ABSTRACT

Title of Thesis:	TOWARD CONSERVATION OF MAGNOLIA BOGS ON UTILITY RIGHTS-OF-WAY: INCREASING IMAGEABILITY
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Magnolia Bogs are a rare wetland type known only to the gravelly sands of the inner Chesapeake Bay watershed. Scattered across upland landscapes just east of the fall-line, these habitats occur where lenses of clay intersect the rolling terrain and groundwater seeps along the faces of hillsides.

Most Magnolia Bogs have been lost to development, but remnant habitats have in several cases been inadvertently preserved on lands managed to support that very development – utility rights-of-way. Magnolia Bogs have become the focus of targeted conservation efforts, but despite intentions, bog remnants on rights-of-way often go unrecognized by

maintenance crews and are unintentionally damaged during management procedures, particularly mowing.

By adopting the perspective of a mower in the field, the patterns and forms of that experience are investigated. Cognitive mapping concepts are then applied to create suggestions for increasing the apparency of magnolia bogs to maintenance crews.

TOWARD CONSERVATION OF MAGNOLIA BOGS ON UTILITY RIGHTS-OF-WAY: INCREASING IMAGEABILITY

by

Jorah Reinstein

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Introduction

"Conservation philosophy, science, and practice must be framed against the reality of human-dominated ecosystems, rather than the separation of humanity and nature."

- David Western
"Human-modified Systems and Future Evolution"

Wetlands are an essential component of the earth's hydrologic and terrestrial systems, filtering water, regulating stream flow, and providing habitat resources fundamental for sustaining biodiversity (Batzer & Baldwin, 2012; Gibbons et al., 2006; Gibbs, 1993; Moler & Franz, 1987; Lane et al.; Semlitsch & Bodie, 1998; Snodgrass et al., 2000; Tiner & Burke, 1995; Williams, 1987; Zedler, 2003).

Since the late 18th century, however, the United States has seen a drastic reduction in wetland acreage as a result of a broad array of destructive practices associated with land development, resource extraction, agriculture, and forestry (Hayes, 1996a). Fifty-three percent of the wetland acreage in the conterminous United States was lost in the two centuries between the 1780's and the 1980's (Dahl, 1990, cited in Noss, LaRoe III, & Scott, 1995). In the Mid-Atlantic, during roughly the same period, Virginia lost 42% of its wetlands, Maryland lost more than 64% (more than 1 million acres), and the District of Columbia lost 90%. (Dahl, 1990, cited in Noss, LaRoe III, & Scott, 1995; Hayes, 1996b). The reductive influence of urbanization on terrestrial hydrology has been so significant that findings from a 2014 national study showed that across the United States, urban development may be a better predictor of surface water abundance than climate or topography (Steele et al., 2014).

In the environmental sciences today, there is a developing branch of study termed "reconciliation ecology," which seeks to harmonize the anthropogenic systems of industrial culture with earth systems. The necessity of this effort is made clear by the shear area over which anthropogenic systems have influence; reserves of unaffected lands are simply no longer adequate to support the earth's biodiversity (Rosenzweig, 2003). As our population continues to grow, it is becoming more and more necessary to look within the weave of the urban fabric for opportunities for habitat conservation (Colding, 2007).

One such opportunity can be found along utility rights-of-way - lands set aside for the transport of utilities across the municipal grid. In the United States, ROW form an extensive network, covering over five million acres of land – an area greater than that of Badlands, Olympic, Redwood, Rocky Mountain, Saguaro, Shenandoah, Yellowstone, Yosemite, and Zion National Parks combined (Wikipedia, 2017; Xerces Society, 2011). Although traditionally considered “secondary,” or “novel” ecosystems by conservation biologists, and therefore poor targets for conservation, ROW are starting to be recognized as opportunities for preserving habitat, especially within highly developed landscapes (Arnold, 1983; DeGraaf & Yamasaki, 2003; Flemming and Patterson, 2017; Forrester, Leopold, and Hafner, 2005; Frye, 2015; Lanham & Whitehead, 2011; Obama, 2014; Pollinator Health Task Force, 2015; Sheridan, Orzell, &Bridges, 1999; Smallidge, Leopold, & Allen, 1996; Wagner et al, 2014).

Management of vegetation along rights-of-way (ROW) has been a critical component of utility distribution since the advent of the municipal grid; for utilities to be provided safely and reliably, vegetation must be kept from interfering with conveyance infrastructure and from blocking access to that infrastructure for maintenance (McGloughlin, 2014; US Fish and Wildlife Service, 2011). In the case of overhead electrical transmission, enough clearance must be established between vegetation and transmission lines to prevent contact caused by line sag in extreme temperatures or under heavy current, line sway in high winds, and “jumping” of electricity off the lines to adjacent vegetation (North American Electric Reliability Corporation, 2017).

The effort directed at suppressing the growth of trees and maintaining all vegetation at a low height results in an ecological state of “perpetual” early succession across ROW lands (Forrester, Leopold, and Hafner, 2005; Lanham & Whitehead, 2011). Magnolia Bogs, rare, low-growing hillslope wetlands which once formed extensive wetland complexes in Virginia, Washington, D.C., and Maryland, have, like other wetlands, been predominantly been lost to development, but have also in several cases been preserved where they occur on utility ROW. Due to the fact that low-growing plant communities are generally short-lived, the relative stability of Magnolia Bog vegetation makes them valuable from a management perspective.

For continued conservation, these plant communities require a different management approach from the mowing typically applied to surrounding upland vegetation, but established cues have not consistently prevented Magnolia bogs from being mowed or from incurring mowing-related damages (Figure 1). Thus, despite incidental protection from development, intrinsic compatibility with ROW vegetation management goals, and cooperation between utility companies and state agencies, Magnolia Bogs remain threatened on utility ROW due to issues of perception.

This thesis seeks to apply findings from the literature on cognitive mapping to the challenge of how Magnolia Bogs are perceived and responded to when encountered by those tasked with mowing utility rights-of-way. Using a representative site, design interventions are suggested for an ecologically sensitive cueing structure, compatible with management needs, that establishes Magnolia Bogs as distinct entities which should not be mowed.

Figure 1: Established cues have not consistently prevented Magnolia bogs from incurring mowing-related damages: A sign directing mowers away from a sensitive area in the Little Paintbranch Bog complex has been mowed over. The sign reads, "STOP: no mowing or spraying between signs: PEPCO tree planting area". December 2016. Photo by author.

Chapter 1: Opportunities and Challenges for Conservation of Magnolia Bogs on Utility Rights-of-Way

"Where a surface layer, usually of coarse white gravel, or of gravel and sand mixed, is underlaid by an impervious layer of clay, and flushed by a constant flow of spring water, there grows without exception, and only there, some combination of the plants which characterize what are here called Magnolia bogs."

- Waldo McAtee, 1918
Natural History of the District of Columbia

1.1 Defining Magnolia Bogs

The term "wetland" refers to any location in a landscape in which soil in the rooting zone is saturated for long enough periods to support hydrophilic plant life. (Cowardin et al, 1979, Dahl et al., 2015). But the influences of topography, geological formations, soil conditions, climate, vegetation, and the activities of animals result in an array of distinct wetland types that support myriad different organisms (Batzer & Baldwin, 2012; Tiner, 2003). A defining feature of Virginia, Washington, D.C., and Maryland, is the fall-line that runs across them - a transitional geologic zone between the ancient bedrock of the Piedmont Plateau and the course sedimentary formations of the Coastal Plain (Schmidt, 1993). This line marks the continental split where over 200 million years ago the North American and African continents broke apart (Schmidt, 1993). Over geologic time, as glaciers melted and formed again, rivers eroded the

Appalachian Mountains, depositing the pieces at the foot of the continent, and the fluctuating sea brought them toward the mountains again. Slowly, these sediments formed a new continental edge – what we know today as the Coastal Plain. Rivers flowing east have since carved into the inside edge of the Coastal Plain, exposing cretaceous-age river terraces and creating a rolling landscape of interlaced gravels, sands, and clays (Fall Line Geology, 2010; Schmidt, 1993). It is this unique geology that gives rise to the distinct wetlands known as Magnolia Bogs (Figure 2). These wetlands occur over a very small geographic range, in a narrow band about 15 miles wide and 60 miles long, from Caroline County, Virginia, to Anne Arundel County, Maryland (Figure 3). (See Appendices A, B, and C for information on currently extant and historically documented Magnolia Bog locations from which this range is derived.)

When naturalist W.L. McAtee first described Magnolia Bogs in 1918, he recognized them as something special. Ringed by all kinds of ericaceous shrubs, with mucky centers full of orchids and ferns, sphagnum mosses, sedges, grasses, lichens and sundews, and signified always by the inevitable presence of Sweetbay Magnolia, he described these wetlands as the most “strikingly characterized” natural areas of the District of Columbia region (McAtee, 1918, p. 74).

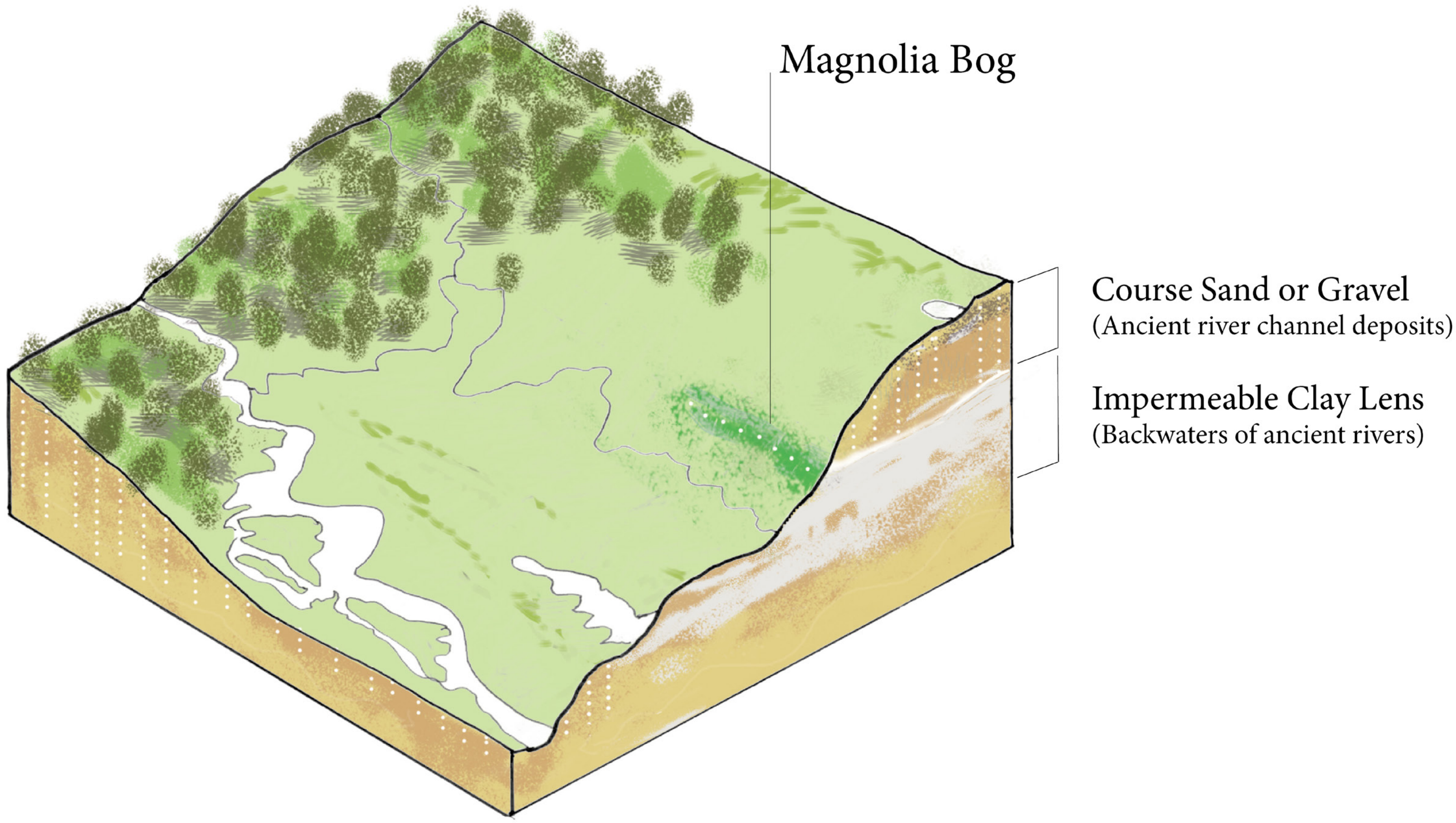

Figure 2: Geologic conditions from which Magnolia Bogs arise.

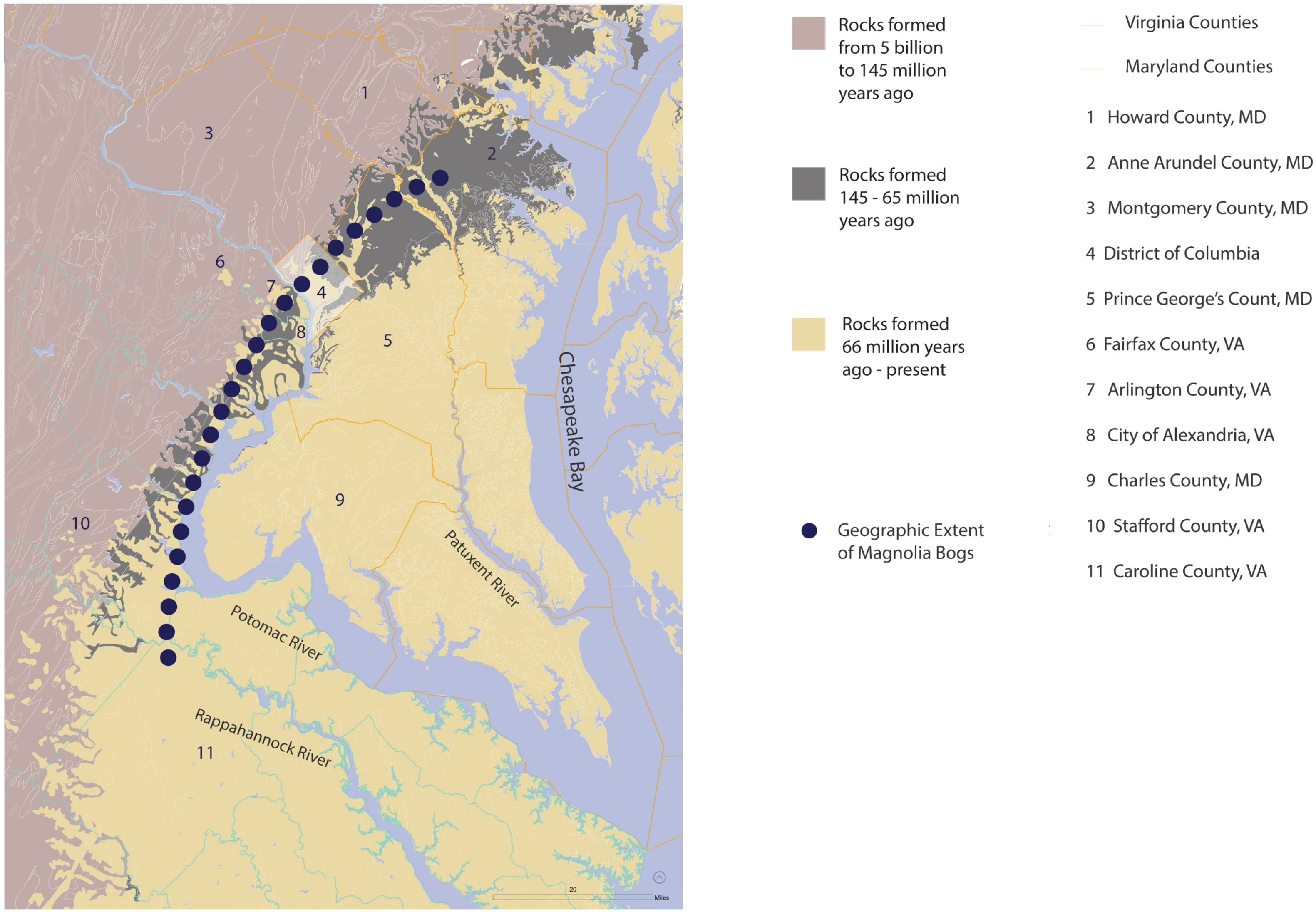

Figure 3: Magnolia Bogs occur over a very small geographic range, in a narrow band about 15 miles wide and 60 miles long, from Caroline County, Virginia, to Anne Arundel County, Maryland, on exposed cretaceous deposits. (See Appendices A, B, and C for the historically and currently documented Magnolia Bog locations from which this range is derived.)

In these habitats, McAtee discovered plants that he recognized from the pine barrens to the north. McAtee realized that the communities he had happened on were vegetational relics of an earlier age. In fact, these assemblages developed during the last ice age, which began 1.8 million years ago and lasted until about 12,000 years ago. During this period, large swaths of the Mid-Atlantic were covered in muskeg – acidic, iron-rich, saturated land dominated by water-loving herbaceous vegetation and ericaceous shrubs whose unique microbial relationships allowed them to survive in low-nutrient environments (Figure 4). In pockets where they have been able to maintain a foothold, these plant communities have persisted as today’s Magnolia Bogs (Simmons, 2017).

Magnolia bogs are designated as scrub-shrub wetlands in the National Wetlands Inventory (United States Fish and Wildlife Service, n.d.), which means that they are characterized as dominated by woody vegetation less than 20 feet tall, (this may include stunted trees that would in other conditions reach greater heights) and that, while separately trees and shrubs each make up less than 30 percent of the uppermost layer of vegetation, in combination they make up 30 percent or more (Dahl et al., 2015; Tiner & Burke, 1995) (Figure 5).

Figure 4: Muskeg on Square Island, Alaska, 2003. Image: A Hike Through The Muskeg on Square Island, Alaska, by M. Byzewski, July 18, 2003, https://www.flickr.com/photos/markbyzewski/11032117413. Used under Creative Commons Attribution 2.0 Generic License: https://creativecommons.org/licenses/by/2.0/

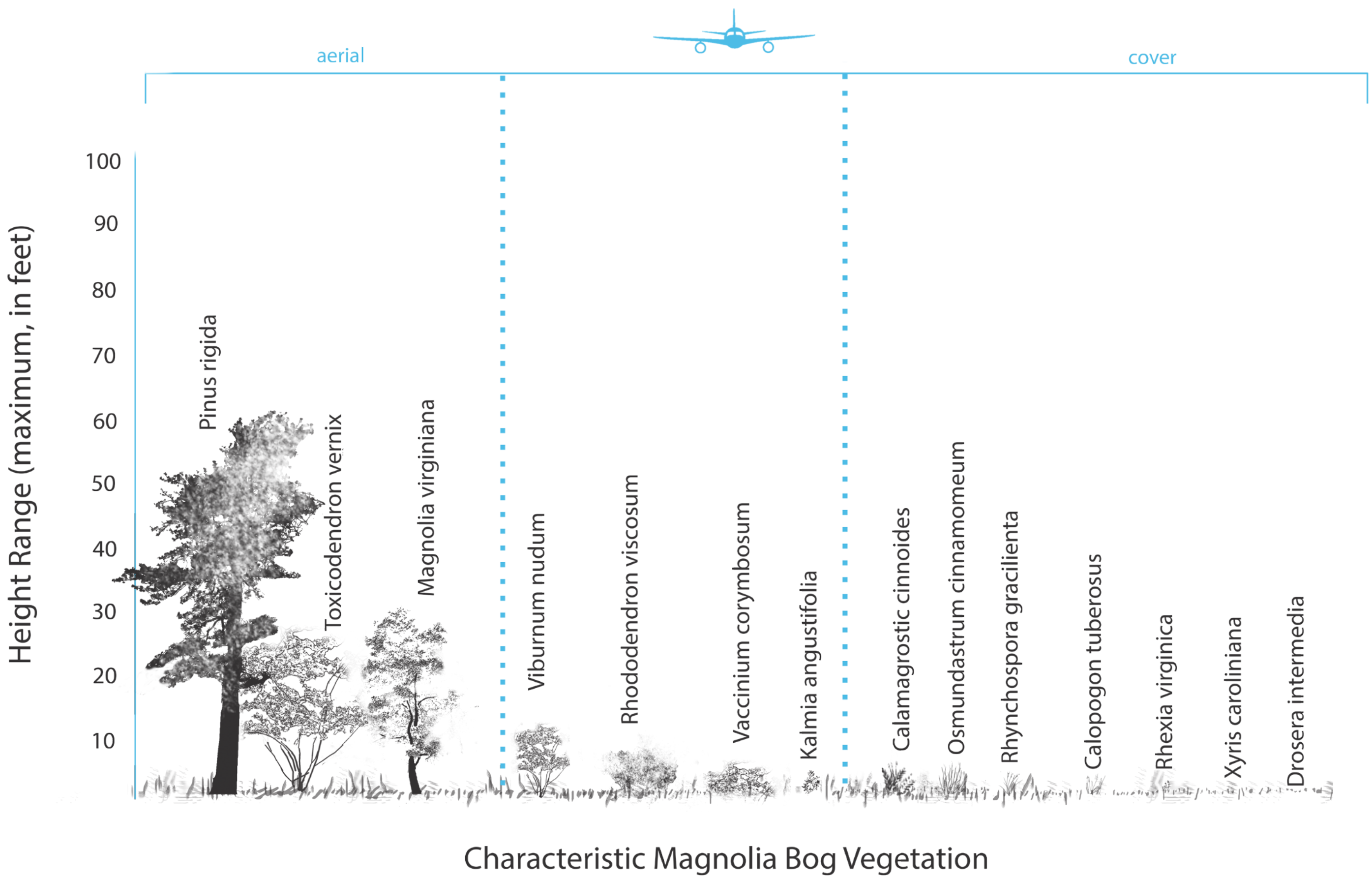

Figure 5: Characteristic distribution of vegetation types, heights, and species one might find in a typical Magnolia Bog. Magnolia bogs are designated as scrub-shrub wetlands in the National Wetlands Inventory, which means that they are characterized as dominated by woody vegetation less than 20 feet tall, (this may include stunted trees that would in other conditions reach greater heights) and that, while separately trees and shrubs each make up less than 30 percent of the uppermost layer of vegetation, in combination they make up 30 percent or more (Dahl et al., 2015; Tiner & Burke, 1995).

Unlike most communities dominated by herbaceous plants, Magnolia Bogs are relatively stable; periodic fires may have historically been important forces in maintaining the high level of diversity and open canopy associated with these habitats (Fleming & Patterson, 2017; Harrison & Knapp, 2010; Simmons et al., 2008), but succession to taller vegetation is generally minimized by low nutrient availability and the instability of the sandy, saturated substrate, which causes uprooting of larger trees during ice storms or high winds (Simmons et al., 2008). Of the trees known to occur in Magnolia Bogs, only Pitch Pine (*Pinus rigida*) and Black Gum (*Nyssa silvatica*) tend to reach mature height (Simmons, 2017). Although over long periods of time, these species may grow to heights of 60 and 75 feet respectively, few other associated species reach more than 12 feet.

Cross-referencing McAtee's A Sketch of the Natural Communities of the District of Columbia (1918), Hitchcock and Standley's Flora of the District of Columbia (1919), Harrison's Natural Communities of Maryland (2016), and Simmons's Native Vascular Flora of the City of Alexandria (2016) produces a list of 118 species (representing 40 plant families) characteristic of Magnolia Bogs. (Complete list provided in Appendix D).

Only two tree species are routinely identified as characteristic of Magnolia Bogs; Sweetbay Magnolia (*Magnolia virginiana*) and Black

Tupelo (*Nyssa sylvatica*). Representative shrub species include Fetterbush (*Eubotrys racemosa*), Common Winterberry (*Ilex verticilliata*), Blue Huckleberry (*Gaylussacia frondosa*), Sheep Laurel (*Kalmia angustifolia*), Swamp Azalea (*Rhododendron viscosum*), Poison Sumac (*Toxicodendron vernix*), Witherod (*Viburnum cassinoides*), and Possumhaw (*Viburnum nudum*).

Associated herbaceous species are diverse; of the above-mentioned 118 species, 84 are herbaceous. These include 25 species listed in Maryland and/or Virginia as rare, threatened, or endangered: Red Milkweed (*Asclepias rubra*), Twining Screwstem (*Bartonia paniculata*), Common Grass-Pink (*Calopogon tuberosus*), Button Sedge (*Carex bullata*), Spatula-leaved Sundew (*Drosera intermedia*), Round-leaved Sundew (*Drosera rotundifolia*), Ten-angle Pipewort (*Eriocaulon decangulare*), Twisted Spike-rush (*Eleocharis tortilis*), Long's Rush (*Juncus longii*), Slender Bog Clubmoss (Lycopodium carolinianum), Clustered Mille-grains (Oldenlandia uniflora), White-fringed Orchid (*Platanthera blephariglottis*), Rose Pogonia (*Pogonia ophioglossoides*), Cross-leaved Milkwort (*Polygala cruciata*), Clustered Beaksedge (*Rhynchospora glomerata*), White Beaksedge (*Rhynchospora alba*), Canada Burnet (*Sanguisorbia canadensis*), Netted Nutrush (*Scleria reticularis*), Halberd-leaved Greenbrier (*Smilax herbacea*), Elliot's Goldenrod (*Solidago latissimifolia*), Bog Goldenrod (*Solidago uliginosa*), Coastal False Asphodel (*Triantha racemosa*), Primrose-leaved Violet (*Viola primufolia*), Zigzag Bladderwort (*Utricularis subulata*), and Carolina Yellow-eyed Grass (*Xyris caroliniana*).

