Unintended Leafy Legacies of Industry: a Montana Case Study in Applying Historical Ecology to Historical Cemeteries

John S. Harris

Abstract:

This chapter applies historical ecology to four 19th-century cemeteries in western Montana, treating surface vegetation as cultural material and evidence of past land use. Drawing on archival records of plant introduction, Indigenous management, fur-trade gardens, mission agriculture, military provisioning, and settler and ethnic horticulture, it reconstructs the botanical palette available to these communities. Paired surveys at burial features and adjacent undisturbed ground show cryptogams consistently serve as the most reliable indicators of burial disturbance, while vascular plants respond more variably to soil exposure and site conditions. Intentional plantings, fruit-eating-mediated dispersal, and persistent ornamentals mark continued ethnic place-making and multispecies use of these landscapes. Across all four sites, burial features and controls differ predictably, showing vegetation retains a measurable record of land use, maintenance, and industrial activity. These botanical legacies demonstrate that surface vegetation is a sensitive indicator of anthropogenic soils, offering evidence for archaeological interpretation, stewardship, and biocultural heritage work.

Keywords Historical Ecology - Historical Archaeology - Botanical Legacies - Anthropogenic Vegetation - Biocultural Heritage - Ethnic Place-Making - Multispecies Archaeology

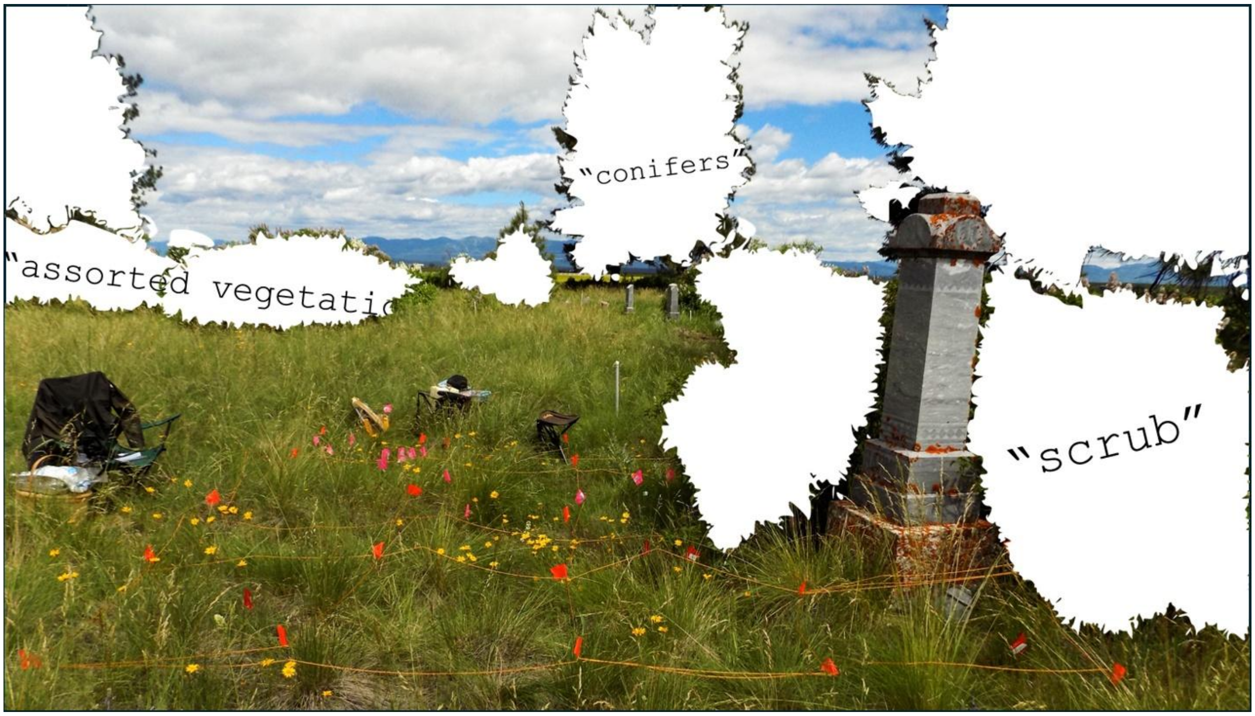
Surface Vegetation as Archaeological Evidence

Industrial landscapes are often described as ruins, but they remain active socio-ecological systems long after extraction ends. Soils shift, hydrology changes, and plant communities reorganize in response to disturbance, abandonment, and new forms of human presence. Cemeteries within these settings participate in the same dynamics. They are not isolated memorial spaces but nodes within broader industrial ecologies shaped by labor, migration, environmental modification, and community practice (Domańska 2018:118–132).

Within these cemeteries, surface vegetation preserves evidence of past human activity as reliably as artifacts, yet archaeologists rarely treat it with the same rigor. Vegetation reflects where soils were turned, where maintenance lapsed, where ornamentals were planted, and where disturbance accumulated. They preserve outlines of vanished structures, mark boundaries of use, and shows the ecological effects of industrial labor. The evidence is already underfoot; what is often missing is the habit of looking. Vegetation, though ubiquitous, has long fallen into a conceptual gap, noticed by every surveyor but seldom documented with the precision given to artifacts or architecture (Harris 2018).

Archaeological categories contribute to this neglect. The "ecofact" label, with its focus on unmodified remains, obscures the cultural significance of living plants and their responses to human activity. Site forms often collapse vegetation into broad habitat descriptors or a few recognizable species, leaving subtler signatures of human–plant entanglement unrecorded (Figure 1). The result is an imbalanced record: architectural features receive detailed description, while vegetation is reduced to labels like "conifer forest," "berry bushes," or "various grasses," categories too coarse to support later interpretation (Harris 2018). Archaeological approaches to vegetation have split into two camps. Palaeoethnobotany focuses on buried remains and subsistence; aerial survey uses crop marks to reveal buried features. Surface vegetation, the plant communities growing directly on archaeological sites, falls between these two scales and remains under studied. (Harris 2018). These communities can signal undiscovered features, reflect soil changes caused by past activities, preserve relict plantings, and express ethnic or community practices. They also reshape sites, obscuring inscriptions, altering fences, and sometimes standing as the only surviving grave markers.

Figure 1. Erasure of site vegetation through reductive terminology.



Plants participate directly in mortuary place-making (Jones and Sloke 2002; McMillen et al. 2017; McWilliams 2017b; Stilgoe 1982). They frame pathways, soften boundaries, and create atmospheres of care or neglect (Jones and Cloke 2002:143–164). Some are planted as memorials; others persist as descendants of earlier plantings. In many cemeteries, lilies or irises mark graves where families could not afford headstones (McWilliams 2017a; Samuels 1999:31). Elsewhere, grave-marking trees stand in for the dead, embodying memory, grief, or spiritual presence (Rival 2001; Samuels 1999:28,31; Stilgoe 1982:165, 220–229). Plants can also carry cosmological meaning, serve as ritual tools, or reflect class, ethnicity, nationalism, or resistance (Augé 2013; Gazin-Schwartz 2001; Jones and Cloke 2002; McMillen et al. 2017; Ozawa 2017; Riggs 2015). Vegetation is not background; it is cultural material and ecological memory.

This chapter demonstrates how surface vegetation in industrial-landscape cemeteries functions as cultural material through four steps. It outlines the conceptual scaffolding, historical ecology, landscape biography, multispecies archaeology, and behavioral archaeology, that makes vegetation legible as evidence. It then situates four Montana cemeteries within their historical and ecological contexts to frame expectations about disturbance, planting, and land-use histories. The results section analyzes species-level patterns in cover, sociability, vitality, stress, frequency, and indicator behavior to identify burial-generated microhabitats and anthropogenic signatures. The chapter concludes by synthesizing these patterns to show how vegetation preserves ecological memory of industrial labor, ethnic place-making, and maintenance regimes, and argues for integrating botanical evidence into archaeological interpretation and stewardship.

