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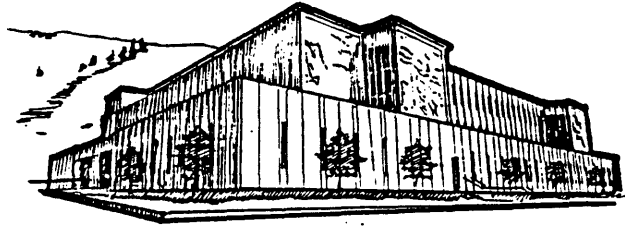
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DEVELOPING A NEW LEAD DISTRICT IN MISSOURI: A CONFLICT BETWEEN
MAINTAINING A MINING HERITAGE AND PRESERVING ECOLOGICAL
INTEGRITY ON THE OZARK HIGHLAND

by

Douglas J. Hawes-Davis

B.A. DePauw University, Greencastle, Indiana, 1989

Presented in partial fulfillment of the requirements

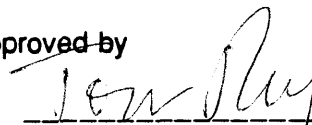
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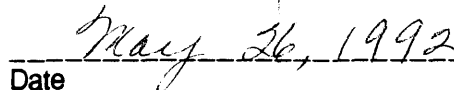
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Developing a New Lead District in Missouri: A Conflict Between Maintaining a Mining Heritage and Preserving Ecological Integrity on the Ozark Highland (89pp.)

Director: Thomas M. Roy *TMR*

The presence of high-grade lead ores in the Ozark Mountains of southern Missouri played a significant role in the settlement of the state. Since the ore was first unearthed by French settlers in the early 1700s near the Meramec River, lead mining has been part of the Ozark heritage. During the mid-1800s, the Old Lead Belt in the St. Francis Mountains, and the Tri-State District in southwest Missouri, were developed. Just prior to the end of mining in those districts, lead was discovered southwest of the Old Lead Belt, east of Salem, Missouri. The Viburnum Trend, as the new mining district is known, has become the world's principal lead producer.

It is apparent that known reserves in the Viburnum Trend will be depleted within the next twenty years. In response to this prediction, several mining companies began to explore an area southwest of the Viburnum Trend where similar lead deposits are suspected to occur. The Doe Run Company, the nation's largest producer, was the first to secure mineral rights in the Eleven Point District of the Mark Twain National Forest. A great deal of controversy surrounds the company's plan to mine this area of the Ozarks.

Indisputably the wildest remaining area of Missouri, its geologic setting is extraordinarily sensitive. A substantial portion of the area consists of karst terrain with interconnected surface and subsurface water systems. Similar topography is uncommon in all of the abandoned Missouri lead districts. Even so, major ecological problems persist in every one of them. An examination of the state's past and present mining history and the ecological and economic situation of the proposed mining area reveals the consequences of mineral development would equal the worst of predictions. The available literature, interviews, and site inspections show a distressing situation would develop in the event further mineral development is permitted in the region. Its social/economic infrastructure would be severely stressed for decades. Environmental degradation would persist indefinitely. And, the wild character of the region would be devastated.

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I. INTRODUCTION

Lead mining in the Missouri Ozarks has been important to the state since French settlers unearthed high-grade ore in small workings near the Meramec River during the early 1700s. Today, the Missouri mines meet the majority of national demand for the element. It has never been a region-wide industry, however. Active mining areas have changed as reserves have become depleted and new discoveries have been made in the exploratory process. Currently, the active mining area, with a total of eight operating mines, is confined to a small area in four counties of southeast Missouri. The mining area, known as the Viburnum Trend, runs generally north to south, with approximately twenty miles between the northernmost and southernmost mine/mill complexes.

The economic situation of the Ozark Mountain region leaves substantial room for improvement. Even the counties with active mine sites have unemployment and poverty rates among the nation's highest. Today most of the few thriving local economies in the region are based in tourism, which continues to be a staple of the regional economy. People generally visit the area to recreate in its forests or on its rivers, to enjoy a comparatively slower lifestyle for a time, or simply to marvel at its natural beauty. The economic value of these qualities has not diminished over time as the returns from extractive industry always do. It is arguable, in fact, that demand for such qualities, plentiful in the Ozarks, has increased as the extent of undeveloped land has decreased throughout the Midwest.

In some areas of the Missouri Ozarks, unlike most of the Midwest, it is still possible to get a glimpse of what the region looked like before the encroachment of white settlement. This is certainly true in a section of

southcentral Missouri often referred to as the "Big Springs" region. While much of the "Big Springs" area retains a pre-settlement character and many of its outstanding natural areas have gained formal protection, the fate of the region is yet uncertain. The lead industry seems determined that full-scale mining will be a part of the area's future. Much of the Mark Twain National Forest (MTNF) is open to extractive industry, pending environmental analysis and the permitting process. Not everyone is convinced, however, that mineral development would be a wise plan for the region.

The dangers of neurological disorders, particularly in children, caused by exposure to lead have been well documented. Because the media has covered the tragedy of widespread childhood lead poisoning extensively, the public can be considered well informed on the issue. The ecological problems with the mining of lead-bearing ore, however, do not seem to be well known by either the media or the general public. The major health risks associated with the dissemination of lead into the environment provide excellent reasons for regulating its use far more stringently. Unfortunately, regulating lead use does nothing to protect ecological systems in regions where it is extracted from the earth. Lead mining has left a legacy of environmental destruction and economic stagnation in every abandoned mineral district in Missouri.

Lead production from the Viburnum Trend remained high throughout the 1980s. For several years during the past decade, the Missouri mines accounted for over ninety percent of total domestic production.¹ However, a rapid decline

¹William D. Woodbury. "Lead." Minerals Yearbook Volume I: Metals and Minerals 1988. (Washington, D.C.: GPO, 1990), 582.

in production is expected to begin near the turn of the century.² The mining companies are well-aware of this likelihood. As a result a number of companies began exploring other promising areas of the Missouri Ozarks for high-grade mineral deposits. The lead industry believes that a southwesterly extension of the Viburnum Trend contains economically recoverable lead ores. Developing this probable extension of the trend would bring lead mining into the heart of the Missouri Ozarks.

The Doe Run Company, the nation's largest producer of refined lead, filed two Preference Right Lease Applications (PRLA) with the United States Forest Service and the Bureau of Land Management (BLM) in 1983 for mineral rights in the Eleven Point District of the MTNF. Doe Run is not the only company to pursue mineral development in the region, but its proposal has gained the most attention by far, perhaps partially because of responses by federal and state governmental agencies.

In addition to the potential problems associated with lead mining in any region, much of the Big Springs region consists of well-developed karst terrain, uncommon in the abandoned mining areas or in the Viburnum Trend.³ Because of the abundance of karst areas, the potential for severely degraded water

²Forest Service, U.S. Department of Agriculture, and Bureau of Land Management, U.S. Department of the Interior. Draft Environmental Impact Statement: Hardrock Mineral Leasing - Mark Twain National Forest, Missouri. (Washington, D.C.: GPO, 1988), executive summary v. Mines have been operating in the Viburnum Trend for several decades. Because the reserve base has decreased steadily over the past several years, it is unlikely that any new mines will be developed in the area. It is expected that known reserves will be totally depleted within the next twenty years.

³Karst terrain involve irregular limestone solution formations including caves, sinkholes, springs, and subterranean streams. The presence of karst landforms usually indicates an interconnectedness of surface and subsurface water systems.

quality is much higher in the proposed new area than in the Viburnum Trend. The preservation of water quality is only one of many concerns voiced over the various mining proposals for the Big Springs region. The incidence of rare and endangered species in the area is perhaps the highest in all of the midwest. Many of these are extremely sensitive to development. Mining also threatens to disrupt the delicate economic situation of the Big Springs region through a rapid transformation of the social and economic infrastructure. All of the concerns pose serious questions about the compatibility of hardrock mining and the preservation of environmental quality in the wildest remaining area of Missouri. An analysis of the past and present lead mining history in Missouri, coupled with an examination of the economic and ecological situation of the Big Springs region will determine the likely repercussions of developing a new lead district in the Ozarks.

II. THE PHYSICAL ENVIRONMENT

1. Geography of the Ozark Highland

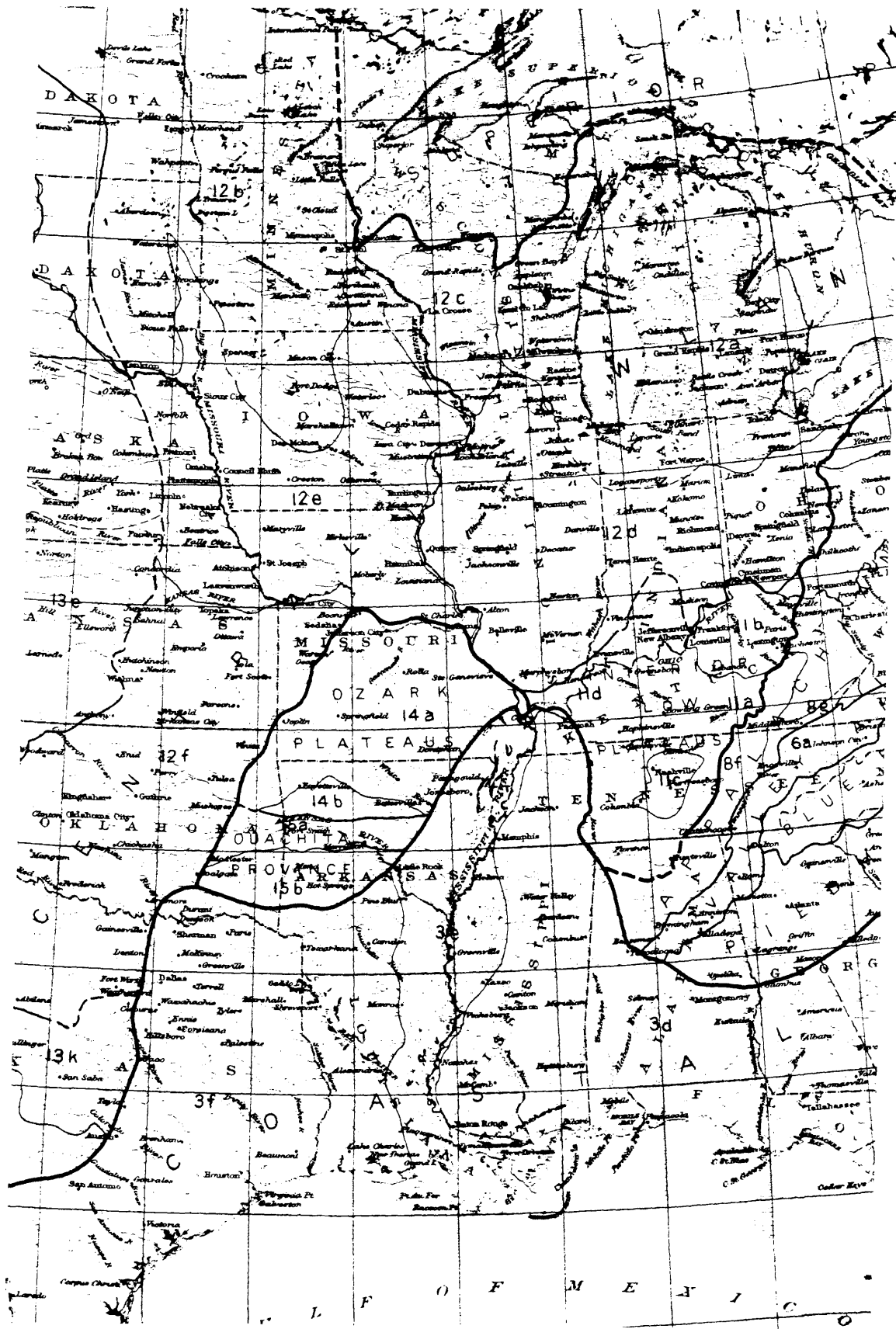
The Ozark Mountains include nearly all of southern Missouri, northwest Arkansas, and small portions of Kansas and Oklahoma (Fig. 1). Sauer noted in his Geography of the Ozark Highland of Missouri, however, that they are not really mountains. Only the Boston Mountains in the Arkansas Ozarks and the adjacent Ouachita Mountains, which are geologically distinct from the Ozarks, take a truly mountainous form. The highest point in the Missouri Ozarks, Taum Sauk Mountain, stands at only 1778 feet above sea level. Although several mountains in the Arkansas Ozarks exceed 2500 feet, they would qualify only as foothills in Colorado or Wyoming.

The remains of a great uplift, the Ozark Plateau, which "is believed to be the oldest continually exposed land mass in the world", is heavily dissected throughout.⁴ The highland region, including the Ouachita Mountains, is the only substantial upland or elevated region between the Appalachian and Rocky Mountain ranges. Owing to its isolation, it was the last great wilderness in the East to be conquered before settlers continued west to the Rockies. Henry Rowe Schoolcraft started his Journal of a Tour Into the Interior of Missouri and Arkansaw in 1818 by stating, "I begin my tour where other travelers have ended theirs, on the confines of the wilderness, and at the last village of white inhabitants, between the Mississippi River and the Pacific Ocean."⁵ Although the Ozark Highland is no longer the vast wilderness that confronted Schoolcraft

⁴"As Old as the Ozarks." Nature Conservancy 42 (March/April 1992), 30.

⁵Henry Rowe Schoolcraft. Journal of a Tour Into the Interior of Missouri and Arkansaw. (London: Sir Richard Phillips and Co., 1821; reprint, Van Buren, Arkansas: Press-Argus Printers, 1955), 21, (pages taken from reprint).

Figure 1. Locator map for the Ozark Highlands Geographic Province.
(Source: Nevin M. Fenneman. "Physical Divisions of the United States."
USGS map, 1946; reprint, 1957.)



in 1818, it is an area of spectacular natural qualities and portions of it still retain a semi-wilderness character.

The boundaries of the region, encompassing an area roughly the size of Ireland, are disputed even by experts. The Missouri River is generally accepted as the northern limit, with Glasgow, Missouri being the northernmost point. The southernmost point lies near Van Buren, Arkansas, and the extreme eastern and western limits are respectively, the Mississippi and Neosho rivers.⁶ The only distinct boundaries are on the south and southeast. To the southeast, the Mississippi bottomland forms a "clearcut boundary" against the St. Francis Mountains, which are the geologic center of the Ozark Highland. On the south, the "Boston Mountains constitute a well-defined escarpment bordering on the Arkansas lowlands."⁷ In every other direction from the highlands, the transition to prairie is very gradual and boundaries are far from distinct. On the less obvious edges of the region, the criteria determining its extent is based on more subtle geologic changes. The western boundary lies where the Mississippian and Pennsylvanian rock formations meet. On the north, the boundary lies approximately at the terminal moraine from the most recent period of glaciation, corresponding with changes in soil types.⁸ Major upland forest types in the Ozarks include oak/hickory towards the region's northern boundary, oak/hickory/short-leaf pine generally from the St. Francis

⁶Carl O. Sauer. The Geography of the Ozark Highland of Missouri. (Chicago: University of Chicago Press, 1920; reprint, New York: Greenwood Press, 1968), 3, vii.

⁷Ibid., 7.

⁸Ibid.

Mountains south into Arkansas, and predominately cedar glades in a portion of southwest Missouri.

Portions of the Ozark Highland have evaded glaciation for perhaps 250 million years and the entire region has remained uncovered by ancient oceans for longer than any other area in North America, excluding the Appalachians.⁹ Over the past several thousand years, the Ozark Highland has been subjected to drastic climate changes. The pattern of climate changes has helped to increase the diversity of species in the region even further by facilitating the invasion of plants and animals suited to a variety of climates and habitats. A fair number of relict species remain in the region under highly specialized conditions. Scorpions, generally associated with the arid southwestern climate, find a niche in the Ozarks. They have undoubtedly persisted since a time when the region looked more like the Mojave. On the cool north-facing slopes of deep hollows lichens and other plant species generally found in more northerly climates maintain a foothold from periods of glaciation that pushed the edge of their range to the Ozark Highland.¹⁰ The Ozarks lie "at the point where the eastern hardwood types meet western prairie and southern pine types and many of the associated species overlap at the edges of their ranges."¹¹ Because of these extremely varied ecological components, the region supports an extraordinary

⁹Gary Reese. "Visitors From Another Age: Relict Plants are Survivors From a Time When the Glaciers Came to Missouri." Missouri Conservationist 47 (July 1986), 4-7.

¹⁰Ibid., 4-7.