Floristically, ground-water seepage wetlands are "among the most diverse of all wetland types," (Bedford & Godwin, 2003) and Magnolia Bogs are among the most diverse ground-water seepage wetlands. In a survey of seepage wetlands on the Maryland Coastal Plain, Harrison and Knapp found a mean species richness of 48 plant species per Magnolia Bog sample plot, compared to values of 11, 25, 20, 11, 33 and 45 recorded for the six other identified seepage plant communities (Harrison & Knapp, 2010). (It should be noted that the community type with a mean species richness of 45, Coastal Plain Acidic Seepage Swales, are very closely related to Magnolia Bogs.) One-hundred and ninety different plant species were identified in the fourteen Magnolia Bog plots collectively, in contrast to thirteen in Sea Level Fens (2 plots), eighty-one in Coastal Plain Dwarf-Shrub Peatlands (9 plots), thirty-one in Coastal Plain Emergent Millpond Bogs (8 plots), forty-nine in Delmarva Poor Fens (3 plots), one-hundred-and-twenty-one in Coastal Plain Acidic Seepage Swamps (10 plots), and one-hundred-and-forty-nine in Coastal Plain Acidic Seepage Swales (5 plots).

Where diverse plant communities flourish, other forms of biodiversity are also amplified – Coastal Plain Seepage Bogs and Fens, within which Magnolia Bogs are recognized as a distinct natural community, are designated in Maryland's State Wildlife Action Plan as "key wildlife habitats" for conservation – meaning that they have been identified as integral for the continued existence of one or more "species of greatest conservation need" in the state (Maryland Department of Natural Resources, 2016).

Magnolia Bog habitats themselves are assigned the highest conservation status - *G1 - critically imperiled at the global scale* - in NatureServe's international community classification (NatureServe, 2017). This designation is given to natural communities "at very high risk of extinction due to extreme rarity, very steep declines, or other factors" (Harrison, 2016). Even within their geographic extent, bog occurrences are few, and thus also receive the highest state conservation designation in Maryland and Virginia - *S1 - critically imperiled at the state scale* (Harrison, 2016).

Fleming and Patterson (2017) write, “Although early botanical explorers of Virginia frequently reported open boggy habitats, natural examples of these small communities have nearly been extirpated by decades of fire exclusion, hydrologic alterations (ditching, draining, and impoundments), or outright destruction” (p. 16). These agents of loss are in most cases associated with land development (Figure 6).

Of forty historically documented Magnolia Bog locations, only five still support bogs. Today, with the inclusion of thirteen newly recorded sites, Magnolia Bogs are known to only eighteen locations over their entire geographic range.

1.2 Magnolia Bogs on Rights-of-Way

Although Magnolia Bogs can be found throughout their range, the highest concentration of remaining bogs is in the NW corner of Prince George’s County, Maryland, within an area of about 20 square miles (Figure 7). Approximately sixty percent of remaining bogs known today are located in this region.

The bogs in this area are what remain of a historically extensive suite of bogs that was once nearly continuous throughout the Anacostia River Watershed. This extensive network included bogs at Lanham, Ammendale,

Figure 6: Development has significantly impacted Magnolia Bog sites. A typical case is shown above: even though the complex of wetlands known as Barcroft Bog, in Arlington, Virginia, has persisted, residential use has reduced it to a fragment of its former extent. 1934 aerial photograph (Left); (Flemming, T., n.d.) vs 2017 (Right) Google Earth.

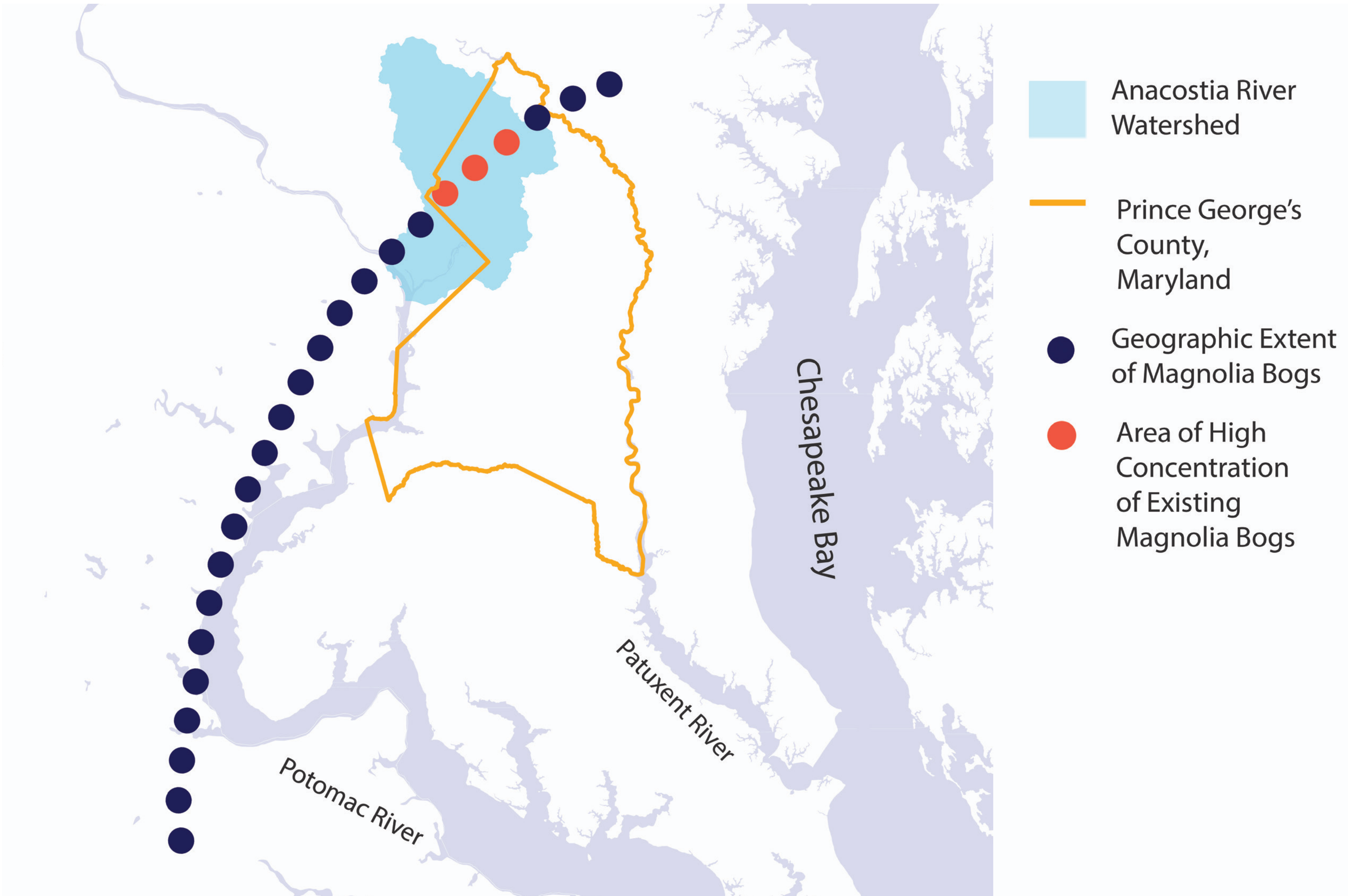

Figure 7: Approximately 60% of remaining Magnolia Bogs are located in the Anacostia River Watershed, in the NW corner of Prince George's County.

Hollywood, Hyattsville, Riverdale, Kenilworth, Bladensburg, Takoma Park, and Fort Totten, all of which have been extirpated since McAtee documented them a century ago (Figure 8).

Two major ROW serve this area, both owned and managed by Potomac Electric Power Company (Pepco). Remaining bogs in the watershed are concentrated around these ROW, and while it is possible that ROW have simply been sited through areas of high bog concentration, the preservation of Muirkirk Bog (northeast corner of the watershed), which is crossed by a power line, despite the loss of nearby Magruder and Sarracenia bogs, supports the idea that ROW may shield these habitats from development pressure (Figure 9).

It is to the great advantage of Magnolia Bog conservation efforts that management of vegetation on ROW has evolved to include a best management practice referred to as “integrated vegetation management” (American National Standards Institute, 2012). Based on the tenets of integrated pest management, a central focus of this practice is on the cultivation of compatible plant communities, as a biological control of “pest” vegetation such as trees (Genua, 2008; McGloughlin, 2014; North American Electric Reliability Corporation, 2012). This technique involves

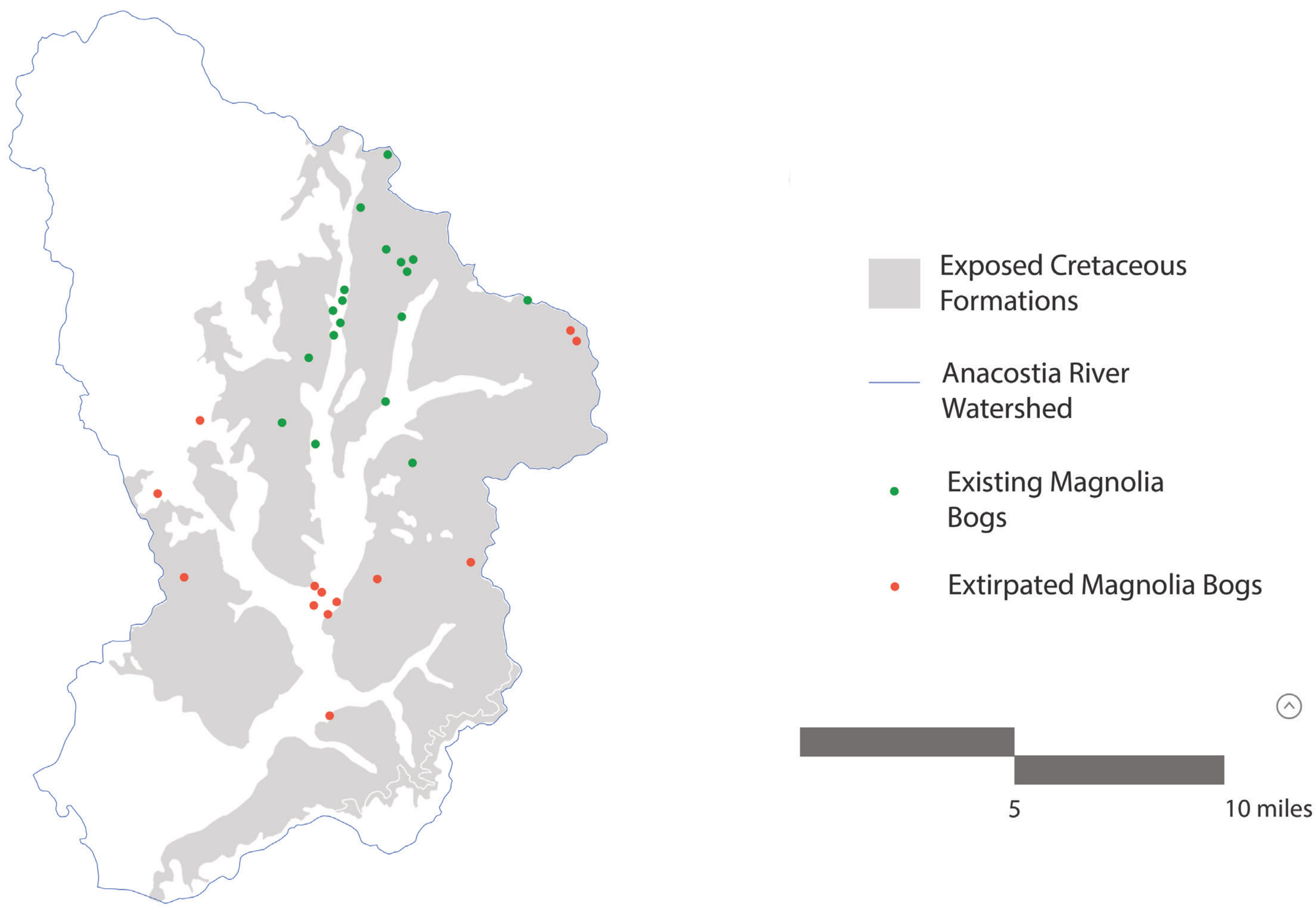

Figure 8: The high concentration of Magnolia Bogs in Prince George's County reflects the historically extensive network of bogs that followed the drainage pattern of the Anacostia River. All bogs in the southern reaches of the watershed have been extirpated.

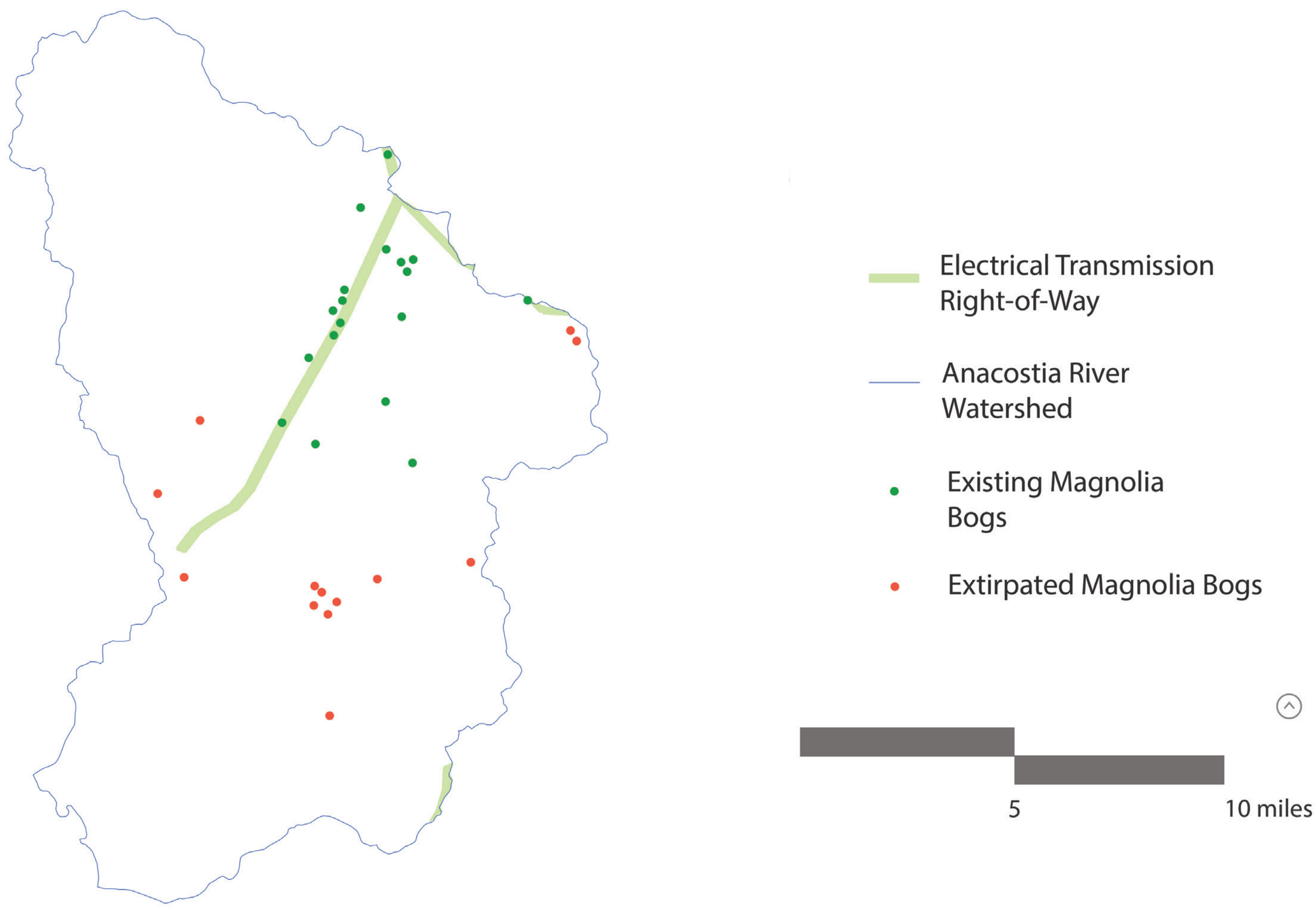

Figure 9: Dispersal of remaining bogs in the Anacostia watershed in relationship to utility rights-of-way.

recognizing existing compatible communities and developing customized vegetation management plans for the areas they cover.

The vegetated state that utility companies are cultivating is the one most susceptible to change; plant communities dominated by low-growing vegetation tend to be short-lived, especially in forested regions (Egler, 1949; Hill, Canham & Wood, 1995; Xerces Society, 2011). Thus, relatively stable low-growing plant communities that require less input to maintain have very high value on ROW. As Magnolia Bogs tend naturally toward low-growing vegetation and benefit from control of woody species, they are ideal communities to cultivate on ROW.

However, management of diverse plant communities over large tracts of land is a challenging task (Figure 10). R. Tillman, chairman of natural resources at Duchess Community College in Poughkeepsie, New York, who was tasked with preparing the first wildlife management plan for a utility company, described the complexity of the ROW vegetation management as follows:

> A four-hundred-acre transmission line corridor extends over twenty miles and . . . may pass over forests, lakes, swamps, bogs, playgrounds, housing developments, expressways, farmlands, or front lawns. The diversity of habitat types and conditions transected by the

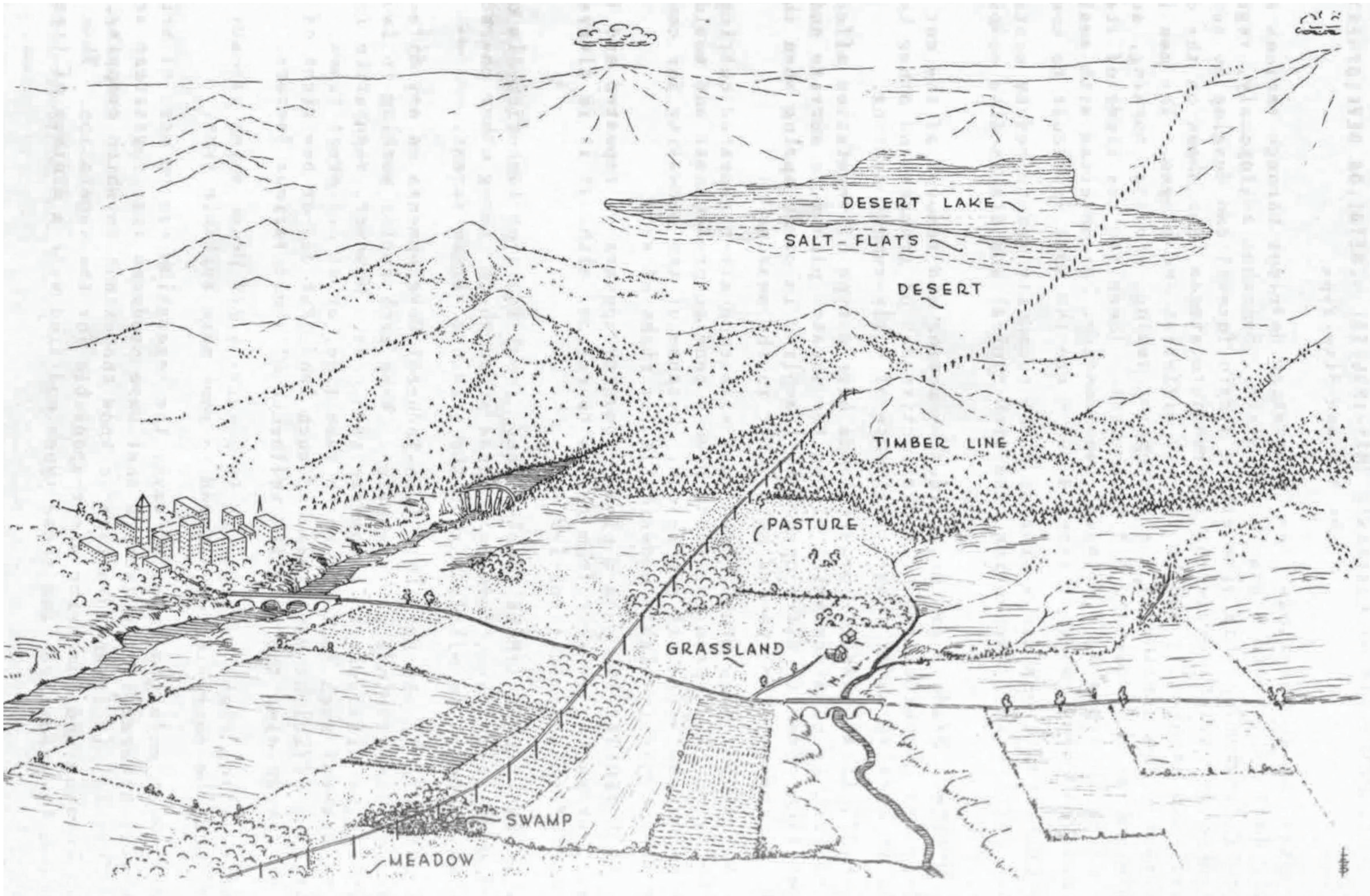

Figure 10: “A diagram showing a few of the cover types which a right of way may traverse in a relatively short distance” (Egler, 1949, p.12).

> line is staggering, especially in the more urbanized northeast. Rarely does a wildlife manager have to deal with so many different habitat types (Tillman, 1973, p.128-129).

Thirty-five years later, that complexity remained unresolved; Stephen Genua, forester for Pepco, repeated the sentiment in a 2008 report on Pepco's environmental stewardship: "ROWs traverse many different ecological systems, from streams, rivers, non-tidal wetlands, tidal wetlands, bogs, meadows, and shrub-scrub, to forests. Natural resource management . . . has posed unique challenges along the transmissions line ROWs" (Genua, 2008, p. 61).

Not only may plant communities be difficult to distinguish from one another, but mapping inconsistencies and interpretive variation among administrators, managers, and laborers, as well as competing expectations for performance (for example, speed vs. accuracy) may also influence actual management behavior. In the case of Magnolia Bogs, on-the-ground vegetation management practices, particularly associated with mowing, have often been detrimental rather than facilitative (Simmons & Strong, 2001; Simmons et al. 2008; Stoudt, 2007).

Several Magnolia Bogs on ROW have been classified by the Maryland Department of Natural Resources (MDNR) as "non-tidal wetlands of special state concern." Among these is Buck Lodge Bog, a two-acre remnant located just southwest of the Beltsville Agricultural Research Center and just northwest of the University of Maryland College Park Campus, on the Burtonsville to Takoma 230kv electrical transmission right-of-way (Figures 11 and 12). The bog supports a diverse plant community - within the small seepage area, populations of ferns, fruiting shrubs such as black chokeberry and elderberry, a wide variety of flowering perennials, and an array of Cyperaceae can be found (Figure 13).

In 2007, neighborhood residents brought public attention to the bog after a mowing event caused "extensive and severe" damage (Stoudt, 2007, n.p.). The MDNR then assisted Pepco in identifying bog boundaries and appropriate management, "to prevent additional losses;" in response to residents' concern that mowing contractors might not recognize the sensitive area, Pepco installed fencing and signage "to preclude accidental intrusion" (Genua, 2008, p. 64).

Unfortunately, a decade of conservation intent has not prevented continued damage at this site. At some point, the protective fence was rolled back and was not replaced, and no signage is currently present (Figure 14). Collaborative efforts between Pepco and MDNR to develop a specialized management plan for the bog have been unsuccessful (McCarthy, 2016), and sporadic mowing continues to occur (Figure 15), as does filling (Figure 16).

In order to propose strategic interventions to draw attention to bogs and to encourage mowers to avoid them, the next section of this thesis explores the influence of environmental cues on landscape interpretation and behavior.