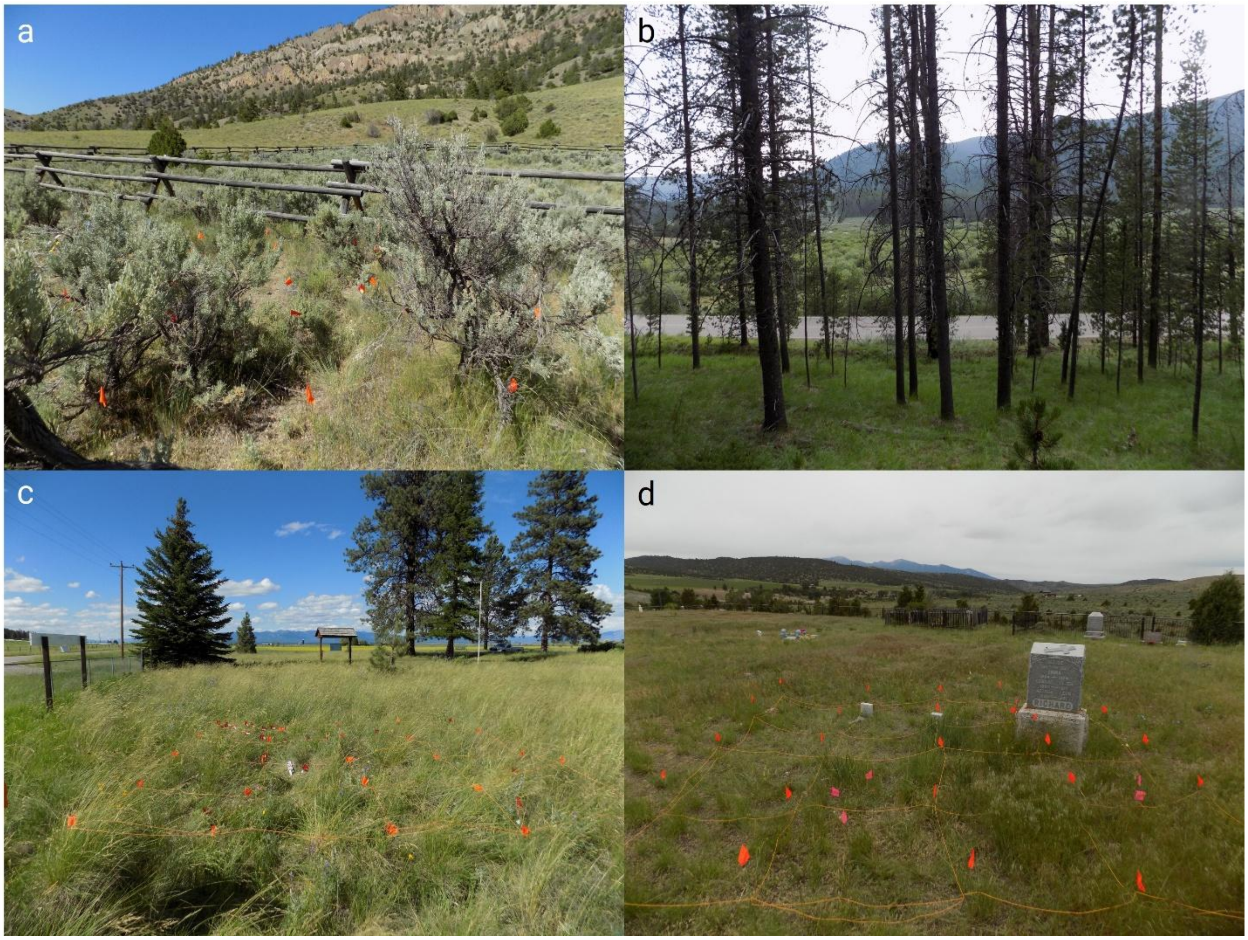
Situating the Montana Case: Cemeteries in Industrial Landscapes

Why These Cemeteries, Why This Approach

This case study focuses on western Montana cemeteries as a manageable way to limit variation in site type, land-use history, and ecoregional context. The temporal scope centers on 19th-century sites, a period marked by rapid ecological change driven by early extractive industries and the unsettled relationships between temporary workers, settlers, and local plant communities before the Homestead Era. Cemeteries offer a consistent site type where intentional and unintentional ecological transformations are both visible and comparable across different industrial site types.

This chapter narrows a larger dissertation project inspired by Brooks and Johannes's (1990) *Phytoarchaeology*, which proposed comparing vegetation responses across historical site types. Early fieldwork weighed a variety of site types, but burials proved more tractable: they are ubiquitous, accessible, and their feature-control structure (grave versus adjacent undisturbed ground) offers a cleaner comparative unit and are less prone to the disqualifying disturbances that ruled out other site types. Reconnaissance further narrowed candidates to sites with intact ground cover. Restricting the study to western Montana served to limit ecoregional variability. As a result, four cemeteries, 24BE1535, Aldridge, Nevada City, and Spring Creek, met the archaeological and ecological criteria for analysis (Figure 2). Although all are cemeteries, they are not treated as direct analogs across environmental settings. Each is analyzed primarily through its own feature-to-control comparisons, with intersite patterns noted only when they emerge despite ecoregional differences.

FIGURE 2. Study cemeteries and paired sampling plots, marked with orange survey pin flags: (a) Aldridge Cemetery; (b) 24BE1535; (c) Spring Creek Cemetery; (d) Nevada City Cemetery.



Each cemetery occupies a distinct ecological setting that shapes its vegetation responses (Table 1). Brief historical and environmental portraits, aligned with Lesica's sub-life zones and EPA Level IV ecoregions, provide the context needed to interpret species-level responses to burial features.

TABLE 1. Cemeteries Compared. Note: Control and Feature blocks at the same site shared same intrasite settings (Lesica 2022; Comstock 2011; USDA NRCS 2026a,b,c,d).

Cemetery	EPA Level IV Eco Region	Lesica's Life Zone	Aspect	Map Unit Soil
24BE1535	Middle Rockies: Pioneer Anaconda Range	Montane Conifer Forest	W-NW	Elve-Sebud families, complex, moderately steep mountain slopes
Aldridge	Middle Rockies: Absaroka Gallatin Volcanic Mountains	Montane Grasslands and Sagebrush Steppe	SW	Typic Cryoborolls and Argic Cryoborolls, terraces and flood plains
Nevada City	Dry Intermontane Sagebrush Valleys	Montane Grasslands and Sagebrush Steppe	SW	Varney clay loam, 8 to 15 percent slopes
Spring Creek	Northern Rockies: Flathead Valley	Plains Grasslands and Sagebrush Steppe	None	Kalispell loam, 0 to 3 percent slopes

Historical Pathways of Plant Introduction and Cultural Dispersal

Reconstructing Montana's Introduced Plant Histories

Introduced plants in Montana followed several overlapping pathways shaped by Indigenous land management, early exploration, fur trade subsistence gardens, mission agriculture, military provisioning, and later orchard and nursery networks. These vectors created the botanical palette settlers drew from when forming homesteads, gardens, and cemeteries, and they help explain why certain ornamentals and food plants appear across the four study sites.

Before Euro-American arrival, Indigenous communities actively shaped plant communities through pyroculture, pruning, aeration, weeding, protection, selective harvesting, replanting, and ceremonial tending (Deur and Turner 2005; Hart 1976; Lepofsky 2004). Some species were intentionally introduced or moved within regional networks. The Crow cultivated Crow tobacco (*Nicotiana quadrivalvis* var. *multivalvis)* in sacred gardens while also using the native manyflower tobacco *(Nicotiana quadrivalvis* var. *quadrivalvis)* (Lowie 1963:274), and groups across the broader region used coyote tobacco *(Nicotiana attenuata)* (Tushingham et al. 2018). These practices created long-standing anthropogenic mosaics that later settlers encountered and sometimes adopted.

Early European explorers (1806–1810s) documented and collected plants, but the first sustained non-Indigenous cultivation came with French Canadian fur traders (1820s-1850s), who established small gardens near posts to supplement diets (Toole 1959; Warner, Beers & Company 1885). Hudson's Bay Company posts introduced wheat and barley, and traders' Indigenous wives contributed camas, berries, and other gathered foods to household and local exchange networks (Weisel 1955:76, 80, 112, 199). Across the interior Northwest, posts such as Fort Colville (est. 1825), Fort Nez Perce and Fort Walla Walla (1830s–1840s), The Dalles (1854), Fort Hall (1845-1856), and Fort Connah (1855) maintained gardens typical of company operations (Weisel 1955:xxxiii–xxxvii). Livestock movements also unintentionally dispersed plant species.

Mission agriculture formed a second major introduction vector. Jesuit missionaries at St. Mary's Mission (est. before 1841) planted wheat, potatoes, peas, and fruit trees (Weisel 1955:xvii, xix). Father De Smet transported potatoes, wheat, and oats from Fort Colville and brought additional garden plants from St. Louis around 1840, linking Montana's earliest mission agriculture to the wider Columbia Plateau (Weisel 1955:xix). St. Ignatius Mission (founded 1854) continued this pattern, establishing gardens, orchards, and livestock herds that became important centers of local food production and plant dispersal (Weisel 1955).

Military posts formed a third introduction pathway. Because transporting food was costly, posts were expected to provision themselves through gardens, fields, and local hunting and fishing. Cavalry operations required hay and alfalfa. At Fort Ellis (est. 1868 near Bozeman), soldiers cultivated wheat, rye, oats, barley, potatoes, turnips, and other northern vegetables along the Gallatin River bottoms (Warner, Beers & Company 1885:205). Around Fort Keogh near Miles City, Oglala Sioux and Cheyenne families grew potatoes, turnips, corn, onions, and other common vegetables (Warner, Beers & Company 1885:207). Fort Assiniboine near Havre maintained a post garden between 1879 and 1882 (Warner, Beers & Company 1885:208). These posts became hubs for the spread of cultivated species across the northern plains.

Within this broader network, Fort Owen stands out as the region's first sustained agricultural settlement. Originating as St. Mary's Mission in the 1840s and converted into a private trading post in 1850, it produced wheat (including fall wheat), rye, potatoes, cabbage, turnips, peas, oats, barley, hay, corn, and onions (Weisel 1955:94–95, 101, 182, 187, 198). Its output circulated through surrounding posts and homesteads, reinforcing regional plant dispersal.

