professional 2 6-18-2007). Although the ONF has been spared the destructive wildfires experienced elsewhere throughout the country, anomalous meteorological events have exacted different levels of damage on restored versus overstocked stands. According to Resource Professional 3, a long-time local resident living near the ONF:

> I think that the conditions that I see in these pine-bluestem studies would be more of an advantage environmentally than overstock situations. What I see from overstock is – I saw an example of that during the 2000 ice storm – you get these huge very thick stands and you have catastrophe…. To me the areas that were more thinned and healthy, and each tree was supporting itself are more vigorous. They can withstand these catastrophes, and that could be ice storms, it could be fire, insects. There were a lot of insect outbreaks after that because the stands were not healthy. (Resource Professional 3 6-28-2007)

Future climate scenarios project a significant increase in the frequency and intensity of disturbance events (e.g., fire and ice, etc.)(McLaughlin and Percy 1999; Moore et al. 2002). Therefore, restoring a fire maintained ecosystem (including pine-bluestem habitat for the Red-Cockaded Woodpecker, *Picoides borealis*, a natural biological control on epizootic Southern Pine Beetle outbreaks) could increase plant community resilience amidst active disturbance regimes. However, even if future conditions are somehow approximated with a high degree of accuracy, no guarantees can be made that their penultimate step in environmental management would adequately prepare the forest for the perturbations that lie ahead. Changing atmospheric CO^2 concentrations, moisture regime, mean temperature, and soil characteristics will all influence the agency's capability to restore PES communities. This has led some to speculate that "within the next 100 years, and much sooner in some regions, prescribing restorations using purely historical references will prove increasingly challenging at best and at worst lead to failure" (Harris et al. 2006, 171). Harris et al. state that "overly prescriptive conservation management" may pose substantial risks to a restored plant assemblage whose maintenance is almost entirely reliant on the maintenance of a single steady-state equilibrium point; something disturbance mediates assemblages are not. Furthermore:

> Conservation schemes tying assemblages to one place may actually lead to ossification of those ecosystems—in effect making them more fragile and less resilient by not providing space for the elements of the total gene pool on the fringes of the bell-curve niche space for occasional regeneration, and thereby reducing or eliminating the ability of the species and ecosystem to adapt to changes in biophysical regime. (Harris et al. 2006, 171)

Resilience, species diversity, habitat connectivity, and a landscape perspective are increasingly becoming central components of restoration efforts (Harris et al. 2006). These issues have been given added emphasis as legal mandates for the protection of threatened and endangered species are passed down. These foci indicate that ecosystem function is perhaps more important than the restored environment's strict association with any historic reference condition. An important goal of restoration projects in the future will be to strike a "proper balance between rebuilding past systems and attempting to build resilient systems for the future. Perhaps in some cases, both goals are achievable, but the prognosis seems to be that this may not always be the case" (Harris et al. 2006, 175). Yet it remains possible for a particular historic reference condition to bolster an ecosystem's resilience against perturbations. Pine-bluestem restoration efforts provide a space for the potentially lost elements of the Interior Highlands' dormant seed bank to exist. Prescribed fire promotes a fuller expression of the region's entire species pool, including the fire tolerant, prairie relict grasses, sedges, and forbs that were discussed in chapter 3. This intermediate diversity fostered by restoration helps bolster ecosystem resilience against possible future forcing factors, including decreased fire return intervals as a result of shifting moisture regimes. Evaluating if the historic conditions, that benchmarks reference, appropriately correspond with a region's unique set of environmental parameters is an important step towards determining their overall merit. This evaluation also helps to achieve the third of this study's three main objectives.

Although Pimm (1991, 4) previously drew attention to the fuzzy or imprecise nature of the stability concept, there now exist rigorous definitions of ecosystem stability (Bodin and Wiman 2007). Resilience is only one of several traits common among stable ecosystems, however (Orians 1975). In terms of the need for frequent disturbances to maintain system states at or near equilibrium, pine-bluestem must be considered an unstable system. Alternatively, in relation to the higher probability that fire will maintain an increased presence in the ONF landscape into the future, pine-bluestem is stable – as measured by the forest type's resiliency (i.e., resistance to fire) and thus capability to persist. These two definitions of stability are compatible within a restoration management framework. According to Resource Professional 2, only a qualified definition of the stability-concept will properly guide forest management decisions in the ONF:

> Stability is probably not a good term ecologically, in a sense, because these are very dynamic systems actually. It's stable within a certain large landscape, timeframe, climate condition, but within the smaller landscape…changes happen all the time in certain size patches or certain forest types and ages and classes. They're very dynamic. So the shortleaf pine-bluestem ecosystem across a large landscape was pretty stable maybe…four thousand years, which is about as far back as shortleaf pine goes in the Ouachita Mountains. (Resource Professional 2 6-18-2007)

The scale and time dependent nature of stability has caused resource managers to evaluate long-term management objectives according to the Callicott and Mumford's (1997, 34) aforementioned idea of sustainability; wherein, both "culturally selected human economic activities and ecosystem health" are maintained in the same place at the same time. In light of future climate scenarios and the wide ecological amplitude of shortleaf-pine, inclusion of this species in our definition of sustainability in the ONF

appears to be warranted. Shortleaf is a key component of the pine-bluestem woodlands associated with PES conditions, as are a diverse suite of native plants. Harvesting of shortleaf is compatible with silvicultural practices allowable in the ONF (e.g., selection logging and natural regeneration). Therefore, pine-bluestem restoration will serve an increasingly important function in the long-term maintenance of stable forest environments at the landscape level.

Restoring native plant communities is about more than merely refining management objectives and advancing our scientific understanding of ecological reference conditions however. Native plant and animal communities are part of the living wealth of a region. Their value is derived not merely from our proclivity to ascribe native plants and animals with the cultural capital normally afforded the preservation of material culture. Rather, it resides in the notion that such diverse species assemblages, and the complex connections between them, provide humans with a relatively stable and productive environment. In the past, these plants did not thrive in spite of human culture but, in part, because of it. Native Americans fired the woodlands as an adaptation that highlighted the human presence in the landscape and blurred the modernist distinction between nature and culture. What the future holds for the continued existence of native plant communities depends largely on society's commitment to restoring them. Accordingly, Resource Professional 1 observes:

> It may be that our restored pine-bluestem is the sustainable community of the future. For five thousand years we've seen basically a change from very dry to more moist conditions with some glitches up and down in that overall pattern. We very likely are into a situation of going back to drier conditions and warmer conditions in many places at least. It's good regardless of whether its people or not people to have those communities and those species maintained in today's environment so that we, as Aldo Leopold said, *hold on to all the pieces*. As long as we've got the pieces our environment can be more resilient; can adapt to either colder, or warmer, or wetter, or drier conditions into the future. When we've lost the pieces then we're going to have to try to reconstruct it from scratch and that's going to be hard to try to accomplish. (Resource Professional 1 6-19-2007)