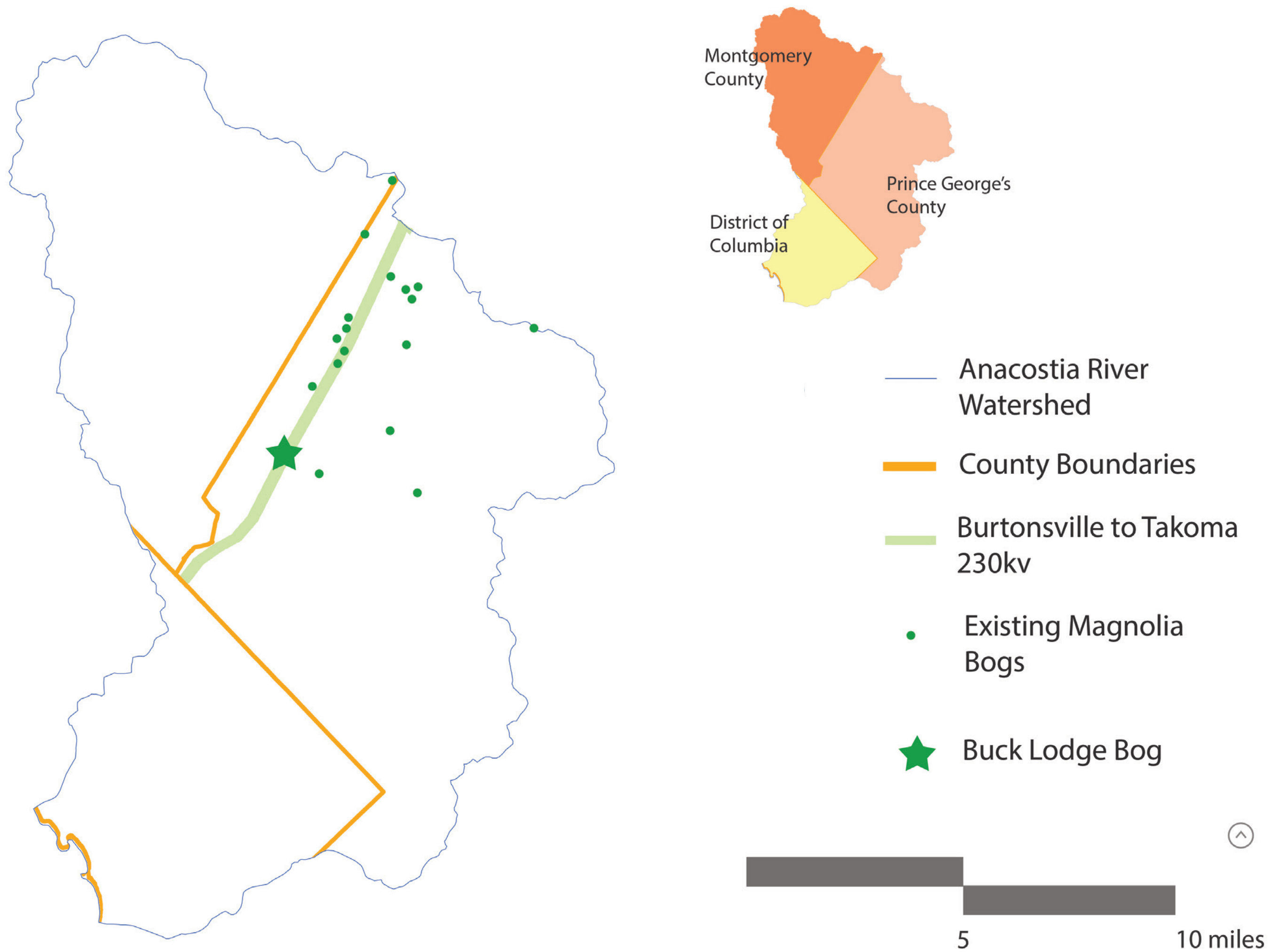

Figure 11: Buck Lodge Bog (pictured) is located directly in the center of the Anacostia River Watershed, at the northeastern edge of Prince George's County, Maryland. It is the southernmost of a series of bogs crossed by the PEPCO Burtonsville to Takoma 230kv Electrical Transmission ROW, which were probably all part of a large network of bogs that McAtee identified as the Powdermill Bogs in 1918.

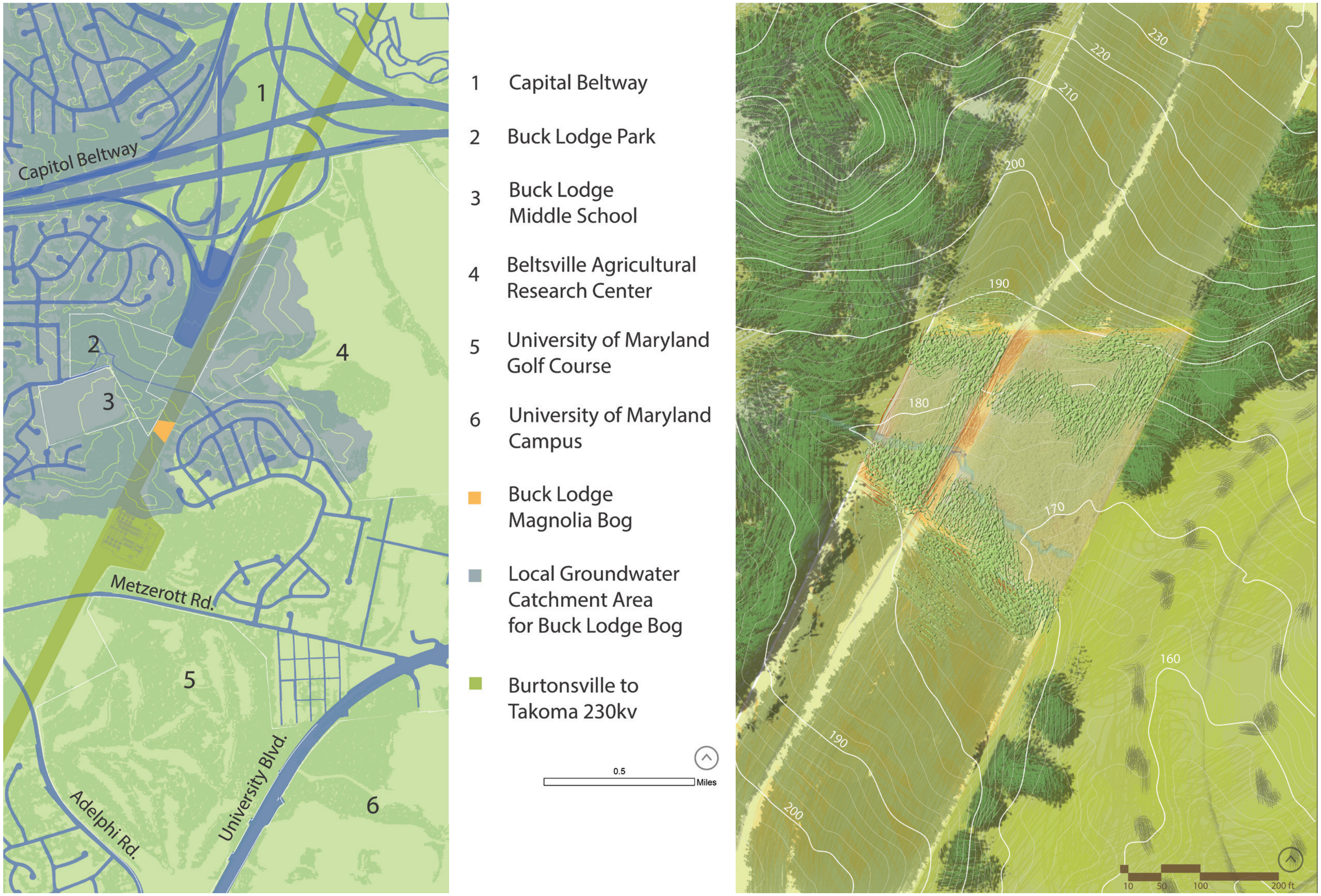

Figure 12: Just over two acres in size, Buck Lodge Bog is located southwest of the Beltsville Agricultural Research Center and northwest of the University of Maryland College Park Campus, between Buck Lodge Park and the neighborhood of College Park Woods (Inset at right).

Figure 13: A sampling of Buck Lodge Bog flora, photographed at Buck Lodge in July of 2015 through October of 2016. Clockwise from left: New York Ironweed, Vernonia noveboracensis (with Peck's Skipper, Polites peckius); Virginia Meadowbeauty, Rhexia virginiana; Crimson-eyed Rosemallow, Hibiscus moscheutos; Woolgrass, Scirpus cyperinus; Maryland Milkwort, Polygala mariana; Virginia Meadowbeauty, Rhexia virginiana, in seed, Flat-topped Goldenrod, Euthamia graminifolia; fertile fronds of Netted chainfern, Woodwardia areolata; Allegheny Monkeyflower, Mimulus ringens. At bottom, Buck Lodge Bog, looking to the southewest, is pictured below. Photos by author.

Figure 14: Fencing that at one point defined the boundary of Buck Lodge Bog lies in a discarded roll at the bog's edge (dog for scale). Photo by author, April 2016.

Figure 15: Equipment-related damages: At left, only small portions of the bog were left unmowed during a July 2015 ROW mowing. At right, a rut approximately eight-inches deep remains after traversage by a tractor in October of 2016. Photos by author.

Figure 16: Fill material has been added to Buck Lodge Bog, presumably to make the saturated ground more easily passable by equipment. Photo by author, July 2017.

Chapter 2: Cognitive Mapping and Behavior

"A supportive environment is one in which choice and information necessary for making choices are readily available."

- Stephen Kaplan, 1983
A Model of Person-Environment Compatibility

2.1 Cognitive Mapping Concepts

Environmental perception and its relationship to behavior has been a focus of study in many disciplines, including psychology, sociology, anthropology, geography, urban planning, and landscape architecture, where over time the processes involved in "recognizing places, and finding one's way between places" (Golledge, 1992) have been termed "cognitive mapping."

The relationship between cognitive mapping and design was first explored by urban planner Kevin Lynch, in his seminal 1960 work *Image of the City*. The concept was new at the time, having been introduced only a decade prior by Edward Tolman, a psychologist studying laboratory rats' ability to learn the layout of a maze. "We believe," Tolman had written, "that in the course of learning, something like a field map of the environment gets established in the rat's brain" (Tolman, 1948, p.192).

In *Image of the City,* Lynch argued that individuals navigate through space not by remembering every detail of the physical environment, but by utilizing significant spatial cues to develop a "generalized mental picture" of the landscape. He called this picture the "environmental image" (Lynch, 1960, p.4).

S. Kaplan (1973) describes the product thusly:

> The cognitive map is a construct that has been proposed to explain how individuals know their environment. It assumes that people store information about their environment in simplified form and in relation to other information they already have. It further assumes that this information is coded in a structure which people carry around in their heads, and that this structure corresponds, at least to a reasonable degree, to the environment it represents. It is as if an individual carried around a map or model of the environment in his head. The map is far from a cartographer's map, however. It is schematic, sketchy, incomplete, distorted, and otherwise simplified and idiosyncratic. It is, after all, a product of experience, not of precise measurement (pp. 275-276).

Golledge (1992) describes cognitive maps as the product of integration of three types of knowledge: "declarative" knowledge, which consists of things remembered as inventory; "procedural" knowledge, which consists of observed linkages by which that inventory can be ordered; and "configurational" knowledge, which consists of "awareness of relationships between features that are not directly sensed" (200). Lynch expresses the same idea in describing the environmental image, as having three dimensions – identity, structure, and meaning (p. 8).

The processes by which knowledge in these three categories, or dimensions, is obtained have been described variously as *assessing, knowing, and acting* (Gärling and Evans, 1991), *cognition, evaluation, and action* (Canter, 1991), and *perception, attention, and planning* (S. Kaplan, 1983); collectively, these processes are referred to as "environmental cognition" (S. Kaplan, 1983).

"Assessing" (Cognition, Perception) is a descriptor for the process of developing an awareness of what exists, of taking inventory, of recognizing in the environment the features that make it distinct. These features function as "cognitive reference points" (Presson & Montello, 1988, p. 379). Our instinctual need to identify features which can stand as points-of-reference is so strong that if we cannot find sufficient material in the environment, we will create it – “we scratch a mark on the sidewalk or wall, or build a cairn or mound of dirt, anything that can represent to us a sense of location” (Golledge, 1992, p.199).

“Knowing” (Evaluation, Attention) is a descriptor for analysis – the individual’s interpretation of the apparent or underlying connections between inventoried features. This analysis is not based purely on spatial linkages; the mapped “territory” extends far beyond geography to include associations, expectations, and social norms (Gulick, 1963; R. Kaplan, 1991; S. Kaplan, 1991; Lynch, 1960).

The value judgements, preferences, perception of locational relationships and distances, sense of personal role or status, and conceptualizations about ownership, such as “us” and “them,” that come out of analysis inform the “Acting” (Prediction, Planning) stage of mapping (Appleyard, 1979; Kaplan, Kaplan, & Ryan, 1998).

In this predictive stage, individuals derive their behavioral options - what actions feel acceptable, welcome, appropriate, or taboo for themselves and others in the given environment. Ultimately, the actions chosen could include such behaviors as passage through, recreational use, advocacy, conservation, extraction, avoidance, vandalism, etc.

In summary, cognitive maps are assembled through creation of an inventory of environmental elements, which are then linked to each other based on their perceived relationships, whether spatial or semantic, to provide a framework for behavioral choice-making, whether navigational or social (Appleyard, 1970; Byrne 1979; S. Kaplan, 1991; Lynch, 1960; Pick, 1972; Presson and Montello, 1988; Sadalla et al., 1980). The cognitive map is formed, as Lynch puts it, "in an interaction between self and place" (Lynch, 1985, p. 248) (Figure 17).

2.2 Influence of Cognitive Maps on Behavior

When sufficient environmental features are available, and when many connections may be readily drawn among them, a strong cognitive map may be formed (Figure 18). The strength of such a map lies in its provision of options. Multiple linkages between features allow the map user to make alternative choices when a given choice does not produce the desired outcome (S. Kaplan, 1991). "Effective behavior, Kaplan writes, "depends on knowledge of a larger space, even though it is impossible to predict what aspect of this knowledge will be useful (S. Kaplan, 1991, p. 179).

When an individual is unable to create a strong cognitive map, action carries with it much more risk. Individuals tend to be reluctant to engage in a

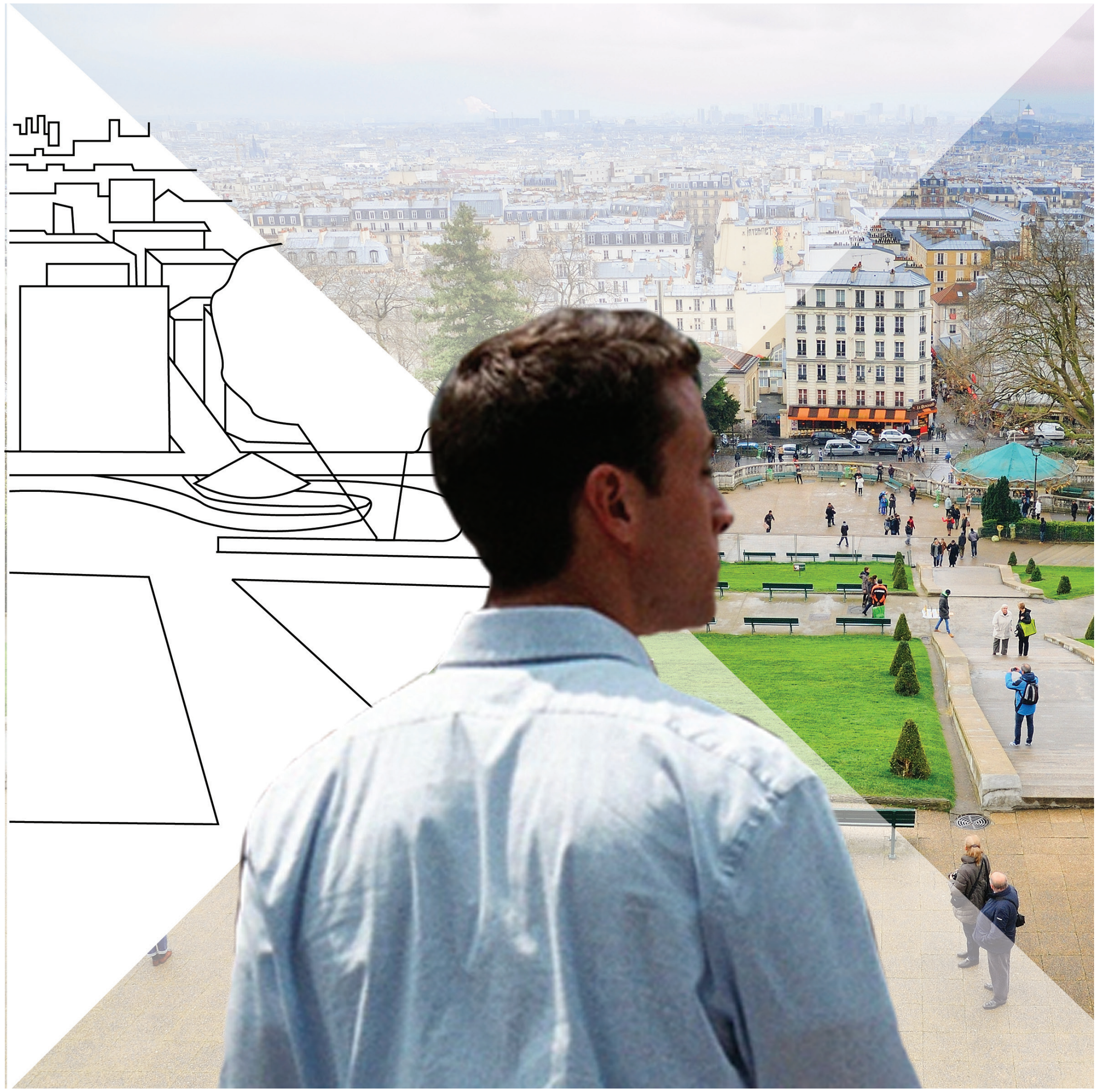

Figure 17: The cognitive map, a simplified “field map” (Tolman, 1948, p.192) of one’s environs, is a product of “experience, not of precise measurement” (S. Kaplan, 1973, pp.275-276), “formed in an interaction between self and place” (Lynch, 1985, p. 248)

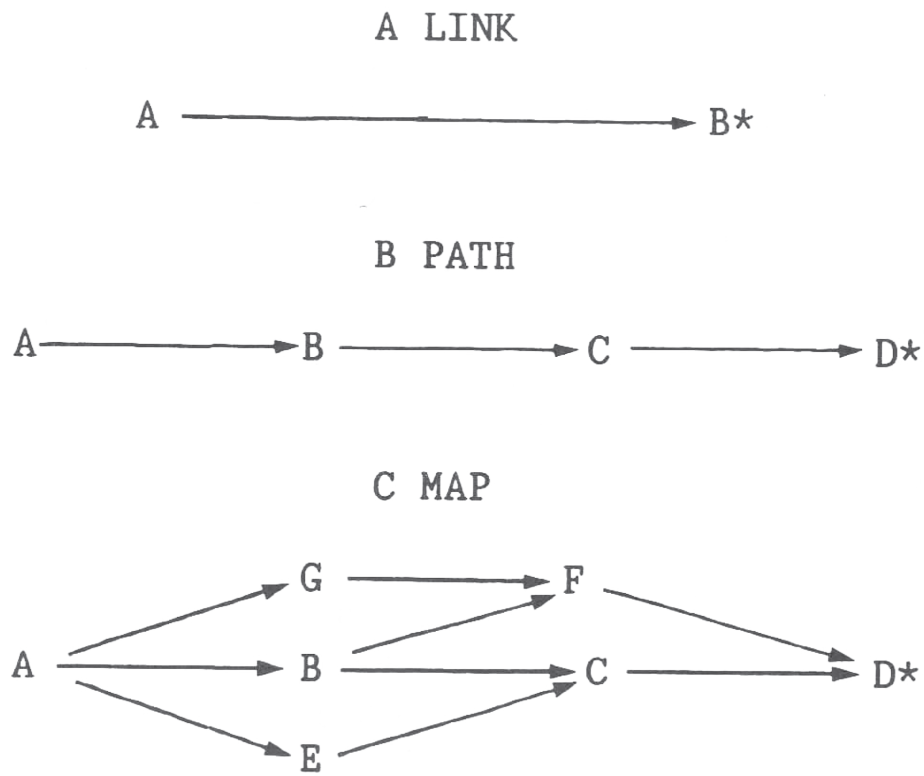

Figure 18: “Alternative structural bases of choice” (S. Kaplan, 1991, p.178). A strong cognitive map allows its user to adapt to a sometimes unpredictable environment by facilitating awareness of multiple options for reaching the same objective.

situation when they feel unable to determine what the outcome will be, or the likelihood that an action will produce a given outcome. In such a scenario people may be afraid that they will find themselves trapped in an unforgiving or humiliating situation. It is a human tendency to go to great lengths, even to our own detriment, to avoid being seen as stupid or wrong (S. Kaplan, 1991, p.177). People have been shown to appreciate "moderate uncertainty," (Evans, 1980, p. 280) and the "promise of new information" (S. Kaplan, 1975, p. 94), but Kaplan notes that "having control when one has little information on which to base a decision can actually reduce self-esteem" (S. Kaplan, 1983, p. 325).

"Clarity of choice, Kaplan writes, "depends on the cognitive structure that represents the extensive problem space in which choice is embedded" (S. Kaplan, 1991, pp.179-180). In landscapes that lend themselves to cognitive mapping, individuals are better prepared and more willing to make participatory choices (S. Kaplan, 1991, p.177). Thus, an environment that supports cognitive mapping also supports engagement, by engendering the confidence to act.

On ROW, if mowers are not able to create strong cognitive maps - if the ROW environment is not "imageable" enough - mowers are apt to feel unsure or conflicted in regard to where bogs actually are and whether or not to mow them. In order to use these tools to increase clarity of cognitive maps and to engender confidence in mowers, we must determine what makes a landscape feature stand out as a reference point, and what environmental elements facilitate awareness and of physical and semantic relationships.

Chapter 3: Design Tools

“Unless we are mentally at risk, our great pleasure is to create order, in an ascending scale of complexity as we mature.”

- Kevin Lynch, 1960
Image of the City

3.1 Points of Reference

R. Kaplan (1991) writes of environmental assessment that “to do justice to the description of the physical environment is an arduous, extensive, and ever-expanding task” (p. 22). “What emerges from this confounding problem,” Kaplan argues, “is the need for the assessor to establish a *hierarchy of import* which dismisses some environmental information” (p. 22).

Lynch proffers that this need is met through recognition of archetypal forms in the landscape (Lynch, 1960). Lynch’s research, corroborated in following years by de Jonge (1962) and Francescato & Mebane (1973), identifies five landscape archetypes which are consistently recognized in cognitive mapping: *paths, nodes, districts, edges, and landmarks* (Figure 19).

Paths are corridors, identified by their linear continuity, and by their connective and kinetic character: “A path is a line of journeying - “a thing

Figure 19: Lynch’s landscape archetypes: Clockwise from left: *path*, a line of journeying; *node*, a hub where paths converge; *district*, a place where cues are continous throughout, and discontinuous elsewhere; *edge*, a line where contrasting regions meet; and *landmark*, a feature distinguished by its singularity (Lynch, 1960).

which goes toward something" (Lynch, 1960, p. 97). A *node* is a distinct convergence, a hub at which paths intersect, or from which things radiate (Lynch, 1960, p.103). A *district* is an area "recognized by clues which are continuous throughout the district and discontinuous elsewhere," and may also be recognized by a sense of enclosure or separation (Lynch, pp.103 - 104). *Edges* are lines of contrast. They may function as seams or barriers, lie overhead or underfoot, and be permeable or impermeable. Edges may separate districts, define paths, demarcate property, separate divergent land uses, and indicate the spatial limits of activity (Lynch p.100).

A *landmark* differs from the other archetypes in that it is defined by its singularity (Lynch, p.100). It is an isolated event, a point in the landscape. It does not lead somewhere, like a path, offer options, like a node, encompass, like a district, or bound, like an edge. Instead, its essential quality as an archetype is its "hereness." It functions as "a spatial cue associated with a location, target object, or behavioral contingency" (Presson & Montello, 1988, p. 379).

In identifying landmarks in the landscape, Golledge (1992) writes, "we look for things that stand out because they are different from their surrounds, or because they have a shape or form or structure that we believe we could recognize again (p.199). Entities identified by individuals as landmarks may vary widely – as Lynch writes, “A landmark may be a doorknob as well as a dome” (p. 101) - but for any feature to have a quality of singularity, it must stand out in some way as a “figure” against a “ground.” For example, Lynch recounts a study in which people participating in maze-navigation experiment, “developed affection for such simple landmarks as a rough board,” (Lynch, 1960, p.125). Figure and ground may be distinguished based on physical characteristics such as size, color, material, surface texture, age, and visual complexity, but they can also be based on less tangible things - as entities in stasis against a ground of change, for instance, or on aural inputs (Appleyard, 1969, 1970, 1979; Jiang, 2013). The operative act is the grouping of some entities and sensory inputs into a category of general context, the matrix in which things exist, and the isolation of other entities from that group as entities which exist within, but are distinct from, that matrix.

No matter how readily a figure can be distinguished from a ground, however, it will not be a viable point of reference if it is not reliable. Stephen Kaplan writes, “Consider an object whose appearance changes under various circumstances. It looks different depending on lighting conditions and viewing angles. Building a well-connected cognitive unit (i.e., an internal representation) to stand for such a variable object is far more difficult” (S.

Kaplan, 1991, p. 181). The confusion that results from trying to use changing elements as archetypal features is apparent in management of edges on utility ROW. Vegetation is by nature in constant change at multiple scales, from plant growth to seasonal change to succession, yet trees and other woody vegetation are often the only feature distinguishing the edge of utility ROW (Figure 20). A common management issue is that as edge vegetation grows into the ROW, mowers tend to move farther in to avoid being scraped by branches. If repeated over time, this response eventually results in the narrowing of the managed area.