By the 1860s-1890s, orchard and nursery networks added new layers of intentional introductions. Settlers planted apples, plums, pears, cherries, currants, gooseberries, and small fruits, drawing on stock from Washington, Oregon, and the Great Lakes region. The Montana State Board of Horticulture (1901) documented widespread experimentation with hardy cultivars suited to local climates. Nurseries in the Bitterroot and Gallatin valleys imported rootstock from

Puyallup, Walla Walla, and Geneva, New York, creating transregional horticultural circuits that supplied homesteads, missions, and cemeteries alike.

Ethnic horticultural traditions further shaped plant introductions. Greek, Slavic, German, and Scandinavian settlers brought preferences for lilacs, roses, currants, gooseberries, and other ornamentals (Papanikolas 1976; Petrović and Jovanović 2016; Francis et al. 2018; Yalom 2008). Many of these species appear in Montana cemeteries as persistent ornamentals or volunteer descendants of earlier plantings. Lilacs, irises, and roses became durable grave markers where families could not afford headstones, a practice documented across multiple regions (McWilliams 2017a; Samuels 1999:31). These ornamentals, along with fruiting shrubs attractive to fruit-eaters, created additional pathways for plant dispersal into burial landscapes.

Collectively, these Indigenous, colonial, military, agricultural, and ethnic vectors formed a layered introduction history that shaped the botanical possibilities available to communities across western Montana. They also established the cultural and ecological contexts in which cemetery vegetation developed, making archival pathways essential for interpreting intentional plantings, persistent ornamentals, and species-level signatures observed in the vegetation surveys (Table 2). Not to mention different groups had different mortuary practices.

TABLE 2. Introduced plants in 19th-Century Montana: A register and assessment of potential persistence at historical archaeological sites in Montana. Sources: (CABI 2024; Dirr 2009; FAO 2010; Flora of North America Editorial Committee 1993–2016; Hong and Ellis 1996; Hummer and Janick 2007, 2011; Kozlowski, Kramer, and Pallardy 1991; Long and Day 2018).

Species	**Probability of Persistence**	**Dispersal Vectors & Contextual Conditions**
Acer spp. **(maples)**	Low- Moderate	Samara dispersal (species dependent); commonly planted as shade trees, may be found around residences, roads, and cemeteries.
Allium cepa **(onion)**	Negligible	Survives from bulbs rarely; needs deliberate planting or bulbils; may persist only in sheltered gardens or compost mounds.
Avena sativa **(common oat)**	High	Light seed dispersed by wind, machinery, and animals; prefers moist seedbeds and cool seasons; establishes on disturbed or abandoned cultivated ground and in low-lying moist patches.

***Brassica oleracea* var. *capitata* (cabbage)**	Low	Requires seed set and repeated disturbance; tolerates cultivated soils but unlikely to spread via animals/wind.
***Brassica rapa* subsp. *rapa* (turnip)**	High	Fast life cycle; seeds disperse short distances by wind and machinery; persists in disturbed, nutrient-rich patches and compost.
***Celtis occidentalis* (common hackberry)**	Moderate	Bird dispersal of fleshy drupes; establishes in riparian corridors, shelterbelts, windbreaks, field edges, roads, railroads, and disturbed urban/edge sites.
***Cucumis melo* (muskmelon)**	Low - Moderate	Seed survives composting; mammal/bird dispersal of fruits; volunteers in warm low-elevation sites, compost heaps, riparian margins.
***Cucumis sativus* (cucumber)**	Low - Moderate	Seed survives composting; bird/mammal movement; establishes in disturbed soils, fence rows, and homestead refuse.
***Cucurbita maxima* (winter squash)**	Moderate - High	Heavy seed production; animal dispersal and compost-mediated recruitment; persists in dump sites, floodplain sediments, and disturbed ground.
***Cucurbita pepo* (field pumpkin)**	Moderate - High	Readily volunteers from discarded fruit; seeds moved by animals, water, and compost; establishes in disturbed, nutrient-rich sites.
***Fragaria* × *ananassa* (garden strawberry)**	High	Vegetative spread via stolons and occasional seed; persists in gardens, edges, and disturbed ground where runners root; bird dispersal possible for seed.

Fraxinus pennsylvanica **(green ash)**	Moderate - High	Wind-dispersed samaras; commonly planted in shelterbelts and yards.
Hordeum vulgare **(common barley)**	High	Seed spilled at threshing/grain stores; moved by livestock, birds, water, and machinery; tolerates short seasons and cool springs so volunteers readily in fence rows, grain-spill sites, ditches, and abandoned plots.
Hydrangea **spp. (hydrangeas)**	Low	Limited natural spread; persistent in cultivated gardens.
Malus domestica **(apple)**	High	Seedlings arise from seed (bird/mammal ingestion and deposition) and from rootstock or graft suckers; established trees persist for decades and can form seedling cohorts along roadsides, irrigation ditches, and riparian corridors.
Medicago sativa **(alfalfa)**	High	Seed and managed sowings produce long-lived stands; seed and root fragments spread along irrigation ditches, hayfields, roadsides, and disturbed riparian soils; persistence reinforced by cutting/grazing regimes and occasional vegetative survival.

Phaseolus vulgaris **(kidney bean)**	Negligible	Seeds long-lived in soil/compost; dispersal mainly by human activity or rodents; persists in sheltered homestead patches and compost mounds.
Pisum sativum **(field pea)**	Low - Moderate	Pods dehisce releasing seed; limited animal dispersal; persists in nutrient-rich disturbed soils and sheltered garden sites.
Pastinaca sativa **(wild parsnip)**	Low	Biennial; requires seed set and vernalization; wind disperses seeds short distances, but adult plants are uncommon outside sheltered or long-undisturbed edges.
Populus spp.	High	Wind- and water-dispersed seeds; fast-growing trees used in riparian plantings, windbreaks, and homesteads.
Prunus spp. **(cottonwoods / poplars)**	Moderate	Several Prunus species recruit from seed and sprout from rootstock; bird dispersal and planting for food/windbreaks encourage occurrence near sites and in refuse contexts.
Prunus virginiana **(chokecherry)**	Moderate - High	Fleshy fruits dispersed by birds/mammals; forms thickets by seedling recruitment and suckering; common in riparian zones and shelterbelts.

***Rosa* spp.** **(roses)**	High	Vegetative spread by suckering and layering; hips eaten and dispersed by birds/mammals; persists in hedgerows, yards, cemeteries.
Rubus* × *boysenii **(boysenberry)**	Moderate	Hybrid Rubus with vigorous vegetative growth; spreads by canes and root fragments; fruit eaten and dispersed by birds; establishes in abandoned fields and edges .
***Ribes americanum* / *Ribes* spp.** **(American black currant, currants, and gooseberries)**	High	Bird/mammal dispersal of fleshy berries; can establish in riparian corridors, thickets, fence rows, and disturbed woodland edges; some Ribes cultivars escape to nearby sites.
Ribes aureum **(golden currant)**	High	Bird/mammal dispersed berries; establishes in woodland edges, riparian margins, and shelterbelts; likely near habitations and in disturbed edge deposits.
Raphanus sativus **(cultivated radish)**	Moderate - High	Rapid lifecycle; abundant seed; short-distance wind and machinery dispersal; establishes in disturbed, nutrient-rich patches and compost heaps.

***Rubus idaeus* (American red raspberry)**	High	Cane and root sucker spread; bird dispersal of fruit; cultivars readily escape into hedgerows, forest edges, and riparian corridors.
***Rubus* × *ursinus* (California blackberry)**	Moderate - High	Strong vegetative and seed dispersal; bird/mammal dispersed fruit; forms dense thickets in riparian zones, roadsides, and disturbed sites.
***Shepherdia argentea* (silver buffaloberry)**	High	Bird and mammal dispersed drupes; establishes in riparian corridors, shelterbelts, and abandoned/edge sites; seeds persistent in local patches and likely in yard/midden contexts.
***Solanum lycopersicum* (garden tomato)**	Low - Moderate	Bird and mammal dispersal of fleshy fruit; seeds survive gut passage and composting; volunteers in fence rows, riparian margins, and homestead refuse.
***Solanum tuberosum* (potato)**	Moderate - High	Vegetative persistence from tubers/culls; dispersed via animal activity or human refuse; persists where tubers remain in soil or cull piles.

***Syringa vulgaris* (common lilac)**	Moderate - High	Typically human-planted ornamental that persists locally; limited natural spread but can naturalize near long-occupied homesteads, cemeteries, and sheltered microhabitats.
***Triticum spp.* (wheat)**	Moderate – High (spring wheat); Moderate (winter wheat)	Seed moved by harvest losses, livestock feed, and machinery; spring wheats suited to short growing seasons volunteer most readily across Zones 2–5; winter wheats need milder microsites or snow cover to survive cold winters.
***Ulmus americana* (American elm)**	Moderate	Wind-dispersed samaras; historically planted as shade/street trees.
***Viburnum* spp. (viburnums)**	Low - Moderate	Bird/mammal dispersed drupes; survives in shelterbelts and homestead plantings.
***Zea mays* (corn)**	Low	Requires dense stands and sufficient season to set seed; kernels more often eaten than dispersed for establishment; persists only with repeated planting.