¹¹Forest Service, 45.

diversity of species and habitat types. Some 200 plant and animal species exist only on the Ozark Highland.¹²

The Ozarks, which make up the majority of land area in the Interior Highlands Geographic Province, are not comprised of a monotonous landscape of uniformly forested hills and valleys. Tallgrass prairie covered at least one fourth of the region in its pre-settlement state.¹³ Cedar glades, bald knobs, shut-ins, and karst areas are other common landscapes found in the region. Shut-ins are one of the more peculiar geologic features in the Ozarks. Shut-ins form where a stream, cutting a gorge through limestone, meets an unyielding mass of igneous rock.¹⁴ They are manifested as a jumbled array of irregular rock formations causing frequent small waterfalls and pools transforming the generally casual flow of Ozark streams. The typical landforms of the region occur more or less frequently in various areas of the Ozarks.

Responding to the topographic diversity of the region, experts in several fields have attempted to subdivide the Ozarks in different ways for use in their particular disciplines. However, the Ozark Highland is truly dissected plateau country and can be divided into three distinct provinces. The Springfield Plateau to the west, the Boston Mountains Dissected Plateau to the south, and the Salem Plateau in the east accurately define the separate provinces of the region.

¹²"As Old As the Ozarks," 30.

¹³Milton D. Rafferty. The Ozarks: Land and Life. (Norman, OK: University of Oklahoma Press, 1980; second printing, 1985), 144.

¹⁴Thomas R. Beveridge. Geologic Wonders and Curiosities of Missouri. (Rolla, Missouri: Missouri Department of Natural Resources, 1978; second edition, 1990), 39.

These areas have been subdivided further for various purposes. Milton Rafferty, a professor in demographics and geography at Southwest Missouri State University has effectively divided the region into nine separate districts. They are the Missouri River Border, Mississippi River Border, Osage-Gasconade Hills, St. Francis Mountains, Central Plateau, Springfield Plain, White River Hills, Courtois Hills, and the Boston Mountains (Fig. 2). The Missouri Department of Natural Resources (MDNR) uses these natural divisions to subdivide the Ozark region; the Springfield Plateau, Upper Ozark, Lower Ozark, St. Francis Mountains, Elk River, Ozark Borders (Mississippi and Missouri Rivers), and White River.¹⁵ What the MDNR calls the Lower Ozark region and geographers call the Courtois Hills, the Missouri's State Division of Tourism more colorfully describes as the "Big Springs" region. The title is appropriate given that several of the world's largest springs are located in the region. Centered around the Current and Eleven Point River drainages within the Salem Plateau Province in south central Missouri, the region exhibits more typical Ozark characteristics than any other of the geographic districts.

2. The Big Springs Region

All of the distinguishing features of the Ozark Highland can be found abundantly in the Big Springs area. The region contains all the elements of well-developed complex karst topography, including caves, sinkholes, subterranean rivers and lakes and huge springs. Narrow ridges, deep valleys,

¹⁵Richard H. Thom and Greg Iffrig. Directory of Missouri Natural Areas. (Jefferson City: Missouri Natural Areas Committee, 1985), 11.

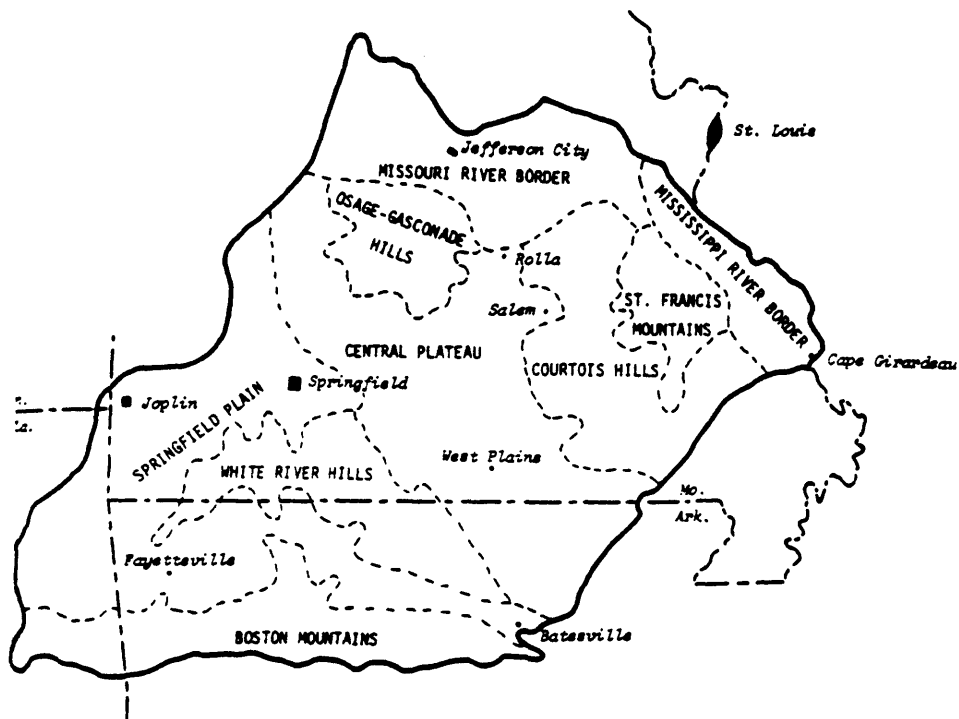


Figure 2. Map of the geographic divisions of the Ozark Highland.
 (Source: Milton D. Rafferty. *The Ozarks: Land and Life*. Norman,
 Oklahoma: University of Oklahoma Press, 1980; second printing, 1985.)

dolomite outcroppings, shut-ins, and occasional glades are also found in the area. The Big Springs Region

has the steepest average slopes and wildest terrain of any part of the Missouri Ozarks. Although it does not have the greatest relief, it is the most rugged district in Missouri, consisting of a maze of deep, confined valleys and sharp ridges. Strikingly rugged terrain is typical of the Irish Wilderness in Oregon, Carter, and Ripley counties near Greer Spring on the Eleven Point River. Greer Spring is only one of several spectacular springs in this region. Among the best known are Round Spring and Alley Spring near Eminence and Big Spring near Van Buren. Caves, sinkholes and solution valleys are also quite characteristic of the region. The Sinks and the natural tunnel on Sinking Creek, a tributary of the Current River are spectacular solution landforms.¹⁶

Because its agricultural potential is small and because of its relative isolation, the area remains largely undeveloped. "Many unsurfaced roads can be traveled only in a pickup truck, and even the best bituminous-surface roads wind along ridgetops and descend into valleys on steep grades."¹⁷ This is particularly true in the southern portion of the area along the federally protected Current, Jack's Fork, and Eleven Point Rivers. Missouri Department of Conservation (MDC) Director Jerry Presley has stated that, "This is actually the heart of what people think of when they talk about the Missouri Ozarks."¹⁸ Although the Viburnum Trend, just north of the region, currently sustains the largest lead mining operations in the world, most of the Big Springs area has endured without major permanent alterations to the landscape.

¹⁶Rafferty, 16.

¹⁷Ibid.

¹⁸Tom Uhlenbrock. "Ozarks Tract Sold to Conservationists." St. Louis Post-Dispatch (December 19, 1991).

This area, which has evaded development more successfully than many in the Ozarks, is recognized as one of the most ecologically significant regions in the Midwest. According to Rod Miller of the Nature Conservancy's Missouri Field Office, the region is "known to have the highest concentration of rare species of plants and animals in Missouri."¹⁹ The Conservancy recently purchased more than 80,000 acres of undeveloped land in the area (the third largest single land purchase in the Conservancy's history) in order to protect its natural diversity.²⁰ The organization has also expressed interest in establishing a biosphere reserve in the Big Springs area, centered around their recent purchase and the adjoining public lands. The Missouri Department of Conservation will eventually own and manage much of the oak/hickory/short-leaf pine forest in the purchase area. Federal and state laws offer varying levels of protection for several of the other more spectacular areas of the Big Springs region as well.

In 1964, four years prior to the passage of the National Wild and Scenic Rivers Act, 134 miles of the Current and Jack's Fork Rivers were designated the Ozark National Scenic Riverways (ONSR). The ONSR, which had nearly two million visits in 1985, is now an 86,000 acre national park, administered by the U.S. Park Service. Over 1500 species of plants, 112 of fish, 200 of birds, and 270 caves have been documented in the park.²¹ The Eleven Point River, south of the ONSR system, gained federal protection in 1968 as one of the

¹⁹"80,000-Acre Land Deal Called largest in Missouri History." Jefferson City Post-Tribune (December 19, 1991).

²⁰Uhlenbrock.

²¹Forest Service, 43.

original eight National Wild and Scenic Rivers. Other ecologically significant areas include Cupola Pond, the Irish Wilderness, and Greer Spring.

Cupola Pond is an ancient water-filled sinkhole that has supported Tupelo Gum trees for perhaps thousands of years at least 40 miles from their traditional range. In recognition of the rarity of a permanent water source in the forested uplands, Cupola Pond is designated a National Natural Landmark. The Nature Conservancy has also listed the barrens near the pond as one of the country's endangered habitat types.²²

Grasshopper Hollow, managed jointly by several governmental agencies, The Nature Conservancy, and the Doe Run Company, is a complex of at least fifteen fens supported by groundwater seepage. Although the preserve technically lies just north of the Big Springs region, its presence is important in exhibiting the ecological significance of the larger region. It has been described as "the largest and most significant fen complex in unglaciated North America."²³

Greer Spring more than doubles the flow of the Eleven Point River at its outlet. Discharging more than 330 cubic feet of water per second, it is Missouri's second largest spring.²⁴ A portion of the Greer Spring area, recently purchased by the Forest Service, is destined for protection in the Eleven Point Scenic River right-of-way. Big Spring, near Van Buren is the largest single-outlet spring in the United States. With a discharge of over 840

²²Robert H. Mohlenbrock. "Cupola Pond, Missouri." Natural History (January 1988), 62-65.

²³"Grasshopper Hollow Dedication." The Missouri Chapter Nature Conservancy (Fall 1990), 1.

²⁴Forest Service, 31.

million gallons per day, it is also one of the world's ten largest.²⁵ These and other areas are what make the Big Springs region geologically and ecologically significant. Some natural areas are "protected" while others remain undeveloped but outside the realm of preservation. The explorers bible to Missouri, The Geologic Wonders and Curiosities of Missouri, lists 61 areas of specific interest, not including caves, which are scattered liberally throughout the area, in just four counties in the region.²⁶

During the past decade interest in mineral development in the Eleven Point River drainage within this spectacular region has escalated. The Missouri mining companies realize that known lead reserves in the active mining area will soon be entirely depleted. The industry believes that the most probable location for significant deposits is in the Eleven Point area. Ordinarily it might seem absurd that mining would even be considered for a region of such outstanding natural qualities. However, in order for lead mining to continue to have a future in the state, it is likely that this area would have to be developed. A brief description of the history of lead mining in the state will help explain why so many people feel that the industry should have a secure future in Missouri.

²⁵Missouri Division of Tourism. "Missouri: Facts & Figures." (pamphlet) (Jefferson City, MO: Missouri Division of Tourism, 1989), 25: Bil Gilbert. "Streams of Contentiousness." Sports Illustrated (June 28, 1982), 68.

²⁶Beveridge.

III. LEAD MINING IN MISSOURI: AN HISTORICAL ACCOUNT

1. Formation of Lead-Bearing Ores in the Ozarks

Although the presence of lead in Missouri has been known for nearly 300 years, its reason for being there is still disputed. The most accepted theory hinges on the presence of a shallow ocean, which 450 to 475 million years ago was dotted with islands in the area which is now the St. Francis Mountains. Over millions of years a barrier reef formed around the islands. As "the seas receded and returned and receded again, the Ozarks and related mountains uplifted and settled and uplifted again."²⁷ The reef eventually solidified into layer upon layer of dolomite.

Bacteria, eating away at the algae and other organic parts of the ancient reef produced pockets of hydrogen sulfide. The tremendous heat and pressure from beneath the earth forced millions of gallons of brine from deep basins through the rock above. As the brine traveled a hundred subterranean kilometers or more, it continually scoured the porous rock and leached out tiny traces of metal ore. When it hit the hydrogen sulfide, a powerful chemical reaction forced the metal from the solution, and it gathered in bodies within the buried reef.²⁸

Galena, today Missouri's state mineral, is the product of this lengthy process.

The French noted early on that the ore yields three-fourths metal, but "when pure, it contains 86.6 percent lead."²⁹ Although miners have been tapping this

²⁷Harper Barnes. "Irish Wilderness." St.Louis Post-Dispatch (June 20, 1983), D1.

²⁸ibid.

²⁹Louis Houck. A History of Missouri, Vol.1, (Chicago: R.R. Donnelly and Son, 1908): Missouri Department of Natural Resources, Division of Geology and Land Survey. "Galena: Official Mineral of the State of Missouri." Fact Sheet; (Jefferson City, MO: 1990).

buried reef for many decades through deep underground mines, the first miners found high quality lead ore at or near the surface.

2. The Early Miners

The presence of lead in the "Mineral Area" was almost solely responsible for the first phase of permanent white settlement in the Ozarks.³⁰ French settlers were the first to mine lead along the Meramec River in the eastern Ozarks in the very early 1700s.³¹ Early mining methods required unearthing the metal ore with a pick-axe and a shovel and smelting the lead in hollowed-out tree trunks or on open-burning wood piles. Similar techniques persisted until the mid-1860s.³² As mining technology progressed and ore was more easily obtained, the Old Lead Belt, as the Mineral Area was eventually known, gradually became famous as a world-class mining area. For the next one hundred years the southeast Missouri district led the country in production and by the 1850s the extensive deposits in southwest Missouri near Joplin and Webb City had become famous.³³ This area is referred to as the Tri-State District because the deposits stretched over into the neighboring states of Kansas and Oklahoma. By the beginning of the Civil War nearly all of the lead ores at or near the surface in the eastern Ozarks had been discovered.

³⁰Rafferty, 39.

³¹Ibid., 120.

³²Charles J. Jennett, Bobby G. Wixson, and Roger L. Kramer. "Some Effects of Century Old Abandoned Lead Mining Operations on Streams in Missouri, USA." Minerals and the Environment (Vol.3, 1981), 17.

³³Walter Renton Ingalls. Lead and Zinc in the United States. (New York: Hill Publishing Company, 1908), 94.

3. "Modern" Mining in the Old Lead Belt and the Tri-State District

"Modern" mining began near Bonne Terre, Leadwood, and Flat River, in the Old Lead Belt as capital investment in the region increased towards the end of the Civil War.³⁴ The St. Joseph Lead Company first used a diamond drill in the exploratory process in 1869. The use of the diamond drill, which "consists of a rotating hollow pipe equipped with diamond cutting edges that cut out a core of rock several hundred feet long...revolutionized exploration for lead and is used even today."³⁵ Eventually, the room-and-pillar method of underground mining developed. This technique involves leaving pillars of bedrock intact to support the ceiling of the mine. Open-pit mining was attempted briefly in some locations, but the room-and-pillar method, still used today, prevails as the principal underground mining technique used in the Ozarks.³⁶

Combined production from the Old Lead Belt and the Tri-State District was the highest in the nation every year between 1907 and 1961.³⁷ By the late 1940s, the lead reserves in the Old Lead Belt had become noticeably depleted.³⁸ By 1950 it had become clear that mining in the Missouri portion of the Tri-State District would soon end. Lead mining in southwest Missouri

³⁴Rafferty, 121.

³⁵Ibid., 122.

³⁶Ibid., 130.

³⁷Mining Industry Council of Missouri. Underground Treasures: The Story of Mining in Missouri. (Reprinted from, "Official Manual, State of Missouri, 1977-1978), 18.

³⁸Ibid., 18-19.

finally ceased in 1957.³⁹ Aggressive exploration revealed a promising new area southwest of the Old Lead Belt in the mid-1950s. This new area, known as the Viburnum Trend, stretches southward for approximately forty-five miles from Viburnum Missouri, in Washington County into central Reynolds County.⁴⁰ (Fig. 3) Production in the Viburnum Trend had begun to exceed that of the Old Lead Belt by the mid-1960s and in 1972 the last operating mine in the Old Lead Belt closed. Since then, "the Viburnum Trend has become the largest lead mining area in the world."⁴¹

4. Ecological Consequences in the Abandoned Lead Mining Areas

The very early stages of mining in Missouri resulted in only minor alterations to the landscape. These operations, almost entirely done by hand, resulted in only semi-permanent landscape disturbances.⁴² However, the use of timber as the primary fuel in the more modern early mining operations caused serious degradation of the forested hills and hollows of the St. Francis Mountains. Recovery of the land to some degree in the Old Lead Belt has taken decades. Forests have regenerated, buildings have been razed, and some of the tailings piles have stabilized or washed away with the rivers, although the latter is itself a problem in some areas.