How far in one direction or the other can ecosystems be nudged, before a loss of native plants and animals shallows their species pool; thereby, diminishing the adaptive capacity of forested landscapes to persist amidst shifting synoptic conditions? One prognosis is that the frequency and intensity of future disturbance events might alter system trajectory enough that existing non-native plant communities are incapable of maintaining a presence in the ONF landscape. The idea that a global warming episode could potentially produce cascading changes in already overstressed forests, resulting in rapid deforestation caused by widespread tree mortality, is not entirely implausible (Resource Professional 2 6-18-2007). This net loss in species would be costly to future restoration efforts. Once whole species assemblages have been extirpated from the landscape, deciphering how they initially came together becomes exceedingly difficult, despite the advanced understanding ecologist have concerning the rules of assembly. Present-day restoration efforts are, in part, an attempt to preserve the ecological blueprint outlining which specific component species historically contributed to pine-bluestem assembly. Because the process of assembly takes place across such extended time-scales restoration does little to reveal how ecosystems emerge over time. The experimental test

plots along Buffalo Road, where ongoing refinements of burn prescriptions occur, are important for another reason. These sites provide scientists an outdoor laboratory for the direct observation of system behavior. Restoration programs at least implicitly heed the advice of Leopold (1949) to "*hold on to all the pieces*" by providing a space for the underlying species pool to fully express itself. By prescribing a regimen of frequent fire, the agency is holding onto a key piece of the Interior Highlands' geographical and ecological capital. With the use of prescribed fire, forest managers are also providing a broader range of alternatives. Accordingly, Resource Professional 2 observes:

> [What are] the options we would be leaving open into the future? The pine forest and even some oak forests of the Ouachitas are fire dependent ecosystems. You take fire out, which we did for many years, and it's going to turn into something else. It's going to do that rather rapidly as the trees mature and stress each other out at a certain time…. Going forward, you know, the same could be said about what we're doing for the people who will come after us in another hundred years. Because they're going to inherit either a forest that comes to a point where it transitions very rapidly into something else because of its condition – the stress that it's under – or they'll have one where their options are very wide. I would like to think that this restoration and its function allows for more options into the future. Options that we were not given, in a sense, because what we inherited was a forest with millions of acres that were in a very poor condition by the time we get to them. (Resource Professional 2 6-18-2007)

Rather than being prone to rapidly transitioning into an alternative state as a result of abiotic stress, pine-bluestem woodlands offer a critical measure of elasticity to the landscape. Accordingly, to manage the forest for greater resilience "you would want to cue your restoration efforts in an accelerated fashion" (Resource Professional 2 6-18-2007). This means the current rate at which pine-bluestem is occurring remains insufficient as a management response to foreseeable changes in the level of deteriorating forest conditions. The ONF has made strong efforts to accelerate the restoration of pine-bluestem woodlands. However, achieving the results they desire have not always come quickly. The argument for returning landscape complexity to the forest extends beyond prescriptions for greater genetic diversity within individual stands. Included in this call are efforts to restore structural features to the architecture of an overall landscape mosaic. Tree trunks, branches, and leaves all compose the open park-like setting of pine-bluestem woodlands, thus their geometric composition is of special interest to forest restoration ecologists for the various reasons discussed below.

5.3 Tuning the Algorithms of an Ecological Archetype

The challenges associated with declaring landscapes "natural" and setting parameters of change extend beyond theoretical arguments related to the social construction of nature (Evernden 1992; Helford 2000; Oelschlaeger 1991; Proctor 1998; Stevens 1995), mimicking of nature (Elliot 1997), artificiality of nature (Katz 2000, 1997, 1993, 1985), or the reinvention of nature (Merchant 2003). Evaluating naturalness (Anderson 1991; Angermeier 2000; Haydon 1997; Shrader-Frechette and McCoy 1995), natural variability (Swanson et al. 1994), and the limits of acceptable change (Brunson 2000; Cole and Stankey 1998) from which managed ecosystems are allowed to deviate is a practical

concern among restoration experts. However, as I will show, these two areas of inquiry – social-construct creation vis-à-vis visual perception and ecological change – are indeed overlapping. Implicit in the later concern, defining ecological naturalness, are issues related to ecosystem function within nonequilibrium and heterogeneous landscapes (Lovett et al. 2005). Ecosystem function may be evaluated relative to biological integrity and diversity (Angermeier and Karr 1994), habitat (Azevedo et al. 2000; Kalisz and Boettcher 1991), and landscape scale processes (Perry 2002; Simenstad et al. 2006). The applied field of environmental metrics has grown out of an explicit concern for the regulation of ecosystem function and structure in intensively managed landscapes. Through the use of mathematical models and statistical analyses, environmental scientists are able to quantify ecological change, including the frequency and distribution of tree species regeneration. Because restoring PES conditions is about recovering historic structure and function, natural regeneration is of special interest to restoration ecologists (Environmental Scientist 4 6-26-2007). Their ability to effectively control the process of regeneration with effective burn prescriptions determines, in large part, how successful they are at achieving the open, park-like setting that signifies a restored PES condition. The forest that has emerged over a century of fire suppression and industrial silviculture is characterized by dense under- and mid-stories often overgrown with brambles and briars. Bragg describes contemporary, post-suppression forest conditions similar to those found in the Interior Highlands as follows:

> Contemporary mature pine and pine-hardwood upland forests typically have a dominant pine overstory with various hardwoods, shrubs, vines, and forbs beneath them. Large regions of the UWGCP [Upper Western Gulf Coast Plain] are intensively managed loblolly pine stands of both natural and planted origin. Competition control is frequently used to improve pine growth, but most managed stands still have abundant understories of oak, gum, elm (Ulmus spp.), maple (Acer spp.), greenbrier (Smilax spp.), honeysuckle (Lonicera spp.), American beautyberry (Callicarpa americana L.), and many other species…. Very few terrace prairies and open, grassy woodlands originally found in the UWGCP remain; most were converted to rice and cotton farms or commercial forestland. Current forest stand composition, density, and structure depend largely upon silvicultural practices. Loblolly pine and certain red oak taxa are preferred timber species, and shortleaf pine and other hardwood species are often cut to favor the more rapidly growing commodities. Stand densities are typically maintained at much higher levels than historical records suggest. Few trees are allowed to grow larger than 50 cm DBH on commercial timberlands in the UWGCP, regardless of species. (Bragg 2002, 263)

A primary function of prescribed burning in ecosystem restoration projects is to eliminate this hardwood mid-story by eliminating the growth of shade-tolerant plants (Figure 8). The use of fire to control woody competition is not without its limitations however. According to Lowery (1986, 147), fire "offers only temporary control of small stems, reduces growth of pine residuals if crowns are scorched and requires careful smoke management," and requires "specialized knowledge for effective use." The aforementioned drawbacks present additional challenges for restoration, but "on many sites throughout the shortleaf pine range, natural regeneration is a viable management alternative and may be the only practical alternative on steep, rocky sites" (Lawson 1986, 60). Of all the tools available to restoration experts, fire is perhaps the most cost efficient (Environmental Scientist 2 5-05-2007). Herbicides are occasionally used in conjunction

with prescribed burning as a more effective way of limiting the growth of woody vines and hardwoods in the understory. Once this vegetative growth has been brought under a minimum level of control, fire alone may be used for the maintenance of pine-grass dominated forest types.

