Clear Creek Natural Area

Approvals for Site Conservation Plan

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SITE CONSERVATION PLAN

Clear Creek Canyon Natural Area



November 2013

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SECTION 1: INTRODUCTION

1.1 Context

Clear Creek Canyon Natural Area is south of Carver on Clear Creek, a free-flowing tributary to the Clackamas River. Clear Creek is a premier large creek supporting abundant salmon populations in the lower Clackamas River and is home to the last significant run of late-run coho in the lower Columbia River Basin. The stream supports 11 varieties of fish, including rainbow trout, fall Chinook and coho salmon, steelhead and coastal cutthroat trout. Clear Creek Canyon's mature riparian forests, wooded canyon walls, ravines, terraced uplands, wet meadows, upland prairies, springs and wetlands provide diverse wildlife habitat. More than 100 species of wildlife are found at Clear Creek, including coyotes, cougar, blacktail deer, elk and nearly 80 species of birds. Clear Creek also contributes to water quality for municipal drinking water intakes that serve approximately 200,000 people.

Metro's ownership includes 586 acres at Clear Creek, including the 511-acre Clear Creek Canyon Natural Area and a 75-acre area managed by the Oregon Zoo. For the purposes of this site-based conservation plan we are considering only the Clear Creek Canyon Natural Area site.

The Clear Creek Canyon Natural Area site conservation plan is a tool for protecting and enhancing the unique characteristics of the site while allowing access by the public. This conservation plan has been developed by Metro staff and includes an overview of the history of the site, existing conditions, conservation targets and recreation and access objectives for the site.

1.2 Goal and objectives of the conservation plan

The goal of this conservation plan is to describe a course of action that will protect and enhance the area as an environmental and recreational resource for Clackamas County and the Portland metropolitan region. With rare and unique plant, fish and wildlife habitats, Clear Creek Canyon Natural Area will be preserved as a historical remnant of the Willamette Valley Oregon white oak savanna, providing an ecological showcase of native habitats and wildlife. A salmon-bearing stream, wetlands and floodplains add significant value for wildlife and water quality. The area will be maintained and enhanced, to the extent possible, in a manner that is faithful to its original natural condition. Only those recreational uses that are compatible with the environmental objectives of the conservation plan will be encouraged.

To achieve this goal, the conservation plan establishes a series of priority objectives, including:

- Restore and maintain high quality habitat including remnant Oregon white oak savanna, upland forests, riparian forests, forested wetland and aquatic habitats.
- Provide public access to Clear Creek Canyon Natural Area that supports appropriate types and levels of recreation.
- Provide opportunities for research and education to local schools.
- Develop appropriate funding strategies to implement strategic restoration and access improvement projects.

Metro's natural areas bond acquisition program and Clear Creek target area

During the last 18 years, two voter-approved natural areas bond measures have allowed Metro to protect 13,000 acres across the region – the equivalent of more than two Forest Parks, or nearly enough land to cover the city of Beaverton. Voters have protected more than 100 miles of river and stream banks, opened three nature parks and supported hundreds of community projects. Metro continues to buy land in 27 key target areas, chosen for their water quality, wildlife habitat and outdoor recreation opportunities.

Additional information about the 2006 natural areas bond measure and goals and objectives for the Clear Creek target area can be found on the Metro web site, www.oregonmetro.gov/naturalareas.

Since 1996, Metro has acquired 586 acres in the Clear Creek area of Clackamas County, preserving this area for conservation rather than development of homes and a golf course. Table 1 below shows the history of purchases at Clear Creek Canyon Natural Area.

Table 1: Metro natural area bond purchased land

Property name (previous owner)	Acres	Bond year	Date acquired	Management
Richard Goheen	342	1995	2/1/1996	Metro
Wayne and Gloria Lewis	32	1995	5/24/1996	Metro
Larry Wallace	19	1995	12/5/1996	Metro
William, Ken and Norman Raetz	45	1995	12/14/2000	Metro
Hewitt	4	1995	6/1/2003	Metro
Hewitt	28	1995	6/1/2003	Metro
Portland Paving Company	55	1995	1/28/2000	Metro
Clackamas County	0.1	1995	5/19/2006	Metro
Stark	61	2006	7/26/2012	Metro

SECTION 2: PLANNING PROCESS SUMMARY

2.1 Planning area

This conservation plan addresses conditions, plans and activities for the site's 511 acres. A map showing Metro ownership and outline of the planning area can be found as Map 1.