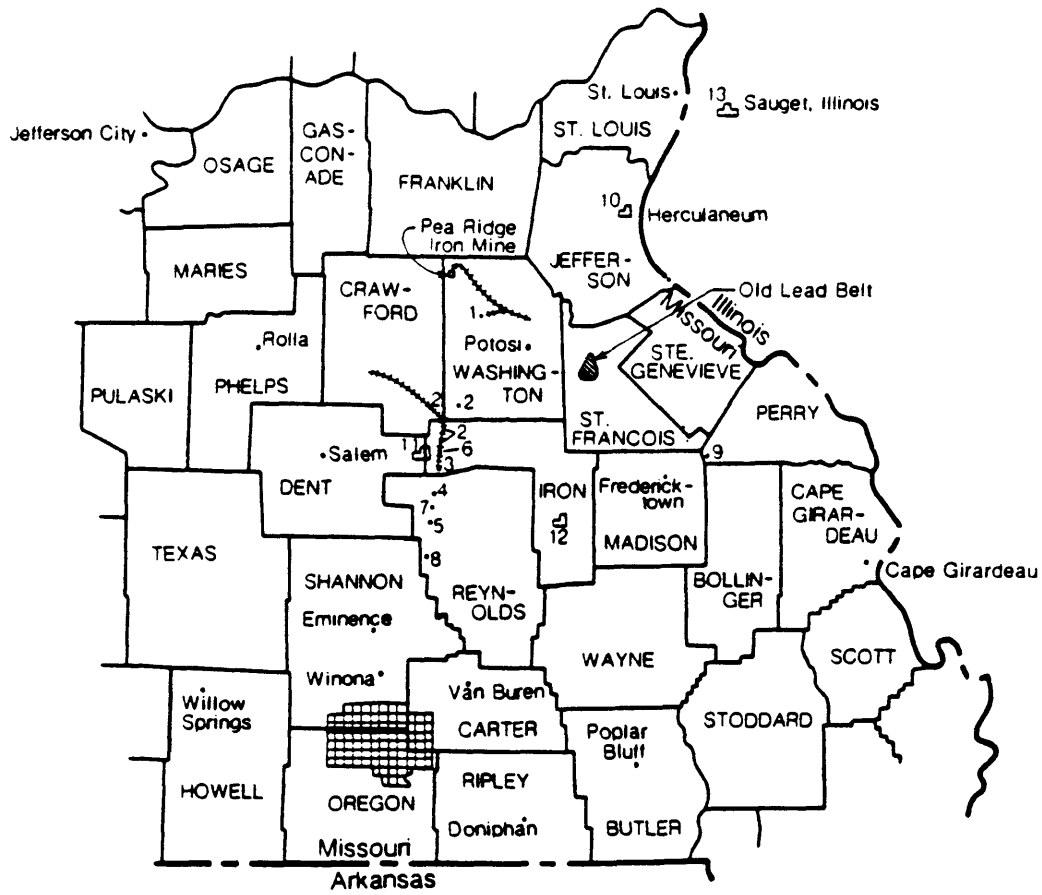
³⁹Ibid., 14, 18.

⁴⁰Forest Service, 9.

⁴¹Mining Industry Council of Missouri, 19.

⁴²Rafferty, 120-121.

Figure 3. Locator map for the abandoned lead mining areas, the Viburnum Trend, and the EIS study area. (Source: Forest Service, U.S. Department of Agriculture, Bureau of Land Management, U.S. Department of the Interior. Draft Environmental Impact Statement: Hardrock Mineral Leasing, Mark Twain National Forest - Missouri. Washington, D.C.: GPO, 1988)



 Old Lead Belt

Viburnum Trend Mines

- 1 Indian Creek Division Mines & Mill (abandoned)
- 2 Viburnum Division Mines & Mill
- 3 Buick Division Mine & Mill
- 4 Brushy Creek Division Mine & Mill
- 5 Fletcher Division Mine & Mill
- 6 Magmont Mine & Mill
- 7 West Fork Mine & Mill
- 8 Sweetwater Mine & Mill
- 9 Higdon Mine

 Lead Smelters

- 10 Herculaneum Division Plant
- 11 Buick Division Plant
- 12 Glover Plant

 13 Electrolytic Zinc Plant

 Railroad Spur

 Study Area

Riparian areas and aquatic life in streams in the Old Lead Belt continue to be affected by sediment laden with heavy metals. This results from run off from the many remaining tailings piles along streams in the Old Lead Belt.⁴³ The piles consist of "coarse to finely ground dolomitic residue," which "contain relatively high concentrations of heavy metals."⁴⁴ Scientific studies also have shown a correlation between mining operations and the substantially elevated amounts of lead and other heavy metals in soils in the Big River and Flat River Creek areas of southeast Missouri.⁴⁵ Bioaccumulation of heavy metals in aquatic life continues to be a problem in some streams in the Old Lead Belt. In response to a study that found lead levels in black redhorse suckers in the Big River at thirty times normal, the Missouri Department of Conservation has barred anglers from 35 miles of the stream.⁴⁶ The study was prompted by a 1977 failure of a St. Joe Minerals Corporation tailings dam during a rainstorm that allowed 120,000 cubic yards of tailings to flow into the river.⁴⁷ Although some environmental problems from these early operations have been mitigated,

⁴³James M. Czarnecki. "Accumulation of Lead in Fish from Missouri Streams Impacted by Lead Mining." Bulletin of Environmental Contamination and Toxicology. 34 (May 1985, 736-745): Jennett:

Notable effects upon the water quality and stream ecosystems in lower Flat River Creek can be directly or indirectly related to the Pb mining waste disposal particles employed in the Old Lead Belt area. (20)

⁴⁴Ibid., 736.

⁴⁵R.R. Tidball, "Lead in Soils." Lead in the Environment. (Washington, D.C.: GPO, 1976), 50.

⁴⁶Martha Shirk. "Lead Tailings Pose Threat in Big River." St.Louis Post-Dispatch. (August 24, 1980), A1.

⁴⁷Robert Goodrich. "Getting the Lead Out: Missouri Exploration Expands." St.Louis Post Dispatch (August 31, 1980), J4.

disturbances to ecological systems persist. A similar situation exists in the Tri-State District.

The Tri-State landscape remains pockmarked by shallow diggings, gaping water-filled open pits, and huge chat piles, many three hundred feet high, formed by waste rock from milling operations. The former mining areas, strewn with abandoned car bodies, castaway refrigerators, and other household dump material, create a forlorn and blasted landscape, a constant reminder that mineral resources are, after all, limited and nonrenewable.⁴⁸

The abandoned Tri-State District is currently noted for its status as an EPA Superfund Site.⁴⁹

Today, mining operations must comply with state and federal water and air quality laws. Because all lead mining in Missouri occurs on national forest land, mining companies must obtain permits from the MDNR, the Forest Service and the BLM. The National Forest Management Act (NFMA), the Mineral Leasing Act (MLA), the National Environmental Policy Act (NEPA), The Organic Act, the Mining and Minerals Policy Act, the Endangered Species Act (ESA), the Clean Water Act, and the Clean Air Act are all directly responsible for controlling mining on federal lands in Missouri. Although lead mining is now regulated to some extent by state and federal government agencies, permanent changes in the landscapes of the early mining districts seem minor when compared with the alterations the land endures from the more recent operations.

⁴⁸Rafferty, 132.

⁴⁹Tom Aley, director of Ozark Underground Laboratory in Protem, Missouri, interview by author, February 1992.

5. The Viburnum Trend

1) The Active Mine Sites

The lead mining operations in the Viburnum Trend continue to be the nation's largest producers. The Missouri mines appear to have peaked in 1988 with ninety-two percent of total domestic production.⁵⁰ All of this comes from just eight mines in the Viburnum area in the southeast portion of the state. The Doe Run Company, which operates six of the eight, is the largest integrated lead producer in the world. ASARCO Incorporated operates the other two mine and mill complexes in the Viburnum Trend. The Doe Run company also runs the country's largest primary smelter-refinery at Herculaneum, Missouri, south of St.Louis. In addition to the primary refined lead produced at its six mines, four mills, and two smelters, the Doe Run Company began producing refined lead from recycled scrap, predominately spent car batteries, at its Buick plant in the Viburnum Trend in October 1991.

Roughly twenty miles separates Doe Run's Fletcher Mine on the southern fringe of the active mining area and its Viburnum Mine at the northern edge. Mining is the predominant activity on the Salem/Potosi District of the MTNF. All of the mines in the area will eventually be interconnected by underground tunnels some 500 to 1000 feet beneath the ground's surface. These tunnels are created as the ore is removed, crushed and lifted to the surface. The pulverized rock and ore are then sent through a complicated milling process before the lead, zinc, and copper is sent to smelter-refinery

⁵⁰William D. Woodbury. "Lead." in Minerals Yearbook Volume I: Metals and Mineral. (Washington, D.C.: GPO, 1988), 582.

operations. Although the Doe Run Company maintains that 85 percent of its mining operations occurs underground, surface occupation constitutes a major disturbance in the forest.⁵¹

2) Surface Disturbances

The underground tunnels must be accompanied on the surface by ventilation shafts connected by unimproved forest roads. Ventilation shafts, which are spaced on average 1500 feet apart above tunnels, consist of a concrete slab roughly ten by twenty feet with a sheet-metal or concrete vent rising from the slab. On Forest Service land, the disturbed area around ventilation shafts must be completely covered with vegetation. On Doe Run land similar areas, covering a radius of approximately one hundred feet from each ventilation shaft, generally are devoid of vegetation. For maintenance purposes and because shafts double as escape elevators for mine workers in case of emergency, roads must run between all of them. Some of these roads were in place long before mining began, but others were built specifically for the mines. Because of the density of tunnels in the underground operations, roads thoroughly dissect the forest in the mining area.

Large tailings ponds are also a part of lead mining operations. Tailings ponds, which range in size from 200 to 700 acres and between 140 and 200 feet deep, are developed by constructing a dam at the downstream end of a valley and allowing it to fill with water.⁵² The ponds are then used for the depositing

⁵¹Doe Run Company. "Mining and Environmental Protection." (St.Louis: Doe Run Company, 1991).

⁵²Ibid.: John Carter, Environmental Manager for Doe Run Company in Viburnum, Missouri, interview by author, December 1991.

of waste rock from the mining process. (Fig. 4) Tailings consist of "finely ground limestone with minute traces of lead, copper and zinc."⁵³ When the pond has completely filled with waste rock, the area is seeded, often with native prairie grasses, but occasionally with a variety of early successional tree species as well. Until vegetation completely covers the inactive tailings impoundment, the site appears a vast wasteland, devoid of everything necessary to sustain life. The mining companies have proved that revegetation is possible, but extraordinarily difficult. What actually occurs on abandoned tailings ponds is plant succession and not reclamation or restoration.⁵⁴

Doe Run recently planted black locust and eastern red cedar on an abandoned tailings pond near Viburnum. The company's environmental manager, John Carter, admitted that the trees were not faring too well, but some saplings are persisting.⁵⁵ Because tailings ponds are lacking in nutrients and have no organic or other soil layers needed to support vegetation, they must pass through all of the successional stages before they are totally "reclaimed." It can take decades before the ponds will support a full cover of native vegetation. Abandoned tailings ponds of this type exist in various stages of reclamation throughout the Viburnum Trend. In all cases, according to John Carter, their

⁵³Doe Run Company.

⁵⁴Aley:

Perhaps the best depiction of plant succession anywhere in the Western Hemisphere is in the old lead mining area around Dubuque, Iowa; the Mines of Spain area which is now an Iowa State Park. If you know the age of the tailings pile, you can look at plant succession that ranges from 500 years ago until the late 1940s. They were all very small workings, but it is a very weird and strange collection of plant communities, because you have all of the successional stages.

⁵⁵Carter.

Figure 4. Topographic map of the northern portion of the Viburnum Trend illustrating the extent of tailings ponds. (Source: Geological Survey, U.S. Department of the Interior. "Rolla, Missouri," 1:100,000-Scale topographic map, USGS: Reston, Virginia, 1987.)



"beneficial use is wildlife habitat."⁵⁶ It is no easy task to hasten the process of succession. Ultimately, the deathly slow process of soil formation must occur.

The waste rock is non-toxic, based on EPA standards which are often suspect, but its sheer volume and the manner in which it is disposed makes it an environmental hazard. The waste is useable as a building material, but because of the huge volume, it is not economically feasible to transport all of it to potential buyers. Dumping the material in water-filled hollows is the most cost effective method of disposal for the mining companies. Backfilling of underground tunnels may be possible in some instances, but it is certainly more expensive.⁵⁷ Mining companies will only utilize that technology if regulatory agencies require it.

To the untrained eye, tailings ponds are not so offensive after reclamation is complete; however, a naturalist would continue to find them unsightly because they hardly resemble the land's original contour. In the end, tailings ponds will never appear completely natural because valleys or hollows constitute the original landscape of such sites.

In the companies' search for further extensions of ore deposits, the exploratory process is ongoing. In the active mining area this process does not occur beneath the surface. Exploratory core holes are continuously being drilled in order to determine the logic of continuing an underground tunnel outward. The area of surface disturbance from each core hole amounts to an exceedingly rough road to access the sites, and a clearing approximately one

⁵⁶ibid.

⁵⁷ibid.

hundred feet in diameter.⁵⁸ According to John Carter, some 10,000 core holes have been drilled in the active mining area of the Viburnum Trend as the range of the underground tunnels is continually expanding.⁵⁹

Each of these exploratory core holes amounts to a single surface disturbance accessed by a 4X4 road. Because of the extent of the underground tunnels core holes are necessary throughout the mining area. The tunnels span huge areas of the national forest, Doe Run Company property, and other private land holdings. The Viburnum Trend is situated in a somewhat remote area and few areas are developed for uses other than mining. The disturbed area is usually reclaimed as rapidly as possible, but on steep slopes, in upland areas where soils are poor, or in other more sensitive areas, reclamation may take some time. This is undoubtedly true in the case of the access roads. When the roads enter more remote areas, they are almost always extremely rough and because they are driven by heavy machinery, they often develop deep ruts and erode severely. This prolongs the natural reclamation process and makes facilitating the process more difficult as well.

3) Long-Term Environmental Impacts of Mining in the Viburnum Trend

Although there has not yet been any major contamination of water or forest ecosystems from lead mining in the Viburnum Trend, it is difficult to assess the long-term environmental consequences of mining in the region. Tom Aley, director of the Ozark Underground Laboratory discussed the problems

⁵⁸Jeffrey L. Zelms. "Mining Can Coexist With Nature: Mark Twain Forest has Thrived for 35 Years While Allowing Lead Extraction." St.Louis Post Dispatch. (June 28, 1991), C3.

⁵⁹Carter.

associated with using the Viburnum Trend as a model for future mining operations.

It's very easy to look at the Viburnum Trend mining and say, "Well gee, it's great and it doesn't cause many problems." There are potentially a couple of flaws in that. One, we really don't have a good assessment of what the impacts have been in the Viburnum Trend. The place you need to do monitoring on is on lands you can't gain access to; lands controlled by the mining companies. How do you know how it's working unless you can test it? There have not been adequate definitive studies of just what the impacts of what the Viburnum Trend mining has been on the environment.⁶⁰

Lead mining companies are required by state law to reclaim all of the mining and milling complexes. This includes the removal of all structures at the sites and the containment of all possible pollutants. According to John Carter, the Missouri Department of Natural Resources requires the mining companies to monitor the "reclaimed" sites indefinitely. Although it may not be necessary in every case, such actions by the state government point to the permanence of some effects of the mining operations. In the end, this is the prescription for all of the mining operations in the Viburnum Trend. This is reasonable because many of the most serious problems associated with lead mining, such as the contamination of water resources, are not quick to develop.

Tom Aley elaborated,

It may be that while the mining is there and you are keeping the mine dewatered, and you are able to handle the problems that occur, you don't have great problems. Many of the problems in former mining areas really accrue after the mineral has been removed and the mining companies have gone.⁶¹

What environmental problems lie ahead for the Viburnum Trend remain to be seen.

⁶⁰Aley.

⁶¹Ibid.

4) Future of the Trend

All mining operations are developed with the realization that they will one day come to an end. The quantity of galena in the trend, regardless of how large, is finite. The quantity of remaining ore determines the future of mining in the Viburnum Trend.

In nearly every case, mineral development results in a boom and bust cycle for the local economy that may play out over years or decades. The severity of the crash depends on how gradual the decline is and the profitability of the operation. Although the mineral industry is more aware of local concerns now than previously, with any nonrenewable resource the bust is inevitable. Any number of towns in the Ozarks can be cited as examples of this phenomenon. Virtually all of the mining towns in the Old Lead Belt and Tri-State District have undergone this process. ASARCO constructed its West Fork mine in 1980 with the idea that it would come into full production in 1984 and operate until sometime around the year 2000.⁶² Developing a lead mine that will employ 170 workers at its peak for sixteen years of production hardly constitutes a long-term investment in the community.