Ecological Pathways: Anticipating Unintentional Legacies

An Anticipated Mosaic of Microhabitats in Industrial Landscapes

Industrial landscapes generate overlapping disturbance regimes that leave long-lasting ecological signatures. Mining districts, with their mix of work areas and domestic zones, create a patchwork of soils and substrates that continue to shape vegetation long after extraction ends.

Residential areas often left behind decaying wood that changed soil chemistry, while collapsed roofs and wall lines created small sediment banks where slumping and redirected runoff favored early colonizers such as dandelions, plantains, and bluegrasses. Privies produced deeply disturbed, nutrient-rich pits that supported nitrophilous plants like nettles, goosefoots, and docks, and their edges often held culturally planted lilacs or fruit trees that thrived in enriched soils (Mytum 2004; Stewart 1977; Stilgoe 1982:166; Watts 1999).

Earthen foundations and dugouts created loose, easily worked soils colonized by disturbance-tolerant grasses and ruderal forbs, contrasting with the packed surfaces of roads and paths. Repeated foot traffic, wagon wheels, and livestock compacted these routes into hardpan, favoring ruderals such as knotweeds and Russian thistles and acting as corridors for seeds moved by people and animals (Howe and Smallwood 1982). Open canopies around work yards and haul roads increased sunlight, encouraging light-loving pioneers like thistles, sagebrush and wormwoods, and bromes. Corrals and stables added manure-rich soils that supported nitrophilous grasses and forbs including wild ryes, Kentucky bluegrass, medicks, and clovers. Kitchen gardens created fenced pockets of improved soil where hardy perennials such as rhubarbs, mints, onions, and blackberries or raspberries often persisted (Francis et al. 2005). Areas outside doors sometimes accumulated alkaline wash water, forming small patches suited to species tolerant of higher pH (Stewart 1977).

Drainage ditches carried runoff that deposited fine sediments and moisture, forming narrow wet areas colonized by rushes, sedges, and horsetails. Tailings piles and waste rock produced chemically harsh soils, alkaline, metal-laden, or nutrient-poor, like serpentine environments, where tolerant species such as saltbush, greasewood, wild buckwheat and metal-adapted grasses established sparse, stress-tolerant communities (Francis et al. 2005). Middens enriched soils with organic refuse, attracting nutrient-responsive plants like pigweeds/amaranths and sunflowers. Commercial storefronts created compacted, trampled forecourts where hardy ruderals such as bristlegrass and purslane took hold (Howe and Smallwood 1982).

Patterns of these disturbances produced a varied mosaic of microhabitats, nutrient-rich pits, compacted paths, loose foundation soils, sunny work yards, manure-enriched corrals, alkaline wash zones, wet ditch margins, chemically extreme tailings, and trampled commercial fronts, each supporting its own suite of plant communities shaped by the industrial, domestic, and ecological processes that structured life in mining landscapes.

Cemeteries as Multispecies Refugia

Historic cemeteries accumulate ecological signatures through the interaction of built features, intentional plantings, and the movements of animals that use these protected spaces as refuges. Because Christian graves align on an east-west axis, headstones cast afternoon shade on their west sides, creating cooler, moister pockets where cultural plantings persist. Trees planted as memorials can also provide data through coring or demographic profiles that help estimate burial ages. Decaying wooden crosses, fences, and grave shafts create loose soils, shaded spots, and nutrient-rich patches where mosses, cryptogams, and opportunistic grasses establish, while iron fencing and stone curbing form sheltered niches that allow introduced perennials, irises, lilies, peonies, roses, to survive long after families have left (Mytum 2004).

In older graves, even skeletal remains enter these exchanges: rodents sometimes gnaw exposed bone for calcium and phosphorus, and microbes break down bone collagen and coffin materials, enriching nearby soils. Burrowing animals frequently occupy grave shafts, taking advantage of the soft fill. Evergreen shrubs subtly alter moisture and nutrient cycles, shaping successional pathways and creating conditions distinct from surrounding grassland or sagebrush communities (Francis et al. 2005). Their layered canopies moderate temperature and retain moisture, forming microclimates that support insects, small vertebrates, and moisture-dependent plants absent from open terrain.

Because cemeteries are socially protected from hunting, grazing, and heavy landscaping, they offer reliable forage and shelter for wildlife. Human-introduced ornamentals and bird-dispersed fruiting shrubs, roses, plums/cherries, mountain-ashes, apples, create concentrated food sources that attract fruit-eating birds. Their repeated visits reinforce these plantings through endozoochory (a plant dispersal method that relies on animals' ingestion and defecation), moving seeds of elderberries, serviceberry, juniper, currant/gooseberry, nightshades, common chokecherry, apples, and mountain-ashes (Howe and Smallwood 1982). Soft-fleshed fruits such as roses, blackberries/raspberries, strawberries, and grapes move through birds and small mammals, while hard-coated seeds of grasses, vetches, wild peas, plantains, and docks survive digestion and arrive incidentally in these favorable micro-niches (Howe and Smallwood 1982).

Other dispersal systems leave their own signatures: epizoochory brings burr-bearing bedstraws/cleavers, beggarticks, and burdocks on the fur of deer and small mammals (Howe and Smallwood 1982); wind dispersal introduces pioneers like dandelions, thistles, and polars/cottonwoods into disturbed soils; ants move fleshy, nutrient-rich appendage of seeds (i.e. elaiosome) from Violets and Trilliums into undisturbed corners (Giladi 2006); corvids and rodents cache chokecherry and hawthorn; runoff carries docks, rushes, and sedges downslope; and gravity concentrates maples and oaks beneath parent trees (Howe and Smallwood 1982). Ungulates browse ornamentals along cemetery margins, shaping shrub form and regeneration, while small mammals and corvids use monuments and plantings for caching, producing tight clusters of woody recruits. Even plot curbing creates small refuges from modern mowing and trimming.

Considered together, these processes reveal cemeteries as multispecies landscapes where plants introduced for mourning or beauty become ecological actors, animals redistribute seeds through daily movements, and built features decay into habitat. These interactions co-author cemeteries in ways not always recognized, leaving ecological clues that reward close archaeological attention.

Field Methods and Interpretive Procedures

Case Study Methods Overview

This study treats surface vegetation as cultural material by drawing on a combined framework in which historical ecology understands cemeteries as cumulative socio-ecological records shaped by long-term human activity (Balée 1998; Brooks and Johannes 1990), landscape biography distinguishes intentional plantings from inadvertent ecological traces within changing cycles of care and disturbance (Samuels 1978; Helphand 2006; Ozawa 2017), multispecies archaeology recognizes plants as ecological actors whose species-specific traits index disturbance, maintenance, and cultural practice (Harris and Cipolla 2018; Alberti and Fowles 2018), behavioral archaeology provides units of analysis from its dimensions of variability: vitality, stress, cover, sociability, frequency, substrate associations, for analyzing vegetation with the same rigor as artifacts while accounting for cultural and natural transforms such as planting, tending, succession, and decay (Schiffer 1983; 1987), and pragmatic Peircean semiotics offers the interpretive logic for cohesively reading species-level patterns as signs of anthropogenic soils, cultural planting regimes, and microhabitat formation (Cipolla and Harris 2017). Taken together, perspectives justify the systematic analysis of vegetation as evidence of past human activity, disturbance regimes, and ethnic place-making that artifact-centered approaches often overlook.

Fieldwork took place during the 2016–2017 summer seasons (Figure 3). Vegetation was recorded using a quadrant sampling method with non-random (judgment) placement of paired 4 × 4 m Feature and Control blocks. This approach matched the inherently nonrandom distribution of cultural features. At each cemetery, a Feature block was placed directly around a grave marker or structural element, while a Control block was placed in adjacent open ground with similar slope, exposure, and representative vegetation but outside any visible burial or cultural feature. Pairing the blocks in this way isolated the microhabitat effects created by burial features and avoided broad, landscape-level "apples-to-oranges" comparisons.

FIGURE 3. The author examining a lichen specimen from a Control quadrant at the Nevada City Cemetery.

The sampling strategy addressed several questions: how to identify anthropogenic vegetation; what its diagnostic limits are; whether certain site types show consistent botanical signatures; and what archaeological insights these signatures offer regarding perceptions, beliefs, symbolism, prestige, identity, place-making, and ethnicity. Field notes documented block placement and context, and each block was surveyed for species presence, direct counts, frequency, cover, sociability, vitality, and visible plant stress. Photographs were taken of representative specimens.

With permission, above-ground plant material was collected within site boundaries, or from matching taxa outside site limits when necessary. Specimens were dried and mounted with assistance from the University of Montana Herbarium. Before field visits, checks for endangered or restricted species ensured no accidental collection of sensitive plants, aided by a laminated field identification guide. Even when no legal restrictions applied, solitary or locally rare individuals were avoided. Pin flags and string grids were used to establish and maintain the boundaries of each sampling unit.