Figure 8. Pine-bluestem experimental test plot along the Buffalo Road restoration area driving tour; note remaining hardwood component in mid-ground [Ouachita National Forest, Arkansas] (photo by author)

Through trial and error, fire ecologists working with the ONF have begun to realize – based on the steady accumulation of scientific evidence – the most effective burn interval required to control species competition. Rather than shifting their burn regimen to later in the season and lighting less intense fires annually, a combination of hot fires set earlier in the season followed by cooler fires set later on achieves better results (Resource Professional 1 6-19-2007). Temporal and temperature variability are important factors that restoration experts are only now beginning to get a handle on. Likewise, selection logging is done to make initial adjustment in forest structure, but the ecological memory associated with PES conditions has been slowly reformatted as basal areas across the ONF steadily increased (Hendry and Mcglade 1995; Peterson 2002). Overstocked second growth forests potentially create a greater number of nutrient-rich microsites, containing residual rootstocks and leaf litter, which encourage the future colonization of trees (Van Lear et al. 2000).

Figure 9. Visible difference in forest matrix basal areas, creating *edge effect* in Management Area 22 [Ouachita National Forest, Arkansas] (photo by author)

Figure (9) shows the visible contrast or *edge effect* between two adjacent matrices in the Buffalo Road restoration area. A major challenge facing restoration experts is the erasure of these unwanted ecological inputs. Commenting on the unique set of logistical problems this presents resource managers with, Forest Manager 2 observed:

> I don't know if this is a drawback, but it's certainly a challenge to manage in a restoration framework as opposed to simpler approaches. We find some of our districts really strapped in terms of keeping up with the keeping of elements of disturbance in the system. They for a lot of reasons are challenged to be able to burn enough to keep the woody component down. They're challenged to thin enough and to keep the midstory down. I wouldn't call that a drawback, but it is definitely a huge implementation challenge. (Forest Manager 2 6-26-2007)

The woody component resource managers are challenged with emerges from a succession of competing hardwood species that are favored by the region's climate and soil in the absence of fire. Concurrent with the campaign on fire suppression during the early to mid-20th century, was a mass influx of genetic information from the suite of fire-intolerant plant species finding expression from the Interior Highlands' larger gene pool. Dense stands of overstocked, mixed pine-hardwood, second-growth forest began dominating the landscape. Despite the return of an active fire regime, significant amounts of stem spray continue to colonize restoration sites (Figure 10).

Figure 10. Honing in the algorithm: prescribed-fire scar and stem-spray in Management Area 22; note emerging herbaceous ground cover in background [Ouachita National Forest, Arkansas] (photo by author)

This stem spray is a byproduct of the residual rootstocks of pioneering hardwood species. Describing the problem in terms of this unwanted ecological information, Environmental Scientist 4 stated:

> It's a question also of: What is the ecological effect that's trying to be eliminated in order to achieve a restored condition? Let me make this point: For the last four thousand years there's probably not much area on this forest that didn't have a burn in the seventy years prior to that. That's the situation that these guys are trying to recover. So that is our prescription out of context in a restored component, and the effect of that seventy years of fire exclusion was the build up of hardwood rootstocks, which by their very sprouting capability are tenacious as the dickens. The rootstocks that are still re-sprouting in that [restoration] area…maybe a tenth of those predated eighty years ago; ninety percent of them postdated eighty years ago. So we're still trying to figure out how to effectively remove that unnatural ecological input from that

> particular stand, and that's on just one stand and it takes a lot of effort to do that. Repeated burning can suppress it, but I'm not convinced that we've figured out the burning prescription that eliminates it. [addition mine](Environmental Scientist 4 6-26-2007)

Figuring out a correct burn prescription is equivalent to determining the solution, an environmental algorithm, to an exceedingly complex problem (Masters and Engle 1994; Masters and Waymire 2000; Masters et al. 2007). Adding ecological information alters both immediate site characteristics and intra-stand dynamics occurring within the landscape mosaic. By creating a positive feedback that is atypical to the fire-maintained ecosystem they now occupy, rootstocks effectively reduce the number of alternative solutions available to restoration experts. According to Bragg, "old-growth is a product of a dynamic environment that helps to both organize and disassemble communities and landscapes, and when decoupled from this system, primary forests deviated from presettlement patterns" (Bragg 2002, 277). This deviation from standard presettlement patterns is indicative of a tendency toward divergent succession. The legacy of fire suppression has altered the boundary conditions; thereby, redirecting the trajectory of ecological change down a path toward different plant community composition. Alongside this change in composition comes an associated change in forest structure. The open, park-like setting characteristic of pine-bluestem stands existed only in small fragments by the late 19th century (Figure 11). Restoration is an attempt at restoring some of the processes that, in turn, will restructure portions of the forest to more closely match this historic condition. According to Resource Professional 2, a primary goal of restoration is "to simulate some of these conditions that happened in the past in the current forest. They know that the trees were in this kind of density and arrangement and composition. And we can kind of figure out what we need to do to simulate that" (Resource Professional 2 6-18-2007).

Although the intended focus is restoring processes, it remains helpful for restoration experts to identify certain features common among pine-bluestem woodlands (e.g., basal area, canopy structure, stem count, suite of species diversity, etc.). These features serve as measurable outcomes, indicating the effectiveness of a chosen prescription. By administering a series of different prescriptions, restoration ecologists are able to hone in on which admixture of management techniques are most effective at restoring these common features. In the jargon of complexity theory, each trial prescription is an attempt to formulate the specific environmental algorithm uniquely associated with pine-bluestem assembly. By trial and error restoration ecologists progressively hone-in on how best to apply to tool of fire towards recovering the biotic elements common to a historic PES condition. On the topics of complexity and emergence, Wilson writes "the commonalities will assist in pruning all the algorithms that can be conceived down to the ones that nature has chosen…. Organisms and their assemblages are the most complex systems known. They are also self-assembling and adaptive" (Wilson 1998, 95). This notion of self-assembly should not be taken without exception, however. Because anthropogenic fire played a significant role in the maintenance of native plant communities, the principles governing pine-bluestem assembly must account for the affect of human agency. By tuning the algorithms behind PES conditions restoration scientists are not uncovering some signature set of processes tucked deep within nature's exclusive domain. They are discovering rather, a state that was achieved historically at

Figure 11. “Virgin” stand of shortleaf pine, Irons Fork, Oden Ranger District, October 29, 1924 [Arkansas National Forest, Yell County, Arkansas] (U.S. Forest Service photo courtesy of the Forest History Society, Durham, North Carolina)

the hands of a culture keen on maximizing the productivity of its surrounding biophysical environment.