The end of mining in the Viburnum Trend may come fairly soon. Predictions conclude that production will remain reasonably high until the beginning of the next century when a rapid decline will occur. Known reserves of lead have been depleted further every year for the past several years. This indicates that the Missouri mining companies have produced more than what

⁶²"New Lead Mine Planned Southwest of St.Louis." St.Louis Post Dispatch. (March 6, 1980), E1.

they have discovered for several years. What this means for the operations in the Viburnum Trend is that they have probably begun a final period of decline. At the beginning of 1991, Doe Run Company cut production and staff by twenty-five percent.⁶³ This is either in response to a weak market for lead or a depleted reserve base. Both factors are partially to blame.

St. Joe Mineral Corporation, now Doe Run Company, essentially constructed the town of Viburnum at the north end of the trend. Roads, houses, sewer systems, even the local golf course were built by the mining company to accommodate the mine and mill workers and their families. Although the company has set up committees to deal with the unavoidable closure of the mines, there will be little that the area residents can do to maintain the community infrastructure when the mines are gone. The town of Viburnum lost a substantial portion of its population during the 1980s indirectly due to reduced production.⁶⁴

Doe Run has begun to plan for the end as well. It is not in the nature of corporations such as Doe Run to dismantle when their reserves are totally depleted. Such companies are constantly searching for new sources of raw materials. Doe Run's search has taken the company deeper into more sparsely populated areas of the Missouri Ozarks, southwest of the Salem-Potosi District of the MTNF and into the Eleven Point-Doniphan Districts.

⁶³Carter.

⁶⁴Ibid.

"It has been said that Missouri is a state built on a foundation of lead."⁶⁵

The presence of high-grade lead ore in the Ozark region was a major factor in the settlement of the state. Successful exploration has kept reserves from being totally depleted and has allowed lead mining to remain important to the state's economy throughout its entire history. The mining industry is tied to the heritage of the Missouri Ozarks. These are not reasons enough, however, to allow yet another wild area of the Ozark Highland to be degraded for a short-term economic gain.

⁶⁵Missouri Department of Natural Resources. "Missouri: Premier Lead Producer of the World." Information Sheet #22. (Jefferson City, Missouri: MDNR, revised 1988).

IV. THE PRESENCE OF LEAD IN THE BIG SPRINGS REGION

1. Exploration

In 1981, no fewer than fourteen mining companies began exploring in and around the Big Springs area for new deposits of lead.⁶⁶ According to a 1980 St.Louis Post Dispatch article, "Small, truck-mounted drilling rigs are operating in tiny clearings that dot the woods at irregular intervals across a broad curving area covering parts of Shannon, Oregon, Carter, Reynolds, Wayne, Ripley and Butler counties."⁶⁷ Between 1980 and 1988, at least 250 core holes were drilled in the region.⁶⁸ This heightened level of exploration was undoubtedly set off by a U.S. Geological Survey (USGS) study, done in cooperation with the Missouri Department of Natural Resources' (MDNR) Division of Geology and Land Survey. The objective of their research, begun in 1977, was to appraise "the mineral-resource potential of the Rolla quadrangle." The agencies' 1980 report, "A Possible Favorable Belt for Mineral Discovery in Subsurface Cambrian Rocks in Southern Missouri," shows a high probability of the existence of a rich trend of Galena, similar to the deposits found in the Viburnum Trend.⁶⁹

⁶⁶Robert Goodrich. "Getting the Lead Out: Missouri Exploration Expands." St.Louis Post Dispatch. (August 31, 1980), J1.

⁶⁷*ibid.*

⁶⁸Forest Service, U.S. Department of Agriculture and Bureau of Land Management, U.S. Department of the Interior. Draft Environmental Impact Statement Summary: Hardrock Mineral Leasing, Mark Twain National Forest, Missouri. (Washington, D.C.: GPO, 1987), 1.

⁶⁹U.S. Geological Survey, U.S. Department of the Interior. "A Possible Favorable Belt for Mineral Discovery in Subsurface Cambrian Rocks in Southern Missouri." (Open-file Report 80-1000, 1980), 2.

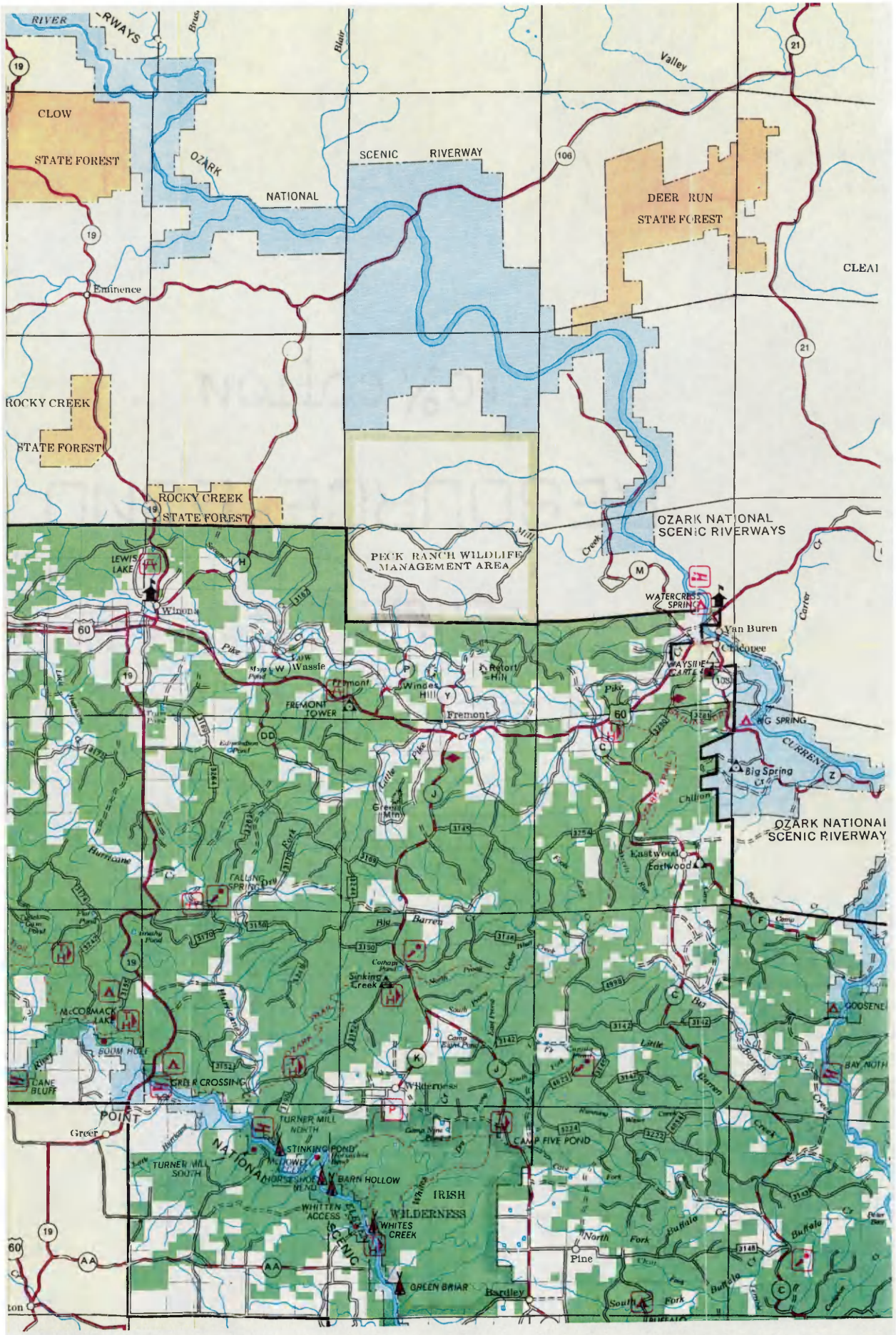
2. Proposals to Mine the Irish Wilderness

An intact 30,000 acre area of the Irish Wilderness adjacent to the Eleven Point River in Oregon County was of specific interest to mining companies. (Fig. 5) The historic Irish Wilderness, named for a failed pre-Civil War settlement of Irish families from St.Louis, covers over 300,000 acres in the southern Big Springs region.⁷⁰ As many as twenty companies originally expressed interest in developing the area.⁷¹ The Forest Service seemed eager to allow as much exploratory drilling as necessary to prove or disprove the existence of an economically recoverable amount of lead in the area. The argument of some proponents of mining was that deep underground mining was compatible with wilderness preservation; others argued that favoring preservation over jobs would be a foolish trade off. These arguments paint a picture of mining with no compromise of environmental quality and a substantial boost to the local economy through the creation of hundreds of jobs. Such arguments give no regard to the benefits of preservation. They do not take into account the possible disruptions to the area's strong service sector of the economy, centered on tourism, if environmental quality is sacrificed. Finally, a substantial increase in jobs for local residents is not guaranteed. Many times workers for new mining operations are imported from other areas because

⁷⁰Much of the original Irish Wilderness has sustained heavy timber harvest and is currently roaded. Several large areas of the historic wilderness remain entirely undeveloped, however. Some of these areas have been ignored by the timber industry for decades and have the appearance of virgin wilderness.

⁷¹Goodrich, J4.

Figure 5. Map of land ownership and land use in the Eleven Point area.
(Green - Forest Service land, White - Private land)
(Source: Forest Service, U.S. Department of Agriculture. "Mark Twain
National Forest Map." Washington, D.C.: GPO, 1989.)



much of the work requires specific skills that most local residents would not have.

In response to the situation, the major environmental groups in the state formed the Missouri Wilderness Coalition to defeat a St. Joe Minerals Corporation proposal for exploratory drilling in the Irish Wilderness.⁷² According to a 1981 editorial in the St. Louis Post Dispatch,

Prospecting isn't something that is done in a day or two: In the Viburnum Trend lead belt 40 miles east of the Irish, it took 10 years of drilling before miners hit a pay hole. In fact, digging enough to disprove the presence of lead might in itself destroy the wilderness. If the Forest Service is serious about preservation, it should say No to the miners."⁷³

In the end the coalition succeeded. In 1983, after a battle between local congressmen, the mining companies, the Forest Service, local residents, and environmental groups, a 17,000 acre portion of the historic wilderness in Oregon County entered the federal Wilderness Preservation System as the Irish Wilderness. Although the original wilderness proposal was reduced from 30,000 acres to 17,000, it halted the exploratory process in one of the most remote portions of the area. The issue of mineral production in the Eleven Point and Doniphan Districts of the MTNF did not end with the designation of the Irish Wilderness, however.

⁷²Jon Sawyer. "Lead Boom Worries Conservationists." St. Louis Post Dispatch. (February 9, 1981), A6: Christopher Carey. "Lead Industry Sees Better Times." St. Louis Post Dispatch. (November 20, 1980), E1. St. Joe Minerals Corporation was restructured in a joint venture by the Flour Corporation and Homestake Mining to form the Doe Run Company.

⁷³"A Threat To Wilderness." St. Louis Post Dispatch. (February 11, 1981), A14.

3. Doe Run Continues to Seek Drilling Rights

In 1983, U.S. Steel (USX) filed two Preference Right Lease Applications with the BLM and the Forest Service for development of mineral resources in the MTNF west of the formally protected portion of the Irish Wilderness. Doe Run Company subsequently bought USX and continued to pursue the leases.⁷⁴ The Forest Service and BLM originally planned to do an environmental assessment (EA) to determine whether to grant the leases, but the analysis area was expanded "to encompass anticipated future mineral leasing activities" and because of "the fact that mining had not previously occurred in this portion of the Forest and the high degree of public concern."⁷⁵ (Fig. 6) The governmental agencies abandoned their plan to do an EA and set out to complete a comprehensive environmental impact statement (EIS). The controversial document was published in 1988.

4. The EIS Study Area

The study area for the EIS, which is ninety-eight percent forested, encompasses a large portion of northern Oregon county, southern Shannon county, and portions of Ripley and Carter counties.⁷⁶ Local communities in and around the area include Winona, Alton, Birch Tree, Greer, Van Buren, Wilderness, Thomasville, and Doniphan (Fig. 7). Although more than three

⁷⁴Forest Service, DEIS Summary, I. The Doe Run Company bought all the assets of U.S. Steel soon after USX filed the PRLAs for the Eleven Point District of the MTNF.

⁷⁵Forest Service, DEIS.

⁷⁶Ibid, 44.

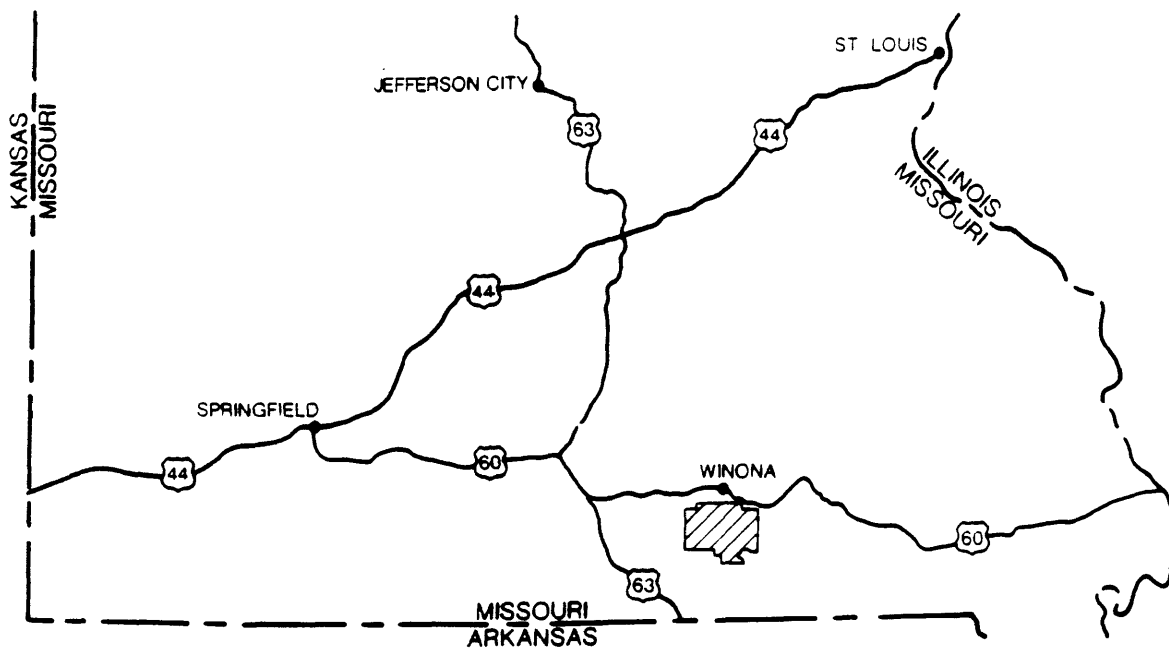


Figure 6. Locator map of the EIS study area. (Source: Forest Service, U.S. Department of Agriculture, Bureau of Land Management, U.S. Department of the Interior. Draft Environmental Impact Statement: Hardrock Mineral Leasing, Mark Twain National Forest - Missouri. Washington, D.C.: GPO, 1988.)

Figure 7. Topographic map of the EIS study area. (Source: Geological Survey, U.S. Department of the Interior. "Poplar Bluff, Missouri; Arkansas." 1:250,000-scale topographic map, USGS: Reston, Virginia, 1979.)



fourths of the area is now in the public trust, the region was at one time entirely privately owned.⁷⁷ The actual Preference Right Lease Application (PRLA) area encompasses 3700 acres of contiguous Mark Twain National Forest land with the southern boundary lying approximately two miles north of the Eleven Point National Scenic River. State highway 19, noted as one of Missouri's most scenic drives, traverses the eastern edge of the area. At least eighteen springs of various sizes and including the state's second largest, are within five miles of the application area.⁷⁸ Tupelo Gum Pond (a rare natural community similar to Cupola Pond) lies barely a mile from the western fringe of the application area and Brushy Pond, including a rare upland plant community, is within the PRLA area.

5. The Draft Environmental Impact Statement: An Overview of Strategies, Findings and Recommendations

The Draft Environmental Impact Statement (DEIS) on Hardrock Mineral Leasing in the MTNF lists several alternatives for forest plan modifications that would be necessary if the Forest Service and BLM permitted mining in the forest. Each alternative states that the type of development would be similar to that in the Viburnum Trend. Acceptance of any of the alternatives amounts to changing the predetermined purpose of the forest district to suit the needs of the Doe Run Company.

⁷⁷Ibid., 43.

⁷⁸Forest Service, U.S. Department of Agriculture. "Mark Twain National Forest (Eleven Point - Doniphan Ranger Districts)." Forest Service Map, (Washington, D.C.: GPO, 1991).

The alternatives listed in the DEIS include various scenarios of action from "no lease" to "high development." Under the "high development" scenario, the Forest Service assumes that "sufficient mineralization is present to develop eight mines within the study area." Under this level of development at least 4000 core holes and forty vent shafts in addition to mine/mill facilities, numerous tailings impoundments, roads, powerline corridors, and other structures would be necessary.⁷⁹ All of the alternatives except alternative A would allow some level of mining depending on the quantity of ore discovered in the region. The other alternatives differ only in varying levels of mitigation for "visual quality." Only alternative C, which could potentially make mining economically unfeasible, does not require a substantial modification of the forest plan.