Analyzing Frequency

Given the small number of sites and the structure of the dataset, permutation-based significance testing was not appropriate. Instead, species associations were evaluated descriptively using the specificity and fidelity components of the Dufrêne and Legendre Indicator Value method (Dufrêne and Legendre 1997). Following common practice in applied ecology when formal inference is not feasible (McCune and Grace 2002), specificity and fidelity were combined into a qualitative indicator classification. Species were assigned to one of five classes: Feature-exclusive, Feature-leaning, Generalist, Control-leaning, or Control-exclusive, based on their A and B values.

Vegetation was recorded at the level of individual units within each 4 × 4 m block, allowing fine-grained counts while maintaining comparability across species. Because absolute counts vary widely among taxa and growth forms, presence/absence within units provided the most consistent basis for analysis. Species presence and estimated frequency were recorded using a modified Braun-Blanquet scale (Braun-Blanquet 1932), and values were converted to percentage midpoints to allow comparison across sites.

Specificity (A) measured how restricted a species was to one block type. It was calculated as the proportion of a species' total frequency that occurred in the Feature block. Fidelity (B) measured how consistently a species appeared in the target block type and, with only one Feature block per cemetery, was expressed simply as presence (1) or absence (0). This simplified approach fit the aims of archaeological prospection by highlighting species with potential to act as anthropogenic indicators.

A cross-site matrix was then constructed to track species behavior across all four cemeteries, identifying consistent Feature or Control associates, species whose behavior shifted with local conditions, and broader ecological guilds. These patterns form the empirical basis for the Results, while their archaeological implications are developed in the Discussion. The analytical approach emphasizes clarity and ecological defensibility, documenting observable patterns without imposing unsupported statistical claims and keeping the workflow accessible to archaeologists using standard tools such as Excel.

Analyzing Sociability

Presence/absence alone cannot capture all anthropogenic vegetation patterns, so sociability was used as an additional qualitative metric. Sociability measures how tightly a species grows and was assessed in Feature and Control blocks using a five-point ordinal scale (1

= solitary individuals; 2 = grouped or tufted; 3 = small patches or cushions; 4 = small colonies forming extensive patches; 5 = great crowds). Field observations were compiled into a table with matched Feature and Control values for each species–site pair.

A sociability difference score (Feature minus Control) indicated whether a species grew more clumped, more diffuse, or showed no change around burial features. Each comparison was classified as “More clumped in Feature,” “More diffuse in Feature,” “No change,” or “Not comparable.” Species-level summaries were then generated by scanning all paired comparisons and assigning each species to the strongest category it exhibited, following a hierarchical rule (clumped > diffuse > no change).

This paired-comparison approach allowed direct evaluation of sociability shifts at each site without requiring distributional assumptions or large sample sizes, making it well suited to the structure and scale of the dataset.

Analyzing Vitality

Presence or heavy colonization does not necessarily indicate plant health, so vitality was used as an additional field-based measure of vigor. Vitality was assessed in Feature and Control blocks using a four-point ordinal scale (1 = well developed; 2 = strong but not completing its life cycle; 3 = feeble but spreading; 4 = unobservable). Values of 4 were treated as non-observations and excluded from paired comparisons. Vitality scores were compiled into a table with matched Feature and Control values for each species–site pair, and only species with observable scores (1–3) in both blocks were compared.

A vitality difference (Feature minus Control) indicated whether a species performed worse, better, or the same around burial features. Positive values signaled poorer vitality in Feature blocks, negative values indicated better vitality, and zero indicated no change. Each comparison was classified as “More impaired vitality in Feature,” “More robust vitality in Feature,” “No change,” or “Not comparable.” Species-level summaries were then generated by applying a hierarchical rule in which any instance of impaired vitality in Feature superseded all other outcomes, followed by robust vitality, then no change; species lacking comparable pairs were classified as “Not comparable.”

This paired-comparison approach allowed direct evaluation of vitality shifts without requiring distributional assumptions or large sample sizes, making it well suited to the structure of the dataset and the archaeological aims of identifying anthropogenic vegetation signatures.

Analyzing Plant Stress

Presence and vitality alone do not explain how a plant is struggling or responding to burial features, so stress was recorded using standardized, field-observable categories: dwarfism, gigantism, premature flowering or senescence, delayed growth, discoloration, subdued growth, and no stress observed. All observations were compiled into a cleaned master dataset with standardized species names, site names, and block types. A unique key combining site, species, and block type allowed precise matching of Feature and Control records.

For each species–site pair, stress values were extracted into a paired-comparison table. Differences were classified into five outcomes: "More stressed in Feature," "Less stressed in Feature," "No change," "Different stress type," or "Not comparable," using normalized text comparisons. Species-level summaries were then generated by counting the frequency of each outcome across all sites and calculating proportional responses.

Because stress observations were qualitative and relatively infrequent, the analysis emphasized descriptive patterns rather than formal statistical inference. This approach documented how specific stress expressions clustered around burial features and provided an additional line of evidence for identifying anthropogenic microhabitats.

Analyzing Cover

Because vitality can vary between observers, percentage cover was collected as an additional proxy for plant health and abundance. Cover values for each species were extracted from the vegetation dataset, which contained one record per species per block (Feature or Control) at each site. A unique key combining site, species, and block type was used to match Feature and Control values for each species–site pair.

Cover differences were calculated as Feature minus Control, with a ±5% tolerance applied to avoid over-interpreting minor visual estimation differences; values within this range were treated as no change. Each species at each site was then classified as having higher cover in Feature, lower cover in Feature, no change, or not comparable (when only one block type was present).

Cross-site tendencies were summarized by tallying the number of sites in each category for every species and assigning a species-level tendency based on the predominant direction of response. All qualitative and ordinal assessments were conducted by the author to minimize interpretive variation and maintain consistency across the dataset.

Vegetation Survey Results from Four Cemeteries

Due to brevity, Table 3 summarizes all species exhibiting Feature-specific responses across any vegetation metric; the narrative below synthesizes the broader cross-metric patterns that the table cannot convey.

TABLE 3. Feature-associated species responses across all vegetation metrics. Note: "+" indicates higher level of a metric in Feature (Cemetery) than Control. "-" indicates lower level of a metric in Feature than Control. Multiples of each show instances of the indicator direction at more than one site.

Species	Sociability Shift	Vitality Shift	Frequency Shift	Cover Shift	Stress Shift	Notes (Interpretive Relevance)
***Achillea millefolium* (common yarrow)**	+				Reduced stress compared to Control	Higher sociability in Feature blocks; reduced stress suggests favorable microhabitats
***Achnatherum nelsonii* (Columbia needlegrass)**			+			Feature-exclusive at Nevada City; bunchgrass benefiting from burial-feature microhabitats
***Anemone multifida* (Pacific anemone)**				+		Higher cover in Feature blocks; mesic forb
***Antennaria rosea* (rosy pussytoes)**	-			-		More diffuse sociability; lower cover in Feature blocks
***Arctostaphylos uva-ursi* (kinnikinnick)**	+					Near-threshold Feature-leaning frequency at 24BE1535; higher sociability in Feature blocks

***Arnica fulgens* (orange arnica)**				+		Higher cover in Feature blocks; forb benefiting from microhabitat buffering
***Artemisia tridentata ssp. Tridentata* (basin big sagebrush)**				-	Increased stress	One of few species showing increased stress in Feature blocks
***Berteroa incana* (hoary alyssum)**					Discoloration	Feature-sensitive species showing discoloration
***Brachythecium salebrosum* (smooth-stalk feather-moss)**			+			Feature-exclusive at Spring Creek; moss thriving in buffered microhabitats
***Bromus ciliates* (fringed brome)**			+			Feature-exclusive at Spring Creek; grass responding to moisture retention

***Calamagrostis canadensis* (bluejoint reedgrass)**			+			Feature-exclusive at Spring Creek; mesic grass indicating cooler, moister soils
***Carex torreyi* (Torrey's sedge)**					Reduced stress compared to Control	Reduced stress in Feature blocks; early-season sheltering effect
***Cirsium scariosum* (meadow thistle)**			+			Feature-exclusive at 24BE1535; responds to disturbed, enriched soils around burial features
***Cladonia cristatella* (British soldiers lichen)**			+			Feature-exclusive at Spring Creek; lichen preferring stable, low-disturbance surfaces
***Cladonia fimbriata* (trumpet cladonia)**			+	+	Subdued growth	Feature-exclusive at Aldridge; cryptogam responding to sheltered niches

Elymus repens **(quackgrass)**			+			Feature-exclusive at Spring Creek; rhizomatous grass exploiting disturbed grave soils
Elymus trachycaulus **(slender wheatgrass)**			+	+		Feature-leaning at Spring Creek; higher cover in Feature blocks
Epilobium ciliatum **(fringed willowherb)**			+			Feature-exclusive at Spring Creek; moisture-responsi ve forb
Ericameria nauseosa **(rubber rabbitbrush)**			+			Feature-exclusive at Aldridge; shrub indicating reduced disturbance
Erigeron pumilus **(shaggy fleabane)**		-	+			Feature-exclusive at Nevada City; impaired vitality in Feature blocks