The pine stands currently being restored along the ONF’s Buffalo Road driving tour (Figure 12) testify to the emergent nature of ecosystems, finding their fullest expression as a response to process driven stimuli. This series of test plots serves both experimental and educational purposes. A driving circuit, complete with informational placards, allows visitors the chance to participate in a self-guided field trip. There are seventeen stops in all; with observation points directing the viewer’s attention toward forested landscapes in various stages of restoration. The gallery of forest types is a study in

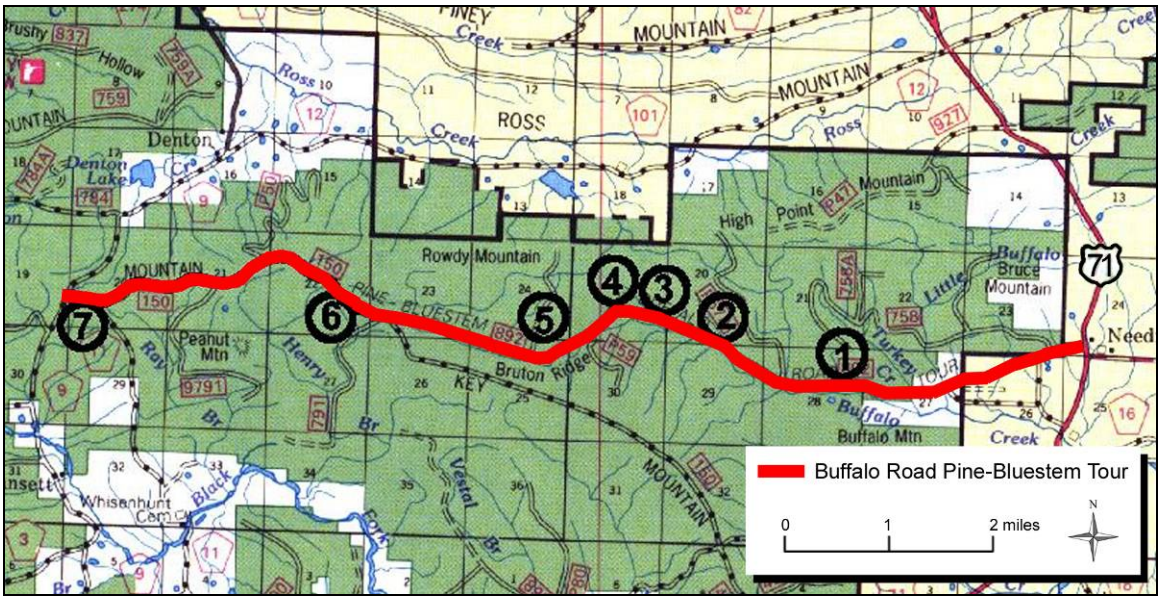

Figure 12. Map showing seven stops along the Buffalo Road pine-bluestem restoration driving tour [additions mine] (reproduced courtesy of USDA Forest Service)

visual contrast. At one end of the spectrum is a control plot whose dense mid-story and red cedar component contrast dramatically from the desired restoration condition. Alternatively, the Henry Mountain seedtree regeneration burn site, whose initial restoration began as recently as 1994, is characterized by a desired 10-30% hardwood component with pine stocking at appropriate levels (USDA 2006). The overall effect is not unlike the open canopy condition recognized in historic photos of the Interior Highlands.

Figure (13) shows a mottled skyward view of the forest canopy atop Management Area 22, where the Henry Mountain restoration site is located. Commenting on how such structural adjustments intersect with the PES conditions, Environmental Scientist 4 stated:

> In terms of, what does the pre-settlement condition tell us? It tells us that some processes used to exist widely through this part of the world that no longer exist. If we're trying to do some restoration activity, we know that some of those elements have to be restored to some degree in order to create the kinds of conditions that resonate with, that resemble what those original descriptions look like. Yesterday you saw a lot of stands that you could ride a horse through and not have your hat knocked off. So these guys and their practices are on the right track with that sort of work. But my sense is that *the pre-settlement descriptions and the old-growth quantifications that are occurring largely help identify the kinds of processes and the kinds of goals that are being achieved but they're really not a part of it. It's more a guidance of how processes work to shape forest structure, and how can managers use similar or surrogate processes to develop that similar kind of contrast in structure.* [emphasis mine] (Environmental Scientist 4 6-26-2007)

Figure 13. Mottled skyward view of forest canopy structure atop Management Area 22 near headwaters of Fourche Lafave River [Ouachita National Forest, Arkansas] (photo by author)

Pre-settlement descriptions have emerged as a point of contention among restoration critics, who view them to be a lodestar for determining what type of prescriptive measures are taken (Lancaster 1991; Norman 1990). The politics associated with representing a dynamic landscape with a static image (see, for example, Figure 11) have prompted critics to conceive of restoration efforts as an attempt to take steady aim at a perpetually moving target. Restoration proponents have countered such skepticism by denouncing the misperception that they intend to ascribe restoration projects with a single goal or target (Environmental Scientist 4 6-26-2007). They have occasionally been

called to prove that one or another stands *looked like that* in the 1800s, referring to an historic archival image. However, as Environmental Scientist 4 remarked, such a line of questioning is misguided:

> We're not looking at specific decades to restore or even stand by stand kind of restoration, but more a general sense of what elements were present historically. We get into some interesting discussion with some of our critics who want us to provide the evidence that on such and such a stand that you had this condition in 1850, and that we're going to put it back to the way it was in 1850. That's just not what we're all about. (Environmental Scientist 4 6-26-2007)

Neither is the agency intent on restoring pine-bluestem everywhere it occurred prior to European settlement. True, the series of adjacent plots along Buffalo Road are less randomly placed across the landscape than what would occur in a heterogeneous patchwork resulting from spatially variable disturbance patterns. However, this is primarily a function of the educational purpose they serve. Future restoration efforts will avoid creating a gallery-forest; where over *here* sits one forest type specified by (hypothetical) prescription X1, and over *there* stands another forest type designated as prescription X2…and so on. This would formalize surrogate processes to a degree that is inconsistent with efforts at establishing random disturbance patterns and restoring forest health at the landscape level. The experimental test plots along Buffalo Road are essentially an effort to tune the ecological algorithms underlying pine-bluestem assembly. They illustrate the evolutionary stages of devising a silvicultural prescription, moving from the experimental control site to a historic condition (Forest Manager 1 6-26-2007). The physical attributes (e.g., stem counts, diameter distribution, etc.), associated with this historical condition, are merely the structural form that emerges from whatever functional processes are being restored. The PES descriptions and static historic photographs, however politically loaded they have become, do happen to coincide with the old-growth quantifications gathered from the Buffalo Road test plots. However, this fact does not necessarily mean they are the centerpiece of restoration efforts rather than, as Environmental Scientist 4 noted, "a guidance of how processes work to shape forest structure" (Environmental Scientist 4 6-26-2007).