Included in the DEIS is a description of all possible environmental problems that could occur if mining is allowed in the district and how they would be mitigated. Below is a partial listing of findings in the DEIS relating to potential environmental destruction in the event the leases were granted:

- 1) Soil erosion: from woods roads, haul roads, core hole areas, tailings ponds, and mine/mill sites.
- 2) Reduced soil productivity from heavy metal contamination: sources include dust, tailings leakage, vent shaft exhaust, and drilling effluent sewage.
- 3) Contamination of surface water and groundwater: from drilling effluent sedimentation, sanitary sewage, tailings, heavy metals, milling reagents, petroleum products, tailings impoundment failure, alteration of flows, and lowering of groundwater levels.
- 4) Adverse affects on wetlands and floodplains: from unintentional drainage from core holes, alteration of recharge and discharge,

⁷⁹Forest Service, DEIS, 14.

contamination from heavy metals, and reduction of habitat diversity.

- 5) Degraded air quality: from dust and fumes, "road and site clearing, vehicular traffic, and mine/mill emissions.
- 6) Degraded visual quality:
 - a) Forest openings: including drill sites, vent shaft clearings, mine/mill sites, dewatering ponds, and tailings impoundments
 - b) Forest corridors: including transmission line rights-of-way, pipelines, and roads.
 - c) Structures: including mine/mill facilities, dams and transmission line supports.
- 7) Destruction of archaeological sites
- 8) Deterioration of ecologically and nationally significant areas: including Eleven Point River, Ozark National Scenic Riverways, Cupola Pond, Tupelo Gum Pond, Brushy Pond, The Sinks, Sinkin Creek, Greer Spring, Irish Wilderness, and Burr Oak Basin.
- 9) Degradation of recreational quality
- 10) Threats to endangered and rare animal and plant species
- 11) Destruction and alteration of habitat
- 12) Destruction of unknown cave systems and other karst features
- 13) Reduction of bat populations
- 14) Heavy metal contamination of cave ecosystems
- 15) Population decline of aquatic species
- 16) Bioaccumulation of heavy metals in aquatic life.⁸⁰

The EIS dismisses most of these potential effects in the presence of mitigative measures. The DEIS concludes,

⁸⁰Ibid, 65-100.

Implementation of Alternative B would result in changes to the physical and biological environment by a reduction in soil productivity: the possible decline in subsurface water levels; a loss of floodplains or wetlands; an increase in particulates released to the atmosphere; the possible disruption of historic or archeologic sites; the loss or degradation of special areas; the removal of vegetation; and disruption of existing lifestyles and social values. Although such changes will occur, the effects will be eliminated or reduced to an acceptable level through the use of mitigating measures.⁸¹

Even in the unlikely event that many of the harmful effects were eliminated, the outright destruction of over 3000 acres in the area and alteration of many more, could not be mitigated. Landscape destruction would not consist of 3000 contiguous acres. The decimation would be distributed throughout the Big Springs region, further fragmenting the forest. Large contiguous tracts of undeveloped land are already rare in the area. Development for mineral production would make such existing areas smaller and fewer. In addition, the construction of tailings impoundments constitutes permanent changes to the landscape. Construction of haul roads and woods roads, ventilation shafts, and other structures are semi-permanent landscape alterations of which reclamation will take decades after mining is completed. Reclamation of many of the disturbed areas may not even be the intent of the governmental agencies responsible for granting mining leases. According to the Forest Service's DEIS, under the high development scenario,

Over 3000 acres of National Forest land would be used for impoundments, structures, roads, powerlines, vent shafts and drillsites. With the exception of the ventshafts and drillsites most of these improvements would probably remain beyond the life of the mines. They would become a part of the area's infrastructure.⁸²

⁸¹ Ibid, 24-25.

⁸² Ibid., 122.

Only 800 acres of developed land could be reclaimed according to the DEIS, but not even all of those 800 acres would be reclaimed since much of that would consist of gravel roads which the Forest Service generally perceives as improvements in the national forests.

Increased soil erosion, reduced soil productivity, degraded "visual quality," diminished water quality, and curtailed air quality from many different sources would be unavoidable if the area is developed in the Viburnum Trend style. All the remaining environmental consequences listed are potential effects, with the degree of each depending on many factors including the scale of the new mining operation. Although the Forest Service maintains that the serious effects of mineral development could be handled through the use of mitigative measures, the prospect is entirely unlikely given the severity of the potential impacts.

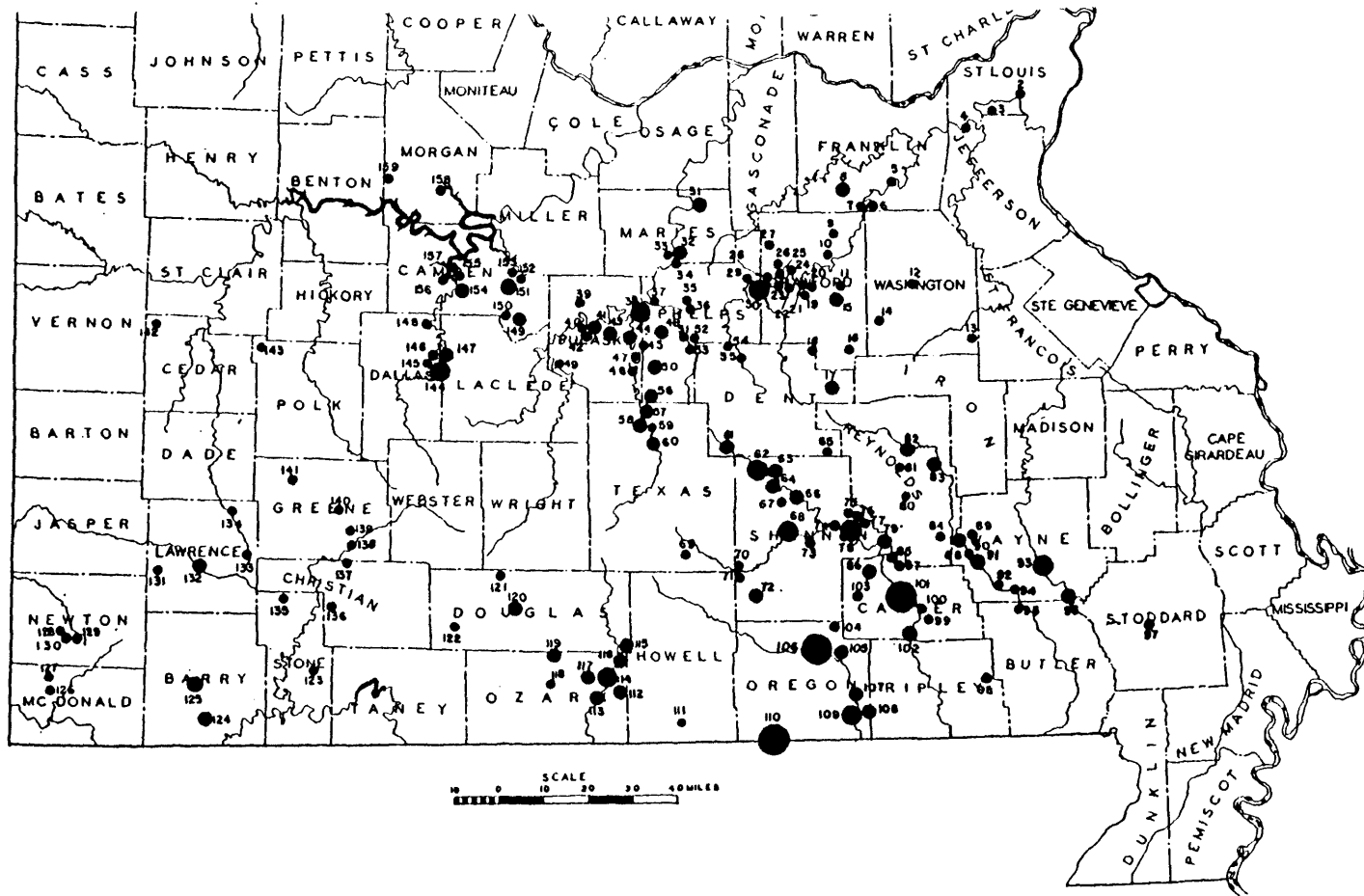
6. Threats to Water Quality

Because of the geological situation of the Big Springs region, water quality is much more sensitive to disturbances such as mineral production than that of the Viburnum Trend. This is because "major springs drain the proposed new area whereas mining sites in the Viburnum Trend area are not in the middle of important recharge areas for springs."⁸³ Springs, which are scattered liberally throughout the area, reveal the interconnection between the subsurface water supplies and the creeks and rivers on the surface. (Fig. 8) The contamination of a single spring, sinkhole, or disappearing stream could

⁸³Aley.

Figure 8. Map illustrating the size and location of major springs in the region.
(Source: H.C. Beckman and N.S. Hinchey. The Large Springs of Missouri. Jefferson City, Missouri: Mid-State Printing Company, 1944.)

- 1-6 Million Gallons/Day
- 6-50 Million Gallons/Day (Approx.)
- 50-226 Million Gallons/Day (Approx.)
- 226+ Million Gallons/Day



lead to the contamination of many other outlets and the creeks and rivers they feed.

Water resource contamination is among the most serious of the threats of hardrock mining in the area. The DEIS does not clearly distinguish the potential level of contamination. According to Tom Aley, the DEIS "is riddled with errors. The report's writers are ignorant of the vulnerability of ground water in the region to pollution from the mines and tailings ponds."⁸⁴

Moreover, the only detailed hydrological studies in the region were done twenty or more years ago. The Hurricane Creek study, according to its author, is outdated and is one of the very few in depth hydrologic studies that have been done in the area. Tom Aley stated that today's methods of hydrological analysis are far superior to the type used on the Hurricane Creek study.⁸⁵ The updated methods should be used in a thorough hydrological analysis throughout the region before a decision is made in favor of mining.

Perhaps the most significant threat to water quality is the construction of tailings impoundments. The DEIS mentions the uncertainty of the stability of tailings areas. Revegetating tailings impoundments may be of limited success over the long term. The material is not soil and does not contain those elements of soil that support a natural nutrient recycling system which sustains vegetation. If not successfully vegetated and reestablished, tailings could well serve as a continual source of sediment to streams and, perhaps, subterranean drainages.⁸⁶

⁸⁴Christine Bertelson. "Ozark Plan for Mining is Hot Issue." St. Louis Post Dispatch. (March 7, 1988), A7.

⁸⁵Tom Aley is nationally certified in groundwater hydrology.

⁸⁶Forest Service, DEIS, 66.

There is also the potential for any source of mine waste to contaminate an uncommon feature of the Ozark landscape; wetlands. Because wetlands are so rare in the area, they are very important to overall habitat diversity. The DEIS briefly explains that there is the potential that they could be drained either intentionally or unintentionally. The DEIS does not acknowledge that the result would be disastrous to regional species diversity. These and other threats to the water quality of the region from hardrock mining has been one of the major concerns of both state and federal agencies and local environmental groups.

7. Threats to Scenic Qualities

Another major issue of concern is the scenic nature of the area. Although the Forest Service maintains that disruptions to visual quality can be avoided by placing structures and other surface disturbances away from major travel routes, that is not really mitigation. What the Forest Service calls mitigation amounts to maintaining visual quality from the vistas of paved highways. According to the DEIS, "The least potential for effects on landscape changes would be under Alternative C. This alternative would not allow powerlines or tailings to be constructed in visually sensitive areas, comprising a significant portion of the study area."⁸⁷ Taken literally, this statement means that if landscape alterations are positioned away from "visually sensitive" locations, then the landscape alteration is less severe. Regardless of where tailings impoundments, roads, mine/mill facilities, and other disturbances are located, they still amount to the same landscape alteration. It is not mitigation of the landscape

⁸⁷Ibid., 114.

change to locate it somewhere else. The disturbance may be in a location where few people will notice it, or it may be in a location where there is a higher concentration of existing disturbances and it is assumed that the change will be perceived as less drastic.

It is possible that concentrating surface occupation sites near major roads, which constitute existing disturbances, would be more environmentally sound than otherwise. Dispersing more surface disturbances further out in the forest makes sense only if motor-vehicle travelers' perceptions are the only concern. The backcountry traveler would suffer more if degradation of visual quality on scenic highways is mitigated. In the DEIS and in the various forest plans, the Forest Service has shown an overwhelming preference for the concerns of motor-vehicle users and a blatant disregard for the users of semi-primitive and primitive areas of the forest.

The Forest Service lists non-motorized recreation as a small percentage of total recreation in the MTNF. This is not surprising for two reasons. First, approximately ninety percent of the forest is open to motorized recreation and less than five percent is marked specifically for non-motorized recreation.⁸⁸ Second, although only a small percentage of the forest is devoted to primitive (non-motorized) recreation, more primitive recreation likely takes place than the available data suggests. In many visits to the several of the Federal Wilderness Areas in Missouri there were no registers at trail heads. There is no record keeping mechanism for canoe trips on the Current, Eleven Point, and Jack's Fork Rivers. Finally, there is virtually no accurate data on primitive

⁸⁸Tim Renken. "Forest Service Road Plan is Heated Topic in the Ozarks." St. Louis Post Dispatch (March 18, 1988), 4D.

recreation in areas open to motorized recreation. The Park Service and Forest Service could easily keep records that illustrate the significance of backcountry and primitive forest usage. They simply do not.

Because of faulty assumptions about how visual quality would be best protected, the DEIS leads the reader to believe that locating surface disturbances in the backcountry and sheltering travelers on major routes equates to mitigation of the disturbance. These assumptions manifest themselves from an agency bias toward more destructive types of recreation and other forest uses. These types of uses are not necessarily the most popular activities on the MTNF.

8. Threats to Rare and Endangered Species

The Endangered Species Act (ESA) forbids any federal agency from knowingly allowing the destruction or degradation of any listed species habitat. There are at least thirteen rare plants in the area and eighteen in the ONSR system.⁸⁹ In addition, no fewer than thirty-four rare animal species in the ONSR and twenty-one in the study area.⁹⁰

The potential exists, however improbable, that no listed species habitat would be destroyed outright. Still, the likelihood is slim that no habitat would be degraded given the sensitivity of some species to disturbance. The Nature Conservancy initiated its recent land purchase in the area because of the presence of an exceptionally high number of rare species. The Conservancy believes there to be at least forty-five rare and endangered animals and eighty

⁸⁹Forest Service, DEIS, 45.

⁹⁰*Ibid.*, 50.

endangered plants in the purchase area.⁹¹ Unlike the rare plants in the Tupelo Gum Pond, which are confined entirely within the boundaries of the sinkhole, the habitat boundaries for many of these rare species are not easily determined. Some exist on tiny pieces of ground throughout the region, while others, such as the Black Bear, are wide ranging, utilizing a variety of habitat types.

The presence of the Eastern Cougar has not been confirmed in the study area, but it is known to exist in adjacent counties to the south in Arkansas. There have also been reliable sightings north of the study area in the ONSR. The probability exists that the species uses portions of the area on a temporary basis. The DEIS acknowledges that the study area is suitable for reintroduction of the species. The Black Bear is also extremely rare in the area. Both of these species need large areas of relatively undisturbed land to survive. Although bears can adapt better to human presence than cougars, mining operations might be enough to force them from the area.

The eleven species of bats in the study area are extremely sensitive to disturbance. Two of the eleven species, the Indiana and Gray Bats, are federally protected as endangered. The Gray Bat has been recorded in three caves in the study area and two adjacent to it. The Indiana Bat is known to reside at nine locations near the study area. Nearly one half of the entire world population of Indiana Bats winter in this region of Missouri.⁹² Given the high concentration of rare and endangered species in the area, mineral development will likely adversely affect some species and their associated habitat.

⁹¹Carol Kiel. "Real Estate Deal will Create Parks in Ozark Forests." Columbia Missourian. (December 20, 1991), 9A.

⁹²Forest Service, DEIS, 49.

9. Economic and Social Impacts of Mineral Development

In addition to the potential and probable adverse environmental impacts of mineral development, there would be distinct economic and social impacts of mining as well. The DEIS states that "there would be no unavoidable adverse effects on jobs or economy. The lifestyle of some area residents could change. Some people would perceive these changes to be negative."⁹³ The people whose lifestyles changed without their consent because of mineral production would undoubtedly perceive the change as negative. The most significant effects on the local economy would occur after mining ceases, which would not necessarily be more than two decades into the future. More immediately, because the character of the region will be altered by mining, the potential for damage to the tourism industry is extraordinarily high. A loss of jobs in the service sector of the economy would occur.