2.2 Planning process

Developing a useful site plan means adequately providing for a site's preservation, enhancement and management. This plan will build on previous restoration and management efforts while acknowledging that future conservation requires analysis of the site, meaningful engagement of stakeholders and integration of historical, current and future needs. This plan includes several important elements: development of conservation targets, access and recreation needs, and implementation of projects.

A two-tiered approach is used to improve natural resource conservation and integrate meaningful human experiences through physical and visual access. The plan recognizes that the conservation of species, habitat and natural features must occur simultaneously with the provision for human access to these natural systems. Education and exposure are the cornerstones for protecting the natural area for decades to come. This two-tiered approach also recognizes that conservation and access

have different stakeholders, different funding sources and different strategic approaches. Initially the plan reviewed the overarching project goals and objectives common to both conservation and access. The project team then developed conservation and access strategies independently. Conservation is discussed in Section 4 of this document. Access is discussed in Section 5.

Planning project goals

The planning goals for both the natural resource conservation and access portions of this plan are listed below.

Natural resource conservation

- Map and define major habitat types.
- Establish habitat and species conservation targets.
- Define key ecological attributes and analyze stresses and their sources for the conservation targets.
- Establish strategies and actions to restore habitat.
- Identify actions and implement.

Access

- Analyze existing public use of Clear Creek Canyon Natural Area.
- Analyze existing trails and road network at Clear Creek Canyon Natural Area.
- Identify potential trail connection opportunities that preserve sensitive habitats and provide high-quality experience; i.e., Springwater Environmental Sciences School connections to the natural area.
- Establish strategies and actions to decommission existing trails and/or roads if deemed inappropriate.
- Identify key locations for regulatory, wayfinding and informational signage.
- Develop cost estimates for potential trail and signage improvements.
- Identify and implement priority actions.

SECTION 3: EXISTING CONDITIONS

This section of the conservation plan provides background on existing conditions for Clear Creek Canyon Natural Area.

Lands surrounding Clear Creek Canyon Natural Area are predominately zoned Exclusive Farm Use and Rural Residential Forest Farm.

The topography of the natural area divides it into three distinct areas. The highest elevation, referred to as the "upper bench" in this report, consists of Oregon white oak savanna with a small forested area near the existing home and barn. The upper bench slopes down to a mid-level bench. Most of this slope between the upper and middle bench is forested with conifer trees. The “lower bench”

along Clear Creek is quite diverse, with some areas of high quality riparian forest, disturbed areas, extensive wet meadows and forests. Old oxbows from Clear Creek are located on the lower bench, increasing the diversity of habitats.

A description of Clear Creek's physical environment including geology, channel-forming processes and soils of the watershed can be found in Appendix A.

3.1 Streams and wetlands

Clear Creek is a large tributary entering the south side of the lower Clackamas River near the town of Carver. Clear Creek Canyon Natural Area is approximately three miles from the confluence with the Clackamas River. Elevations in the Clear Creek watershed range from 4,226 feet on Goat Mountain to 79 feet where Clear Creek joins the Clackamas River near Carver Park. The large range in elevation in the watershed results in several different ecotypes that range from prairie terraces and valley foothills in the lower elevations to western cascade lowlands and valleys in the higher elevations.

The reach of Clear Creek that runs though Clear Creek Canyon Natural Area can be described as a low gradient (<1%-3%) floodplain channel. Along the main stem of Clear Creek, the stream channel is incised into old terraces and the stream alternates between unconfined and moderately confined low gradient channel habitat types. The typical pattern observed at several locations along Clear Creek are high mudstone walls alternating with gravel bars or landslide debris along the channel margins. The landslide debris appears to be a source of gravel, boulders and large wood; large pools commonly are present near the landslide tail-outs. Overflow and side channels tend to be present on these areas. The bars of sorted gravels and side channels provide excellent native fish spawning and rearing habitat.