***Festuca idahoensis* (Idaho fescue)**	+			+		Higher sociability and higher cover in Feature blocks
***Fragaria virginiana* (Virginia strawberry)**			+			Feature-exclusive at Spring Creek; stoloniferous forb benefiting from shade and moisture
***Geranium viscosissimum* (sticky purple geranium)**			+			Feature-exclusive at Spring Creek; mesic forb
***Heterotheca villosa* (hairy false goldenaster)**			+			Feature-exclusive at Nevada City; forb tolerant of stable, low-disturbance soils
Homalothecium aeneum (bright copper homalothecium moss)			+		Discoloration	Feature-exclusive at Spring Creek; discoloration indicates Feature-sensitive physiology
***Iris flavescens* (yellow flag iris)**			+			Feature-exclusive at Aldridge; ornamental persisting in grave-associated soils

Iris missouriensis **(Rocky Mountain iris)**			+			Feature-exclusive at Nevada City; ornamental or mesic forb persisting in shaded niches
Juniperus scopulorum **(Rocky Mountain juniper)**	-					More diffuse sociability in Feature blocks
Koeleria macrantha **(prairie Junegrass)**	-	+	+	-		More diffuse sociability; higher vitality; lower cover in Feature blocks
Linum lewisii **(Lewis flax)**			+			Feature-exclusive at Nevada City; forb benefiting from reduced disturbance
Lithospermum ruderale **(western stoneseed)**					Reduced stress compared to Control	Reduced stress in Feature blocks; early-season microclimate benefit
Lupinus argenteus **(silvery lupine)**				+		Higher cover in Feature blocks; nitrogen-fixing forb
Melilotus officinalis **(yellow sweetclover)**			+			Feature-exclusive at Nevada City; nitrogen-fixing forb exploiting disturbed soils

Nassella viridula **(green needlegrass)**	-			-		More diffuse sociability; lower cover in Feature blocks
Oenothera caespitosa **(tufted evening primrose)**			+			Feature-exclusive at Nevada City; forb responding to burial-feature microsites
Peltigera aphthosa **(common freckle pelt)**	+			+	Subdued growth	Feature-leaning at 24BE1535; also shows higher sociability and cover in Feature blocks
Peltigera canina **(dog pelt lichen)**			+			Feature-leaning at Aldridge; lichen favoring stable, shaded soils
Peltigera membranacea **(membranous dog lichen)**			+			Feature-exclusive at Spring Creek; lichen responding to reduced disturbance

Pinus contorta **(lodgepole pine)**						Feature-leaning at 24BE1535; seedling recruitment in protected microsites
Poa pratensis **(Kentucky bluegrass)**			+			Feature-exclusive at Nevada City; strong Feature association
Poa secunda **(Sandberg bluegrass)**				+		Higher cover in Feature blocks; grass responding to reduced disturbance
Pohlia nutans **(nodding pohlia moss)**			+	+		Feature-leaning at Aldridge; moss responding to microclimatic buffering

Potentilla gracilis **(slender cinquefoil)**						Feature-exclusive at 24BE1535; mesic forb benefiting from shaded microhabitats
Potentilla pectinisecta **(combleaf cinquefoil)**			+			Feature-exclusive at Spring Creek; forb benefiting from microhabitat buffering
Rhizocarpon macrosporum **(map lichen)**	+					Lichen showing increased clumping in Feature blocks
Ribes inerme **(whitestem gooseberry)**			+		Discoloration	Feature-exclusive at 24BE1535; discoloration indicates Feature-sensitive physiology
Rosa* × *harisonii **(Harison's yellow rose)**			+		Dwarfism	Feature-exclusive at Aldridge; dwarfism reflects age & neglect

***Rosa arkansana* (prairie rose)**			+		Reduced stress compared to Control	Feature-leaning at Spring Creek; shrub responding to reduced disturbance
***Rusavskia elegans* (elegant sunburst lichen)**			+++			Feature-exclusive at Spring Creek, Nevada City, Aldridge; consistent cross-site Feature indicator
***Sphaeralcea coccinea* (scarlet globemallow)**			+			Feature-exclusive at Nevada City; forb benefiting from microhabitat stability
***Symphoricarpos oreophilus* (mountain snowberry)**			+			Feature-exclusive at Aldridge; shrub benefiting from microhabitat buffering
***Syringa vulgaris* (common lilac)**			+		Dwarfism	Feature-exclusive at Spring Creek; dwarfism reflects age & neglect, not Feature stress
***Taraxacum officinale* (common dandelion)**			+		Subdued growth; delayed growth	Strong Feature-leaning at 24BE1535 & Nevada City; only species at all four cemeteries

***Tortula ruralis* (star moss)**			+			Feature-exclusive at 24BE1535; cryptogam sensitive to microclimatic buffering
***Tragopogon dubius* (yellow salsify)**			+			Feature-exclusive at Aldridge; forb responding to reduced disturbance

Frequency

Across all cemeteries, Feature and Control blocks supported distinct vegetation signatures even though species pools differed widely. Feature blocks consistently hosted a small subset of taxa that were either exclusive to or strongly associated with burial features, while Control blocks held more disturbance-tolerant or drought-adapted species. Spring Creek and Nevada City showed the strongest Feature-exclusive patterns; 24BE1535 was more evenly mixed. These contrasts reflect local environmental histories but point to a repeatable Feature-Control differentiation across sites.

Sociability

Sociability captured subtle but consistent behavioral shifts. Some species formed tighter patches in Feature blocks, likely responding to slightly moister, more stable, or less disturbed soils. Others became more diffuse, suggesting that Feature conditions can also disrupt typical patch structure. These shifts reveal microhabitat effects that frequency alone cannot detect.

Vitality

Vitality produced few comparable observations due to phenology and the prevalence of cryptogams with unobservable scores. Only a handful of species showed measurable differences, and these were species-specific rather than community-wide. Even so, vitality confirmed that Feature blocks do not uniformly enhance or suppress vigor; instead, they create localized conditions that benefit some species and disadvantage others.

Cover

Cover responses were mixed but interpretable. Many species showed higher cover in Feature blocks, consistent with sheltering, moisture retention, or reduced disturbance. Others had lower cover, especially species tied to open or stable soils. These patterns align with sociability and vitality: burial features shift competitive balances rather than producing a uniform effect.

Stress

Stress indicators were infrequent and generally mild. Most species showed no difference between block types, but a small number exhibited increased or reduced stress in Feature blocks. These responses were highly species-specific and highlight sensitivity to microhabitat variation rather than broad Feature-driven stress.

Cross-Metric Synthesis

Taken together, the metrics show that burial features act as localized ecological modifiers. Cryptogams consistently appear as Feature-exclusive or Feature-leaning, especially at Nevada City and Spring Creek, while vascular plants show a wider range of responses tied to disturbance, soil exposure, or moisture. Despite low species overlap across cemeteries, the types of species associated with Feature blocks, cryptogams, mesic forbs, shrubs, and ornamentals, are consistent, demonstrating that burial features shape vegetation in predictable ways even when the taxa differ.

Interpreting Anthropogenic Vegetal Signatures

Patterns across cover, vitality, sociability, stress, and frequency show that burial features function as distinct ecological microsites that generate anthropogenic vegetation. The strongest evidence comes from species exhibiting multiple reinforcing indicator responses. When these patterns are interpreted alongside habitat affinities and dispersal mechanisms, a coherent ecological logic emerges: cultural features filter species based on their ability to exploit exposed, compacted, shaded, or structurally altered substrates, while disadvantaging taxa tied to stable soils or limited dispersal.

Table 4 organizes species by anthropogenic category to provide a practical checklist of the different ways surface vegetation can carry archaeological meaning. Rather than presenting analytical results, this table illustrates the full range of interpretive pathways, intentional plantings, stress signatures, sociability shifts, abundance patterns, spatial modifications, and substrate-dependent cryptogams, using examples from this case study. It serves as a reference framework for recognizing how surface vegetation can register cultural activity, disturbance regimes, and microhabitat formation in historical archaeological contexts.

Comparing Between Anticipated Disturbance Vegetation and Observed Vegetation

The vegetation survey revealed a suite of taxa that closely match the disturbance signatures predicted for industrial landscapes and cemetery microhabitats. These correspondences show that present plant communities retain ecological memory of past human activity, even where structural features have degraded.

Ruderal forbs and disturbance-tolerant grasses appear exactly where the disturbance model anticipates them. Common dandelion, yellow salsify, common pepperweed, and yellow sweetclover signal nutrient enrichment, soil turnover, and chronic trampling typical of work yards, compacted paths, gardens, and manure-rich zones. Their presence indicates that soils continue to reflect grave digging, historical foot or vehicle traffic, and ongoing instability. Disturbance-tolerant grasses, Kentucky bluegrass, Sandberg bluegrass, cheatgrass, and quackgrass, reinforce this pattern, thriving in compacted or nitrogen-enhanced substrates and dominating several survey plots.