5.4 Geometry and Structure

The geometric composition of such a structural form is of particular interest to restoration because of its ecological function. Forest canopy characteristics help determine the light regime or amount of sunlight penetrating through to the forest floor (Conway et al. 1997; Gholz et al. 1991; Lowman and Wittman 1996; Montgomery and Chazdon 2001). This determines, in part, the photosynthetic activity of regenerating tree seedlings and sprouts (Blackburn and Milton 1996; Collins and Good 1987; Hilbert and Messier 1996; Wilder et al. 1999). Tree branch geometry is adaptive, meaning the growth angle, position, and ratio of branch lengths and clustering of leaves is determined according to their equitable distribution (Borchert and Slade 1981; Honda and Fisher 1979). The equitable distribution of leaves determines, along with the amount of under- and mid-story vegetation present, the amount of photosynthetic activity occurring upon the forest floor. Restoration ecologists focused on understanding how changes in light

regime affect tree regeneration often measure canopy architecture, including leaf area index (LAI), using a method called gap fraction analysis (Welles and Cohen 1996). This method relies on the measurement of a given canopy's percent open sky or available radiation. Using a fisheye lens to take a hemispherical photograph (similar to that shown in Figure 13), computer software is used to translate the image into raster format (Robison and McCarthy 1999). From this representation – visually akin to the mottled canopy structure viewed by the naked eye – a series of calculations produces a dimensionless number expressing the ratio of leaf cover to gap area.

Other methods for measuring a forest's leaf area index, similar in function to hemi-photo/gap analysis conducted at the ground level, utilize remote sensing technology, including LiDAR-derived measurements and photosynthetically active radiation meters (Deblonde et al. 1994; Roberts et al. 2005). Additional techniques were developed some time ago for measuring the LAI of pine forests due to their elongated, cylindrical needle foliage (Harms 1971). Prior to the invention of more sophisticated technologies (Gist 1974; Pierce and Running 1988), forest ecologists fashioned a crude method for measuring light regime called ocular estimation (Gower and Norman 1991). This technique involves the use of a small, handheld convex mirror with a grid superimposed upon its surface curvature. While standing beneath the forest cover one is able to view the canopy being reflected from overhead. The observer simply enumerates how many graticules reflect an entirely darkened sky (i.e., complete leaf cover) and applies this number as a logarithmic function; thereby, providing an arithmetic shortcut for estimating canopy coverage. This is similar in nature to the formation of topological categories based on the visual clustering associated with varying surface characteristics. This topic is of interest to researchers studying various aspects of geovisualization.

My aim here is to provide only a general account of the technical procedures use to measure canopy characteristics and the importance thereof. These observations serve as launching ground for a discussion of the relationship between: (1) mental calculations involved in ocular estimation, (2) their connection with environmental perception, and (3) the subsequent production of visual archetypes which serve as import for the social-construction of environmental metaphors. To pursue such a line of questioning I turn to the field of aesthetics, where the idea of visual complexity can be further explored. Drawing from the nonrepresentational work of Dutch painter, Piet Mondrian, I argue for the presence of an autonomous aesthetic, like that outlined by Gandy (1997) in chapter 3, liberated from the ideological critiques normally reserved for nature-based art.

5.5 Discovering the Universal in Neo-Plastic Art

Is pine-bluestem's aggregate of structural elements, evidenced by the canopy composition described above, reducible to a sort of ecological archetype associated with "optimal" (i.e., desired, according to its correspondence and human association with specific resource values) visual complexity? This is *not* to suggest the presence of a Jungian archetype rising out of the individual psyche (Jung 1959). I propose instead an ecological archetype originating in the perceptual space that connects intelligent actors with their surrounding environment. This will require a conceptual framework and visual ontology altogether different from any discussed in previous chapters. The idea of complexity will serve as a conceptual bridge between the landscape forms described

earlier and an aesthetic common to modern abstract art. The goal is to use notions from the fine arts to shed new light on the nature of the archetypal phenomenon of "optimal" visual complexity. Is the aesthetic appeal evoked by pine-bluestem woodland's open, park-like setting indicative of something else at work than merely individual preference? In reference to a similar elegance expressed in the work of Dutch painter Piet Mondrian, Wilson writes:

> In *Study of Trees II* (1913) the canopies of several trees are brought forward, dominating fences and other skeletonized and unfocused structures, yet all still balanced in composition and close to optimally complex by measure of brain arousal. Other variations of the same period increasingly abstract the whole into a mazelike configuration of reticulate lines. The interspaces capture patterns of light and color that change from one compartment to the next. The overall effect is not unlike that of a mottled sky viewed upward through a woodland canopy…. We do not see in the evolution of Mondrian a localized production of Western culture. The same process was at work in the confluence of Asian art and writing…. They too approach the optimum level of complexity by EEG standards [measured by electroencephalogram, a standard test for measuring electrical activity of the brain]. [addition mine](Wilson 1998, 242)

The mottled skyward view described above is not unlike that seen in Figure (13) of the forest canopy atop Management Area 22. Likewise, Mondrian's further exploration of the tree motif is evident in the piece *Wood with Beech Trees* (c.1899), a landscape painting whose sparse woodlands have a striking resemblance to the open, park-like setting of a PES condition. Of greater interest to this discussion is the artist's later use of rectilinear forms, straight lines and blocks of primary colors, to achieve an optimal level of complexity (OLC)[8] in his pictorial work. These ultra-reductive elements and the compositions created by moving them freely about the canvas, toward achieving the effect of balance, became the hallmark of his modern portfolio. In Figure (14) a montage of Mondrian's work, leading up to the *Neo-Plastic* period, shows a progression in style from realistic, to abstract, to non-objective. The term *plastic*, meaning 'bringing to form', was used as a way of describing the creative act inherent in his neutral method (Dennis 1970). Likewise, Mondrian viewed "the neutral plastic elements, a straight line and a primary color, as being reduced to their purest form when used to create a 'pure plastic' composition without subjective feeling" (Dennis 1970, 298).

This marked interest in devising a neutral method was part of the artist's self appointed "responsibility in the development of a modern art to seek a new level of objectivity from which subjective expression could be greatly excluded" (Dennis 1970, 298). In Mondrian's work and non-objective or nonrepresentational artists in general, we see a bold attempt at breaking "through the visible into the eternal" (Fingesten 1961, 3-4). They endeavored through a scientifically informed aesthetic to capture the fluid formation of a visual archetype, elemental not in the human psyche but nature itself. By blurring the distinction between the viewing 'self' and a perceived external reality, these artists sought to collapse the process of symbolization toward achieving a direct experience of the world:

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[8] My use of the OLC term here is defined by Wilson's (1998) reference to an EEG standard of brain stimulation (see also Milner and Goodale 1995 for an extensive treatment of the topic), and relates to epistemological work on visual perception and knowledge acquisition (Dretske 2000).