Springs and tributaries

Numerous intermittent streams form from springs emerging from the upper and middle benches. These streams form three large, perennial tributaries that run into Clear Creek.

Wetlands

Multiple large wetlands (ranging from ¼ acre to over 5 acres) are present at the site. Hydric soils can be found in numerous areas indicating wetland characteristics. Hydric soils are soils that are, or have been, saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions in the upper part. If soils classified as hydric do not currently support wetlands they may be areas where wetlands formerly were located. The NRCS soil survey of the Clackamas area (Natural Resource Conservation Service 1985, 1998) identifies hydric soils within the Borges Silty Clay Loam, Cove Silty Clay Loam, Delena Silt Loam, Huberly Silt Loam, Wapato Silt Loam and Wapato Silty Clay Loam soil series. Not all of the area within these mapping units contains hydric soils, and not all of the hydric soils necessarily supported wetlands historically. However, this information provides us with an approximation of the extent that may have been occupied by wetlands historically.

Map 2 shows the soils present at Clear Creek Canyon Natural Area. Descriptions of hydrologic soil group properties can be found in Appendix A.

Map 3 details the topography, streams, wetlands and rivers of Clear Creek Canyon Natural Area.

3.2 Major habitat types

Clear Creek Canyon Natural Area can be characterized by five natural habitat types: riparian forest, Oregon white oak savanna, upland conifer-hardwood forest, forested wetlands and shrub wetlands. Map 4 shows areas of major vegetation habitat types present at the site.

Oak savanna

Savanna habitat at Clear Creek Canyon Natural Area includes mosaic of Oregon white oak and Douglas fir trees, prairie and emergent wetland habitats. For the purpose of this conservation plan these habitats are combined into a single conservation target. Oregon white oak habitats are identified as conservation priorities within both the Oregon Conservation Strategy and the Regional Conservation Strategy for the Greater Portland-Vancouver Metropolitan Area. Native dominated oak savanna and prairie have largely disappeared in the Metro region.

Oak savanna is essentially prairie with a few trees per acre. Savanna is characterized by widely spaced, open canopy trees dominated by Oregon white oak. In general, the understory is relatively open with shrubs, grasses and wildflowers. In healthy oak savanna habitat, total native woody cover is typically 5 to 30 percent, and canopy architecture represents an appropriate mix of large open grown oak trees and younger tree recruitment that will replace older trees when they die. In healthy native prairie and emergent wetland habitats, native herbaceous plant species (grass and wildflower) typically compose over 90 percent of the vegetation cover, with less than 5 percent cover of woody vegetation. Emergent wetland habitat has natural vegetation structure similar to prairie.

Oak savanna habitat at Clear Creek Canyon Natural Area includes mosaic of Oregon white oak and Douglas fir trees, prairie and emergent wetland habitats. For the purpose of this conservation plan these habitats are combined into a single conservation target.

Key plants

Native forbs found in this habitat may include camas, brodiaea lily, Oregon sunshine, large rose mallow (Sidalcea), Oregon saxifrage, large leaf lupine, tarweed, collinsia and bracken fern. Native grass species found in this habitat may include Roemer's fescue, California oat grass, tufted hairgrass, slender hairgrass and blue wildrye. Shrubs found in this habitat may include poison oak, spiraea, snowberry and tall Oregon grape.

Key wildlife

Partners in Flight identifies the following focal species occurring in our area for grassland or savanna habitats: western meadowlark, streaked horned lark, common nighthawk, American kestrel and northern harrier. Oak focal species include white-breasted (slender-billed) nuthatch, acorn and downy woodpecker, western wood-peewee, bushtit, chipping sparrow, Bewick's wren and house wren. Other birds utilizing oak, savanna and emergent wetland habitats may include white-crowned sparrow, rufous hummingbird, western bluebird, lazuli bunting and red-tailed hawk, as well as waterfowl, rails, herons and shorebirds in wetter habitats. Other wildlife utilizing this mix of habitats may include Pacific tree and red-legged frogs, garter snake, rubber boa, butterflies, black-tailed deer, coyote, fox and various native rodents.