In addition to the influence of singularity and reliability on which features are selected as landmarks, a great influence is exerted by perception of relevance. Each of us have existing backgrounds and agendas, and we often come to an environment with an existing perception of our role and existing action plans. We naturally tend to filter for entities that have meaning in the particular context in which we are operating. Rachel Kaplan illustrates this phenomenon by describing differences in the way a room may be mentally mapped by a writer who works in it and a carpenter who makes a repair in it – the writer may hold in memory the writing desk, writing tools, and source of light, while the carpenter might be more aware of the features of room's architecture (R. Kaplan, 1991, p.21). Kaplan writes, "Implicit in

Figure 20: Vegetation is not a reliable landscape feature on ROW, due to its naturally changing nature, and its mutability in a mowed environment. The photo above highlights the ambiguity of vegetation as demarcation of edge. Photo by author.

[a decision about *what* to include in cognitive inventory] is a theory of 'what matters'" (R. Kaplan, 1991, p.22). Presson & Montello (1988) make the same argument, writing, "the nature of the task largely determines the 'landmark' or target status of particular elements. Results may reflects as much about the task structure as they do about the underlying process of spatial representation" (p. 379).

Greenbie (1975) cautions that if due to our expectations, interests, and experiences, we consciously or unconsciously fail to recognize something as important, it may not be observed at all. He writes, "there are two aspects of human perception which relate to this problem. One has to do with what a particular individual is *capable* of seeing or otherwise perceiving, and the other has to do with what he or she is *interested* in seeing" (p. 66). Sophocles commented on this topic as well: "What is unsought will remain undetected."

Landscape elements which are not necessarily relevant to an individual's "task" or "plan," may gain relevance through connections to elements that are. Such connections can be as simple as proximity – features may be more likely to be noted if they are located in places where attention is already directed. For example, several studies have shown that features are more often recalled when located near to or visible from major roads or intersections (Appleyard, 1970, 1976; Heft, 1979; Herman & Siegel, 1978, Lynch, 1960). Relevance may also be assigned to landscape features which share patterns already associated with relevance. Such patterns may be found in the layout of circulation, in the contextual use of materials, in stylistic cues, and in social behaviors.

Perception of relevance may also be influenced by interpretation of common familiarity. Golledge (1992) argues that interpreted status increases when a feature is “regarded as being familiar or well known by a significant number of people, (p. 201). This phenomenon is illustrated in the work of Joan Iverson Nassauer, who showed that landscape features which show “evidence of human intention” are “noticed” more than others (Nassauer, 2011).

An example of the influence of perceived common familiarity can be found in the power of names and labels to indicate significance. Anthropologist Edward Sapir’s argument for how names arise explain why names, by their nature, indicate common familiarity:

> Properly speaking . . . the physical environment is reflected in language only in so far as it has been influenced by social factors. The mere existence, for instance, of a certain type of animal in the physical

> environment of a people does not suffice to give rise to a linguistic symbol referring to it. It is necessary that the animal be known by the members of the group in common and that they have some interest, however slight, in it before the language of the community is called upon to make reference to this particular element of the physical environment (1912, p. 228).

Lynch writes, “The named environment, familiar to all, furnishes material for common memories and symbols which bind the group together and allow them to communicate with each other” (1960, p. 126). The authority associated with naming is apparent in a comparison of two studies on building recognition. In a 1969 study, Donald Appleyard found that buildings with characteristics such as high use, symbolic significance, high size contrast to surroundings, sharp contours, and bright surfaces were more frequently recalled by respondents, and a later study by Pezdek and Evans (1979) replicated these findings . . . until labels were applied to the buildings. With the addition of labels, Pezdek and Evans founds that the relationship between physical features of the buildings and memory completely disappeared, while at the same time, relocation memory was improved. The conclusion can be drawn that in the cacophony of potentially mappable environmental features, the common familiarity implied by the existence of a name influenced respondents' perceptions of "what matters."

3.2 Awareness and Configuration of Relationships

Stephen Kaplan explains that in order for an environment to be coherent, for logical relationships to be understood among reference points, "there must be some degree of pattern, of order, running through the variety. We look for themes, for rules, and for "variable but identifiable physical forms" (Evans, 1980, p. 280; S. Kaplan, 1973; S. Kaplan, 1975), and experience "frustration and disappointment" when we cannot find order of some kind (R. Kaplan, 1973; S. Kaplan, 1973, p. 280). We undertake this search within a hierarchy of schema under which we conceptualize the landscape at different scales.

A study by Stevens & Coupe (1978) demonstrates the phenomena of schematic hierarchy by showing that cognitive distortions often occur when people try to judge spatial relationships between entities that fall cognitively under different superordinate categories. For example, although San Diego, California is in fact south*east* of Reno, Nevada, many respondents could not place it there because of California's geographical position *west* of Nevada.

When larger schema are too big to handle the relationships we need to understand, it is common for us to mentally break the landscape into "chunks" (Allen, 1981; Allen & Kirasic, 1985; S. Kaplan, 1975). The process of creating boundaries around information sets increases our ability to create functional cognitive maps (Herman & Siegel, 1978), and the separation of routes into segments allows us to remember sequence "far more effectively than would be the case if one tried to learn the correct sequence of an extremely large number of individual cues" (Allen, 1981).

Doubt manifests when an understanding of order that we have worked hard to develop is contradicted – when our "expectations do not correspond to the perceived reality" (S. Kaplan, 1973, p. 180), as shown in a study by Norman and Rumelhart (1975) in which respondents had a difficult time situating their balconies when drawing floor plans of their apartments yielded similar results:

> Norman and Rumelhart . . . found that when residents drew their apartment floor plans in a particular housing complex, nearly half of them incorrectly extended their balcony beyond the flush, exterior plane of the apartment. An additional 20% had to redraw the balcony several times. The authors suggested that the resident's difficulty in

drawing the balcony stemmed from its unusual construction. The balcony was recessed within the exterior plane of the building instead of overhanging as most balconies do (Evans, 1980, p. 261).

Landscapes that fail to exhibit clear rules of organization, such as regular street patterns, tend to be difficult to map (de Jonge, 1962; Tzamir, 1978) - and we will often re-imagine landscapes to ameliorate dissonance. De Jonge (1962) showed that in cognitive maps, “people tend to imagine patterns that are almost regular as perfectly regular” (p. 274), and Byrne (1979), in a study wherein respondents were asked to estimate the angles of familiar road intersections found that although the junctions were all, in reality, at angles between either 60 and 70 or 110 and 120 degrees, in the resulting maps drawn by the respondents, “all the estimates differed little from 90 degrees” (Byrne, 1979, p.147).

Divisionary conceptualizations such as “us” and “them” can also obstruct connection-building. Features which are seen as “symbolic imports from outside,” may be perceived as meant to serve someone else, and thus be met with resistance to assimilation into the mapping structure (Appleyard, 1979, p.143).

Chapter 4: Analysis

"Interpretive research strategies start from the recognition that the meanings of objects, events, words, actions, and images are not always plain and obvious, and they require the investigator to actively engage in 'making sense' of the phenomena they encounter."

- M. Elen Deming and Simon Swaffield, 2011
  Landscape Architecture Research: Inquiry, Strategy, Design

4.1 Methods

Deming and Swaffield characterize an interpretive strategy as one in which "the researcher moves reflexively through the observed data and the theoretical concepts that are brought to the investigation and used to make sense of what is found" (2011, p.152). In order to apply the findings from cognitive mapping research to a site and produce an applicable design, an attempt was made to evaluate the ROW environment from the perspective of a person tasked with mowing it. Although it was impossible to escape the fact that, as Deming and Swaffield write, conclusions from this strategy "can never be totally independent of the investigator" (p. 152), the goal was to develop an empathetic picture of what that experience might be.

In order to inform this interpretation, I:

- Walked long extents of the study site ROW
- Took photographs and made video recordings

- Examined aerial images
- Talked with MDNR employees about conservation efforts
- Talked with managers from maintenance contractors about mowing procedures
- Familiarized myself with equipment used to mow the lines

These observations informed the “cognitive site analysis” on which the final design for an enhanced cueing system for the Buck Lodge Bog site is based.

4.2 Results

Spatial Schema

Transmission along the Burtonsville to Takoma ROW is shared by Washington Gas, Washington Suburban Sanitary Commission, and a variety of communications companies. Under the leadership of Black & Veatch, contracted by PEPCO, vegetation on the ROW is managed through sub-contracts with Asplundh and Davey Tree Company. The Burtonsville to Takoma ROW is one of many that serve the region, each managed separately under different contracts (Figure 21). These have been humorously likened by some to “fiefdoms,” and it is not difficult to imagine that in cognitive mapping terms, they may be seen by mowers as akin to individual city-states.

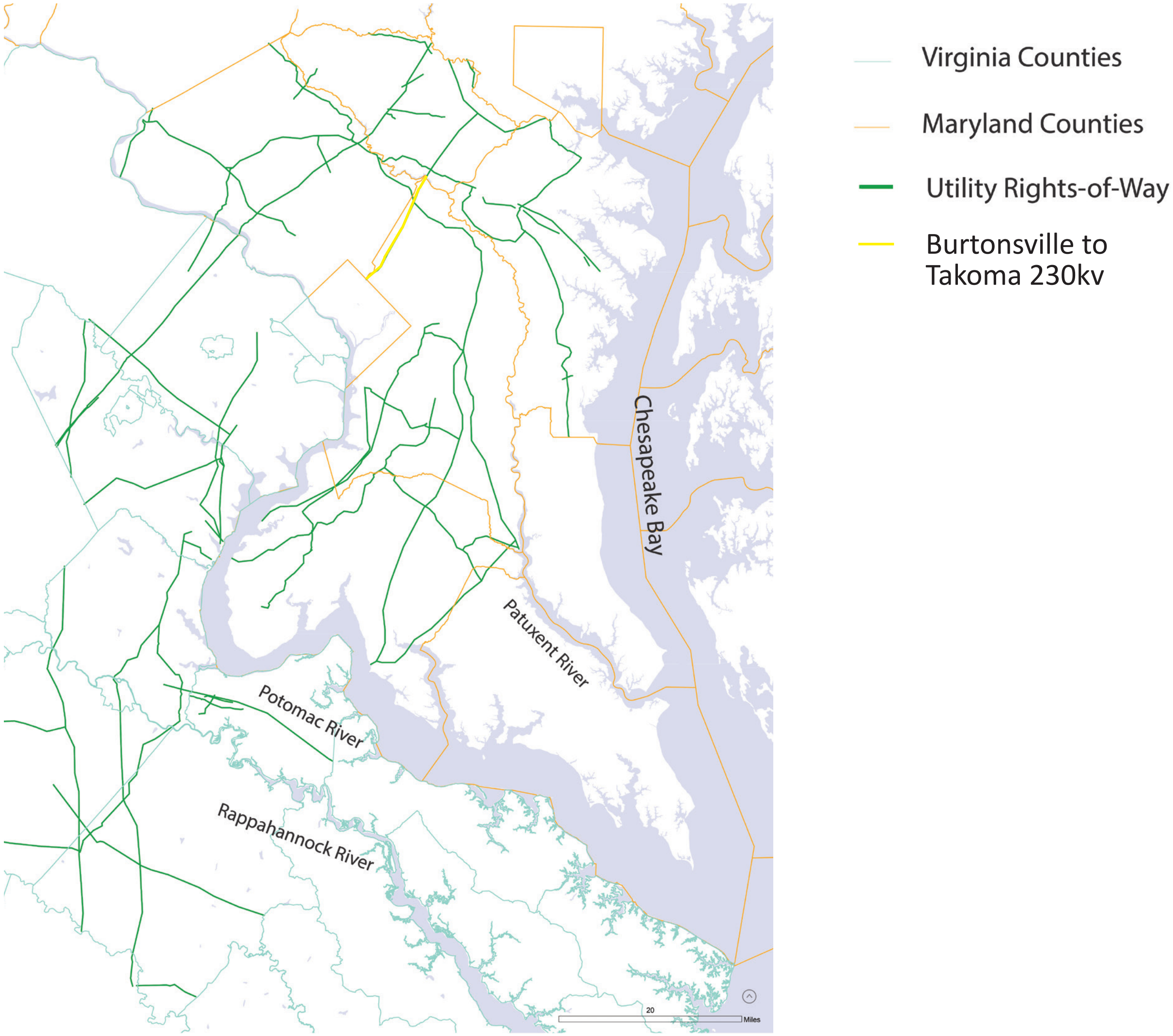

Figure 21: Many separate ROW cross the counties in which Magnolia Bogs are found. These are generally managed as distinct entities.

Within each ROW, the landscape is divided into a sequence of segments and interruptions (Figure 22). Segments, the stretches of ROW through which continuous movement is possible, are interrupted by roads, waterways, and freeways which intercept that movement (Figure 23). Although some of these "interruptions" might be crossed and forward motion continued, all serve to separate segments from each other. This separation is reinforced by the common presence of more or less symbolic gates at segment entrances (Figure 24).

Remembering that landscape information is often learned in "chunks" (Allen, 1981; Allen & Kirasic, 1985; Herman & Siegel, 1978; S. Kaplan, 1975), it is likely that these segments form the divisions mowers use to cognitively organize their memory of the landscape. For example, a segment might be distinguished in memory by topography, e.g. "the one with two hills;" landmarks, e.g. "the one with the substation;" or simply boundaries, e.g. "the one between Cool Spring and Adelphi," but it is almost certain that each is distinguished from the other as mowers proceed with their task of mowing the entirety of the line, due to the fact that a choice has to be made at either edge – namely, whether it is possible to cross, or whether one must "go around." Although cues may be mirrored across segments, the sense of enclosure and separateness, combined with the opportunity for change at every border line, endows each segment with a district-like quality.

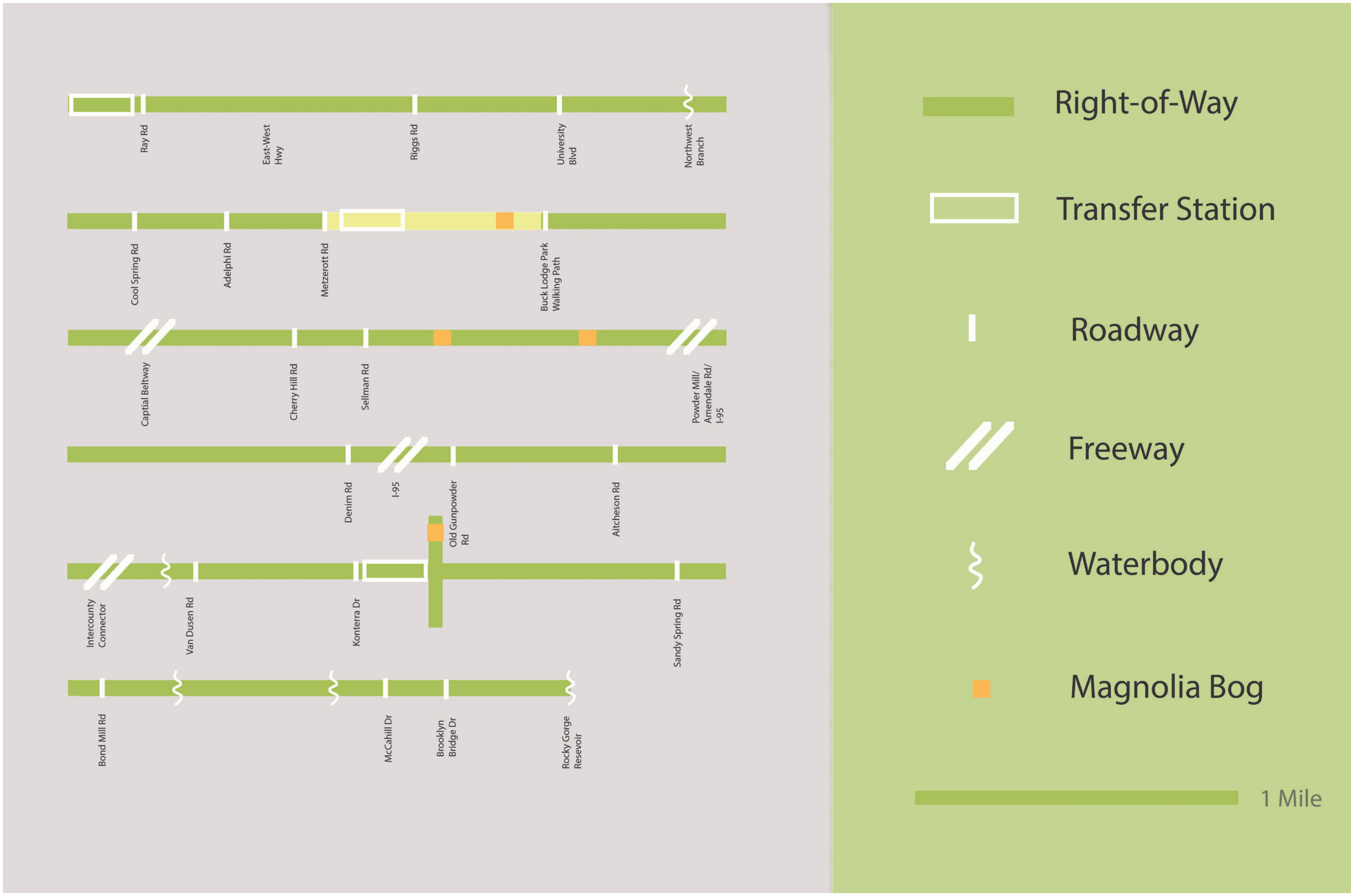

Figure 22: Schematic representation of segment and interruption sequence on the Burtonsville to Takoma 230kv ROW. The segment containing Buck Lodge Bog is highlighted in yellow.

Figure 23: Segmentation of the Burtonsville to Takoma 230kv by the I-95/495 Interchange. Photo by author, December 2016.

Figure 24: The use of symbolic gates at junction points reinforces a sense of segmentation on the ROW.

Figure and Ground

As with most ROW, management on the Burtonsville to Takoma generally entails suppression of vegetative growth, whether in the form of trimming or removal of woody vegetation, or mowing of herbaceous vegetation. Mowing is generally performed once annually, but because there are so many miles of ROW, mowers are generally full-time employees, and there is a high retention rate, with many mowers having held positions for over 10 years (Asplundh, 2017; Ferguson, 2017). Mowing is done by tractor equipped with mowing attachments. Before mowing a ROW, crew leaders go over with their crews maps which detail areas which are to be avoided, some due to steep slopes, others due to protected habitat (Asplundh, 2017). These areas are not necessarily marked in the field, but must be remembered by the mowers.

In this setting, where the mowers' task is to discern what should and should not be mowed and to act accordingly, it stands to reason that the "ground" against which singularity is perceived is likely that which it is physically possible to mow. In the ROW environment, mowed not by riding mower but by a powerful tractor with articulated attachments, almost any organic object might thus be perceived as "ground", whether on the ground plane or not. Standing out from this matrix as figures are objects made of metal, plastic, or very large-diameter wood. These are the materials used for functional infrastructure as well as for markers which indicate buried structures. After an annual mowing, these figures stand out among felled saplings and sizable tree branches “chewed” by the mowing blade. (Figure 25).

Hierarchy of Significance

The material composition and scale of these figures may be interpreted as relaying important information about relevance and authority. The towering, 90-ft high-voltage transmission structures, literally associated with power, are made of heavy galvanized steel (Figure 26). Sub-transmission lines, which deliver lower-voltage electricity to the local area, are carried on 30-ft milled tree trunks which also support telephone and other communications signals (Figure 27). Below-ground utilities are marked with plastic or metal posts less 5-ft high (Figure 28). As high-voltage power distribution is the priority function of the ROW (remember that Pepco is the land-owner), it is logical to imagine that all other transmission may be seen as subordinate by mowers, who may then associate the descending longevity and scale of transmission objects with a hierarchy of significance (Figure 29).

4.3 Discussion

Magnolia Bogs, composed entirely of “ground” materials, subject to vegetative change and human intervention, are marked ambiguously if at all, with

Figure 25: Perception of figure and ground on ROW: A visit to the Burtonsville to Takoma ROW after a mowing revealed that although even large trees had been "chewed" by the mowing blade, metal objects were clearly avoided. Photo by author.

Figure 26: The towering, 90-ft high-voltage transmission structures, literally associated with power, are made of heavy galvanized steel. Photos by author.

Figure 27: Sub-transmission and communications signal lines are carried on 30-ft milled tree trunks known familiarly as "telephone poles." Photo by author.

Figure 28: Below-ground utilities are marked with plastic or metal posts less than five feet high. Photos by author.

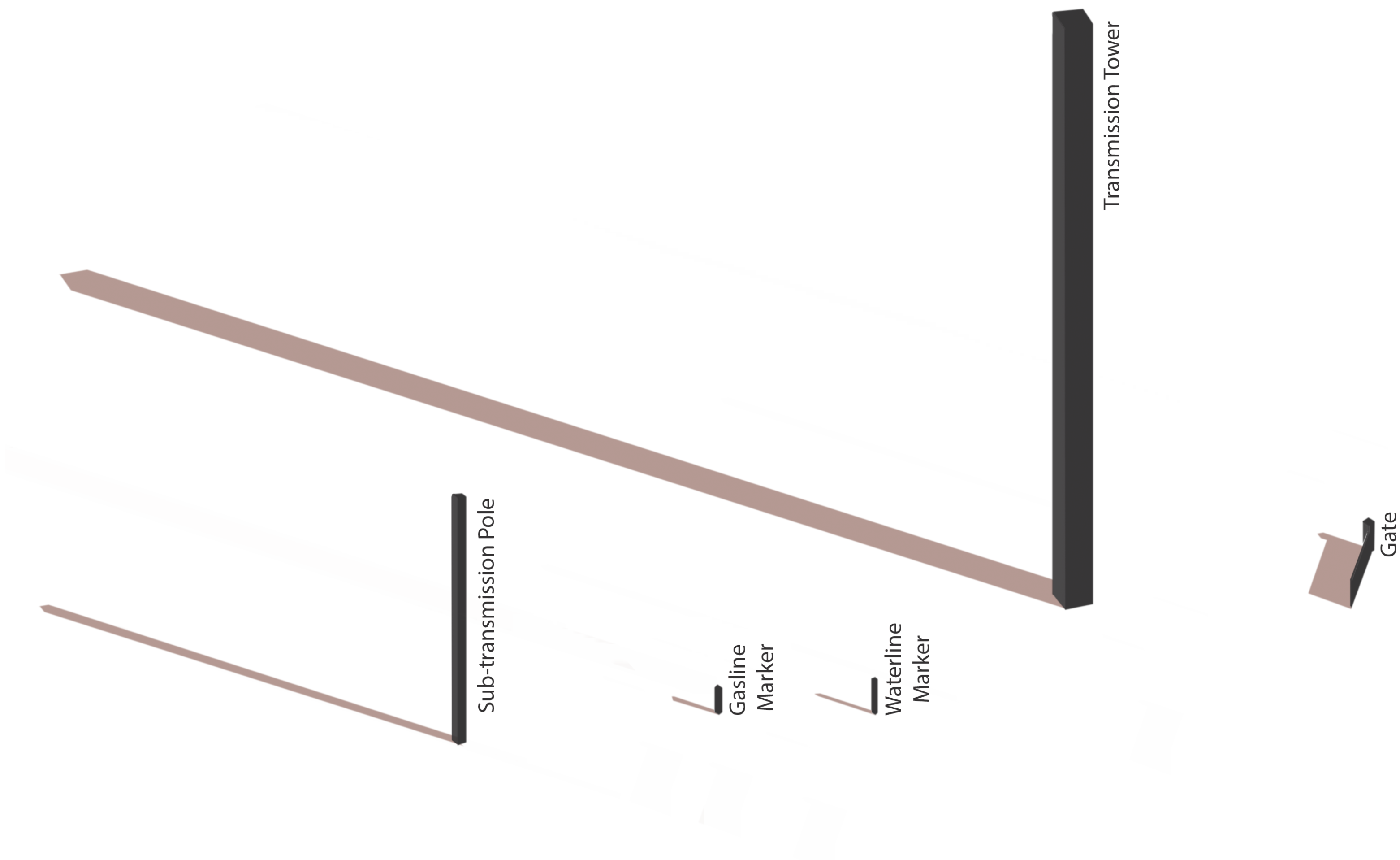

Figure 29: Mowers may associate the descending longevity and scale of transmission objects with a hierarchy of significance.

little to convey to the mower a significance in relation to their task, or to the larger ROW schema (Figure 30).

It thus follows that mowing of Magnolia Bogs on ROW may occur as the result of one of the following cognitive scenarios:

- Mowers are not aware of the existence of the bogs along the right-of-way.
- Mowers are aware of the existence of the bogs along the right-of-way, but aren't able to distinguish them from the surrounding landscape.
- Mowers are aware of the existence of the bogs along the right-of-way, are able to distinguish them from the surrounding landscape, but do not know what is expected of them at bog locations.
- Mowers are aware of the existence of the bogs along the right-of-way, are able to distinguish them from the surrounding landscape, know what is expected of them at bog locations, but feel that this expectation may be lower priority than others.

In an effort to respond to each of these possibilities, the proposed cueing scheme attempts to incorporate authoritative materials in a manner consistent with existing patterns of scale to formalize bog boundaries and paths, alert mowers to the presence of bogs, and bolster mowers' confidence in the action of leaving the bogs unmowed.

Figure 30: Magnolia Bogs, composed entirely of "ground" materials, subject to vegetative change and human intervention, are marked ambiguously if at all, with little to convey to the mower a significance in relation to their task, or to the larger ROW schema.