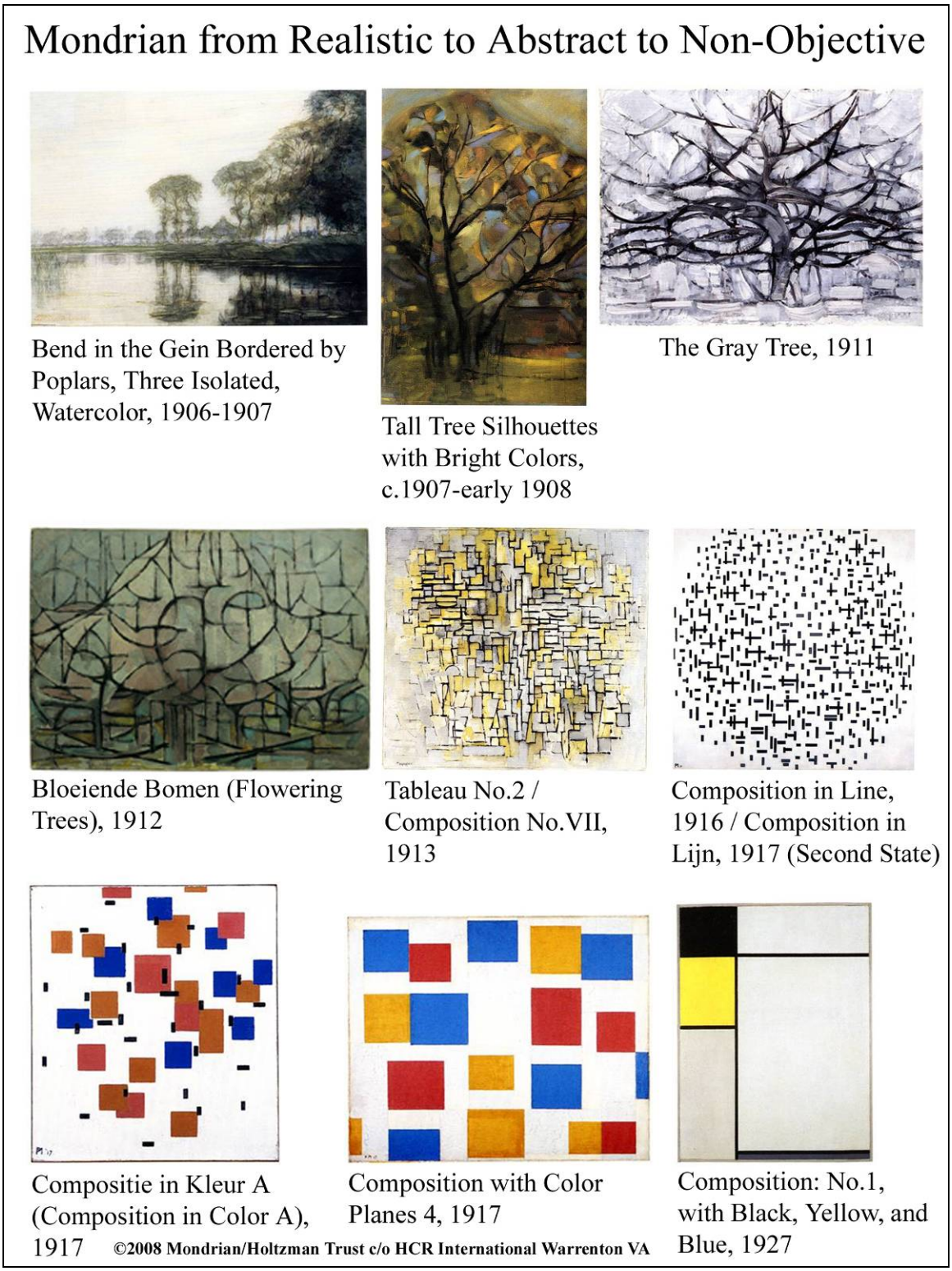

Figure 14. Progression of Mondrian's work, leading up to the Neo-Plastic Period, shows a trend toward ultra-reductionist style (Joosten 1998; Welsh 1998) (copyright permission granted by © Mondrian/Holtzman Trust c/o HCR International Warrenton VA)

> Non-objective paintings are shortcuts to experience, eliminating two important steps essential in language and representational art. The classic procedure was 1) object or idea, 2) the symbol, i.e. the painting, 3) the viewer. Now there is only 1) the painting, and 2) the viewer. Consistently non-objective paintings depend upon neither object nor symbol. What is left is a direct experience of a reality confronting the viewer. Non-objective art has broken through the process of symbolization itself. The cardinal point of difference between non-objective and representational art is that in the former the formal referents are not symbols in the traditional sense, evoking something outside of themselves, but that they simply are without denotative content altogether…. Non-objective art has made an important contribution to the history of the development of the mind, opening up new dimensions of perception and being. (Fingesten 1961, 5)

Accordingly, simple objects became the centerpiece of such nonrepresentational work. Speaking on their choice of subject matter, James noted the keen ability of non-objective painters "to find deep truths in things so close and simple and scrutable as a flower, a tree, a pair of old shoes" similar to "the early Netherlandish realists who found spiritual values, such as purity, in a transparent glass or a white towel…" (James 1963-1964, 111). This focus upon the objects themselves should not be mistaken as an effort to uncover some inscrutable superstructure in nature. Rather, Mondrian and his contemporaries were more concerned with capturing in their work the dynamic processes underlying the creation of organic forms themselves. In relation to my earlier discussion of the ideological nature of landscape and landscape art, the nonrepresentational aspects of Mondrian's work succeed where the static, historically contingent quality of historic pine-bluestem photos fail. In contrast to a landscape chorology, creating a static picture, his images reveal the process and change underlying the constituent forms and internal relations of optimally complex organic structures. According to Fingesten, non-objective art in serving its spiritual function "tore the veil from visible nature and presented its animating forces in the process of creation out of chaos or rest" (Fingesten 1961, 2). Using the example of a crystalline formation, Loeb discusses this contrast between reading Mondrian's work as a study in visible structure versus an expression of the dynamic processes that lead to its creation:

> It is known from his early series of tree studies that some of his later paintings do in fact represent for him the structural essence of trees. What is fascinating about a crystal is this type of reduction to an ultimate structural simplicity. As crystals increase in size, a complexity arises that is the result of interactions of thermal and gravitational forces; crystal dislocations, in seemingly endless variations, provide pleasing patterns that stem from the still recognizable theme of basic simplicity. (Loeb 1977, 313)

Figure (14) demonstrates Mondrian's gradual transition toward more simplified geometric compositions. Yet, this pictorial montage is not an attempt to distill the structural characteristics of the first image, *Bend in the Gein Bordered by Poplars, Three Isolated* (1906-1907), into the last, *Composition: No.1, with Black, Yellow, and Blue* (1927) – as if a single tree were plucked from the forest and made the focal point of a still-life. This progression is illustrative instead of the artist's rendering of nature's creative forces in visible form. Much like the crystal's complexity arising from the 'thermal and gravitational forces' acting upon it, the geometric design seen in

Composition: No.1, with Black, Yellow, and Blue (1927) emerges from the same processes affecting every preceding image in the series. Mondrian was widely known to be influenced by theosophical thought. The movement's inherent mysticism seemed to jibe with the "non-objective artists aim towards *participation creatif*, for they identify with the creative forces of nature" (Fingesten 1961, 5). Likewise, Riley describes how ideas typically associated with the constructive processes inherent in architecture made their way into his work:

> Mondrian makes it quite clear in 'The New Plastic in Painting' of 1917 that he refers to a form of making which lays a strong emphasis on construction; to put something *with* and *against* something. This aspect of his thinking seems to take him close to architecture but he makes an important distinction. Architectural form absorbs its own constructive relationship within itself in other words the resolution of its weights, tensions and pressures is hidden within its final appearance. But it has part of Mondrian's insight that if the means were sufficiently purified, painting could not only reveal how it was built – how it, too, dealt with tensions, pressures and weights – but also that these 'plastic' relationships could become expressive in themselves. (Riley 1996, 751)