Current extent and attributes

Clear Creek Canyon Natural Area includes 171 acres of Oregon white oak savanna habitat over three separate areas of the site. Native wildflowers can be found in bloom from March to July.

Riparian forest

River mainstem and tributary native fish habitat conditions are moderately to severely degraded within much of the region. Widespread development and land use activity affect habitat quality and complexity, water quality and watershed processes in lower Willamette and Columbia tributaries. Stream habitat degradation is primarily due to past and current land-use practices that have affected properly functioning stream channels, riparian areas and floodplains, as well as watershed processes. The Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan identifies the Clackamas River and its tributaries as primary habitat necessary to the recovery of coho and winter steelhead, and as important contributing habitat for fall Chinook and chum salmon (Primozich and Bastash 2004).

Key plants

Native forbs found in this habitat may include Pacific waterleaf, false hellebore, nodding beggartick and skunk cabbage. Sedge and rush species found in this habitat may include slough sedge, awl-fruited sedge, dewy sedge, slender rush, common rush and spreading rush. Shrubs and trees found in this habitat may include red alder, Oregon ash, Western red cedar, cottonwood, big leaf maple, Pacific ninebark, red-osier dogwood, Sitka and Pacific willow, red elderberry and Douglas' spiraea.

Key wildlife

Partners in Flight identifies the following focal species for bottomland shrub and tree habitats: willow flycatcher, red-eyed vireo, yellow warbler, Swainson's thrush, downy woodpecker and yellow-billed cuckoo. Other birds utilizing this habitat may include green heron, great blue heron, Wilson's and other warblers, yellow-breasted chat, black-headed grosbeak, common yellowthroat, song sparrow, ruby-crowned kinglet, downy woodpecker and red-breasted sapsucker. Other wildlife species that regularly use this habitat include Pacific tree frog, northern red-legged frog, various salamanders, common garter snake, black-tailed deer, elk, coyote and fox.

Current extent and attributes

Clear Creek Canyon Natural Area includes approximately 66 acres of forested riparian habitat. Some variations of canopy structure in this habitat type include big leaf maple, red alder/western red cedar and big leaf maple/Douglas fir community types.

Upland conifer-hardwood forest

Upland coniferous and mixed conifer/deciduous forests are the dominant natural habitat of the region. Low-elevation Pacific Northwest old-growth forests typically are dominated by the conifers Douglas fir, western red cedar and western hemlock, with grand fir and hardwood species also occurring. Under natural conditions, trees of many of the dominant species live to be 350 to 750 years old or older and frequently have diameters of eight feet or more. Plant and animal use of forests follows the changes in forests over time, with different suites of species dominating depending on forest age, canopy closure and site conditions. Biodiversity is higher in forests where some light reaches the forest floor and where standing and fallen dead wood is ample and of mixed

age and size. Forests younger than 60 years dominate western Oregon due to current forestry practices, and the decline of old growth-associated species reflect these changes in overall forest structure across the region.

Stands of forest can be categorized by the age of trees, species and composition of understory species. Upland forests in the greater Portland-Vancouver region provide primary habitat for at least 94 species and are used by at least 129 more species (Portland-Vancouver Regional Conservation Strategy 2012).

Key plants

Native forbs found in this habitat may include sword fern, licorice fern, false Solomon's seal, false lily of the valley, trillium, fairy bells, miner's lettuce, stinging nettle, hedge-nettle and heal-all. Shrubs and trees found in this habitat may include Pacific yew, Pacific madrone, bigleaf maple, red alder, Douglas fir, Grand fir, Western red cedar, black hawthorn, Western serviceberry, tall and dull Oregon grape, mock orange, blue and red elderberry, salal, red huckleberry, Indian plum and snowberry.