Chapter 5: Application

"Since image development is a two-way process between observer and observed, it is possible to strengthen the image either by symbolic devices, by the retraining of the perceiver, or by reshaping one's surroundings."

- Kevin Lynch, 1960
Image of the City

5.1 Cueing Scheme

The cueing scheme proposed here is made up of four design components (Figure 31) that would be encountered by mowers in the following order:

- Segment markers indicating entry into the bog "district"
- A line of demarcation at the mowing boundary
- Monumentation identifying Buck Lodge Bog
- A formalized bog crossing

The design of these interventions reflects a desire not only to improve imageability, but to do so with the least possible environmental impact, and without interfering with management needs.

5.2 Materials Palette

Repurposed large-diameter wood

As the ROW is maintained, felled trees and retired telephone poles accumulate in the landscape (Figure 32). With large diameters that make

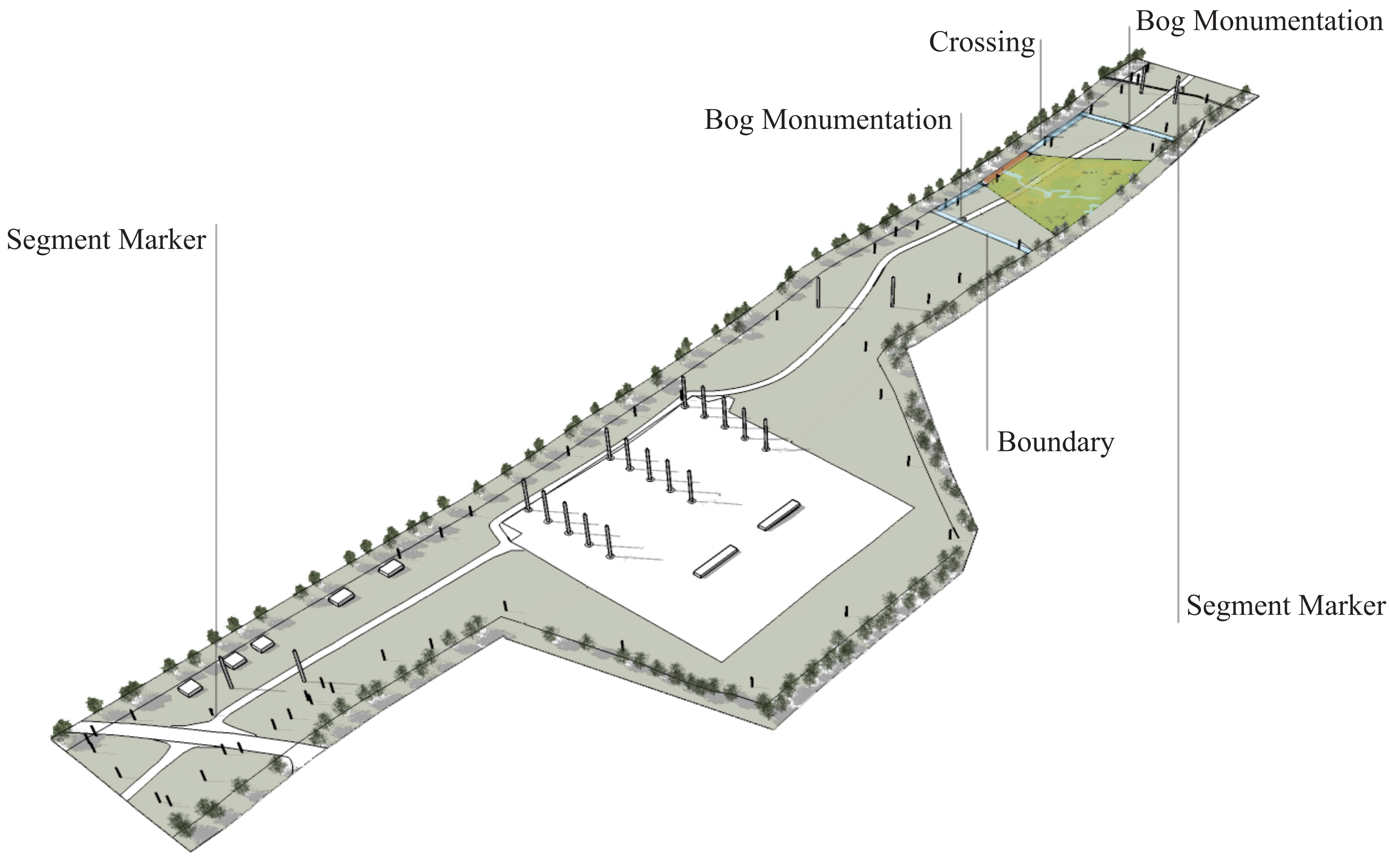

Figure 31: Proposed cueing scheme: formalized crossing, bog monumentation, boundary indications, and segment markers.

Figure 32: Felled trees and retired telephone poles accumulate in the ROW landscape, becoming readily available materials for reuse in cueing structures. Photos by author.

these objects stand out as figures, these readily-available materials are ideal for use in cueing structures. As they originate from the ROW landscape and are already the property of Pepco, their use could also support interpretation of cueing structures as authoritative.

Weathering steel

While steel may be associated with permanence and authority on the ROW, iron is associated with Magnolia Bogs. Bog iron is a deposit that results from the concentration of waterborne iron by anaerobic bacteria that thrive in bog soils. This material was much sought-after in the Mid-Atlantic during the colonial period. Boulders of bog iron can be easily found along the Burtonsville to Takoma ROW (Figure 33), and the presence of the iron-concentrating bacteria at Buck Lodge Bog is evidenced by the orange, oily film on patches of surface water and soil (Figure 34). The use of weathering steel, an alloy of carbon and iron which oxidizes to a deep rust-red, is thus proposed to provide a cognitive connection between bogs and the significance associated with metal objects on the ROW.

Figure 33: Bog iron is present all along the Burtonsville to Takoma ROW.

Figure 34: The oily orange film on standing water and wet soils reveals the presence of iron-concentrating anaerobic bacteria at Buck Lodge Bog, as well as the presence of iron-rich groundwater.

Crushed urbanite

Crushed urbanite (reused stone and concrete building materials) is presently used on the ROW to quickly lay down paths traversable by large equipment. (Figure 35). This material is resistant to weathering and remains in place over time. Its white coloration makes it stand out against the greens and browns of vegetation. As a very resilient material already associated with circulation, crushed urbanite is proposed here for creating pathways.

5.3 Symbology

We discussed earlier that divisionary conceptions can result in dismissal of some information from cognitive maps. Although it was found that names and labels can be powerful indicators of group familiarity, it is also true that they can create the perception of exclusion – a sense of “us” and “them”. Tufte (1990) refers to the words of movement researcher Anne Hutchinson Guest in explaining the value of communicative symbology in place of language; “any serious system of movement notation avoids words because they are a strong deterrent to international communication (1984, cited in Tufte, 1990, p. 27). In a language-rich environment like the Washington, D.C. region, use of a particular language is likely to exclude

Figure 35: Crushed urbanite is used on the ROW to quickly lay down paths that can be travelled by large equipment.

some observers. For this reason, a symbolic pictogram was developed to represent Magnolia Bogs.

The design of this symbol uses a perforated, slanted line to reference both the hill-slope characteristic of bogs and their nature as seepages rather than pools or channels (Figure 36). The symbol is intended to be easily recognizable, and to be simple to apply to notation of maps in the field.

5.4 Scale of Interventions

Because Magnolia Bogs are predominantly at and below ground-level, especially in relation to other ROW landscape features, scaling of cues is modeled around existing markers that indicate below-ground utilities such as water and gas lines.

5.5 Design of Individual Components

Segment markers

We have seen that the ROW landscape is divided into segments. The segment on which Buck Lodge appears is bounded by Metzerott Road to the south, and a paved pedestrian path to the north (Figure 37). In the proposed cueing system, segment markers at these entry points are intended to establish the segment as a "bog district," with the aim of alerting mowers to

Figure 36: Magnolia Bog pictogram.

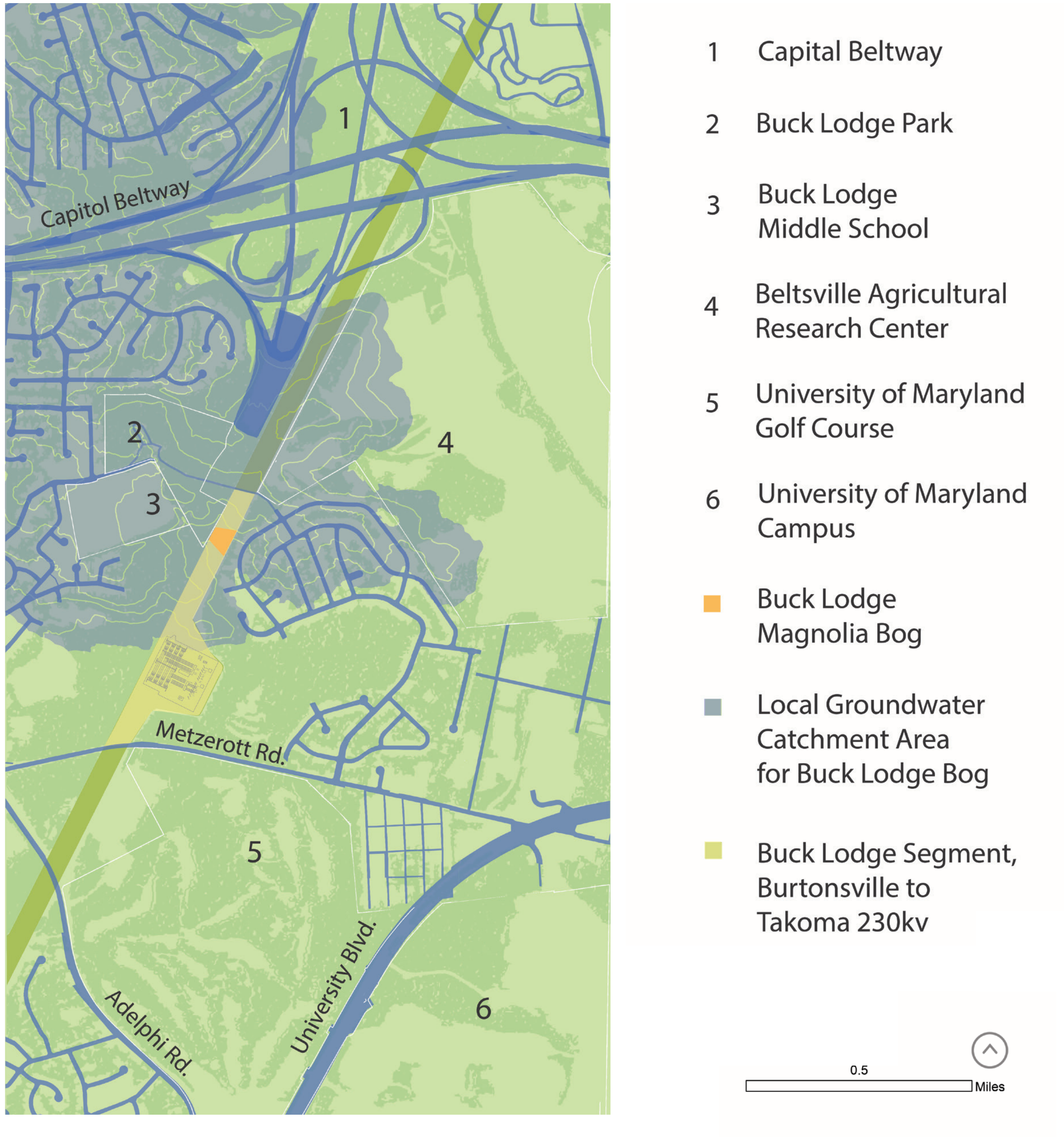

Figure 37:
The Buck Lodge Bog ROW segement, highlighted in yellow.

the upcoming presence of a bog (Figure 38). These markers are intended to be used on all segments containing bogs. Consistent placement at either segment entrance could reinforce the sense of entrance and exit - markers could be placed so as to be always on the left when entering a bog segment, and on the right when leaving one.

The design vision for these markers progressed from monumental to modest. Initial designs aimed to draw public attention to the bogs at these high-visibility locations, with the goal of increasing mowers' perception of bog value by increasing common familiarity. Sculptural forms and stormwater features were explored, until the possibility that this approach might undermine perception of the markers as official instruments of communication between the utility company and ROW laborers became a concern. It was important to avoid the ambiguity of interpretation that might result from the markers being viewed as imposed from outside of the ROW management schema.

In the final design, a simple indicator was chosen – a signpost similar to what one might at an entrance to a farm or ranch – a heavy wooden post supporting a metal sign with a strong identifying mark. In this case, the post and sign-support would be made from retired telephone poles, the metal sign would be of weathering steel, and the insignia would be the Magnolia Bog

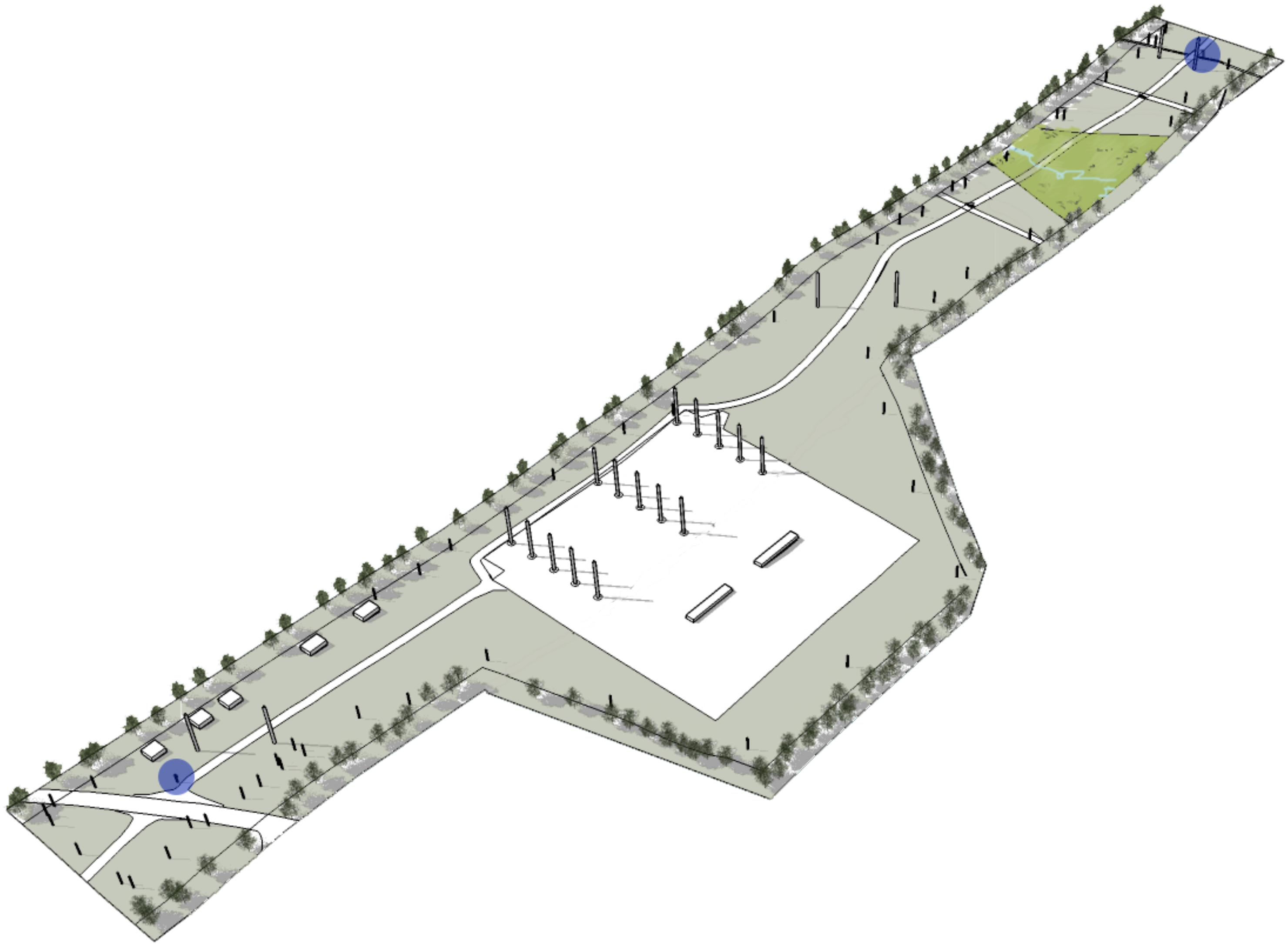

Figure 38: Segment marker locations for Buck Lodge Bog ROW segment.

pictogram. The suggested height of the marker is around 13’ – tall enough to be larger than the upcoming bog monument and to be easily visible to mowers whose eye level would be about nine feet from the ground when seated in a tractor (Figure 39).

Boundary demarcation

The Burtonsville to Takoma ROW runs through areas in which roads are not strongly connected. The inefficiency that would thus result from creating a barricade around the bog and requiring mowers to backtrack and return from the other side would likely make this option undesirable from a management perspective (Figure 40).

The boundary thus needs to be permeable, and also needs to be easily passed over by the mowing blade. Raised boundaries can create problem areas for vegetation management, requiring the extra management step of using a string trimmer to reach plant growth that the mower cannot. The problem is a akin to the difficultly of trying to vacuum the edges of a room (Figure 41).

In addition, due to fact that mowing implements are attached at the side and back of the mowing tractor rather than the front, forward driver visibility is limited by the height of mature grasses. Unless viewed from

Figure 39: Segment marker.

Figure 40: The route mowers would need to take to avoid crossing through the bog makes the option of a barricade undesirable.

Figure 41: Raised boundaries create areas of vegetative growth that cannot be reached with a mowing attachment, necessitating the additional management step of string-trimming. Image: Deer fence, at Burnicombe Farm enclosing a new plantation of what appear to be blueberries, by R. Cornfoot, December 5, 2009. Retrieved from https://commons.wikimedia.org/wiki/File:Deer_fence,_at_Burnicombe_Farm_-_geograph.org.uk_-_1607202.jpg. Used under Creative Commons Attribution 2.0 Generic License: https://creativecommons.org/licenses/by/2.0/

uphill, objects less than six feet in height are not generally visible to mowers. Even objects designed to stand out are sometimes mowed down under these conditions (Figure 42).

Thus, a ground-level boundary will not be visible until this mower has reached it. With a turning radius of 14.7 feet, a John Deere 6430 Cab Tractor MFWD requires 20 forward feet to make a 90 degree turn (Figure 43). 20 feet is also the width of the afore-mentioned paths of crushed urbanite that can be found along the ROW.

The boundary demarcation proposed here uses redirection rather than physical exclusion to establish the mowing boundary of Buck Lodge Bog. Mowing of ROW is typically done lengthwise to minimize turns (Asplundh, 2017). Thus, mowers will approach the bog numerous times from a roughly perpendicular direction. Acknowledging the prior association of 20-foot crushed urbanite swaths with pathways, the design proposes laying such swaths perpendicular to the path of mowing where redirection is desired, signifying to mowers when to turn and the intended path of travel (Figure 44).

Because state law requires a hundred-foot buffer between any wetland of special state concern and surrounding land uses, this boundary-path is located 100 feet from the actual bog boundaries (based on the remains of the

Figure 42: Driver visibility is limited by the height of mature grasses when conducting annual mowing. Objects less than six feet in height are sometimes mowed down under these conditions.

John Deere 6430 Cab Tractor
Mechanical Front-Wheel Drive

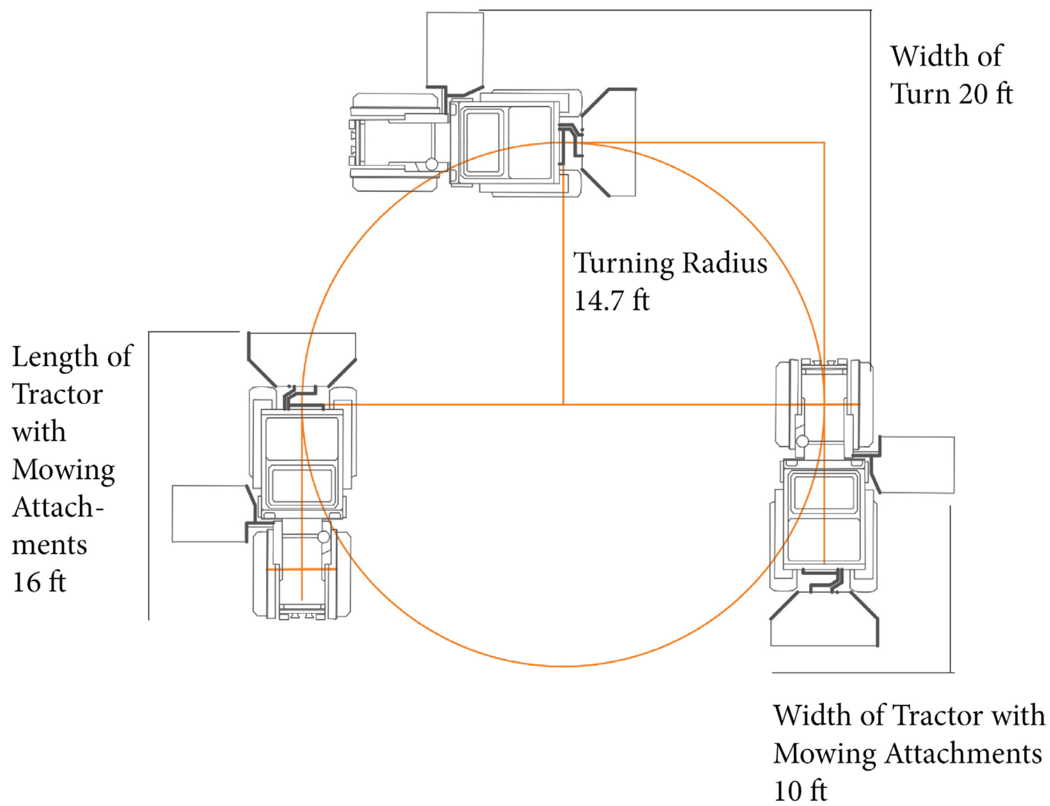

Figure 43: A John Deere 6430 Cab Tractor MFWD dimensions.

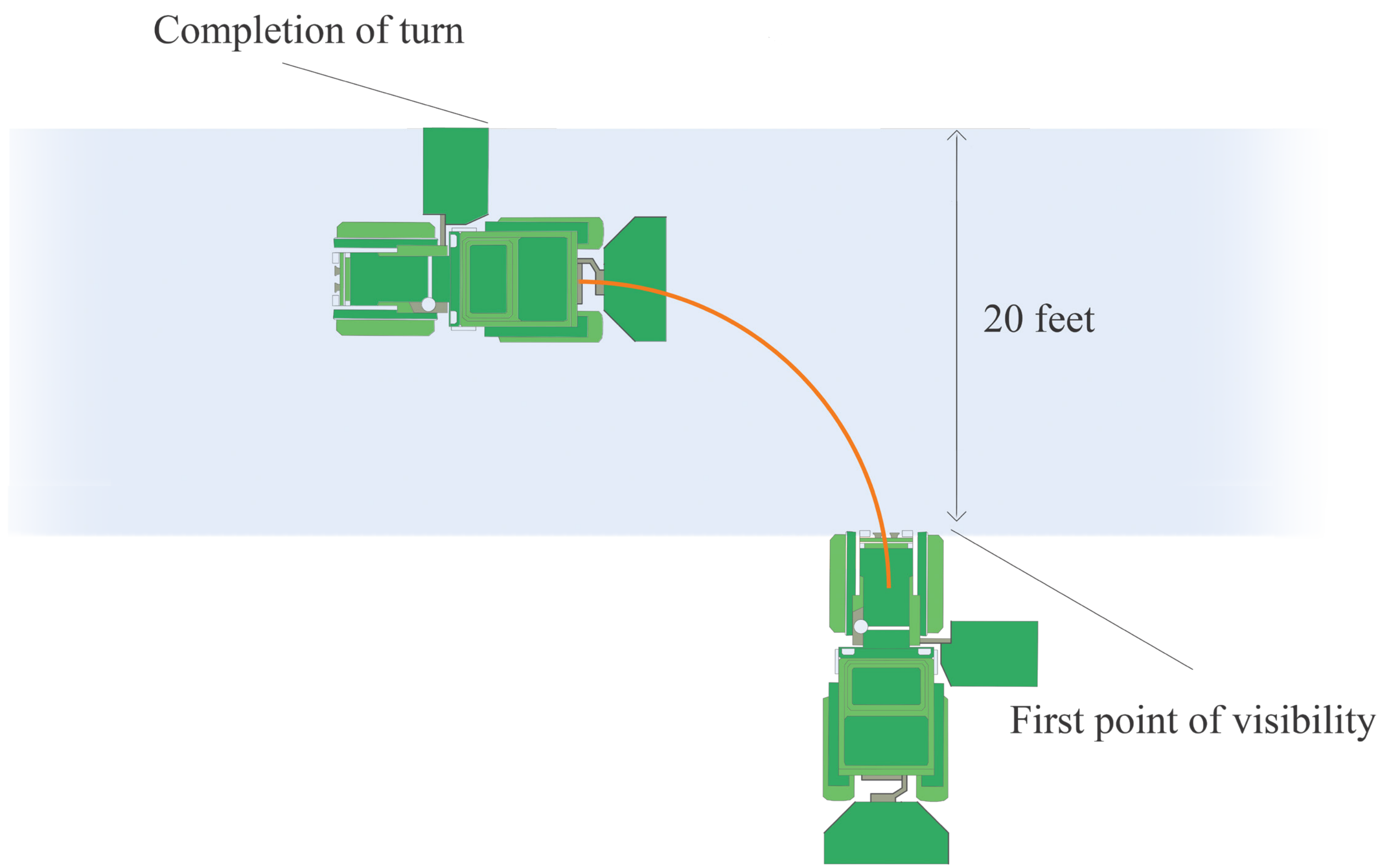

Figure 44: 20-foot swaths of crushed urbanite perpindicular to the path of mowing signifying to mowers when to turn and the intended path of travel.

old fence). However, because Buck Lodge Bog has a trapezoidal form, its edges run at an angle to the ROW. To increase the legibility of the intervention, the proposed boundary demarcation is adjusted to be at an actual right angle to the mowing direction (Figure 45).