Further, mining does not always deliver the number of jobs originally promised. Iron County, Missouri, for example, boasted a twelve percent unemployment rate in 1988.⁹⁴ Iron county currently has several mines and a smelter operating within its borders and several more are located in adjacent counties. In 1983, when mining in the wild 17,000 acre section of the Irish Wilderness was at issue, a St.Louis Post Dispatch editorial suggested it is "crazy" to believe,

St. Joe Lead will create thousands of jobs in Oregon County. This is the same company that recently created thousands of

⁹³Ibid., 120.

⁹⁴Christine Bertelson. "Firm Plans Plant for Recycling." St.Louis Post Dispatch. (December 21, 1988), A1.

unemployed in Washington County, when it 'un-unionized' and mechanized its operations there. Right now, today, Washington County has one of the highest unemployment rates in the nation while St. Joe is operating at full capacity.⁹⁵

Many of the tasks required of mining personnel are highly technical. Many of the area residents undoubtedly do not have the training to fill such positions. Such skilled labor positions will be filled by workers imported to the area. Also, if commencement of production in the new area coincides with the final stage of decline in the Viburnum Trend, many of the Viburnum Trend workers would possibly be transplanted to the Eleven Point area. A Doe Run Company official admitted this probability in a 1988 newspaper article.⁹⁶

Historically, opponents of mineral development have based their arguments in environmental themes. The environment of the region is clearly sensitive to hardrock mineral development, but the local economy is also threatened by development. Extractive industry in the Big Springs region has already caused serious long-term economic effects. At the end of the "lumber era" the Ozark Highland was left with a seriously depleted resource base and a relatively high population. In order to sustain the population, the resource base was depleted further through open range grazing and farming on cutover land. In 1903 the population of Winona, Missouri was two and a half times its current population.⁹⁷ If the economic base of the region, currently dominated by the tourism industry, is expanded to include substantial lead mining operations, a similar boom and bust cycle will likely develop in the region.

⁹⁵Emily Horton. "Mining the Irish." St.Louis Post Dispatch (May 23, 1983), A10.

⁹⁶Bertelson. "Ozark Plan For Mining is Hot Issue." A7.

⁹⁷Rafferty, 184-185.

The population of towns in the Viburnum Trend have fluctuated in size with the stability of the lead mining operations. John Carter, environmental manager for the Doe Run Company, also sits on a planning board for the City of Viburnum. He stated that the town had lost nearly ten percent of its population between 1980 and 1990 as mineral production from the Viburnum Trend decreased.⁹⁸ The Forest Service noted in its DEIS that there would be long-term social/economic consequences of mining in the region. "There would be a sudden loss of jobs and revenues. This could strain the community structure. Local businesses that expanded or began as a result of mining operations could also face long term economic hardship."⁹⁹ This is definitely understated, but to the point nonetheless.

The argument often posed by local residents that mining would greatly increase royalties to the county governments and school systems is erroneous. Such arguments were omitted in the DEIS for good reason. Royalties from mining operations in the national forest are "allocated to a county according to the percentage" of its land located in the national forest as a whole, not the amount of minerals mined in that particular county.¹⁰⁰ A portion of Callaway County, for instance, is included in the Cedar Creek Purchase Unit, but no mining occurs there. The county still receives its determined percentage of mineral royalties from mining operations elsewhere in the forest. Wilderness preservation or protection of other qualities in a particular county does not

⁹⁸Carter.

⁹⁹Forest Service, DEIS, 122.

¹⁰⁰Harper Barnes. "Wanted: Irish Wilderness: 'Just the Way it is.'" St. Louis Post Dispatch. (June 21, 1983), D4.

diminish the percentage of royalties the county receives because its percentage of land in the national forest remains the same. In addition, the counties also receive Payments in Lieu of Taxes (PLTs) which increase as revenues from extractive industry such as mining or timber production decrease. When mining in the Viburnum Trend declines, PLTs will increase to all counties with land in the MTNF.¹⁰¹

Tom Aley elaborated on the long-term economic perspectives of mineral development.

The mines come in and they last for ten years. You have to build an infrastructure that you pay off for thirty or forty years. Just because the mining companies have moved away the lender doesn't say, 'OK, you don't have to pay the last three-quarters of what you owe.'¹⁰²

Once local communities begin the process of transformation to compensate for the influx of new residents, they are committed to maintaining the enlarged infrastructure. The communities will be responsible indefinitely for maintaining roads, sewer systems, schools, and other public works. The responsibility to care for the expanded infrastructure will not diminish when the mine workers and their families inevitably leave the area. In addition, impacts on the local environment, such as leaching of heavy metals and pollution of surface and groundwater, contribute another problem that will strain the communities economically.

Although mining might generate a short-term economic boom for the area, depending on the immediate impacts to tourism, mineral development presents a long-term economic liability to the area. The idea that the protection

¹⁰¹Ibid.

¹⁰²Aley.

of environmental quality is unrelated to the economics of the proposal is absolutely false. Mineral production would not only involve the sacrifice of many of the region's natural qualities, but inevitably the collapse of the social economic infrastructure as well.

10. Forest Service Grants Leases

The DEIS clearly outlines the potential for substantial environmental and economic disruptions in the area if mineral leases were granted. Public sentiment overwhelmingly opposes the mining proposal. Over eighty percent of comments received by the Forest Service in response to the DEIS was from people expressing strong reservations about the development of lead mines in the region.¹⁰³ The EPA, United States Fish and Wildlife Service, United States Park Service, Missouri Department of Natural Resources (MDNR), and the Missouri Department of Conservation (MDC) all opposed Doe Run's mining proposal. Despite public sentiment, the documented consequences of mining, and the opposition of several other government agencies, the Forest Service and BLM granted Doe Run the two leases conveying the right to drill.¹⁰⁴ The Final Environmental Impact Statement indicates,

The proposed decision is to offer leases to the Doe Run Company for the two pending Preference Right Lease Applications (PRLAs)-ES-19219 and ES-19220. The leases will contain a stipulation, among others, which will deny Doe Run the right to

¹⁰³Bertelson. "Couple Threatened over Opposition to Lead Mining in Ozarks," 8A.

¹⁰⁴Marjorie Mandel. "U.S. Weighs Mining Bid in Twain Forest." St. Louis Post Dispatch (August 24, 1986), C1; Christine Bertelson. "Couple Threatened Over Opposition to Lead Mining in Ozarks." St. Louis Post Dispatch (July 11, 1988), 8A.

develop the leases but conveys the right for further exploration and developmental drilling.¹⁰⁵

Mineral development in the MTNF is regulated under the Mineral Leasing Act of 1920. The law has often been "interpreted as requiring the granting of leases regardless of other concerns."¹⁰⁶ Such interpretations would make it difficult for the Forest Service to enforce its "no guaranteed development" stipulation. Under the law, "'preference right leases' are issued to holders of prospecting permits who demonstrate the discovery of a valuable deposit of a hardrock mineral(s) under the permit."¹⁰⁷ The federal government rarely denies the leasee the right to develop once a lease has been granted.¹⁰⁸ The quantity of lead discovered, rather than potential environmental damage, appears to determine the level of development allowed within the area. The DEIS states, "Those resources discovered and economically producible would be irreversibly committed to development."¹⁰⁹ Clearly, the "no guaranteed development"

¹⁰⁵Forest Service, U.S. Department of Agriculture and Bureau of Land Management, U.S. Department of the Interior. Final Environmental Impact Statement: Hardrock Mineral Leasing Mark Twain National Forest, Missouri. (Washington, D.C.: GPO, 1988), 5.

¹⁰⁶Caroline Pufalt. "Senators Support Mining Scam." Ozark Sierran 23 (November/December 1991), 4.

¹⁰⁷Forest Service; DEIS, appendix 2-1.

¹⁰⁸Charles F. Wilkinson and H. Michael Anderson. Land and Resource Planning in the National Forests. (Washington, D.C.: Island Press, 1987), 260:

Forest Service implementation of the regulations has been somewhat tentative. Many district rangers are still uncertain about their authority, partly because the Forest Service Manual does not generally allow rejection of operating plans.

¹⁰⁹Ibid., 121.

stipulation does not offer the Forest Service enough latitude in denying mineral production.

The problems associated with any type of surface disturbance cannot be adequately addressed until specific locations are known. The MDNR, which scolded the Forest Service and BLM for "sloppy research," was a vocal critic of the EIS. "The department called the Forest Service's EIS 'highly generalized and of extremely limited value,' adding, 'You can't comment on the environmental impact...without knowing exactly where and what mining activities are proposed.'"¹¹⁰ The alternatives discussed in the DEIS could not possibly address Doe Run's two lease applications because they include no mining plan.

Analysis of the potential impacts of hardrock mineral production is useless because operation sites have not yet been determined. This is mentioned in the DEIS itself. "Since it is unknown exactly where a mine/mill facility might be located, the significance of such landscape changes on land character are difficult to assess."¹¹¹ Further, "the siting of conventional tailings impoundments in the study area is of major concern due to the presence of karst topography. Studies have not yet been conducted within the area to determine the potential for suitable sites."¹¹² The decision to grant leases is absolutely unreasonable given that the agencies concluded their research before studies could be completed to determine environmental consequences on issues of "major concern". The reason for undertaking an EIS is to determine the consequences of such actions. According to federal law, the Forest Service cannot issue a lease

¹¹⁰Bertelson. "OSHA Fines Won't Affect Mine Ruling," A7.

¹¹¹Forest Service; DEIS, 114.

¹¹²Ibid., 12.

until it clearly shows that "surface uses will not be compromised."¹¹³ Because the studies necessary to confirm that surface uses would not be compromised had not been done prior to issuing the leases to the Doe Run Company, the decision is in violation of the National Environmental Policy Act (NEPA).¹¹⁴

The DEIS also assumes that the proposed mining would consist of Viburnum Trend style operations. This may or may not be an accurate assumption. According to Tom Aley, the long-term environmental impacts of the Viburnum Trend operations are not yet known since the mines there have not been operating all that long and none have permanently shut down or been "reclaimed." Using the Viburnum Trend for a model as the EIS often does is not necessarily a good argument for allowing mining in the Eleven Point area.

We can look at other lead mining areas, the Old Lead Belt and the Tri-State District. There were indeed differences in the deposits, but whether the new activities will make any difference remains to be studied. It is easy to say, "Well, yeah the old ones caused problems, but we're doing it differently." I don't think we've had objective investigations that say that's valid and we won't have these problems in the future.¹¹⁵

The Forest Service did not conduct the many studies necessary to determine the probable effects of mining in the region. In addition, Doe Run Company's mineral development proposal included no mine plan. Given these gross inadequacies in the DEIS, the Forest Service decision to issue drilling permits is rash and perhaps illegal. On the basis of this information, several regional environmental groups appealed the decision.

¹¹³Ibid., appendix 2-1.

¹¹⁴The National Environmental Policy Act regulates the procedures for the decision making process on public lands.

¹¹⁵Aley.

11. Decision to Grant Leases Appealed

Appeals were filed by the Missouri chapter of the Sierra Club, the Coalition for the Environment, Committee for a Lead-Free Ozarks, and one individual. The appeals were based on the evidence presented in the DEIS that mining would cause irreparable environmental harm and that the federal agencies had not followed correct procedures outlined in the NEPA. In addition, the agencies decision to grant leases with the "no guaranteed development" stipulation was not among the alternatives listed in the EIS.¹¹⁶ In April of 1990, Larry Hensen, Associate Deputy Chief of the Forest Service remanded the original decision, although the appeals were not granted. Hensen maintained, because the leases would give Doe Run the right to develop if a valuable deposit is discovered, the company must first submit a mine plan. The required plan would force Doe Run to give exact locations of all surface disturbing activities.¹¹⁷

Doe Run Company eventually submitted an operating plan for exploratory drilling. The BLM and Forest Service then completed an EA on ten to twenty core holes on 1580 acres in the PRLA area. In April of 1991 the federal agencies consented to the drilling.¹¹⁸ Two days prior to the announcement by

¹¹⁶Christine Bertelson. "Forest Drilling to be Appealed." St.Louis Post Dispatch (January 15, 1989), D5.

¹¹⁷Christine Bertelson. "Lead Company Denied Permit for Mark Twain Forest." St.Louis Post Dispatch (April 8, 1990), 6E.

¹¹⁸Jody Eberly, wildlife biologist in Eleven Point District, Mark Twain National Forest, phone conversation with author, April 1992: Tracy L. Barnett. "Forest Service Weighs Ozark Lead Drilling." Columbia Daily Tribune (March 14, 1991): Tom Uhlenbrock. "Doe Run to Drill in Forest." St.Louis Post Dispatch (April 11, 1991). B1.

the district ranger to allow the exploratory drilling, the Doe Run Company announced it would cut production and staff by twenty five percent each because of a weak market for lead.¹¹⁹ Doe Run's chief geologist, Harold Myers has stated that, "We don't want to spend any more money until we have assurances that we will be able to mine."¹²⁰ Still, the company is actively pursuing its "special use" permits to do the exploratory drilling necessary for the development of a mine plan. The company obtained "special use" permits under a BLM regulation allowing for the "collection of information" in national forests by private corporations. Although the exploratory drilling was to begin in the Fall of 1991, none has yet been done.¹²¹

Six appeals to the drilling were filed with the Forest Service, but were all dismissed. The Doe Run Company filed one of the six appeals to its own exploratory drilling permits. The corporation appealed on the grounds that the regulations governing its specific exploratory drilling were too strict. Regardless, the Forest Service sent a letter of consent to the BLM on March 12 of 1992. The BLM appeals period ends on April 17, 1992.¹²² A decision on the exploratory drilling plan is in the hands of the BLM.

Doe Run Company has no permit to develop a mine/mill operation, and the reclamation of core hole sites generally takes only a few years. Maintaining that the exploratory process is the first step to full-scale development,

¹¹⁹Uhlenbrock. "Doe Run To Drill in Forest," B1.

¹²⁰Bertelson. "OSHA Fines Won't Affect Mine Ruling," A7.

¹²¹Joe Wagner of Doe Run Company in St.Louis, phone conversation with author, November 1991.

¹²²Eberly.

however, most of the Missouri environmental groups adamantly oppose more exploration. In addition, the integrity of both the mining company and the federal agencies responsible for managing the uses of the national forests is continually in question.

V. MATTERS UNRESOLVED

1. Integrity of the Forest Service and Doe Run Company

The Forest Service has received nation-wide criticism for its preference for developmental programs over recreational and preservation programs that serve the general public. Timber sales have become a focal point for much of this criticism. According to Tim Bechtold, an Earth First! activist who keeps a close watch on Forest Service activities, "The Mark Twain forest is notorious for poor resource management."

A 1990 Sierra Club study blasted the agency for its preference to clearcutting in its timber sale programs. The regional office uses a computer planning program (FOREPLAN) to determine the correct "multiple uses" of the MTNF. Because Forest Service resource planners have assumed that clearcutting the forest benefits recreation (hunting), wildlife (increased forage), and timber stands, the computer program shows that 88 percent of the forest is suitable for clearcutting. This is the highest percentage for any eastern national forest.¹²³ The recommendations of FOREPLAN in this case have no scientific basis. Clearcutting in most of the Ozark Mountain region is ecologically damaging because of frequent steep slopes and unstable soil structure.¹²⁴ The agency's road building programs and preference for ATV-style recreation have also received sharp criticism.¹²⁵

¹²³Christine Bertelson. "Sierra Club Study Rips Forest Service." St. Louis Post-Dispatch (August 12, 1990), D3.

¹²⁴Gordon Robinson. The Forest and the Trees: A Guide to Excellent Forestry. (Washington, D.C.: Island Press, 1988), 93:

The forested areas in the Ozarks of Missouri and Arkansas tend to be steep and unstable, like those in much of the Pacific Northwest. Local

There are also good reasons for considering the ethical and environmental principles of the Doe Run Company. For example, in 1988, the company proposed buying the pristine Greer Spring tract along the Eleven Point River from conservationist Leo Drey and then trading it to the Forest Service for 2700 acres in the Indian Creek area near Viburnum. The company wanted to build a 700 acre tailings impoundment on Indian Creek. The 2700 acres is the center of a popular recreational area. Apparently the company believed that if they traded the Greer Spring tract to the agency, the public interest would be distracted from the tailings dump. Drey would not even talk to Doe Run about such an arrangement.¹²⁶

The company's smelter/refinery operations have also been cited for both environmental and health and safety violations. Doe Run was fined a total of \$1.25 million by the Occupational Safety and Health Administration (OSHA) for such violations in 1988 at its smelter in Herculaneum, Missouri. The fines were levied because the company failed to report worker injuries, exposed "workers to unsafe levels of lead," and because the company fired "some employees when their blood levels of lead became too high." The smelter was also the source of the nation's highest levels of airborne lead.¹²⁷

The Forest Service either failed to see or would not admit that there is a connection between the OSHA fines and the company's mining proposal. Soon

people have pointed out that after the roots of cut trees decay in an area previously clearcut, the mountain slopes tend to slide.

¹²⁵Renken, 4D.