Key wildlife

Partners in Flight identifies the following focal species for coniferous forests in western Oregon: Vaux's swift, brown creeper, red crossbill, pileated woodpecker and varied thrush (old growth and mature forests); hermit warbler, Pacific-slope flycatcher, Hammond's flycatcher, winter (Pacific) wren, black-throated gray warbler and Hutton's vireo (mature/young/pole forests); and in young forests, olive-sided flycatcher, western bluebird, orange-crowned warbler and rufous hummingbird. Other birds utilizing this habitat may include Townsend's warbler, evening grosbeak, Swainson's thrush, Anna's hummingbird, cedar waxwing, bushtit, chestnut-backed and black-capped chickadee, American robin, Steller's jay, Bewick's wren, golden-crowned kinglet and Cooper's hawk. Other species may include Douglas' squirrel, common garter snake, rubber boa, elk, black-tailed deer, mountain lion, bobcat, coyote, fox, weasel and a variety of small mammals.

Current extent and attributes

The site includes 256 acres of upland coniferous forest habitat, with tree age in the range of 2 to 100+ years. A large portion of the site was planted as part of a carbon sequestration experiment and these conifer forested areas are relatively young compared to other stands at the site. Some variations of canopy structure in this habitat type include Grand fir/big leaf maple, Douglas fir/big leaf maple/red alder and big leaf maple/Douglas fir community types.

Forested wetlands

Sometimes called swamps, forested wetlands occur on seasonally or perennially wet flats, depressions or stream terraces. Hydration occurs via precipitation, groundwater discharge or inflowing streams. Forested wetlands sometimes are located within riparian zones but differ from riparian and floodplain habitat in their higher water tables and longer duration of surface water. Forested wetlands typically are flooded for several weeks during the growing season (seasonal flooding), and are differentiated from riparian stands that may have surface water for only a few days during a temporary flood.

Key plants

Native forbs found in this habitat may include false lily of the valley, false hellebore, star-flowered Solomon's seal and skunk cabbage. Sedge and rush species found in this habitat may include slough sedge, awl-fruited sedge, dewy sedge, slender rush, common rush and spreading rush. Shrubs and trees found in this habitat may include cottonwood, Sitka alder, Oregon ash, Pacific ninebark, red-osier dogwood, red elderberry, twinberry and Douglas spiraea.

Key wildlife

Birds utilizing this habitat may include green heron, great blue heron, Wilson's warbler, song sparrow, cedar waxwing, bushtit, black-capped chickadee, orange-crowned warbler and red-breasted sapsucker. Other wildlife utilizing this habitat include Pacific tree frog, northern red-legged frog, northwestern salamander, common garter snake, black-tailed deer, coyote and fox.

Current extent and attributes

The site includes six acres of forested wetland over three separate areas of the site.

Shrub wetland

Shrub (commonly called scrub shrub) wetlands include areas dominated by woody vegetation less than six meters (20 feet) tall (Portland-Vancouver Biodiversity Guide 2012). Characteristic species include shrubs, young trees and trees or shrubs that are small or stunted because of environmental conditions. Shrubs add complexity to other habitats, greatly increasing the amount of area available for cover and nesting. Numerous studies in the Pacific Northwest document the importance of shrubs to a wide variety of arthropods, amphibians, small mammals and birds. The fruit and flowers of shrubs – particularly deciduous ones – host abundant pollinator and prey species. The diets of deer and elk consist largely of shrub browse. Shrubs also provide important habitat connectivity and may effectively widen a forested biodiversity corridor.

Key plants

Willow, spirea, ninebark and red twig dogwood are common dominant shrub species found in shrub wetlands in this region. May include stands on gravel or sand bars. This habitat may also contain small amounts of Oregon ash. Deeper or more year-round water areas may include wapato, pond lily, bulrushes and bur-reed.

Key wildlife

Partners in Flight identifies willow flycatcher as a focal species for Willamette Valley floodplain shrub. Other species associated with scrub-shrub wetlands include beaver, otter, yellow-breasted chat, common yellowthroat, green heron, yellow warbler, Pacific chorus frog and other amphibians. Shrub wetlands often intergrade with herbaceous wetlands, particularly in floodplain habitats, and the two types of wetlands share many of the same wildlife species, and both may serve as important habitat for rearing or overwintering salmonids.

Current extent and attributes

Clear Creek Canyon Natural Area includes approximately 10 acres of shrub wetlands, often intergrading in a mosaic with the other conservation target habitats.