Crossing

At present, common use has created a track through roughly the center of the bog (Figure 46). This track has a negative environmental impact. The weight of heavy equipment has compacted and created ruts in the soil, and the division of the bog into two halves further fragments an already fractured ecosystem.

In order for these damages to be remediated and further traversage damages avoided, an elevated crossing structure is proposed. Such a structure would need to able tractors, as well as the largest and heaviest equipment used on the lines – bulldozers (Asplundh, 2017). Structures referred to as “low-water bridges” have been used in similar cases to protect habitat in shallow watercourses, and provide a good precedent (Figure 47). Additionally, the decking material used should allow water and light to reach the bog plant life below. Riveted bar grating, a strong, weather resistant steel decking, is proposed for this application (Figure 48). This type

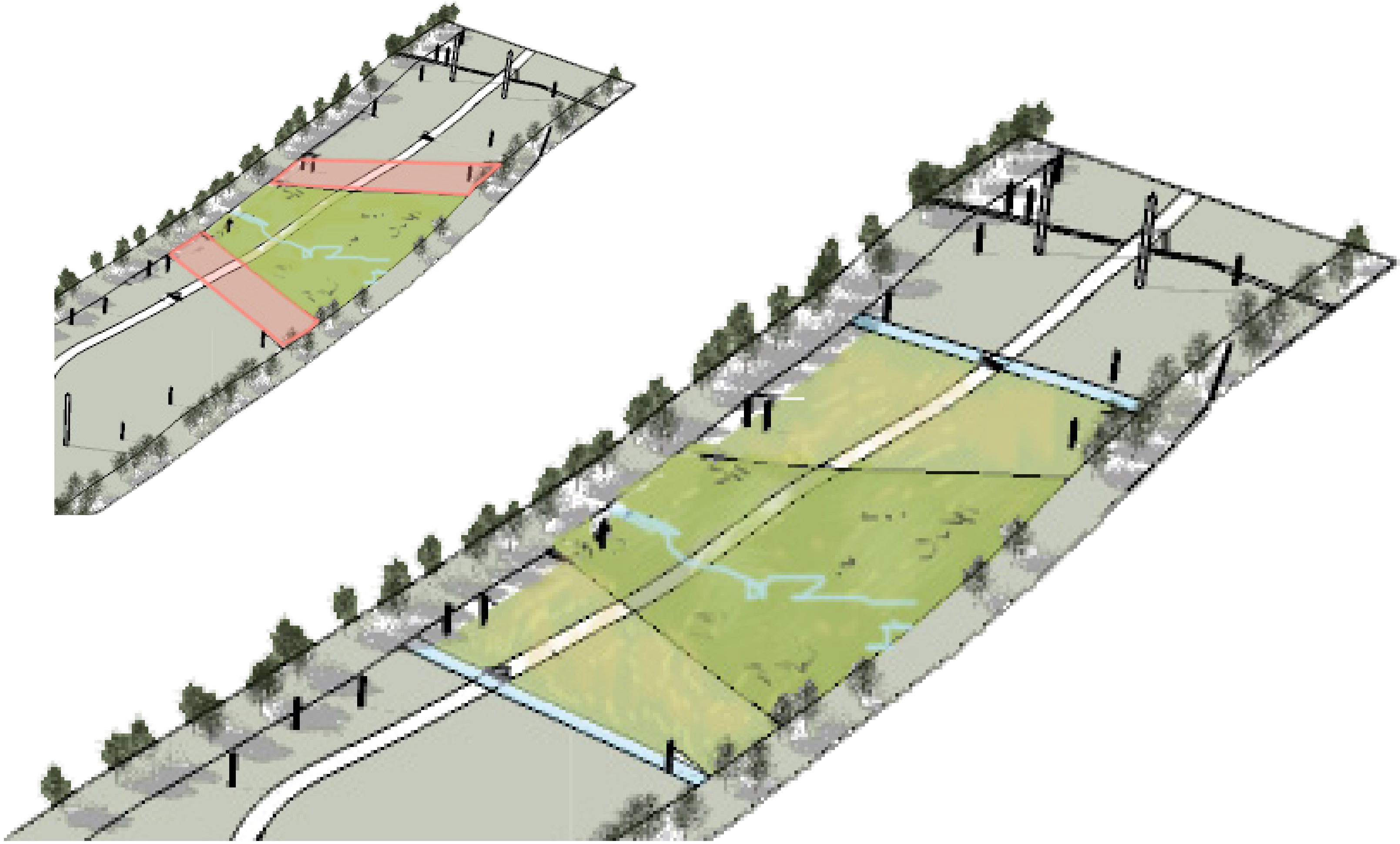

Figure 45: To increase the legibility of the intervention, the proposed boundary demarcation is adjusted to be outside the hundred foot buffer (top) at an actual right angle to the mowing direction (bottom).

Informal Equipment Path

Figure 46: Common use has created a track through roughly the center of the Buck Lodge Bog .

Figure 47: Low-water bridge in San Dimas, California. (Clarkin et al., 2006, p. 5-19).

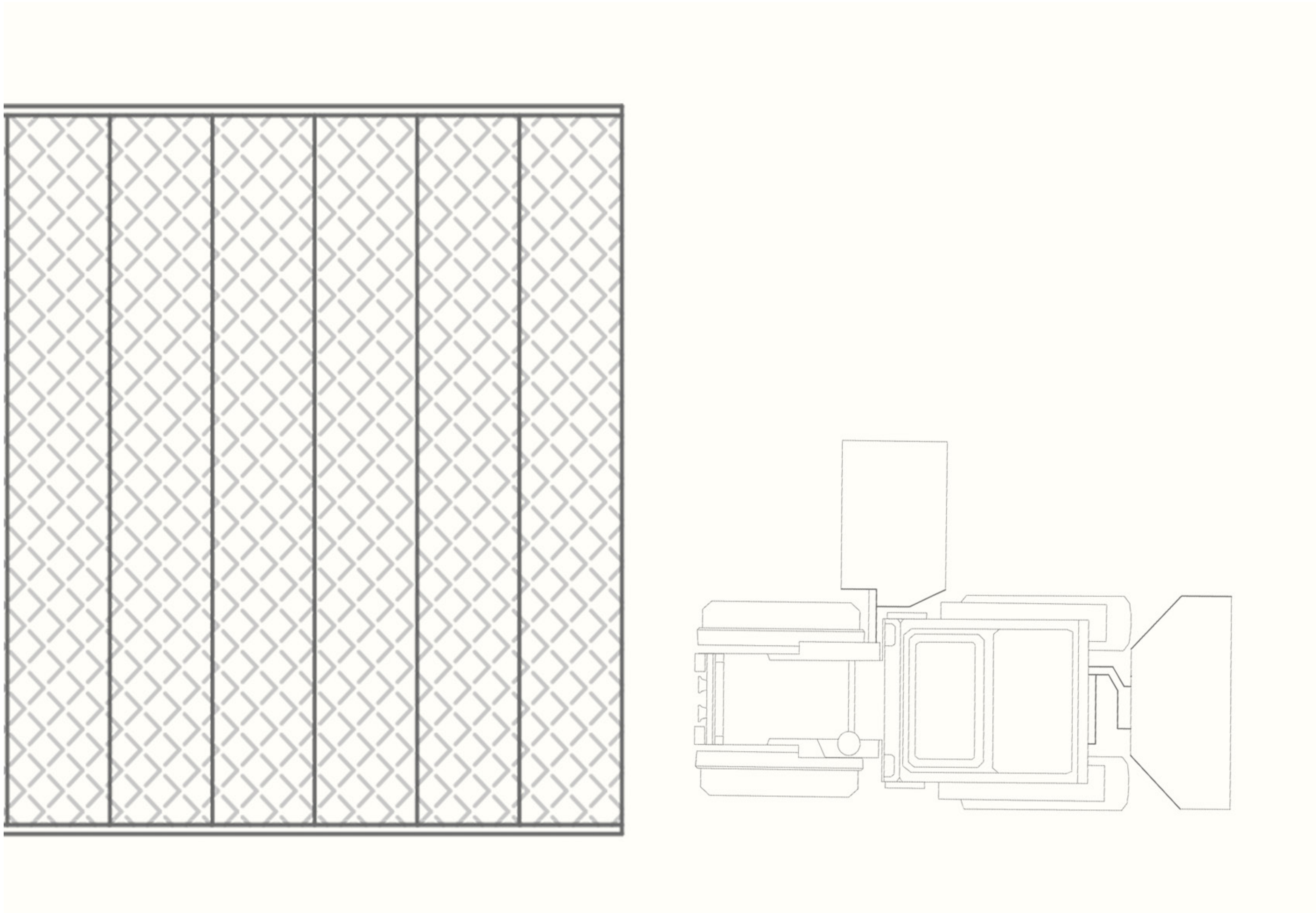

Figure 48: Riveted bar grating offers traction when wet, is strong enough to support the large equipment used on ROW, is permeable to air and light, and is manufactured in 3-ft X 20-ft panels.

of grating is produced in panels 36 inches wide and 20 feet long; perfect for a crossing 20 feet wide.

Through a comparison of cross-sections of the bog at the current crossing location and at parallel sections at either edge of the ROW, allowing for a six feet extension beyond the bog boundary, it became apparent that a crossing on the westward edge of the bog would not only have the least impact, but would also use the fewest materials, and require the least amount of structural support (Figures 49 and 50).

A crossing at this location provides additional benefits - it ensures access to the dense forest area to the west, and it allows for greater efficiency during mowing, since mowers will finish their passes over the width of the ROW at the edge, not in the middle. If a mower begins on the east side of the ROW, after four repetitions, the final pass will put the mower in position to cross on the westward elevated crossing. A crushed urbanite path can be used to transition mowers across the mowing boundary, to the low-water crossing, and back across the boundary on the other side (Figure 51). Figures 52, 53, and 54 provide plan and birds-eye, and perspective views, respectively, of the proposed crossing structure in context.

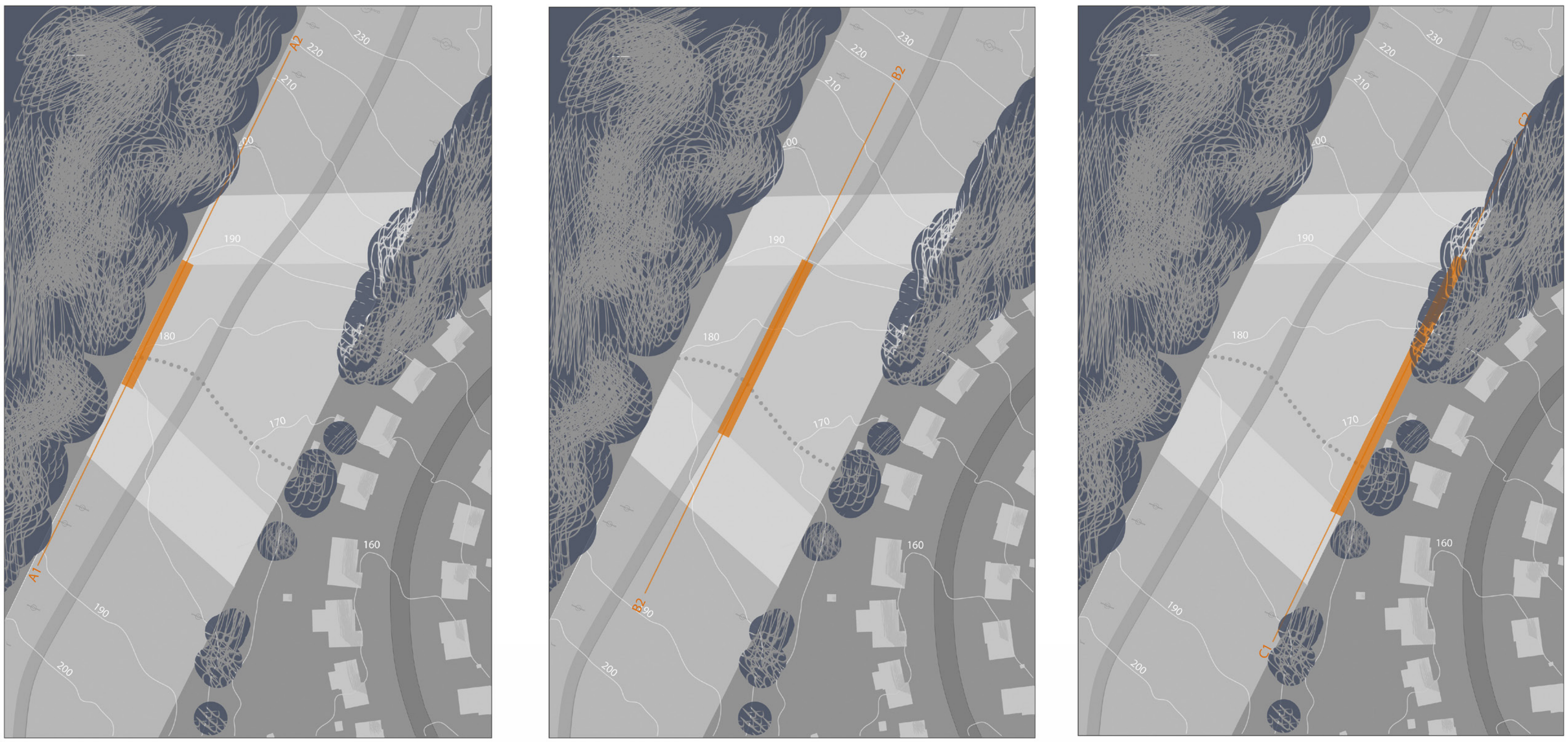

Figure 49: Crossing possibilites at the existing crossing location and at either edge of the ROW were compared, allowing for a six-foot extension beyond the bog boundary in each case.

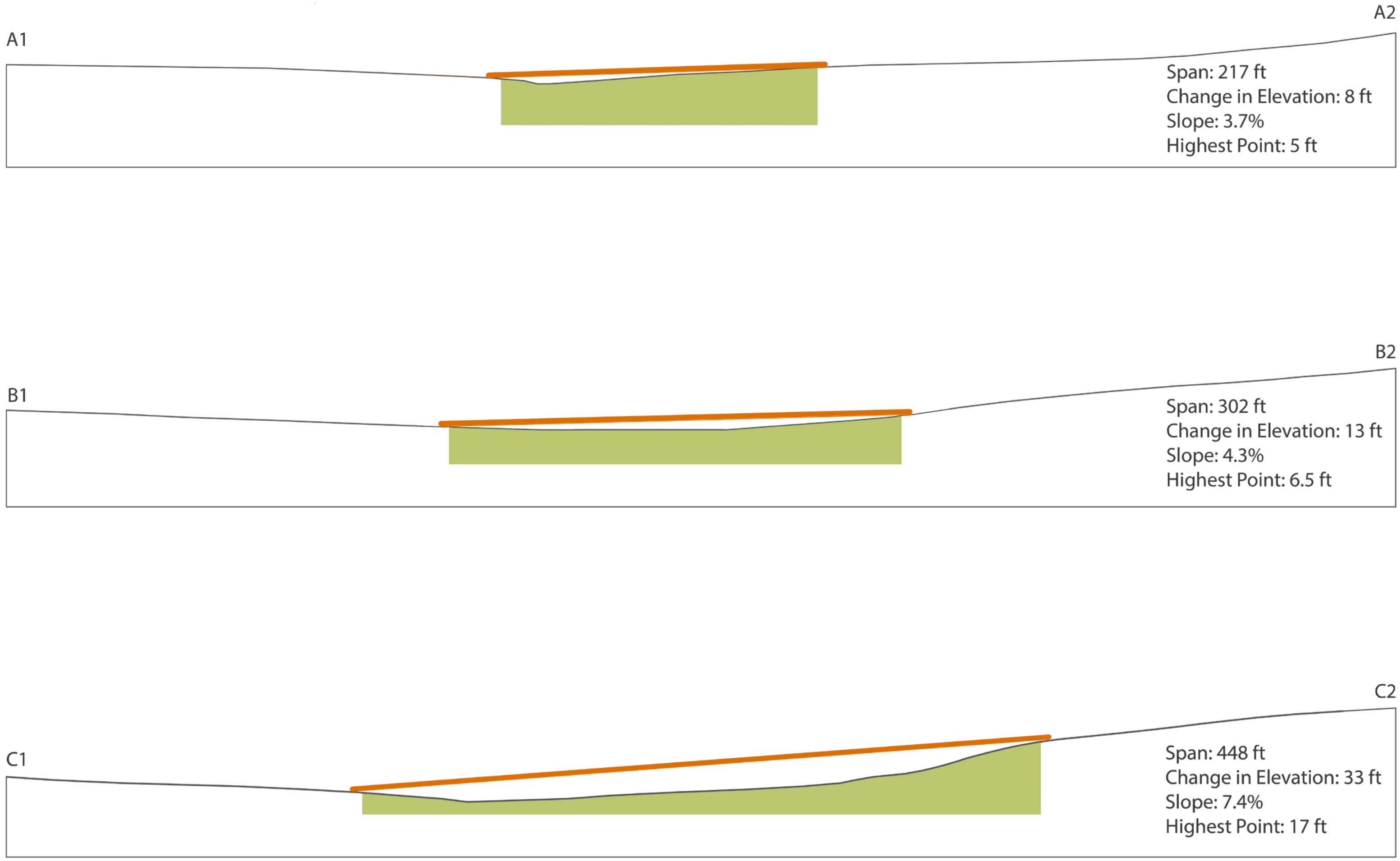

Figure 50: A crossing on the westward edge of the bog would not only have the least impact, but would also use the fewest materials, and require the least amount of structural support.

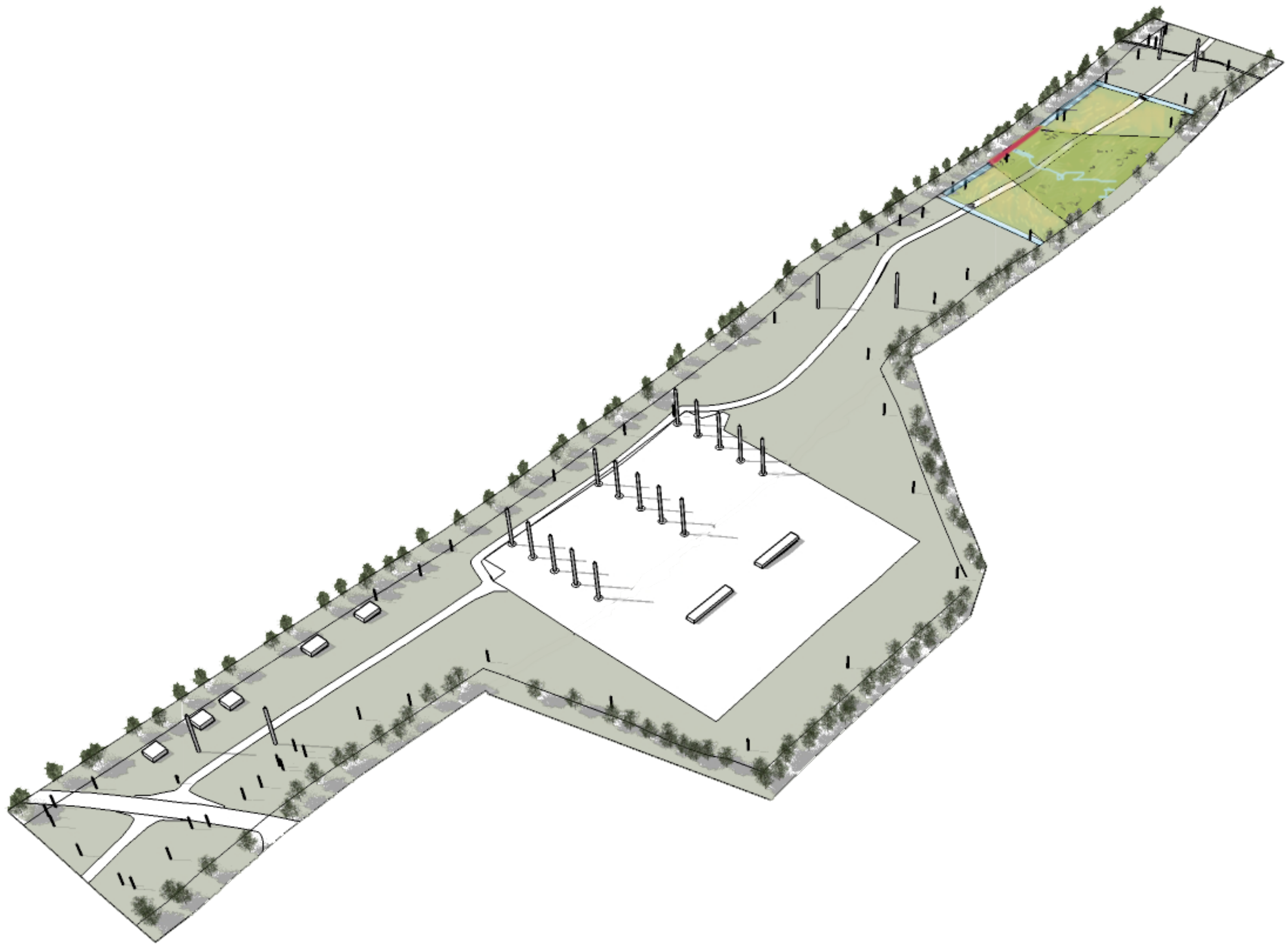

Figure 51: The crushed urbanite boundary path can be continued to transition mowers across the mowing boundary, to the low-water crossing, and back across the boundary on the other side.

Figure 52: Plan view of the crossing structure in context.

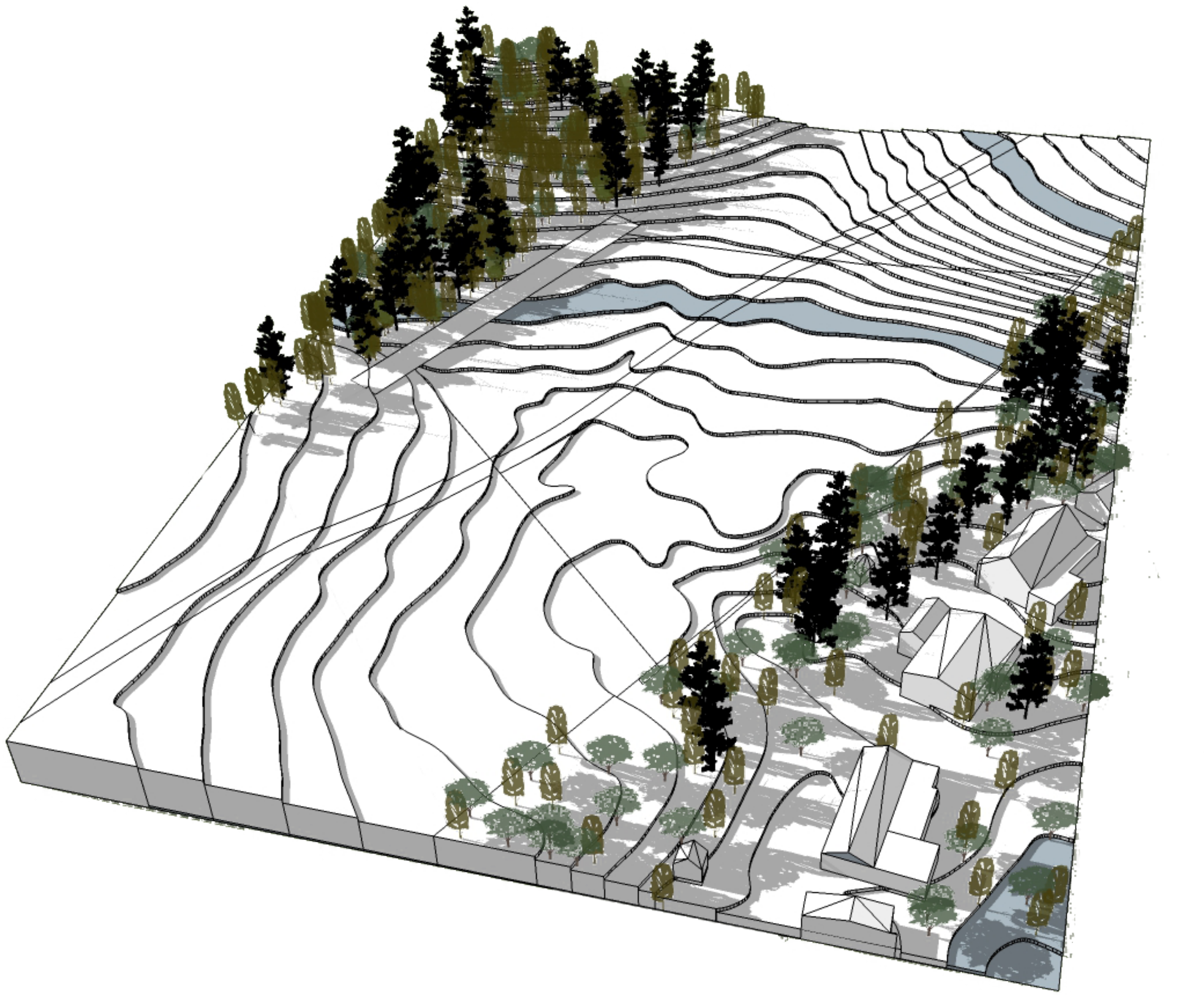

Figure 53: Bird's-eye view of the crossing structure in context.