In contrast to other landscape art, which seeks to hide the underlying tensions in human-environment relations, Mondrian's plastic art aspires to build upon these relationships as a way of expressing a universal notion of truth in nature. I argue that his ultra-reductionist rendering of natural phenomena, and stylistic progression in general (Figure 14), approach the autonomous aesthetic spoken of by Gandy (1997). Mondrian's work succeeds, according to Gandy's definition, in demonstrating "the capacity of art not to disclose 'truth' through the mimesis of 'higher' orders of truth revealed by the physical and mathematical sciences, but to reveal aspects of reality that would otherwise be overlooked" (Gandy 1997, 638). Despite the geometric quality of Mondrian's non-objective pieces, there remains a strong interpretive aspect to his creations. This straddling-the-intellectual-divide between positivist concerns with understanding the world through number, and creative or intuitive approaches to uncovering transcendental truth, places Mondrian alongside Renaissance environmentalists. They share an openness to knowledge "constituted neither in solely operational, nor entirely speculative terms, but rather through the construction of metaphor and image by individuals actively embracing the materiality of the world" (Cosgrove 1990, 345). The images of an open, woodland canopy, when viewed either through Mondrian's *Study of Trees II* (1913) or a visual archetype of optimal complexity (Figure 13), are "conceived not as surface representations of a deeper truth but as a creative intervention in making truth" (Cosgrove 1990, 345). Native Americans and the culture of restoration alike have harnessed the tool of fire, as a cultural adaptation, to shape forest structure and species composition, and consequently the aesthetic of the woodland's open, park-like setting. By understanding how past and present-day cultures have shaped local forest ecologies, and vice verse, we may realize, as Sauer once suggested, the "reality of the union of physical and cultural elements of the landscape" (Sauer 1969 [1925], 325). The pine-bluestem woodlands of the Interior Highlands are indeed a geognostic factor which points to this physical-cultural union propagated by human-environment interactions – a universal theme unparticular to either the pre-scientific or scientific era.

Amidst more abstruse concerns related to truth formation and resolving the relational puzzle between the 'universal' and the 'particular,' Mondrian also turned outward in an effort to catalyze his art toward finding practical applications. The artist believed that "in abstract art, space determination and not space expression, is the pure plastic way to express universal reality. In this way, art develops from the domain of fantasy and accident to the solution of technical problems" (Mondrian 1943, in Frampton 1968, 470). Despite a lingering esoteric tone, the artist truly held a favorable view of the role science might play in improving the human condition. According to James, "Mondrian, seeking to bridge the gap between the ideal and the empirical, welcomed the age of technology: the world could be controlled with the aid of science for the benefit of all" (James 1963-1964), 111). The artist's grid system was conceived at a time when:

> The application of quantum theory to the atom and the properties of motion, strain, stress, and electromagnetism to the conceptualization of the structure of matter was manifest in the constitution of space as dynamic; an activating continuum that could be harnessed, restrained, and let go, no longer segmented but, rather, strung as a flexible and charged field. (Zion 2000, 75)

Mondrian's use of a dynamic grid to examine the universal properties inherent in natural phenomena allowed the merger of reasoned mathematical thinking with human instinct (Evans 1992). This was an important step toward creating an aesthetic medium, around which new questions concerning the influence of abstraction on the process of knowledge acquisition, and thus visual perception, could be framed (Zeki 2001). Many of these questions have been taken up by scholars working in the field of topology; which, if we recall, has played an important role in developing the ideas and technological means, including ocular estimation, for measuring photosynthetic activity in forest environments. Employing information theory, they have examined the linear networks of Mondrian's compositions in an effort to compute their topological information content (Hill 1968). Although no 'hidden geometry' was ever found, these studies developed the idea that this topological information would, according to Hill,

> …become valuable data for a statistical account of the changes and of the stable factors (invariants) in Mondrian's structural syntax. And this in turn could lead to establishing the 'set of Mondrian axioms'. Mondrian's 'axioms' allow for a very large range of syntactical usage, of which his own works drew upon only a significantly small range. I believe it would be valuable to explore fully the entire set of these lattice structures and, within them, the subset that was drawn upon by Mondrian. I believe this could provide us with part of the essential material with which to tackle the obvious but puzzling question-what lay behind Mondrian's choice? (Hill 1968, 234)

If any axioms are to be found in the artist's nonrepresentational work they surely arise from its plastic relationships which sought to, as Fingesten (1961) noted, "open up new dimensions of perception" through a direct experience of nature. Newly informed by emerging scientific theories that posited space as a dynamic entity, Mondrian's pictorial compositions explored not only a new aesthetic liberated from the excesses of subjective thought, but also those laws governing the efficient exchange of information between the visual brain and its surrounding environment. His visual art, much like the visual brain, attempted to capture the invariant structures that composed a natural environment

ineluctably changing from one point in time to the next. Accordingly, Zeki describes how vision serves a dual function in both the areas of artistic interpretation and environmental perception:

> Visual art also obeys the laws of the visual brain, and thus reveals these laws to us. Of these laws, two stand supreme. The first is the law of constancy. By this I mean that the function of the visual brain is to seek knowledge of the constant and essential properties of objects and surfaces, when the information reaching it changes from moment to moment. The distance, the viewing point, and the illumination conditions change continually, yet the brain is able to discard these changes in categorizing an object. Similarly, a great work of art tries to distill on canvas essential qualities. A major function of art can thus be regarded as an extension of the function of the brain, namely, to seek knowledge about the world. (Zeki 2001, 52)

Returning to the first example, *Study of Trees II* (1913), its mottled skyward view of an open woodland canopy may now be interpreted as an artistic rendering of the law of constancy. Consider the open, park-like setting associated with PES condition. Just as Hill (1968, 234) asked the "obvious but puzzling question-what lay behind Mondrian's choice," a comparable question appropriate to this study is: What lay behind Native Americans' choice to apply, in artistic fashion, the tool of fire towards shaping the aesthetic of PES forest conditions? Did they associate the open, woodland aesthetic with certain resource values necessary for their survival? We see that ocular estimation, the technique used to measure the leaf area index of variable canopy structures, is an example of the visual brain attempting to move beyond its functional capacity to differentiate between minute changes in environmental conditions. Unaided by even the crudest instrumentation (e.g., convex mirror overlain with latticework), the required calculations (logarithmic functions) are not easily completed. Instead, the naked eye distills the information content of a canopy structure into a single abstract idea – an open, park-like setting which becomes, in turn, an ecological archetype.