Native fish and wildlife

Nearly 100 wildlife species or their sign have been observed at Clear Creek Canyon Natural Area. These include at least 76 bird species, eight mammals, three amphibians, one reptile, seven Lepidoptera and numerous aquatic macro invertebrate species. In addition, 11 fish species are known to occur in Clear Creek. It is highly likely that additional amphibians, reptiles, birds and mammals use the site for breeding, nesting, foraging and migration. The site has diverse cover, breeding and travel habitats which provide numerous food sources including seeds, fruit, pollen sources, bark and insects. This would include species such as hawks, falcons, Neotropical migrants such as willow flycatcher and solitary vireo, and gallinaceous birds such as ruffed grouse or ring-necked pheasant. Small and large mammals and birds also provide food for species such as raptors and large predatory mammals including cougar, which is known to occur on site. Wetlands with open water could also provide suitable resting habitat for painted and pond turtles. Forest habitats could support additional small mammals including Douglas' squirrel and several bat species. Clear Creek, because of its perennial flow and intact riparian habitat, is potentially suitable for river otter. Open grassland habitat could support striped skunk. Other possible species for this site include wood rat, chipmunks, voles and mice, mink, weasel, bobcat, cougar, black bear, black tail deer and elk.

Anadromous fish occurring in the Clackamas basin include spring and fall Chinook, Coho salmon, winter steelhead, summer steelhead (non-native), migratory cutthroat trout and Pacific lamprey (Runyon and Salminen 2005). Resident native fish potentially occurring in Clear Creek include cutthroat trout, rainbow trout and mountain whitefish. The last confirmed sighting of a bull trout in the Clackamas River was in the early 1970s; bull trout are thought to have been eliminated from the basin. Other resident fish potentially occurring in Clear Creek include sculpin, longnose dace, speckled dace, shiners, brook lamprey, pacific lamprey, suckers and northern pike minnow.

Biodiversity connectivity (corridors)

Native animals and plants require the ability to establish or re-establish local populations in a specific location to persist over time. Furthermore, ongoing breeding interaction between small populations can create a larger, more genetically robust meta-population. In areas such as ours, where significant habitat fragmentation has occurred, relatively narrow, linear connections (corridors) can help meet these needs.

In 2010-2011, Metro hosted a series of biodiversity corridor workshops on behalf of The Intertwine Alliance. The results were compiled and made available to participants via a map server. The workshops gathered the opinions of wildlife and habitat professionals in the region; the results are best professional opinion only, are not meant to be property specific, and make no attempt to prioritize or assess on-the-ground issues such as barriers. Nonetheless, the information can provide valuable insight into existing and potential connectivity from Clear Creek Canyon Natural Area to other important habitat areas in the region. Biodiversity corridors in the area of Clear Creek Canyon Natural Area include:

- Clear Creek riparian corridor north to the Clackamas River.
- Connection north along forested slopes, through to Foster Creek drainage, which also connects eastward to Metro natural areas on the Clackamas River near Barton.

- Clear Creek riparian corridor south and east to Bureau of Land Management forest lands in the upper Clear Creek watershed. This connection provides access to the Cascade Range.
- West up the Clear Creek tributary and across South Hattan Road to large forested areas in the Abernethy Creek watershed.

Climate change adaptation considerations

At Clear Creek Canyon Natural Area, stressors from climate change will likely derive primarily from increased competition from invasive species, intensified summer drought and altered hydrology and water temperature. Prairie and savanna habitats are particularly at risk from invasive species. Altered hydrology may result in flashier streams and decreased dry-season flows, reducing or degrading native fish and riparian habitat. However, there could also be potential floodplain benefits from flashier streams – for example, larger floods could inundate floodplains for longer time periods. In forests, drier summer conditions could curtail tree growth and increase the risk of stand-replacing wildfires.