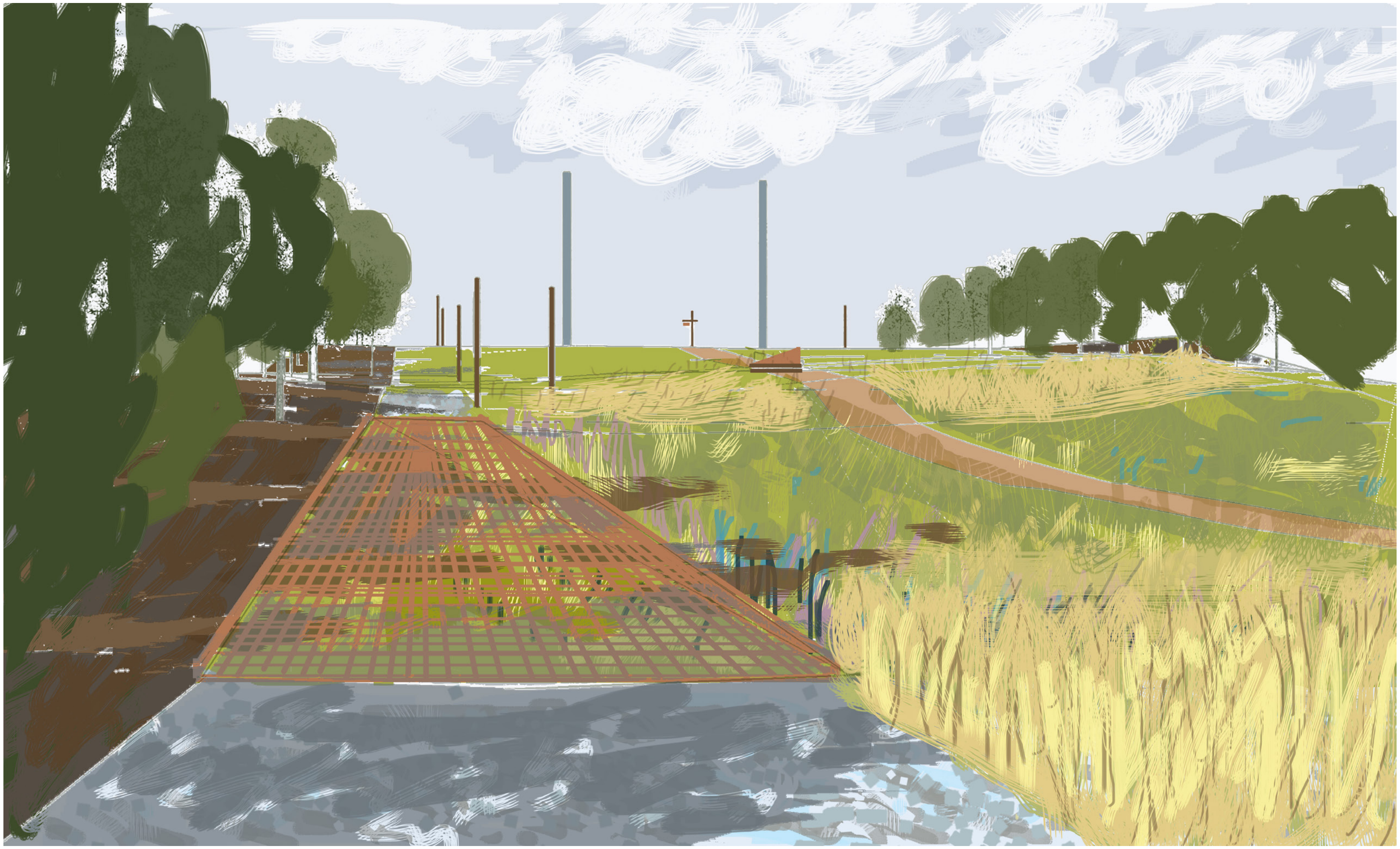

Figure 54: Perspective view of the crossing structure in context.

Bog Monumentation

The design of monumentation identifying individual bogs would need to be flexible to allow for variation in conditions. For example, the initial proposal for Buck Lodge Bog specified a trail-marker-style design, to sit adjacent to the path at the bog entry (Figure 55), and this approach might still be appropriate in some scenarios. However, the analysis of crossing options described above resulted in an abandonment of the existing track through the bog. A monument which would not only draw attention to the bog as a landmark, but would also discourage mowers from taking the previously established path was now necessary (Figure 56). The proposed design is modeled on the scale of segment gates, standing just tall enough at six feet to protrude above tall grass. The 16-foot proposed width prevents entry to the bog by equipment but allows the pedestrian access necessary for long-term management. The monument is designed to be easily assembled with minimal impact on the landscape. Using retired telephone poles as a base, accented by one felled limb or trunk as a nod to the natural system, a slab of weathering steel laser-cut with the name of the bog and the Magnolia Bog pictogram could be easily bolted in place (Figure 57). Additional details such as the silhouettes of associated flora or fauna, or variation in slab shape could be added to differentiate bogs in different districts (Figures 58 and 59).

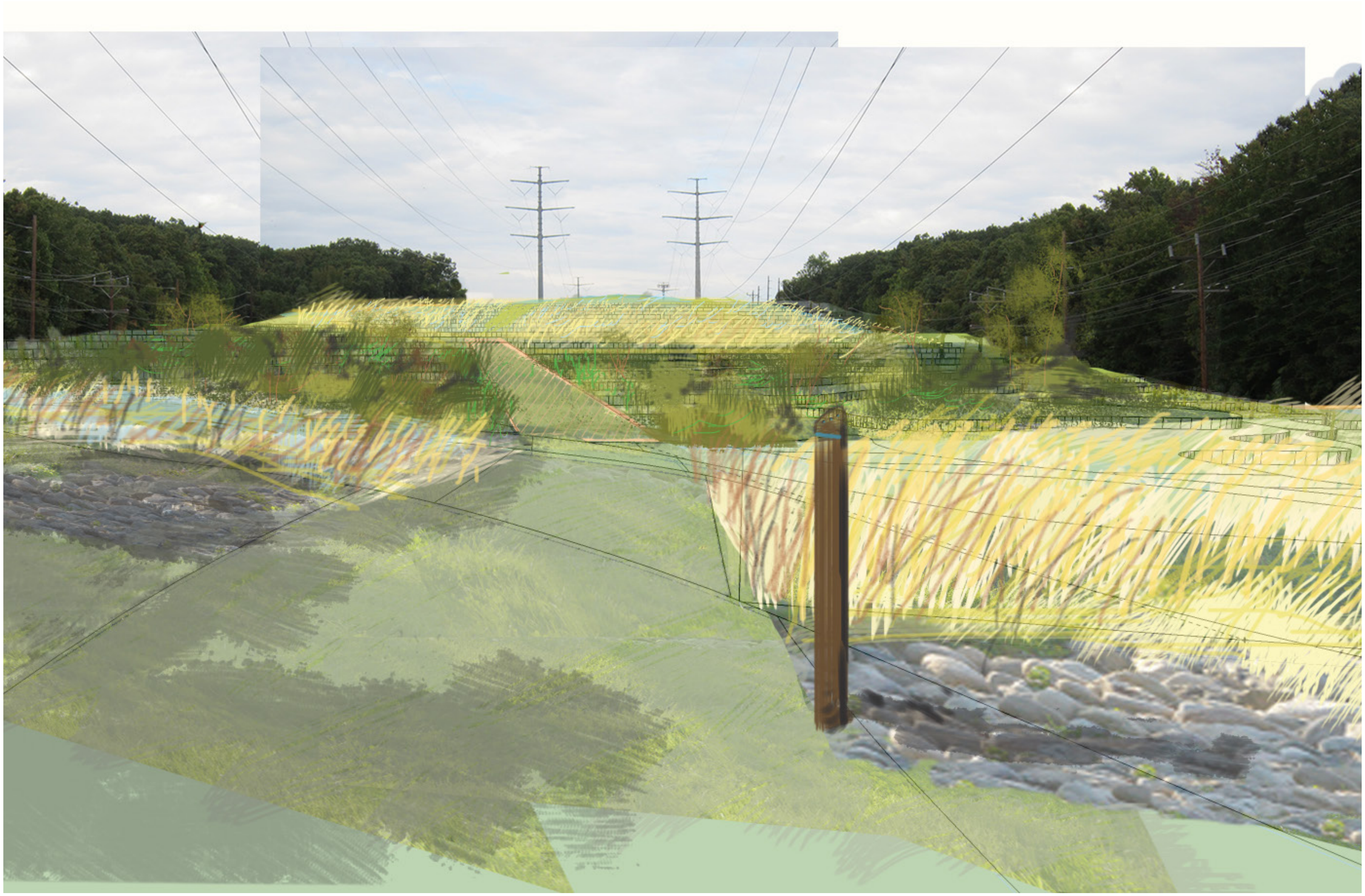

Figure 55: The initial proposal for Buck Lodge Bog specified a trail-marker-style design, to sit adjacent to the path at the bog entry.

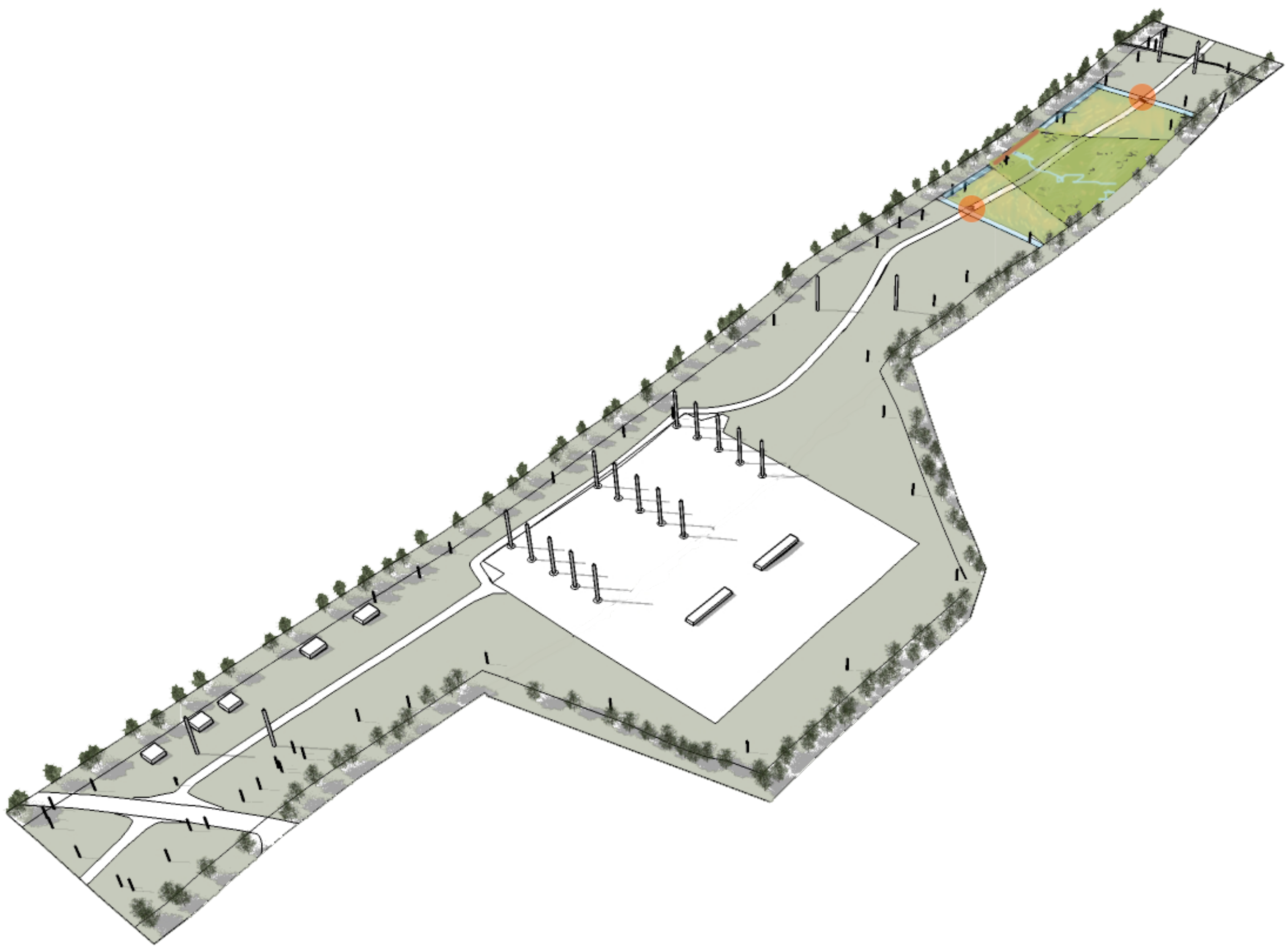

Figure 56: Abandoning the existing track through the bog necessitates a monument which will not only draw attention to the bog as a landmark, but will also discourage mowers from taking the previously established path.

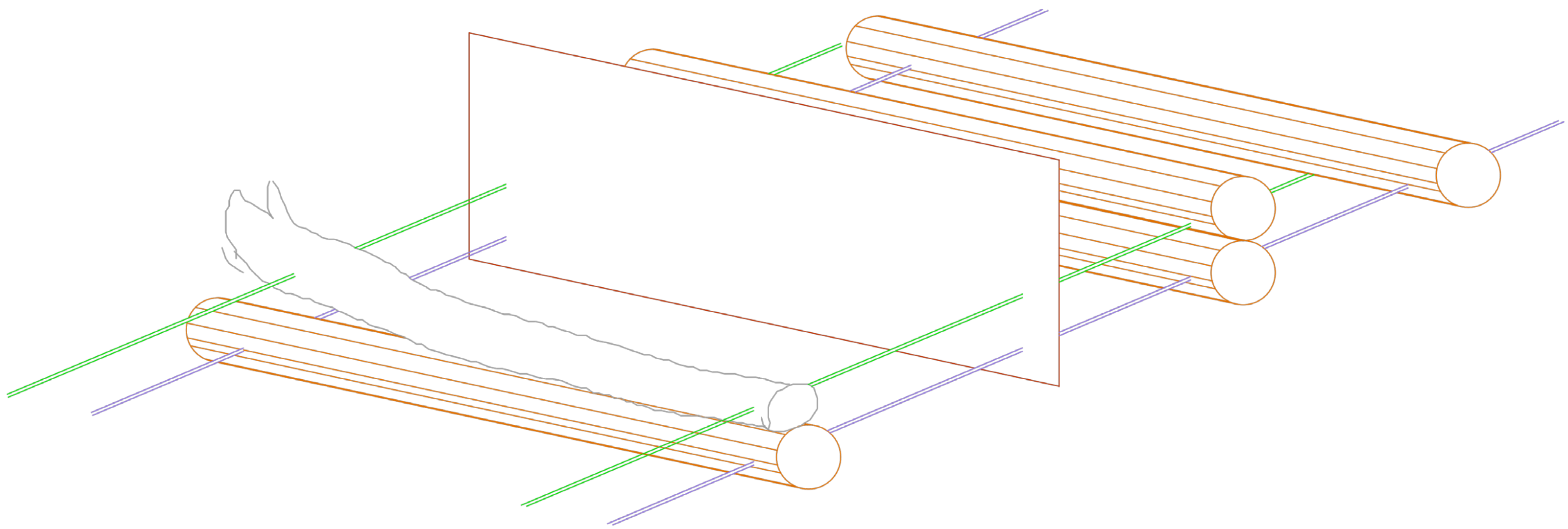

Figure 57: Using retired telephone poles as a base, accented by one felled limb or trunk as a nod to the natural system, a slab of weathering steel laser-cut with the name of the bog and the Magnolia Bog pictotram could be easily bolted in place.

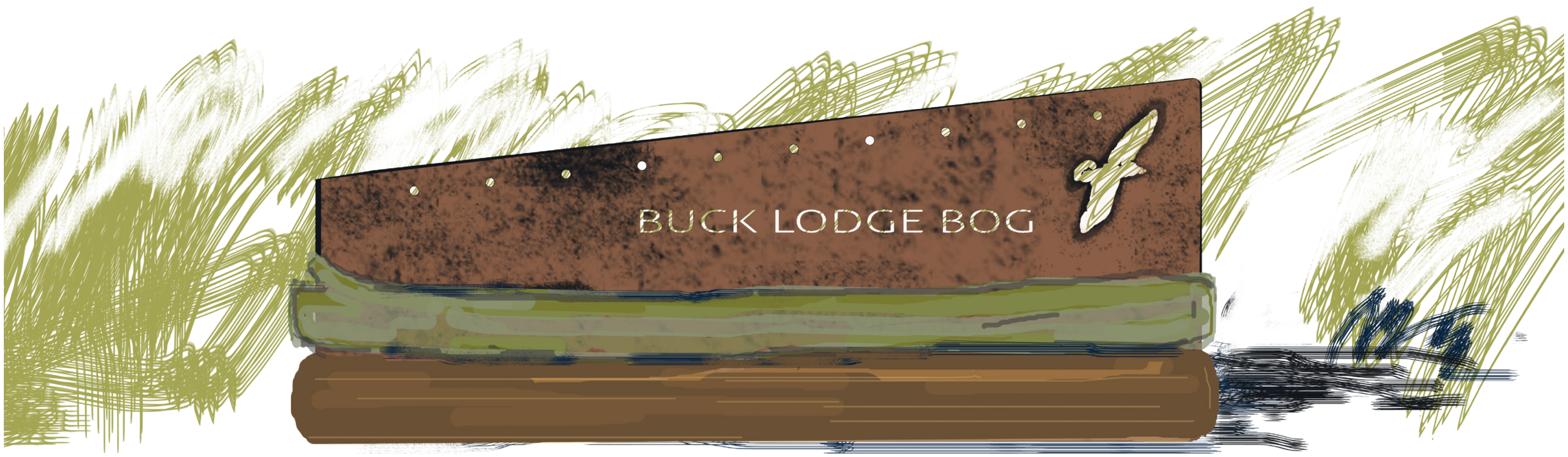

Figure 58: Additional details such as the sillouhettes of associated flora or fauna, or variation in slab shape could be added to differentiate bogs in different districts.

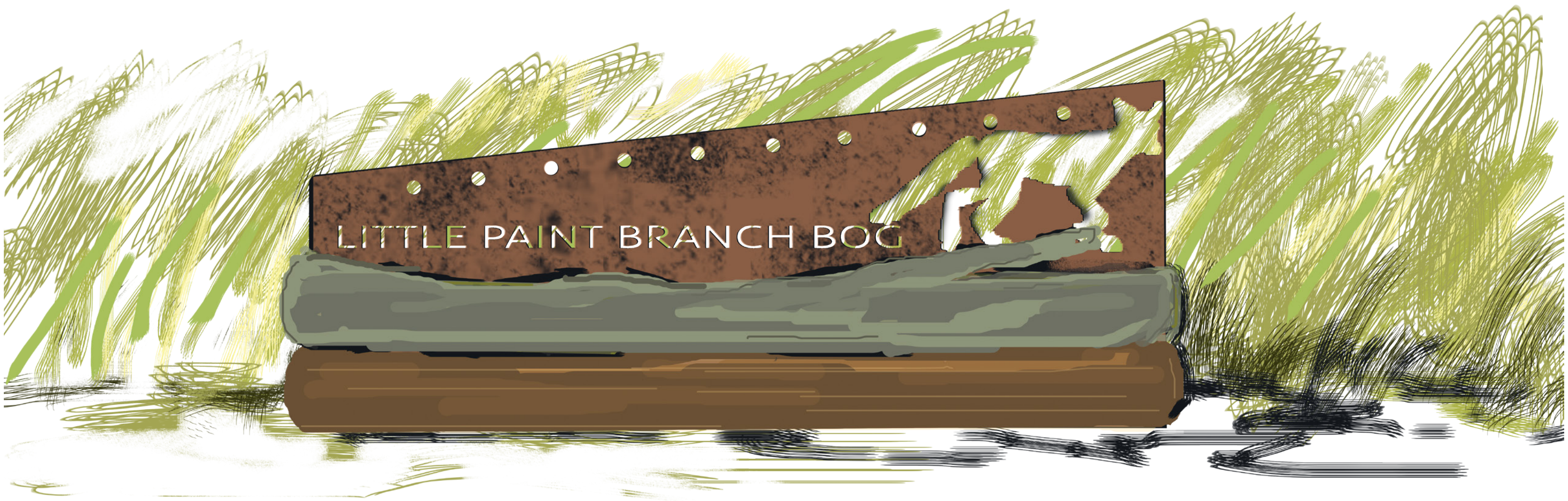

Figure 59: An example of district variation.

Conclusion

"There is something to be gained by thinking of humans as profoundly concerned with information, as being motivated both to make sense of their world and to learn more about it"

- Stephen Kaplan, 1975
  "An Informal Model for the Prediction of Preference"

The cueing scheme proposed here is designed to convey clear messages to mowers about their task and about the significance of bogs in relation to other protected features. The approach demonstrated here could be applied to all ROW Magnolia Bogs, but also to sensitive habitats in a variety of infrastructural landscapes such as highways, airports, and railroad lines.

In his essay, "The business of ecological restoration," Brian Lavendel (2002) urges those interested in habitat conservation to be open-minded to niches we might fill. For landscape architects, for whom, "environmental benefits have been part of the intent of design . . . since the 19th century," (Nassauer & Opdam, 2008, p. 633-634), maintenance design may be such a niche.

Michael Geffel (2013) argues that maintenance activities "effect change at a larger scale than is typically available to designers" and that in our attempts as landscape architects to "reclaim infrastructure design," we should consider maintenance design “uniquely within our professional realm” (p. 6).

Brian Davis, assistant professor of landscape architecture at Cornell University, argues, “landscape interventions that get away from massive initial infusions of capital, instead focusing on management and enabling agency among valued actors is one promising way forward for theoretical development and intervention in the landscape” (2010, p. 2).

Davis emphasizes the importance of “enabling agency among valued actors,” but describes the maintenance of public landscapes as “carried out by lowly-paid and divested public employees who wander around the premises picking up trash and cutting anything that looks like fescue to the nub when they aren't sitting in the maintenance truck by the curb” (p.1).

The research undertaken here has shown that by supporting environmental clarity, design can encourage environmental engagement: “strategic links in communication,” can turn a neglected or avoided landscape into an inviting place (Lynch, 1960, p. 110), and can foster feelings of ownership and responsibility, which bring forth further willingness to engage (Appleyard, 1979; Kaplan, Kaplan, & Ryan, 1998). Agency is crucial for human health; Stephen Kaplan refers to a 1979 study which found that “by far the most powerful predictors of health were a coherent world view and some means of participating in what is going on around one" (1983, p. 325). Increased imageability can result in less "divested" stewardship, and in increased pride and sense of belonging among "valued actors." "The environment is a social medium," Appleyard reminds us, and "sense of self in a place is as important as sense of place (Appleyard, 1979).

"It seems to be a human quality that one prefers to be treated as if one is capable of understanding and can make a difference" write Kaplan, Kaplan, & Ryan (1998, p.158); rather than embracing an unflattering perspective of laborers and their relationship to the landscapes they steward, landscape architects have a great opportunity to create a positive impact both environmentally and socially if we design accordingly.

Figure 60: Entry to the Buck Lodge Bog District from Metzerott Road.