One line of thought suggests that culture produces the archetype and then enjoys whatever resource values arise from its creation. However, it is more likely the case that any archetype corresponding with the open, woodland aesthetic is a byproduct, meaning that resource needs are satisfied by a particular environment, which a culture in turn comes to value and seek to reproduce. Of course, according to this logic, only those archetypes associated with resource values that satisfy the long-term needs of societies would find pronounced expression in the coevolution of culture and environment. In recalling a frontier ideal one is simply referring to an archetypal structure associated with a set of environmental algorithms which either no longer exist or occur to some limited degree. As fire was suppressed over the last century an optimum level of ecological complexity was slowly lost. In the absence of an archetypal forest the metaphor of a frontier ideal was socially-constructed. The creation of such a metaphor, a hallmark characteristic of postmodern thought, came perhaps in response to the widening distance between environmental thought and action, and the need to forge an accessible memory. By restoring the forest, the culture of restoration is in one sense recovering an archetype of complexity. Commenting on the connection between archetype and metaphor, Wilson writes:

> The archetypes spawn legions of metaphors that compose not only a large part of the arts but also of ordinary communication. Metaphors, the consequence of spreading activation of the brain during learning, are the building blocks of creative thought. They connect and synergistically strengthen different spheres of memory. (Wilson 1998, 238)

If the condition defined by pine-bluestem woodlands exists as an ecological ideal, this begs another question: Does pine-bluestem's aesthetic encompass an ecological archetype which Native Americans were well aware of, but the culture of restoration has yet to become conscious of? Pine-bluestem's open, park-like setting, its woodland architecture, is an indicator of an optimal level of structural complexity – defined by key resource values, including ecological resilience and a fuller expression of the vast preponderance of species occurring across the Interior Highlands. Trunk decay columns, snags, an open mid-story, herbaceous groundcover, canopy structure, soils exhibiting high net primary productivity levels, and innumerable other physical features beneficial to living organisms, including humans, contribute to the overall aesthetic form of pine-bluestem woodlands. These are also characteristic of an exceedingly productive environment in the ONF, which over the human evolutionary time scale provided better material sustenance than other forest ecosystems. Whatever principles of complexity underlie pine-bluestem development, they find visual expression in the forest conditions created by the active set of disturbance regimes discussed in chapter 3. Pine-bluestem is the visual indicator of our preceding syllogism of ecological health – restored woodlands signify a healthy condition. The closer restoration ecologists are able to simulate pre-suppression disturbance regimes, the more precisely they will have honed in on pine-bluestem's foundational algorithms.

In this section I have drawn several distinctions between a conventional (scientific) and an unconventional (cultural) reading of two key elements of restoration, fire and the PES benchmark. These include: 1) view of fire as either ecosystem process or cultural adaptation, that has influenced historic Native American agricultural practices and present-day silvicultural regimes, 2) understanding of fire as practical forest management tool or as artistic instrument, that shapes our aesthetic appreciation and the meanings attached to forest archetypes, 3) consideration of the PES benchmark as either "optimal state" for management objectives or an "optimal" state of brain stimulation, and 4) correspondence between the PES benchmark and a socially-constructed frontier ideal, or the PES benchmark as expression of an archetypal ideal originating in the perceptual space between intelligent actors and their environment. The last two contrasts were illuminated through a discussion on nature-based art, and the capacity of aesthetic experience to express a universalist notion of creating truth in nature.

5.6 Conclusion

> "We see nothing truly till we understand it." – John Constable (C.R. Leslie 1845)

At the outset of this paper three secondary questions were posited, the answers for which would address my primary research question concerning the PES benchmark's correspondence with either socially-constructed goals or attention to social, cultural, and historical meanings associated with pre-European conditions. To reiterate, is the consistency in which ecosystem restoration projects tend to converge on a PES and/or

old-growth state coincidental? Or is it rather: (1) a function of utilizing the most recent common reference condition relative to anthropic degradation, (2) a regional optimum of some sort that may have happened to exist, merely by chance, from the early-18th to mid-19th century, or (3) a socially-constructed yearning for a frontier ideal? PES benchmarks correspond simultaneously with all three aforementioned phenomena. The creation of PES benchmarks appears to be an unintentional consequence of attempts to restore forest health rigorously defined by biometric standards. The time period immediately preceding European settlement (three to four hundred years ago) was indeed a partly culturally produced regional optimum that existed as a result of forest conditions propagated through a regime of frequent anthropogenic fire. Likewise, the Interior Highlands' natural history, including human occupation, suggests the PES time period marks the last series of instances before modern industrial silviculture increasingly modified ecosystem processes. Because of this unique convergence, between historical human activities and natural processes, contemporary culture has conceived of the PES time period as a sort of frontier ideal.

The social-construction of such an idea serves not merely as a romantic notion of some historicized encounter between settlers and the New World. The frontier ideal is intimately linked with the knowledge that Native Americans did indeed actively maintain forest environments in a desired state relative to their own needs. By all accounts things were better then, ecologically speaking, than they are today (e.g., greater biodiversity, higher levels of soil net primary productivity, etc.). Indeed, Forest Manager 1 remarked that "that was some sort of *great time* ecologically" (Forest Manager 1 6-26-2007). Associating the PES period with a frontier ideal (and an associated archetype) is more about looking beyond epiphenomena toward the ecological imperatives (realities) which Native American culture and the culture of restoration have both been required to deal with. The fact that PES benchmarks are, in part, socially-constructed should not detract from the overall project of restoration. The skepticism such thinking brings to the dialogue on forest management is healthy, but is unconvincing given the benefits of restoration projects.

The PES benchmark's association with some socially-constructed frontier ideal should not be viewed so much as a fallacy, but rather a truth more deeply rooted in the coevolution between ecological inheritance and an emerging psychobiogeography (Trudgill 2001). This psychobiogeography refers to a growing awareness among forest managers of the need to emphasize resiliency-concepts and ideas related to disturbance ecologies when communicating the tangible benefits associated with restoration to local constituencies – especially those who view restoration in an unfavorable light. Rather than resting their arguments on value-laden terms like *pristine* or *naturally-balanced*, ecological resiliency-concepts set the foundation for meaningful discussions over how best to restore long-term forest health. The success of the agency in accelerating restoration efforts depends, in part, on the meaning that pine-bluestem woodlands carry in the minds of people. This meaning is influenced by the connection between landscape aesthetics and scientific understanding, and reflected in the comments of Environmental Scientist 1 concerning the beauty of restored woodlands:

> There is just something to be said for going out into those open landscapes and seeing that flush of wildflowers for example. You're not necessarily identifying the wildflower species and appreciating the scientific value of that species as much as it is the spiritual or aesthetic

> value of seeing that landscape out there. It's not quantifying it necessarily. It's more of a qualitative thing. It's kind of within an individual, but I think society again values those aesthetic attributes. (Environmental Scientist 1 6-27-2007)

This heartfelt sentiment voices a further elaboration on a theme within Renaissance environmentalism urging the collapse of modernist distinctions between spirit and matter (Cosgrove 1990). Conflating the spiritual with the aesthetic, agency Environmental Scientist 1 relocates the human presence in nature, and much like Jackson (1984, xii) eschews the idea of an aesthetic "conformity to certain biological or ecological laws." Rather, beauty arises from the emblazonment of our cultural imprint upon the landscape, and its occasional reminder of humanity's place among the animating forces of nature.

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