¹²⁶Christine Bertelson. "Drey Refuses to Deal With Lead Company." St. Louis Post Dispatch (June 1, 1988), 10A.

¹²⁷Bertelson. "OSHA Fines Won't Affect Mine Ruling," 7A.

after the problems at Herculaneum became public, the Forest Service stated that the OSHA fines would have no bearing on the agency's decision to allow mining in the Eleven Point area.¹²⁸

The proposal to allow mining in the southern portion of the Big Springs region alone has cast doubt on the credibility of the Forest Service. The agency lacks a reasonable argument in favor of the proposal. The potential for environmental destruction is extremely high given the geologic setting of the region and its high density of rare natural communities. The region also displays more wild characteristics than any other in the Missouri Ozarks. Although several of the most significant areas are "protected" at various levels, none can survive as individual islands. Ecological processes are connected throughout the region as they are throughout the world. Disturbances to portions of the region will inevitably harm or destroy the "protected" areas.

2. Forest Service Strategy and Motivations

Although approximately three-fourths of the land mass of the region is in the public trust, most of it is far from being adequately protected. Much of the public lands suffer the consequences of extractive industry and road building as well as heavy recreational development such as RV parks and ATV-use areas. Because so much of the National Forest System is open to extractive industry, the small number of designated primitive areas are in a state of deterioration as a result of over-use. "The number of individuals seeking wilderness experience

¹²⁸*ibid.*

is at an all-time high. With the increasing number of wilderness users the resulting impact may seriously threaten the very values they seek."¹²⁹

The substantial economic benefits that the Forest Service maintains will follow mineral development are illusory. It is inevitable that a boom and bust cycle will result in a short-term economic gain for the region and a long-term decline to stagnation once the lead reserves are depleted. In addition, counties with operating mines in the state have unemployment and poverty rates at or above those of the proposed mining area. A 1988 newspaper article noted the essence of the opposition argument stating, "Environmental degradation is a poor trade-off for jobs that might never materialize."¹³⁰

In the future, the market for the region's refined lead may not exist. More than seventy-five percent of the nation's domestic lead production already is generated from recycled scrap.¹³¹ That figure is expected to increase dramatically. Recycling spent auto batteries and lead from other secondary sources is much more environmentally and economically sound than mining and smelting ore from primary sources. Recycling provides a cleaner and cheaper alternative than the traditional method of obtaining lead ores.¹³² Of the many uses of lead, there are economically viable substitutes for all of them except

¹²⁹Forest Service, U.S. Department of Agriculture. "Irish Wilderness Map." (Washington, D.C.: GPO, 1990).

¹³⁰Bertelson. "Ozark Plan For Mining is Hot Issue," A7.

¹³¹Lead Industries Association, Inc. "Lead: A Vital and Versatile Element." (New York: Lead Industries Association, Inc., 1990), 6.

¹³²Bertelson. "Firm Plans Plant for Recycling," A1.

lead-acid batteries.¹³³ Even here technology is advancing so that economically viable substitutes may soon be available. Most other uses of the element, such as gasoline additives, ammunition, and paint have steadily declined over the last several decades. When these factors are considered, the difficulty in determining what has motivated both the Forest Service and the Doe Run Company to pursue development so eagerly becomes apparent.

The reasoning behind the Forest Service's obvious preference toward mining in the region can only be explained as a result of political pressure or a matter of national security. A letter from Forest Service Chief Max Peterson in 1986 points directly to the political pressure exerted on Forest Service bureaucrats to allocate mineral resources to the private sector. Peterson stated,

Forest Service policy is to encourage, facilitate, and administer the orderly exploration, development, and production of mineral and energy resources on National Forest System lands to help meet the present and future needs of the nation.¹³⁴

Because the DEIS states clearly that the "no lease" option "would not result in a significant threat to the security of lead supplies to the U.S.," the agency's actions must be explained otherwise.¹³⁵ The bureaucratic scandals during the

¹³³William D. Woodbury. "Lead." Mineral Facts and Problems. (Washington, D.C.: GPO, 1985), 443.

¹³⁴Forest Service, U.S. Department of Agriculture and Bureau of Land Management, U.S. Department of the Interior. Environmental Analysis: Doe Run Exploratory Drilling Project. (Washington, D.C.: GPO, 1991), 5.

¹³⁵Forest Service; DEIS, 24: William D. Woodbury. "Lead." Mineral Facts and Problems (Bureau of Mines Bulletin #675) (Washington, D.C.: GPO, 1985):

Although lead is a strategic and critical commodity, it does not have a high potential for supply disruptions. A large quantity of old scrap currently exists, mostly storage batteries, which were manufactured in the late 1970s but not recycled owing to lower lead demand in recent

Reagan years have demonstrated that the political process can effectively penetrate the lower levels of bureaucracy. The regional offices of the Forest Service are undoubtedly under pressure to make political, non-scientific decisions.

The lack of an ecosystem-wide management plan for the region is the reason that the governmental agencies and the Doe Run Company are able to convince a certain portion of the public, however small, that mining and environmental protection in the region can co-exist. The strategy behind the DEIS conveys the appearance of a region-wide approach to interpreting the potential problems associated with new mining operations, but the document is a poor attempt at that. Even Doe Run's environmental manager, John Carter, candidly criticized the research in the DEIS.¹³⁶ Although the document may have limited use as a theoretical assessment of the potential effects of hypothetical mining operations, it is useless for assessing the environmental viability of Doe Run's specific PRLA's.

Although the Forest Service may have undertaken a wide-ranging EIS with malicious intent, there are other possible scenarios. Tom Aley elaborated;

The Forest Service has a very interesting history, sometimes being much more protective of resources than you might initially think. I have seen various strategies used over the years that I don't think are merely coincidence. During the early years of the Reagan administration, he went on a kick of getting rid of "excess" public lands. The Forest Service and the Park Service both had to deal with that. They dealt with it in very different approaches. The Park Service's general approach was to say, "We need everything, but I guess there are some things we can let go and

years. Supplies of lead from Australia, Canada, and Mexico, which in recent years have accounted for over 80% of the refined lead imported in the United States, are considered secure. (443-444)

¹³⁶Carter.

here they are." The Forest Service said, "Here's a whole lot we can get rid of. We can get rid of this whole ranger district. Here's a whole bunch here, here's a whole bunch here." It so upset the public that the Forest Service basically lost nothing. Lets suppose that strategy was used in the proposed mining in the Mark Twain. What the mining company originally wanted was just a few square miles. The Forest Service said, "Gee, this stuff could be pretty wide spread. It might occur anywhere in there." Suddenly everybody is concerned and upset. If you look at the history of the Forest Service, this kind of strategy has often worked. You make a few mistakes in there. You do the EIS too early and it gets reversed. The politicians who are trying to do favors for other politicians have a hard time getting it through when it becomes a major issue. I think the lead mining in this new area would have gone through had the Forest Service done an EIS on the smaller area. I think the greatest chance of stopping it was by doing it exactly as they did it.¹³⁷

There was clearly pressure to allocate resources on public lands to the private sector at the time work on the EA began. However, the Forest Service bureaucrats may not have wanted development to occur in the region. Given that scenario, the easiest way to postpone development or defeat the proposal may have been to do just what the agency did. Mining may very well have already been developed there had the Forest Service kept a low-profile and done an EIS based only in the immediate area of proposed mining.

Of course, no Forest Service personnel would admit to playing a part in the implementation of such a strategy, but they would not admit to succumbing to political pressure either. Whatever the motives of the Forest Service were in producing such a poorly constructed document, the outcome is the same. However, Larry Hensen's reversal of the original Forest Service plan only postpones a final decision on the issue. Hensen's remanding of the decision to grant leases simply points to the procedural errors of the federal agencies. It

¹³⁷Tom Aley holds a BS and an MS in forestry and worked seven years with the Forest Service.

does not remove the area from potential mineral leasing. Doe Run Company, and perhaps others, will continue to pursue whatever lead deposits exist in the region.

3. Sole Source Aquifer Designation

The Park Service, which has gone on record in opposition to mining in the area, may have been trying to buy time as well when it petitioned the Environmental Protection Agency (EPA) to designate 967 square miles of the area a Sole Source Aquifer (SSA). This means that the underlying aquifer is "the sole source of drinking water for 20,000 people in the area."¹³⁸ And, "there are no reasonably available alternative sources should the aquifer become contaminated."¹³⁹ According to Arthur Sullivan, supervisor of the Ozark National Scenic Riverways, "The designation is needed because no other planning mechanism can provide the region with the necessary protection."¹⁴⁰

Under such a designation, all federally financed projects would be subject to approval by the EPA. Because the source of project funding is the focal point of aquifer protection under the SSA designation, water quality protection is not assured. The EPA would be the third federal agency, in addition to the BLM and the Forest Service, that the mining companies would have to consult before any development could begin. This would only be the case if the

¹³⁸Christine Bertelson. "U.S. Files Challenge to Mine." St. Louis Post Dispatch (February 13, 1991), A1.

¹³⁹"Public Hearing Thursday on Sole Source Aquifer." Shannon County Current Wave 118 (November 13, 1991), 1.

¹⁴⁰*Ibid.*, A5.

courts perceive the proposed mineral development as a federally funded project. The designation might at least make obtaining necessary permits for mining substantially more difficult.

Patrick Costella of the EPA commented that he did not know whether the aquifer would be designated, but stated that the "boundaries are defensible." However, it is not absolutely clear whether fifty percent of the area's residents could not find a reasonable alternative source of water should the upper aquifer become contaminated. Regardless, Costella believes that the designation would be a useful tool for protection of water resources in the area.¹⁴¹

It is possible that Costella used an equally resourceful strategy, as Tom Aley has suggested the Forest Service might have, in discussing the designation with the press. Costella made sure to mention that the designation would have no effect on the proposed mining operations because they would not be directly financed by federal funds.¹⁴² Because the proposed mining would be on federal land and the environmental analysis is federally funded, Costella's statement may not be accurate. Ultimately, the decision as to whether the mining could proceed in an area with such a designation would be made in the courts. Costella would certainly understand that, but by giving a legal opinion on record that verifies any proposed mining by private corporations would not be affected, the lead industry no longer has a reasonable defense in opposition to the designation.¹⁴³ Despite these potential problems the SSA designation may be an

¹⁴¹J. Patrick Costella, Water Management Division, Office of Groundwater Protection, U.S. Environmental Protection Agency, interview by author, 2 April 1992.

¹⁴²"Public Hearing Thursday on Sole Source Aquifer," 1.

¹⁴³Aley.

excellent mechanism for protecting the region from inappropriate and destructive types of development.

VI. CONCLUSION

Larry Hensen's reversal of the Forest Service's original decision to grant leases to Doe Run Company does not mean that the region will be free from lead mining or other environmentally destructive land uses. The 1988 DEIS was completed in response to only one proposal for hardrock mineral development. It is certain there will be more. The decision should be viewed only as temporary protection for the region from one source of environmental destruction. Unfortunately, it does not necessarily mean the unending preservation of the region's remaining wild forested hills and hollows, or its unspoiled sinkholes, springs, caves, rivers, and streams. As the federal agencies move full speed ahead on the exploratory drilling phase of development, Doe Run Company's original proposal for lead mining in the Eleven Point District of the MTNF is not yet dead. It may be, as many concerned individuals have noted, that exploratory drilling is the first step towards full-scale mining.

Pointing to the mass recycling of auto batteries, the declining use of lead in most products, health problems associated with its use, and environmental problems with its extraction, Tom Aley stated, "I think the lead industry is in big trouble."¹⁴⁴ That may be the case, but Doe Run Company and others are undoubtedly looking down the road and anticipating future uses of the element. Unless protection of other values of the area in question is made permanent, there will continue to be a chance that mining will occur there. Tom Aley stated,

I think the resources that are there far exceed the value that would accrue from any of the proposed lead mining. Looking in the long run, preservation is going to be the wisest and best use of that

¹⁴⁴ibid.

land. Look at the other lead mining areas. It is something that will be there in perpetuity.¹⁴⁵

The existence of springs, caves, sinkholes, disappearing streams, and other sensitive formations dispersed liberally throughout the area is enough to illustrate the extreme risk involved in allowing hardrock mineral development there. The industry will continue to persuade the public into believing that they can mine the area safely without jeopardizing the local environment and simultaneously stimulate long-term economic growth in the region. That prospect seems highly unlikely given the absence of critical hydrological information about the area's springs, creeks, and rivers, the legacy of environmental destruction in abandoned lead mining areas, the classic boom and bust economic cycles of mining regions, the economic and ecological sensitivity of the Eleven Point area, and the uncertain nature of environmental consequences of the Viburnum Trend operations. But the mining industry will only give up when the land has been mined out, lead use has dwindled below levels of continually available scrap, or when the land has gained permanent protection. The Big Springs region of the Ozarks still lacks an adequate mechanism for ensuring its protection. As long as there are corporations desiring to mine, mill, smelt, and refine lead, they will continue to pursue mineral development on the public and private lands of this region.

¹⁴⁵Ibid.

Selected Bibliography

- Ahmed, Safir. "Official Challenges Significance of Company's Air-Quality Data." St.Louis Post-Dispatch. (January 30, 1991): C4.
- Aley, Tom. director of Ozark Underground Laboratory in Protem, Missouri. Interview by author. February 1992.
- "Aquifer Petition Planned, Praised." The Shannon County Current Wave. (November 20, 1991): 1, 3.
- "As Old as the Ozarks." Nature Conservancy 42 (March/April 1992): 30.
- "A Threat to Wilderness." St.Louis Post-Dispatch. (February 11, 1981): A14.
- Barks, James H. Effects of Abandoned Lead and Zinc Mines and Tailings Piles on Water Quality in the Joplin Area, Missouri. (Washington, D.C.: GPO, August 1977): USGS/WRI 77-75.
- Barnes, Harper. "Irish Wilderness." St.Louis Post Dispatch. (June 20, 1983): D1, D4.
- Barnes, Harper. "Wanted: Irish Wilderness 'Just the Way It Is'." St.Louis Post-Dispatch. (June 21, 1983): D1, D4.
- Barnett, Tracy L. "Forest Service Weighs Ozark Lead Drilling." Columbia Daily Tribune (March 14, 1991).
- Bechtold, Timothy. Environmental Activist representing Earth First! in Missoula, Montana. Interview by author. February 1992.
- Beckman, H.C. and N.S. Hinchey. The Large Springs of Missouri. Jefferson City, Missouri: Mid-State Printing Company, 1944.
- Bertelson, Christine. "Couple threatened Over Opposition to Lead Mining in Ozarks." St.Louis Post-Dispatch. (July 11, 1988): A1, A8.
- _____. "Drey Refuses to Deal With Lead Company." St.Louis Post-Dispatch. (June 1, 1988): 10A.
- _____. "Firm Plans Plant for Recycling." St.Louis Post-Dispatch. (December 21, 1988): A1, A6.
- _____. "Forest Drilling to be Appealed." St.Louis Post-Dispatch. (January 15, 1989): 5D.

- _____. "Forest Lost \$3 Million Last Year." St.Louis Post-Dispatch. (May 27, 1990): D3.
- _____. "Lead Company Denied Permit For Mark Twain Forest." St.Louis Post -Dispatch. (April 8, 1990): 1E, 6E.
- _____. "Mine Offers Deal Involving Greer Spring." St.Louis Post-Dispatch. (May 28, 1988): A1, 9A.
- _____. "OSHA Fines Won't Affect Mine Ruling." St.Louis Post Dispatch. (March 7, 1988): 7A.
- _____. "Ozark Plan For Mining is Hot Issue." St.Louis Post-Dispatch. (March 7, 1988): A1, A7.
- _____. "Sierra Club Study Rips Forest Service." St.Louis Post-Dispatch. (August 12, 1990): D3.
- _____. "U.S. Files Challenge to Mine." St.Louis Post-Dispatch. (February 13, 1990): A1.
- Beveridge, Thomas R. Geologic Wonders and Curiosities of Missouri. Jefferson City, Missouri: Missouri Department of Natural Resources, 1978; second edition, 1990.
- Buehler, A.H. The Disseminated-Lead District of Southeastern Missouri. (International Geologic Congress, U.S. 1933, Guidebook 2).
- Bureau of Mines, U.S. Department of the Interior. "Mineral Commodity Profiles: Lead." (Washington, D.C.: GPO, 1983).
- "Buy Up 126 Square Miles in Ozarks." The Fayette Advertiser. (December 21, 1991): 1.
- Carey, Christopher. "Fluor to Evaluate Stake in Doe Run." St.Louis Post Dispatch. (March 30, 1989): D8, D15.
- Carey, Christopher. "Lead Company Allowed to Explore in Forest." St.Louis Post-Dispatch. (December 7, 1988): 1C.
- Carey, Christopher. "Lead Industry Sees Better Times." St.Louis Post-Dispatch. (November 20, 1988): E1, E7.
- Carter, John, environmental manager for Doe Run Company in Viburnum, Missouri. Interview by author, December 1991.
- Carter, John. "Mining and Wilderness Can Coexist." St.Louis Post-Dispatch. (December 20, 1987): 3C.