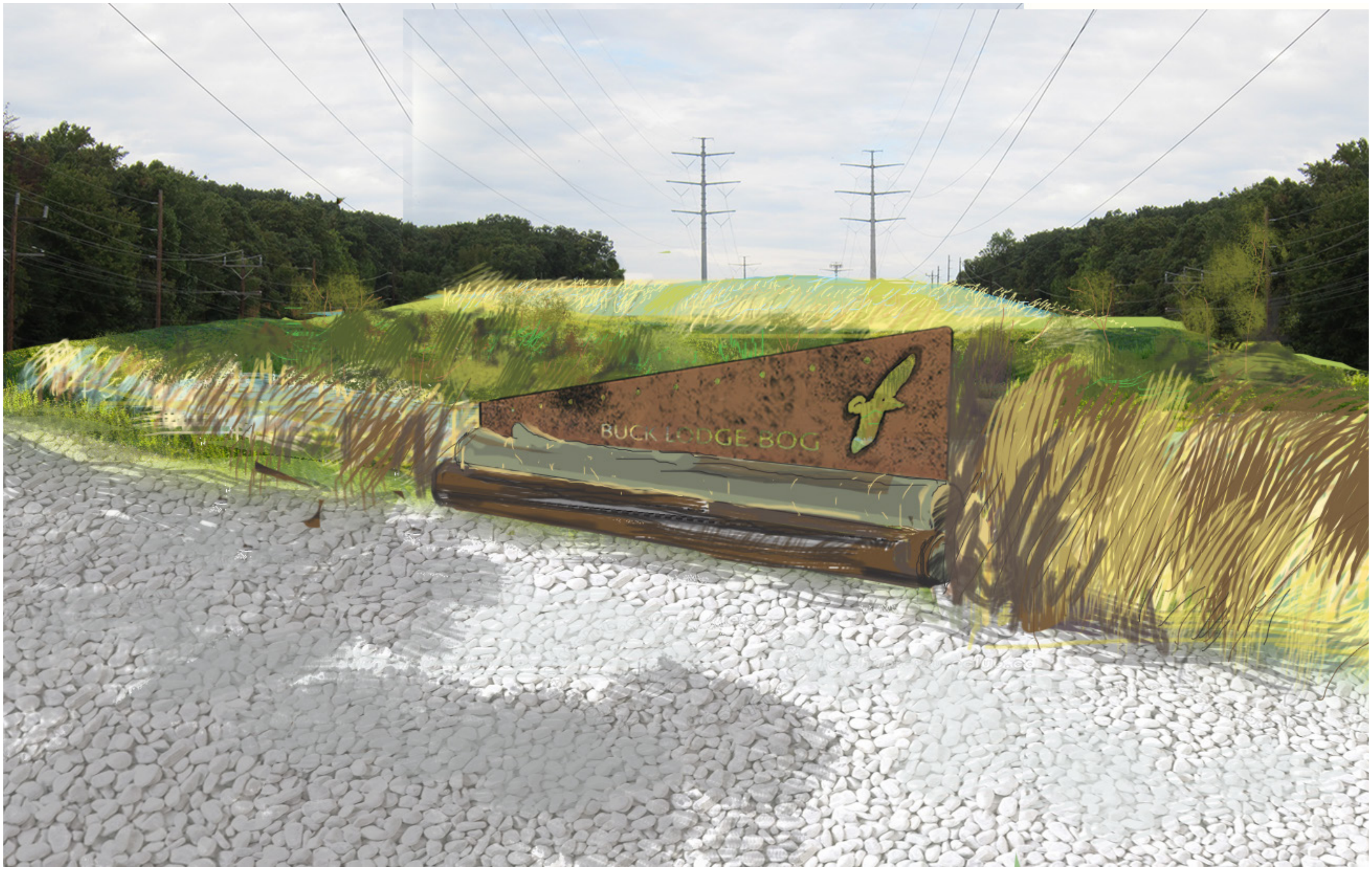

Figure 61: Bog Monument identifies Buck Lodge Bog as a landmark, while discouraging mowers from following the previously-used track across the bog.

Figure 62: At it’s highest point, the proposed crossing structure is about five feet from the ground.

Figure 63: The proposed cueing system allows pedestrian access to the bog for management activities.

Appendix A: Historically Documented Magnolia Bogs and Geographic Locations

Bogs documented by McAtee		**Approximate Location on Present-Day Map**	**Bogs Remaining at this Location?**
	Accotink		Maybe - Might be today's Franconia Bog
	Along Indian Creek and Eastern Branch		No
	Ammendale	Rt. 1 and Indian Creek, PG County	Yes
	Arundel		No
	Bladensburg		No
	Brightwood Bogs	Along Piney Branch and Rock Creek	No
	Brookland	Associated with NW Branch	No
	Carter's Lane		No
	Deanewood	East Corner of DC, at head of Brier Ditch	No
	Four Mile Run Hill Complex		No
	Four Mile Run Valley Complex	SW of Reagan Airport	Yes - Barcroft Bog is last surviving remnant
	Green Valley Complex		No
	Hollywood		No
	Holmead (or one of the Brightwood Bogs?)		No
	Hunting Creek	Across the river from Oxon Hill	No
	Hyattsville		No
	Kenilworth		No
	Lanham		No
	Laurel		No
	Lygodium		No
	Macgruder	Along Beaver Dam Branch	No
	Magnolia Run (or one of the Brightwood Bogs?)		No
	Odenton		No
	Powdermill Bog Complex		Yes
	Reform School	Bladensburg	No
	Riverdale		No
	Sarracenia	Along Beaver Dam Branch	No
	Savage	East of North Laurel	No
	Silver Hill		No
	Suitland		Yes
	Surattsville	South of Andrews Air Force Base in Clinton, MD	No
	Takoma	Associated with NW Branch	No
	Terra Cotta	Associated with NW Branch	No
Historically Documented Bog Locales in Alexandria, listed by Simmons in Native Vascular Flora of Alexandria			
	Alexandria Resevoir/Lake Barcroft		No
	Hume Spring		No
	Lincolnia	now 5110 Mark Center Dr.	No
	St. Elmo		No
	Unnamed Bog	"Scattered from Lincolnia NE through the Winkler property and down the Lucky Run drainage to Four Mile Run." May overlap with Four Mile Run Valley, Green Valley, and Four Mile Run Hill complexes	No
	Unnamed Bog	Adjoining Arlington Cemetary	No
	Unnamed Bog	Adjoining Turkeycock Run near the boundary of Fairfax County	No

Appendix B: Extant Magnolia Bogs and Geographic Locations

Bog Name		Location Information	12-Digit Watershed	8-Digit Watershed	County	State
Aitcheson		I-95, Edge of Konterra Gravel Mining Complex	Inidian Creek	Anacostia	Prince George's	Maryland
Ammendale		Rt. 1 crossing of Indian Creek	Inidian Creek	Anacostia	Prince George's	Maryland
Araby		Near Hunter's Brooke and Falcon Ridge housing developments, flows into Mattawoman Creek		Mattawoman Creek	Charles	Maryland
Beatly					Alexandria	Virginia
Bryan's Road		Under a powerline easement		Lower Potomac River	Charles	Maryland
Four Mile Run Complex	Barcroft Park	Allie S. Freed Park, Barcroft Park, Four Mile Run			Arlington	Virginia
Franconia		Near Accotink Stream Valley Park			Fairfax	Virginia
Fredericksburg		Near Fredericksburg			Caroline	Virginia
Greenbelt		in Indian Creek watershed in Greenbelt Park	Inidian Creek	Anacostia	Prince George's	Maryland
Konterra Complex	Konterra #1	Near the Western End of Muikirk Road adjacent to Konterra mining complex	Inidian Creek	Anacostia	Prince George's	Maryland
	Konterra #2	in Indian Creek watershed	Inidian Creek	Anacostia	Prince George's	Maryland
	Gunpowder	In old gravel washing pond, west side of Gunpowder Road, north of community center near Konterra gravel pits.	Little Paint Branch	Anacostia	Prince George's	Maryland
	Bear Branch	Near headwaters of Little Paint Branch and Indian Creek by the Konterra gravel pits		Indian Creek	Prince George's	Maryland
Lorton Bog		Off I-95 near the MARC Train station, on a residential utility ROW			Fairfax	Virginia
Montevideo		near Jessup, MD		Little Patuxent River	Howard	Maryland
Montpelier/Muirkirk		Northern-most headwaters of Upper Beaverdam Creek, next to the road near Montpelier Elementary School, on a utility ROW		Patuxent River Upper	Prince George's	Maryland
Mount Joy Store		on penninsula			Stafford	Virginia
Oxon Run		Oxon Run Parkway Natural Area, DC				District of Columbia
Powdermill Complex	Powder Mill #1	East side of the Paint Branch, South side of Powder Mill Road	Paint Branch	Anacostia	Prince George's	Maryland
	Powder Mill #1 additional remnant	Western end of Selman Road in Powder Mill Community Park	Paint Branch	Anacostia	Prince George's	Maryland
	Powder Mill #2		Paint Branch	Anacostia	Prince George's	Maryland
	Powder Mill #3	East side of the Paint Branch, North side of Powder Mill Road	Paint Branch	Anacostia	Prince George's	Maryland
	Little Paintbranch #1	Under a powerline easement between I-95 and Little Paint Branch Park, wooded section preserved within Little Paint Branch Park	Little Paint Branch	Anacostia	Prince George's	Maryland
	Little Paint Branch #2	in Little Paint Branch watershed, under a powerline easement	Little Paint Branch	Anacostia	Prince George's	Maryland
	Buck Lodge	under a powerline easement at the edge of Buck Lodge Park, north of Metzerott	Paint Branch	Anacostia	Prince George's	Maryland
	Paintbranch/University	East of Paint Branch Golf Course and Paint Branch Trail, Just North of University Blvd.	Inidian Creek	Anacostia	Prince George's	Maryland
Sandy Spring/McKnew		Northeastern edge of Montgomery County	Little Paint Branch	Anacostia	Montgomery	Maryland
Suitland		Intersection of Suitland Road and Suitland Parkway, crossed by a powerline easement		Potomac River U Tidal	Prince George's	Maryland
Sunnyside		Bordered by the Beltway, near the train tracks and Sunnyside and Edmonston Roads		Anacostia	Prince George's	Maryland

Appendix C: Extant Magnolia Bogs: Sources of Information and Additional Notes

Bog Name		Reference	Notes	Species of Note
Aitcheson		Simmons, Parrish, & Flemming, 2003; Simmons et al., 2008		*Pinus rigida, Smilax pseudochina*
Ammendale		Simmons, Parrish, & Flemming, 2003; Simmons et al., 2008	Hit by hurricane in recent past	*Aronia prunifolia, Aster radula, Kalmia angustifolia, Pinus rigida, Smilax pseudochina, Solidago uliginosa, Woodwardia virginica*
Araby		Simmons & Strong,2001; Simmons, Parrish, & Flemming, 2003	"most undisturbed of known remaining Magnolia Bogs" - Simmons, Parrish, & Flemming, 2008	*Lyonia mariana*
Beatly		Simmons, 2017	deeply degraded by feeding of geese on site	
Bryan's Road		Simmons, Parrish, & Flemming, 2003		*Oldenlandia uniflora, Rhynchospora gracilienta, Scleria reticularis, Xyris torta*
Four Mile Run Complex	Barcroft Park	Simmons, Parrish, & Flemming, 2003	Last remnant of historic Four Mile Run bogs, restoration efforts underway through Arlington Parks and Recreation	*Alnus serrulata, Chasmanthum laxum, Chelone glabra, Chionanthus vurginicus, Ilex verticillata, Leucothoe racemosa, Magnolia virginiana, Osumda reaglis, Osmundastrum cinnamomea, Rhododendron viscosum, Sphagnum sp., Toxicodendron vernix, Vaccinium atrococcum, Vaccinium corymbosum, Viburnum nudum*
Franconia		Simmons, Parrish, & Flemming, 2003	Last surviving Magnolia Bog in Fairfax County. Could be McAtee's Accotink Bog.	*Pinus rigida, Smilax pseudochina*
Fredericksburg		Simmons,2017		
Greenbelt		Simmons et al., 2008		
Konterra Complex	Konterra #1	Simmons, Parrish, & Flemming, 2003; Simmons et al., 2008	high-quality, mostly undisturbed, threatened by ICC	*Aralia nudicaulis, Aster radula, Gaultheria procumbens, Ilex laevigata, Pinus rigida, Smilax psuedochina*
	Konterra #2	Simmons et al., 2008	variant	
	Gunpowder	Simmons et al., 2008	variant	
	Bear Branch	Simmons, 2008		*Magnolia virginiana, Viola primufolia*
Lorton Bog		Simmons, 2017		
Montevideo		Copiz, 2017	only know bog in Howard County	
Montpelier/Muirkirk		Ellis, 2017		
Mount Joy Store		Simmons, 2017		
Oxon Run		National Park Service, n.d.		
Powdermill Complex	Powder Mill #1	Simmons et al., 2008	remnant/variant	
	Powder Mill #1 additional remnant	Simmons et al., 2008	remnant	
	Powder Mill #2	Simmons, 2017	deeply degraded by invasive species	
	Powder Mill #3	Simmons, Parrish, & Flemming, 2003; Simmons et al., 2008	Army Research Lab and Maryland Wildlife and Heritage Program involved in restoration efforts	*Aronia prunifolia, Eriocaulon decangulare*
	Little Paintbranch #1	Simmons, Parrish, & Flemming, 2003; Simmons et al., 2008	The little Paint Branch and Powder Mill Bogs are small remnants of the once-extensive Powder Mill Bogs complex, which were "among the most floristically diverse of any known" (Simmons & Strong, 2001; Simmons, Parrish, & Flemming, 2003, p.17). Little Paint Branch Bog #1 is the "largest, most diverse, and uppermost bog in a series of terraced sand and gravel seeps" (Simmons, Parrish, & Flemming, 2003). Repaving of I-95 in 2000 altered seepage flow to Bog #2, which is no longer (Simmons, Parrish, & Flemming, 2008). Little Paint Branch Bog #1 is designated a wetland of special state concern.	Aronia prunifolia

Appendix C: Extant Magnolia Bogs: Sources of Information and Additional Notes

	Little Paint Branch #2	Simmons et al., 2008	variant	
	Buck Lodge	Simmons et al., 2008	variant	
	Paintbranch/University	Ellis, 2017	not verified yet	Huge stand of Magnolia virginiana
Sandy Spring/McKnew		Simmons, Parrish, & Flemming, 2003; Simmons et al., 2008	threatened by ICC and a golf course	Bartonia paniculata
Suitland		Simmons, Parrish, & Flemming, 2003	"The most floristically diverse of known remaining Magnolia Bogs (Simmons, Parrish, & Flemming, 2003, p.18). A powerline runs through part of the bog.	Asclepias rubra, Aster radula, Eleocharis tortilis, Eriophorum virginicum, Linum intercursum, Rhyncospora oligantha
Sunnyside		Simmons, 2017	could be McAtee's Hollywood Bog	

Appendix D: Characteristic Vegetation of Magnolia Bogs

Key

Reference Codes		**Conservation Rank**	
A	McAtee1918	**V**	Virginia
B	Hitchcock & Standley, 1919	**M**	Maryland
C	Simmons, 2015	**S3**	Vulnerable
D	Maryland Department of Natural Resources, 2016	**S2**	Imperiled
E	Harrison, 2016	**S1**	Critically imperiled
Latin names are concurrent with Maryland Biodiversity Project -		**SH**	Known only from historical records
prior names are shown in parentheses as they appear in source record		**SX**	Presumed extirpated

Latin Name	**Common Name**	**Family**	**Reference Code**	**Conservation Rank**
TREES				
Acer rubrum	Red Maple	Sapindaceae	E	
Amelanchier canadensis	Canadian Serviceberry	Rosaceae	E	
Chionanthus virginicus	Fringetree	Oleaceae	C	
Ilex opaca var. opaca	American Holly	Aquifoliaceae	E	
Liriodendron tulipifera	Tulip Poplar	Magnoliaceae	E	
Magnolia virginiana	Sweetbay Magnolia	Magnoliaceae	ABCDE	
Nyssa sylvatica	Black Tupelo	Cornaceae	CDE	
Pinus rigida	Pitch Pine	Pinaceae	C	
SHRUBS				
Amelanchier arborea (Amelanchier oblongifolia)	Common Serviceberry	Rosaceae	B	
Amelanchier canadensis	Canadian Serviceberry	Rosaceae	C	
Amelanchier intermedia	Intermediate Serviceberry	Rosaceae	A	
Aronia arbutifolia (Photinia pyrifolia)	Red Chokeberry	Rosaceae	CE	
Aronia melanocarpa	Black Chokeberry	Rosaceae	B	
Aronia prunifolia (Aronia atropurpurea)	Purple Chokeberry	Rosaceae	A	MS3
Eubotrys racemosa (Leucothoe racemosa)	Fetterbush	Ericaceae	CDE	
Gaylussacia dumosa	Dwarf Huckleberry	Ericaceae	A	MS1
Gaylussacia frondosa	Blue Huckleberry	Ericaceae	CDE	
Ilex laevigata	Smooth Winterberry	Aquifoliaceae	CE	
Ilex verticillata	Common Winterberry	Aquifoliaceae	ACE	
Itea virginica	Virginia Sweetspire	Iteaceae	A	
Kalmia angustifolia	Sheep Laurel	Ericaceae	ABDE	VS2, MS3
Lyonia ligustrina (Xolisma ligustrina)	Maleberry	Ericaceae	A	
Lyonia mariana (Pieris mariana)	Stagger-bush	Ericaceae	A	
Myrica carolinensis	?	Myricaceae	AB	
Rhododendron viscosum (Axalea viscosa)	Swamp Azalea	Ericaceae	ABCDE	
Rubus hispidus	Swamp Dewberry	Rosaceae	A	
Smilax rotundifolia	Common Greenbrier	Smilacacea	E	
Toxicodendron vernix	Poison Sumac	Anacardiaceae	ACDE	

Vaccinium corymbosum	Highbush Blueberry	Ericaceae	A	
Vaccinium fuscatum (Vaccinium atrococcum)	Hairy Highbush Blueberry	Ericaceae	AD	
Vaccinium spp.	e.g. Blueberry, Huckleberry, Cranberry	Ericaceae	CE	
Viburnum cassinoides	Witherod	Adoxaceae	ABE	
Viburnum dentatum	Southern Arrowwood	Adoxaceae	A	
Viburnum nudum	Possumhaw	Adoxaceae	ACD	

HERBACEOUS DICOTS

Asclepias rubra	Red Milkweed	Apocynaceae	ADE	VS2, MS1
Ascyrum stans	St. Peterswort	Cluciaceae	A	
Aster antrorsa	?	Asteraceae	A	
Symphyotrichum dumosum (Aster dumosus)	Rice Button Aster	Asteraceae	A	
Symphyotrichum lateriforum (Aster lateriflorus)	Calico Aster	Asteraceae	A	
Symphyotrichum patens (Aster patens)	Late Purple Aster	Asteraceae	A	
Symphyotrichum puniceum (Aster puniceus)	Purple-stemmed Aster	Asteraceae	A	
Eurybia radula (Aster radula)	Low Rough Aster	Asteraceae	AE	
Bartonia paniculata	Twining Screwstem	Gentianaceae	A	VS3, MS3
Bartonia virginica	Yellow Screwstem	Gentianaceae	A	
Dioscorea villosa	Wild Yam	Dioscoreacea	D	
Eupatorium pilosum	Vervain Thoroughwort	Asteraceae	C	
Eupatorium rotundifolium	Round-leaved Thoroughwort	Asteraceae	A	
Eupatorium verbenaefolium	?	Asteraceae	AB	
Helianthus angustifolius	Swamp Sunflower	Asteraceae	AE	
Hypericum canadense	Lesser Canadian St. Johnswort	Cluciaceae	A	
Hypericum densiflorum	Bushy St. Johnswort	Cluciaceae	A	
Ionactis linearifolius	Flax-leaved Whitetop Aster	Asteraceae	A	
Linum virginianum	Woodland Flax	Linaceae	A	
Mitchella repens	Partridgeberry	Rubiaceae	D	
Oldenlandia uniflora	Clustered Mille-graines	Rubiaceae	A	MS3
Polygala cruciata	Cross-leaved Milkwort	Polygalaceae	AB	VS3, MS2
Rhexia mariana	Maryland Meadowbeauty	Melastomataceae	A	
Rhexia virginica	Virginia Meadowbeauty	Melastomataceae	ABE	
Sagittaria latifolia var. pubescens (Sagittaria pubscens)	Broadleaf Arrowhead	Alismataceae	A	
Sanguisorba canadensis	Canada Burnet	Rosaceae	A	
Smilax herbacea (Smilax pseudochina)	Halberd-leaved Greenbrier	Smilacaceae	ACD	MS2
Solidago rugosa (Solidago aspera)	Wrinkle-leaved Goldenrod	Asteraceae	A	
Solidago latissimifolia (Solidago elliottii)	Elliot's Goldenrod	Asteraceae	A	VS2, MS3
Solidago erecta	Slender Goldenrod	Asteraceae	A	
Solidago uliginosa (Solidago neglecta)	Bog Goldenrod	Asteraceae	ADE	VS2, MS3
Viola cucullata	Marsh Blue Violet	Violaceae	A	
Viola primulifolia	Primrose-leaved Violet	Violaceae	AD	MS3

HERBACEOUS MONOCOTS

Grasses

Andropogon glomeratus	Bushy Bluestem	Poaceae	A	
Andropogon virginicus	Broomsedge Bluestem	Poaceae	A	
Calamagrostis cinnoides (Calamagrostis coarctata)	Arctic Reedgrass	Poaceae	AE	
Dicanthelium dichotomum var. dichotomum (Panicum ensifolium)	Forked Panicgrass	Poaceae	AE	
Dichanthelium acuminatum	Woolly Panicgrass	Poaceae	D	
Panicum lucidum	Bog Witchgrass	Poaceae	A	
Panicum mattamuskeetense	?	Poaceae	A	
Panicum microcarpon	?	Poaceae	A	
Panicum verrucosum	Warty Panicgrass	Poaceae	A	
Panicum virgatum cubense	Switchgrass (cubense)	Poaceae	A	

Sedges

Carex atlantica ssp. Atlantica	Prickly Bog Sedge	Cyperaceae	E	
Carex bullata	Button Sedge	Cyperaceae	E	MS3
Carex folliculata	Northern Long Sedge	Cyperaceae	AC	
Carex intumescens	Greater Bladder Sedge	Cyperaceae	A	
Carex leptalea	Bristly-stalk Sedge	Cyperaceae	AC	
Eleocharis tenuis	Slender Spikerush	Cyperaceae	A	
Eleocharis tortilis	Twisted Spikerush	Cyperaceae	C	MS3
Eriophorum virginicum	Tawny Cottongrass	Cyperaceae	AB	
Fuirena hispida	Hairy Umbrella-Sedge	Cyperaceae	AB	
Rhynchospora alba	White Beaksedge	Cyperaceae	AB	VS2, MS3
Rhynchospora glomerata	Clustered Beaksedge	Cyperaceae	A	MS3
Rhynchospora gracilenta	Slender Beaksedge	Cyperaceae	ACE	
Scleria pauciflora	Few-flowered Nutrush	Cyperaceae	B	
Scleria reticularis (Scleria torreyana)	Netted Nutrush	Cyperaceae	A	MS2

Rushes

Juncus effusus	Soft Rush	Juncaceae	A	
Juncus longii	Long's Rush	Juncaceae	CDE	MS1

Yellow-Eyed Grasses

Xyris caroliniana	Carolina Yellow-eyed Grass	Xyridacea	AB	VS1
Xyris torta (flexuosa)	Slender Yellow-eyed Grass	Xyridacea	AE	

Lilies

Medeola virginiana	Indian Cucumber	Liliaceae	D	
Triantha racemosa (Tofieldia racemosa)	Coastal False Asphodel	Liliaceae	AB	VSH, MSX

Orchids				
Calopogon tuberosus (Limodorum tuberosum)	Common Grass-Pink	Orchidaceae	ABE	VS1, MS1
Gymnadeniopsis clavellata (Habenaria clavellata)	Small Green Wood Orchid	Orchidaceae	A	
Platanthera blephariglottis (Habenaria blephariglottis)	White-fringed Orchid	Orchidaceae	B	VS2, MS2
Pogonia ophioglossoides	Rose Pogonia	Orchidaceae	ABE	MS3
Spiranthes cernua (Ibidium cernuum)	Nodding Lady's Tresses	Orchidaceae	A	
Spiranthes lacera (Ibidium gracilis)	Northern Slender Lady's Tresses	Orchidaceae	A	
Pipeworts				
Eriocaulon decangulare	Ten-angle Pipewort	Eriocaulaceae	ABDE	MS1
FERNS AND FERN ALLIES				
Ferns				
Woodwardia virginica (Anchistea virginica)	Virginia Chainfern	Blechnaceae	AC	
Dryopteris cristata	Crested Woodfern	Dryopteridaceae	A	
Dryopteris carthusiana (Dryopteris spinulosa)	Spinulose Woodfern	Dryopteridaceae	A	
Dryopteris thelypteris	Eastern Marsh Fern	Dryopteridaceae	A	
Osmunda regalis var. spectabilis (Osmunda spectabilis)	Royal Fern	Osmundaceae	AC	
Osmundastrum cinnamomeum	Cinnamon Fern	Osmundaceae	CDE	
Pteridium aquilinum	Brackenfern	Dennstaedtiaceae	A	
Carnivorous Plants				
Drosera intermedia (Drosera longifolia)	Spatula-leaved Sundew	Droseraceae	ABDE	VS3
Drosera rotundifolia	Round-leaved Sundew	Droseraceae	AB	MS3
Utricularia spp.	Bladderworts	Lentibulariaceae	E	
Utricularia subulata (Setiscapela subulata)	Zigzag Bladderwort	Lentibulariaceae	B	MS3
Lichen and Clubmosses				
Cladonia spp.	Lichen spp.	Cladoniaceae	A	
Lycopodiella appressa (Lycopodium adpressum)	Appressed Bog Clubmoss	Lycopodiaceae	ABE	
Lycopodium carolinianum	Slender Bog Clubmoss	Lycopodiaceae	A	MS1

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