A second cluster aligns with cemetery plantings and fruit-easting-mediated dispersal. Yellow flag iris, Rocky Mountain iris, Harison's yellow rose, and common lilac point directly to intentional horticultural planting and long-term persistence of ornamentals rarely found in wildland settings. Complementary taxa, whitestem gooseberry, prairie rose, and Virginia strawberry, match the predicted “perch-dispersed” and “soft-fleshed fruit” guilds, indicating continued redistribution by birds and small mammals along fence lines, monuments, and canopy edges.

These matches show that the vegetation is not simply regional flora but a patterned response to specific anthropogenic microhabitats. Disturbance-adapted grasses and forbs mark earthmoving and compaction, while ornamentals and fruit-eating-dispersed shrubs trace cemetery plantings and animal movement. Their convergence demonstrates that the current vegetation mosaic is a palimpsest of past land use, with ecological memory preserved in both species composition and the microhabitats they occupy.

Comparing Between Anticipated Historical Introduced Plants and Observed Vegetation

Table 2 was designed to broaden expectations about what introduced plants might still persist, not as a comprehensive or testable inventory. Even so, the few direct matches between the survey flora and the register of historically introduced plants are meaningful. Harison's yellow rose, common lilac, and whitestem gooseberry are the only taxa that overlap with the documented suite of persistent introductions, and all fall within moderate-to-high or high persistence categories, underscoring their durability as cultural plantings in cemetery and settlement contexts.

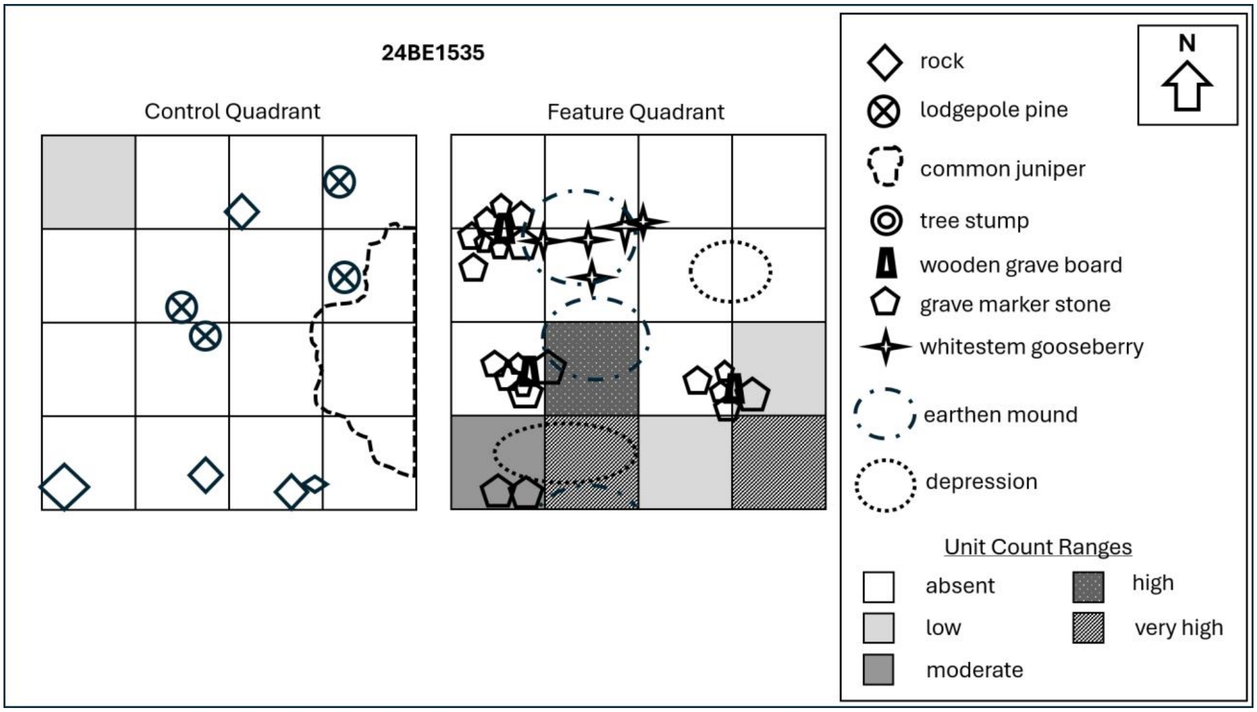
However, Table 2 is built largely from agricultural records that emphasize food crops, small-scale cultivation, and late-19th-century garden plants associated with habitation sites. It therefore underrepresents the ornamental species historically planted in cemeteries, where horticultural choices followed different aesthetic and commemorative logics. This helps explain why intentional cemetery plantings observed in the field, such as lilacs and irises, do not appear in the register despite their clear cultural origin.

Their presence, along with other ornamentals encountered outside the quadrats, highlights both the limitations of the archival register and the narrow footprint of quadrat sampling. Despite these constraints capturing a fragment of the site's horticultural legacy, the vegetation itself preserves a broader and more durable record of past planting practices.

Relational Context: Botanical Co-occurrences and Plant–Site Associations

Cryptogams provide the strongest relational signal. Trumpet cladonia, common freckle pelt (Figure 4), dog pelt lichen, nodding pohlia moss, and map lichen repeatedly occurred on or immediately adjacent to cultural features, coinciding with higher cover, higher frequency, and stable or increased sociability. Their habitat preferences, exposed mineral soils, decaying wood, stone, and humus-rich pockets with low vascular competition, match the micro-niches created by burials through soil disturbance, compaction, and exposure of stone or wood. Their dispersal modes (wind-borne spores, soredia, fragmentation) allow rapid colonization of newly exposed surfaces, while slight depressions around graves help trap fragments. These traits explain their consistent hemerophilic behavior.

FIGURE 4. Frequency Ranges Distribution of *Peltigera aphthosa* across paired Control and Feature quadrants at 24BE1535.



Even cryptogams showing stress responses remain informative. Star moss and common freckle pelt thrive in Feature environments yet experience stress when pushed beyond their moisture or shade tolerances, common freckle pelt under dry, sunny exposure and star moss in waterlogged or overly shaded conditions. Their contrasting needs suggest that burials create moderated micro-niches that balance shade and moisture relative to surrounding arid or cooler, wetter settings. Despite their diagnostic value, cryptogams remain almost universally undocumented in U.S. archaeological site forms (Harris 2018).

Several vascular plants also show relational associations with cultural features. Orange arnica, Idaho fescue, silvery lupine, and Sandberg bluegrass occupy dry prairies, rocky openings, and disturbed soils, and their dispersal strategies, wind-borne achenes, gravity-assisted seed fall, explosive pods, or tuft expansion, enable them to exploit patchy disturbance. Their repeated positive responses in Feature blocks reflect their ability to capitalize on reduced competition, altered soil structure, and increased microsite heterogeneity created by burials. In each case, habitat preferences and spreading mechanisms directly explain their burial-associated behavior.

Qualitative Context: Hemerophilic and Hemerophobic Edaphic Effects In Field Findings

Hemerophilic effects, higher abundance, vitality, or sociability in Feature blocks, appeared in both cryptogams and disturbance-tolerant vascular plants. Their habitat preferences align closely with the microhabitats burials create. Exposed mineral soil favors Nodding pohlia moss and trumpet cladonia, both efficient dispersers via wind-borne spores or soredia. Rocky or woody substrates produced by collapsed coffins, exposed stones, and decaying wooden markers support map lichen and common freckle pelt, specialists of nutrient-poor, low-competition microsites. Map lichen especially benefits from the humid microclimates created by grave plantings and the siliceous stones of grave markers (Brodo et al. 2001:637). Dry, open prairie soils or disturbed burial mounds favor Idaho fescue, silvery lupine, and Sandberg bluegrass, whose wind, gravity, or ballistic dispersal allows them to exploit sheltered microsites within curbing, fenced plots, and depressions.

These species are not merely tolerant of disturbance, their distributions are structured by it. Their dispersal strategies and habitat affinities match the edaphic conditions burials reliably produce, and their multi-indicator responses reflect genuine hemerophilic advantage.

Conversely, species such as rosy pussytoes, umber pussytoes, prairie Junegrass, green needlegrass, and basin big sagebrush showed lower abundance, reduced vitality, more diffuse sociability, or increased stress in Feature blocks, indicating hemerophobic responses. These taxa typically require stable, undisturbed soils, intact litter layers, consistent moisture, and low compaction. Their dispersal, gravity-dropped seeds, limited wind transport, stoloniferous mats, or clonal spread, is poorly suited to recolonizing compacted, exposed, or nutrient-altered burial soils. Their negative responses reflect hemerophobic edaphic effects: burials disrupt the soil stability and moisture regimes these species depend on, and their limited dispersal prevents rapid recovery in disturbed microsites.

Spatial Context: Anthropophytes, Non-Random Distributions, and Planting Regimes

Introduced ornamentals and naturalized exotics, common lilac, Harison's yellow rose, yellow flag iris, Kentucky bluegrass, yellow sweetclover, hoary alyssum, and others, represent clear spatial anthropogenism. Rocky Mountain iris, though native to Montana, functions similarly at Nevada City Cemetery, where its placement beside a headstone in an arid microhabitat indicates deliberate planting. In this context it fulfills the commemorative role typically played by introduced ornamentals, showing that even native species can signal anthropogenic influence when found in habitats they could not naturally reach or occupy. Such anomalous occurrences mark intentional placement, legacy horticulture, and non-random distributions aligned with grave rows, plot edges, and former plantings. These species may not always produce strong indicator scores, but their spatial displacement is itself an anthropogenic signature.