- Coalition for the Environment. Notice of Appeal (Decision Notice and Finding of No Significant Impact for Doe Run Exploratory Drilling) 28 May 1991. Doe Run Company project file, Mark Twain National Forest, Eleven Point Ranger District.
- Conservation Federation of Missouri. "Urges New Environmental Impact Statement on Mining Forest Lands." Jefferson City, Missouri: CFM, February 28, 1988.
- Costella, J. Patrick. Water Management Division, Office of Groundwater Protection, U.S. Environmental Protection Agency, Kansas City, Missouri. Interview by author, April 2, 1992.
- Czarnecki, James M. "Accumulation of Lead in Fish from Missouri Streams Impacted by Lead Mining." Bulletin of Environmental Contamination and Toxicology 34 (May 1985): 736-745.
- "Doe Run Leases Rare Community." The Missouri Chapter Nature Conservancy. (Spring 1990): 1.
- Doe Run Company. Information Brochure, (St.Louis: Doe Run Company, 1987).
- Doe Run Company. "Mining and Environmental Protection." St.Louis, Missouri: Doe Run Company, 1991.
- Doe Run Company. "Some Interesting Facts on Lead." Information sheet, 1988.
- Dorst, Hank. "A Clear-Cut Problem of Mismanagement." St.Louis Post-Dispatch. (December 18, 1990): C3.
- Dummit, Ralph. "Lead Readings Drop Nationally, But Rise Around Herculaneum." St.Louis Post-Dispatch. (February 18, 1988): A3.
- Eberly, Jody. Wildlife Biologist, Eleven Point District, Mark Twain National Forest, phone conversation with author, April 8, 1992.
- "Emerson Introduces Bill to Acquire Greer Tract for River Corridor, Special Management Area." The Shannon County Current Wave. (October 30, 1991): 1.
- "80,000-Acre Land Deal Called Largest in Missouri's History." Jefferson City Post-Tribune. (December 19, 1991).
- Esparza, Leon E., Laurence M. Nuelle, and Ardel W. Rueff. "The Mineral Industry of Missouri." Missouri Minerals Yearbook, Area Reports: Domestic, Vol.II 1988. (Washington, D.C.: GPO, 1990).
- Fenneman, Nevin M. "Physical Divisions of the United States." (USGS Map, 1946; reprint, 1957).

- Fishman, M.J. and J.D. Hem. "Lead Content of Water." Lead in the Environment, Professional Papers #955-965. (Washington, D.C.: GPO, 1976).
- Forest Service, U.S. Department of Agriculture. "Decision Notice and Finding of No Significant Impact for Doe Run Exploratory Drilling." 5 April 1991, Doe Run Company project file, Mark Twain National Forest. Eleven Point Ranger District, Winona, Missouri.
- Forest Service, U.S. Department of Agriculture. Ecological Land Classification Terrestrial Subsystem: A Basic Inventory System for Planning and Management on the Mark Twain National Forest. (Washington, D.C.: GPO, 1985).
- Forest Service, U.S. Department of Agriculture. "Facts: Minerals on the National Forest System." Information sheet, 1990.
- Forest Service, U.S. Department of Agriculture. "Irish Wilderness Map." (Washington, D.C.: GPO, 1990).
- Forest Service, U.S. Department of Agriculture. "Mark Twain National Forest Map." Washington, D.C.: GPO, 1989.
- Forest Service, U.S. Department of Agriculture. "Mark Twain National Forest Map (Eleven Point - Doniphan Ranger Districts)." (Washington, D.C.: GPO, 1991).
- Forest Service, U.S. Department of Agriculture. Plan for Managing the National Forests in Missouri. (Washington, D.C.: GPO, 1977).
- Forest Service, U.S. Department of Agriculture, and Bureau of Land Management, U.S. Department of the Interior. Draft Environmental Impact Statement: Hardrock Mineral Leasing - Mark Twain National Forest, Missouri. (Washington, D.C.: GPO, 1988).
- Forest Service, U.S. Department of Agriculture, and Bureau of Land Management, U.S. Department of the Interior. Draft Environmental Impact Statement Summary: Hardrock Mineral Leasing, Mark Twain National Forest, Missouri. (Washington, D.C.: GPO), 1987.
- Forest Service, U.S. Department of Agriculture and Bureau of Land Management, U.S. Department of the Interior. Environmental Analysis: Doe Run Exploratory Drilling Project, Eleven Point Ranger District. (Washington, D.C.: GPO), 1991.
- Forest Service, U.S. Department of Agriculture, and Bureau of Land Management, U.S. Department of the Interior. Final Environmental Impact Statement: Hardrock Mineral Leasing Mark Twain National Forest, Missouri. (Washington, D.C.: GPO, 1988).

- Forest Service, U.S. Department of Agriculture, and Bureau of Land Management, U.S. Department of the Interior. Record of Decision: Hardrock Mineral Leasing - Mark Twain National Forest, Missouri. (Washington, D.C.: GPO, 1988).
- Geological Survey, U.S. Department of the Interior. "Poplar Bluff, Missouri; Arkansas." (1:250,000-scale topographic map), (USGS: Reston, Virginia, 1979), NJ 15-12.
- Geological Survey, U.S. Department of the Interior. "Rolla, Missouri." (1:100,000-scale topographic map), (USGS: Reston, Virginia; 1987), 37091-E1-TM-100.
- Gilbert, Bil. "Streams of Contentiousness." Sports Illustrated. (June 28, 1982): 65-78.
- Goodrich, Robert. "Getting the Lead Out: Missouri Exploration Expands." St.Louis Post-Dispatch. (August 31, 1980): J1, J4.
- "Grasshopper Hollow Dedication." The Missouri Chapter Nature Conservancy. (Fall 1990): 1.
- Hanson, Eric and Arsentia. "Irish Wilderness." St.Louis Post-Dispatch. (February 22, 1981): 2D.
- Heyl, A.V. "Distribution of Principal Lead Deposits in the Continental United States." Lead in the Environment Professional papers #957, (Washington, D.C.: GPO, 1976).
- Horton, Emily M. "Mining the Irish." St.Louis Post Dispatch. (May 23, 1983): A10.
- Heumann, Blane. "Grasshopper Hollow." The Nature Conservancy Missouri Chapter. (Summer 1991): 1.
- Ingalls, Walter Renton. Lead and Zinc in the United States. (New York: Hill Publishing Company, 1908).
- Jackson, Donald D. "Every State Should Have a Leo Drey." Audubon. 90 (July 1988): 78-83.
- Jaroff, Leon. "Controlling a Childhood Menace." Time. (February 25, 1991): 68-69.
- Jennett, Charles J., Bobby G. Wixson, and Roger L. Kramer. "Some Effects of Century Old Abandoned Lead Mining Operations on Streams in Missouri, USA." Minerals and the Environment (Vol. 3, 1981), 17-20.

- "Jobs in a Wilderness?" St.Louis Post-Dispatch. (May 13, 1983): A14.
- Karel, John. "Building Missouri Citizen Support." Living Wilderness. 42 (October 1976): 7-8.
- Kiehl, Carol. "Real Estate Deal Will Create Parks in Ozark Forests." Columbia Missourian. (December 20, 1991): 9A.
- Koenig, Marcia L. "Action By OSHA: Fine, Charges At Smelter in Herculaneum Surprise Officials But Not Some Workers." St. Louis Post-Dispatch. (February 15, 1988): B1.
- Koenig, Marcia L. "Lead Firm to Check Soil At Homes Near Herculaneum Smelter." St.Louis Post-Dispatch. (September 28, 1990): C4.
- Koenig, Robert L. "U.S. Forest Service Implored to Prohibit Drilling in Ozarks." St.Louis Post-Dispatch. (September 27, 1989): 5A.
- Kohler, Steve. Two Ozark Rivers: The Current and the Jacks Fork. Columbia, Missouri: University of Missouri Press, 1984.
- Lamey, Carl A. Metallic and Industrial Mineral Deposits. (New York: McGraw-Hill, Inc., 1966).
- Lead Industries Association, Inc. "Lead: A Vital and Versatile Element." (New York: Lead Industries Association, Inc., 1990).
- "Local Land Acquisition Biggest in MDC History." The Shannon County Current Wave. (December 25, 1991): 1.
- Local Committee for a Lead Free Ozarks. Notice of Appeal (Appeal of the Decision Notice and Finding of No Significant Impact for Doe Run Exploratory Drilling). 29 May 1991, Doe Run Company project file, Mark Twain National Forest, Eleven Point Ranger District.
- Malone, Roy. "Many in Oregon County Favor Jobs Over Trees." St.Louis Post-Dispatch. (May 10, 1983): A1, A5.
- Malone, Roy. "Three From Congress Visit Disputed Irish Wilderness." St.Louis Post-Dispatch. (May 8, 1983): A13.
- Mandel, Marjorie. "Foresters Hold Up Mining, Order Study." St. Louis Post-Dispatch. (September 30, 1986): 4A.
- Mandel, Marjorie. "U.S. Weighs Mining Bid in Twain Forest." St.Louis Post-Dispatch. (August 24, 1986): C1, C10.

- Martin, Guy R. (Attorney for Doe Run Company), to B. Eric Morse (Forest Supervisor, Mark Twain National Forest), 27 May 1991. Doe Run Company project file, Eleven Point District, Winona, Missouri.
- "Mining Firm, OSHA Talk Over Problems." St.Louis Post Dispatch. (February 19, 1988): A8.
- Mining Industry Council of Missouri. Missouri Mining and You. Jefferson City, Missouri: Modern Litho Printing, 1st Revision, 1988.
- Mining Industry Council of Missouri. Underground Treasures: The Story of Mining in Missouri. Reprinted from "Official Manual, State of Missouri: 1977-1978".
- Missouri Department of Natural Resources, Division of Geology and Land Survey. "Galena: Official Mineral of the State of Missouri." Jefferson City, Missouri: MDNR, 1990.
- Missouri Department of Natural Resources, Division of Geology and Land Survey. "Missouri: Premier Lead Producer of the World." Information Sheet #22, Jefferson City, Missouri: MDNR, revised 1988.
- Missouri Division of Tourism. "Missouri: Facts & Figures." (Jefferson City: Missouri Division of Tourism, March 1989).
- Mohlenbrock, Robert H. "Cupola Pond, Missouri." Natural History. 97 (January 1988): 62-65.
- Morse, B. Eric (Forest Supervisor, Mark Twain National Forest), to Kitty Cone Local Committee for a Lead Free Ozarks), 22 October 1991. Doe Run Company project file, Eleven Point Ranger District, Winona, Missouri.
- Morse, B. Eric (Forest Supervisor, Mark Twain National Forest), to Guy R. Martin (Appellant on behalf of Doe Run Company), 22 October 1991. Doe Run Company project file, Mark Twain National Forest.
- Morse, B. Eric (Forest Supervisor), to Nick Wilson and Michael K. Davis (Appellants of exploratory drilling decision), 22 October 1991. Doe Run Company project file, Mark Twain National Forest.
- Morse, B. Eric (Forest Supervisor), to Roger Pryor (Coalition for the Environment) and Dan Lehocky (Sierra Club, Ozark Chapter) 22 October 1991. Doe Run Company project file, Mark Twain National Forest, Eleven Point Ranger District.
- National Park Service, U.S. Department of the Interior. "Ozark National Scenic Riverways, Official Map and Guide." 1991.

- "New Lead Mine Planned Southwest of St.Louis." St.Louis Post-Dispatch. (March 6, 1980): E1.
- Nigh, Tim. "Sinkhole Ponds." Missouri Conservationist. 52 (July 1991): 13-16.
- Novak, J.T., and G.B. Hassewander. Control of Mine Tailings Discharges to Big River. (Jefferson City, Missouri: MDNR, 1980).
- Peterson, Sarah. "Ozarks: Where Life Can be Hard But Beautiful." U.S. News and World Report. 95 (July 11, 1983): 58-59.
- Pollack, Stephanie. "Solving the Lead Dilemma." Technology Review. 92 (October 1989): 22-31.
- Power, Thomas Michael. The Economic Pursuit of Quality. (New York: M.E. Sharpe, Inc., 1988).
- "Public Comment Sought on Land Purchase Deal." The Shannon County Current Wave. (January 8, 1991): 1.
- "Public Hearing Thursday on Sole Source Aquifer." The Shannon County Current Wave. (November 13, 1991): 1.
- Pufalt, Caroline. "Senators Support Mining Scam." Ozark Sierran 23 (November/December 1991): 4.
- "Purchase to Protect 'Most Important' Ecosystems." The Shannon County Current Wave. (January 1, 1991), 1, 3.
- Rafferty, Milton D. The Ozarks: Land and Life. (Norman, OK: University of Oklahoma Press, 1980; second printing, 1985).
- Reese, Gary. "Visitors From Another Age: Relict Plants are Survivors From A Time When the Glaciers Came to Missouri." Missouri Conservationist. 47 (July 1986): 4-7.
- Renken, Tim. "Forest Service Road Plan is Heated Topic in Ozarks." St.Louis Post-Dispatch. (March 18, 1988): 4D.
- Robinson, Gordon. The Forest and the Trees: A Guide to Excellent Forestry. Washington, D.C.: Island Press, 1988.
- Ryck, Frank M.Jr. Water Quality Survey of the Southeast Ozark Mining Area 1965-1971. (Jefferson City, Missouri: Missouri Department of Conservation, 1974).

- Sauer, Carl O. The Geography of the Ozark Highland of Missouri. Chicago: University of Chicago Press, 1920; reprint, New York: Greenwood Press, 1968.
- Sawyer, Jon. "Lead Boom Worries Conservationists." St.Louis Post-Dispatch. (February 9, 1981): A1, A6.
- Schoolcraft, Henry R. A Journal of a Tour Into the Interior of Missouri and Arkansas. London: Sir Richard Phillips and Co., 1821; reprint, Van Buren, Arkansas: Press-Argus Printers, 1955.
- Schoolcraft, Henry R. A View of the Lead Mines of Missouri. New York: Charles Wiley & Company, 1819; reprint, New York: Arno Press, 1972.
- "Senate Approved Greer Spring Bill Goes to Bush." The Shannon County Current Wave. (December 4, 1991): 1.
- "Senate Passes Amendment Protecting Irish Wilderness." St.Louis Post-Dispatch. (September 20, 1983): A4.
- Shirk, Martha. "Lead Tailings Pose Threat in Big River." St.Louis Post-Dispatch. (August 24, 1980): A1, A17.
- Tarr, W.A. "Origin of the Southeastern Missouri Lead Deposits: Part I." Economic Geology. 31 (August 1936): 712-754.
- "The Blind Ozark Cavefish." The Missouri Chapter Nature Conservancy (Spring 1991): 1.
- Thom, Richard H. and Greg Iffrig. Directory of Missouri Natural Areas. Jefferson City, Missouri: Missouri Natural Areas Committee, 1985.
- Thomson, Susan. "Lead Company's Plan Clears the Air in More Ways Than One." St.Louis Post-Dispatch. (March 28, 1990): B1.
- Tidball, R.R. "Lead in Soils." Lead in the Environment, (Washington, D.C.: GPO, 1976), Professional papers #955-965.
- Uhlenbrock, Tom. "Doe Run To Drill in Forest." St.Louis Post-Dispatch. (April 11, 1991): B1.
- Uhlenbrock, Tom. "Ozarks Tract Sold to Conservationists." St.Louis Post-Dispatch. (December 19, 1991).
- U.S. Environmental Protection Agency. Air Quality Criteria for Lead. (Washington, D.C.: GPO, 1977), EPA-600/8 77-017.

U.S. Geological Survey, U.S. Department of the Interior. "A Possible Favorable Belt for Mineral Discovery in Subsurface Cambrian Rocks in Southern Missouri." (Open-File Report 80-1000, 1980).

Wilkinson, Charles F. and H. Michael Anderson. Land and Resource Planning in the National Forests. Washington, D.C.: Island Press, 1987.

Wirtz, Arthur L. (District Ranger, Eleven Point District), to Vince Vogt (Bureau of Land Management), 3 January 1992. Doe Run Company project file, Mark Twain National Forest.

Woodbury, William D. "Lead." Mineral Facts and Problems. (Washington, D.C.: GPO, 1985): 433-452.

_____. "Lead." Minerals Yearbook Volume I: Metals and Minerals 1988. (Washington, D.C.: GPO, 1990).

Woodbury, William D. and John A. Rathjen. "Lead." Mineral Commodities Profiles. (Washington, D.C.: GPO, 1983).

Zelms, Jeffrey L. "Mining Can Coexist With Nature: Mark Twain Forest has Thrived For 35 Years While Allowing Lead Extraction." St. Louis Post-Dispatch. (June 28, 1991): C3.