This is especially evident in cemetery ornamentals such as Harison's yellow rose and yellow flag iris, which persist through rhizomatous growth, suckering, or bird-mediated dispersal. Their continued presence near graves in otherwise inhospitable surroundings reflects cultural planting practices rather than ecological filtering, yet they remain integral components of the broader anthropogenic vegetation mosaic.

Habitat and Dispersal as Predictors of Anthropogenic Indicators

Across all categories, a consistent ecological logic emerges (Table 4). Species adapted to disturbance, exposure, or low competition, and capable of long-distance or opportunistic dispersal, tend to be hemerophilic and strong anthropogenic indicators. Cryptogams and disturbance-tolerant grasses exemplify this pattern. Cryptogams tied to stable soils and limited dispersal can behave hemerophobically, yet in burial contexts the initial disturbance removes competitors, and grave structures create refugia that allow even typically sensitive species to persist. Introduced ornamentals and naturalized exotics contribute to spatial anthropogenism regardless of indicator values, reflecting cultural planting regimes rather than natural dispersal.

TABLE 4: Cemetery vegetation by conceptual classification. Note: Asterisks indicate this species shows this indicator by more than one indicator.

Anthropogenic Category	**Species**
Human-Created or Introduction Dependent Species	*Iris flavescens, Rosa × harisonii, Syringia vulgaris*
Plant Stress	*Achillea millefolium*, Artemisia tridentata ssp. tridentata, Berteroa incana*,Carex torreyi, Cladonia fimbriata, Gaillardia aristata, Homalothecium aeneum, Krascheninnikovia lanata, Liatris punctata, Lithospermum ruderale, Peltigera aphthosa, Rhaponticum repens, Ribes inerme, Rosa × harisonii, Syringa vulgaris, Taraxacum lyratum, Taraxacum officinale*, Tortula ruralis, Toxicoscordion venenosum*
Lower Sociability	*Antennaria rosea, Juniperus scopulorum, Koeleria macrantha, Nassella viridula*

Anomalous Absence	Dry Intermontane Sagebrush Valleys: *Agoseris parviflora, Agrostis scabra, Astragalus* (sp.), *Boechera hoboellii, Penstemon eriantherus, Trifolium hybridum, Xanthoparmelia chlorochroa* Montane Grassland–Sage Steppe: *Astragalus purshii, Orobanche fasciculata, Penstemon attenuatus* Montane Coniferous Forest Edge: *Danthonia californica, Dasiphora fruticosa, Letharia vulpina, Lomatium triternatum* Substrate-Dependent Cryptogams (Cross-Ecoregion): *Physcia adscendens, Xanthoparmelia chlorochroa*
Lower Vitality	*Erigeron pumilus*
Lower Abundance (in terms of cover)	*Antennaria* spp., *Artemisia tridentata* ssp. *tridentata*, *Koeleria macrantha*, *Nassella viridula*
Higher Sociability	*Achillea millefolium*, *Arctostaphylos uva-ursi*, *Festuca idahoensis*, *Peltigera aphthosa, Rhizocarpon macrosporum*
Higher Vitality	*Koeleria macrantha*
Higher Abundance (in terms of Frequency)	*Achnatherum nelsonii, Brachythecium salebrosum, Bromus ciliatus, Calamagrostis canadensis, Cirsium scariosum, Cladonia cristatella, Cladonia fimbriata, Elymus repens, Epilobium ciliatum, Ericameria nauseosa, Erigeron pumilus, Festuca idahoensis, Fragaria virginiana, Geranium viscosissimum, Heterotheca villosa, Homalothecium aeneum, Iris flavescens, Iris missouriensis, Koeleria macrantha, Linum lewisii, Melilotus officinalis, Oenothera caespitosa, Peltigera aphthosa, Peltigera membranacea, Pinus contorta, Poa pratensis, Potentilla gracilis, Potentilla pectinisecta, Ribes inerme, Rosa × harisonii, Rusavskia elegans, Sphaeralcea coccinea, Symphoricarpos oreophilus, Syringa vulgaris, Taraxacum officinale, Tortula ruralis, Tragopogon dubius*
Higher Abundance (in terms of Cover)	*Anemone multifida, Arnica fulgens, Cladonia fimbriata, Elymus trachycaulus, Festuca idahoensis, Lupinus argenteus, Peltigera aphthosa, Poa secunda, Pohlia nutans*
Indirect Modification to a Plant (Spatial Distribution)	*Ribes inerme*, *Rosa arkansana, Fragaria virginiana*

Botanical Co-Occurrences	*Arnica fulgens, Cladonia fimbriata, Festuca idahoensis, Lupinus argenteus, Peltigera aphthosa, Peltigera canina, Pohlia nutans, Poa secunda, Rhizocarpon macrosporum*
Spatially Dislocated Species	*Berteroa incana, Iris missouriensis, Poa pratensis, Melilotus officinalis*

Cultural features therefore function as distinct micro-niches that filter species based on habitat affinity and spreading strategy. Resulting vegetation patterns reflect the interaction between species traits and the physical, chemical, and structural modifications created by burials. This multispecies perspective underscores that burials act as ecological drivers, shaping plant communities through disturbance, substrate exposure, altered competition, and horticultural legacies.

Although clear ecological patterns emerged, the proportional representation of native versus introduced species did not differ statistically between Feature and Control blocks, nor did synanthropic class proportions. Given the proximity of paired plots, this is unsurprising: dispersal between them is easy, environmental gradients are shallow, and many species respond to disturbance at scales larger than the micro-spatial separation used in sampling. Synanthropic guilds are therefore shared across both block types, even as individual species show meaningful indicator responses.

These findings caution against relying on nativity status as a proxy for archaeological integrity or cultural feature presence. Native species can be disturbance-responsive or opportunistic, while introduced species may persist benignly or reflect historical plantings. Simple species inventories or nativity labels in CRM site forms risk oversimplifying these dynamics. Instead, the aggregate behavior of plant communities, their habitat affinities, disturbance preferences, spatial patterning, and qualitative indicator responses, provides a more accurate basis for interpreting archaeological landscapes. As additional features and contexts are compared, this multispecies, context-rich approach will remain essential for recognizing the ecological memory preserved in site vegetation.

Closing Reflections: What These Plants Teach Us

In the frontier industrial communities of western Montana, cemeteries were never empty margins of settlement. Their inhabitants inscribed faith, gender, social status, and relationships into the landscape through intentional plantings, floral symbolism, grave markers, fraternal emblems, and family plot enclosures. Even after these structures disappeared, their traces persisted in seed rain from birds perching on former fences and monuments. These cultural signatures mingled with ecological ones created by nonhuman species drawn to the shelter, forage, and microhabitats produced by human modification, revealing cemeteries as culturally saturated and ecologically generative places.

Vegetation patterns across the four study sites show how these multispecies histories endure. Plants persisting around burial features retain evidence of labor, ethnic community life, disturbance, and long-term ecological processes. Species-level attention makes these signatures legible in ways that generic labels, "native," "weedy," "wildflowers", cannot. Such broad categories flatten the very histories archaeologists seek to interpret. Reading cemetery vegetation at this finer scale reveals subtle but useful imprints of ethnicity, disturbance, and care (e.g., grave tendence) embedded in these landscapes.

The methodological model developed here demonstrates that botanical resources can be documented with enough precision to support archaeological interpretation. Metrics such as frequency, sociability, vitality, cover, and stress provide a robust framework, while streamlined approaches using presence–absence, percent cover, sociability, and simple vigor or stress flags still detect anthropogenic soils and microhabitats. With tools like iNaturalist lowering identification barriers, field crews can capture meaningful species patterns without specialized botanical training.

Interpreting these vegetal signatures requires integrating archival research, ecological survey, and biocultural interpretation. Archival sources reveal who lived and were buried in these landscapes; ecological data show how plants responded, biocultural analysis connects species patterns to lived experience. Together, cemeteries emerge not only as places of mourning but as sites where vegetation records ecological adaptation and cultural identity.

These insights carry implications for stewardship, conservation, and environmental justice. Many historic cemeteries, especially those tied to marginalized or laboring communities, are under-documented or threatened. Recognizing vegetation as cultural heritage broadens the caretaker's toolkit and affirms the ecological value of these sites as refugia for cryptogams, native forbs, and other disturbance-sensitive species. In many cases, cemetery plantings function as grave markers.

Ultimately, the plants in these cemeteries remind us that landscapes remember. They retain ecological memory of change, adapting to its disturbance, and persist in ways that reflect both human intention and ecological agency. Learning to read their signatures, through detailed metrics or streamlined field observations, opens access to a quiet but enduring archive written in leaves, stems, and spores. This vegetation continues to preserve evidence of cemetery history. Our task is to document it carefully, interpret it with appropriate care, and steward these sites so the evidence remains available for future study.

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