Metro will need to be vigilant in Early Detection-Rapid Response activities for invasive species, and more staff and financial resources may be needed to deal with invasive species in the future. Establishing native plants where needed now can help defend against invasive species at Clear Creek Canyon Natural Area. The potential for altered hydrology increases the importance of riparian forest health and width, as well as looking at the larger landscape for biological connectivity. Creating and enhancing in- and off-channel habitat in the near future, including increasing the resilience of such habitat elements against altered hydrology, can help enhance native fish habitat. These activities are addressed in this conservation plan and the related Site Stewardship Plan.

3.3 Existing trails and use by the public

To date there has been no formal master plan developed to help identify appropriate levels of public access and use of Clear Creek Canyon Natural Area. However, people have been recreating informally on the Clear Creek site since the time it was purchased. Public access has been primarily isolated to the existing road networks. At this time, the use of the existing road network by the public is relatively light. There are no signs or trail maps to assist in wayfinding within Clear Creek Canyon Natural Area.

Springwater Environmental Sciences School

The adjacent Springwater Environmental Sciences School consists of approximately 175 students in grades K-7. The school operates on educational principles of integrated instruction with a focus on science and sustainability. During the school year, Fridays are reserved for field studies by the school. Students utilize the adjacent Clear Creek site to engage in natural resource-based research and observation. The trail from the school to the natural area is seasonally wet and muddy and primarily consists of a grassy trail. Currently, the school accesses Clear Creek Canyon Natural Area under an annual special use permit. They have had a permit for at least four years.

SECTION 4: CONSERVATION

This section provides a comprehensive framework for conservation planning at Clear Creek Canyon Natural Area. This framework generally follows The Nature Conservancy's Conservation Action Planning template (The Nature Conservancy, 2007) and includes analyzing the site, establishing conservation targets, evaluating key ecological attributes for each conservation target, analyzing threats affecting conservation targets and developing action plans to abate serious threats. More detailed information is available in Appendix B.

4.1 Conservation targets

Conservation targets are composed of a species, suites of species (guilds), communities and ecological systems that represent and encompass the full array of native biodiversity of the site, reflect local and regional conservation goals and are viable or at least feasibly restorable (The Nature Conservancy, 2007).

The methodology for determining conservation targets and key ecological attributes is discussed in detail in Appendix B.1, Conservation Targets, and Appendix B.2, Key Ecological Attributes. Using onsite natural habitat types and regional conservation planning efforts as guides, conservation targets were selected that encompass the site's biodiversity values and regional conservation priorities. These conservation targets are:

- Oak savanna (upper and middle bench)
- Riparian forest (lower bench)
- Mixed conifer-hardwood forest (entire site)
- Native fish (Clear Creek and tributaries)

The habitat conservation targets represent the most regionally rare and threatened major habitat types present at the site, as well as patches of coniferous forest, one of the region's most representative habitats. The site's habitat diversity, connectivity at the landscape level and importance to anadromous fish can help conserve rare and at-risk species and keep our common native species common. More detail about each of these conservation targets can be found in Appendix B.1.

4.2 Key ecological attributes

Key ecological attributes (KEAs) are aspects of a conservation target's biology or ecology that, if missing or altered, would lead to the loss of that target over time (The Nature Conservancy, 2007). KEAs define the conservation target's viability. They are the biological or ecological components that most clearly define or characterize the conservation target, limit its distribution or determine its variation over space and time. They are the most critical components of biological composition, structure, interactions and processes, and landscape configuration that sustain a target's viability or ecological integrity. KEAs are rated from poor to good. This rating helps establish the restoration goals and guide us in development of restoration actions for the conservation targets.

Appendix B.2 (Key Ecological Attributes) describes the site's KEAs and indicators for each of the five conservation targets in more detail.

4.3 Threats and sources

An effective conservation strategy requires an understanding of threats to targets and the sources of those threats. Adjacent development and subsequent disruption of natural systems place stress on the resource and its inhabitants and threaten the health of the greater ecosystem. At Clear Creek Canyon Natural Area, the following threats are evident:

- Increased competition (woody plant invasion in oak savanna habitats and invasive species throughout the site; see Appendix B.4)
- Altered fire regime
- Altered vegetation structure
- Habitat conversion
- Human disturbance
- Altered hydrology

The methodology for defining threats and sources was established by The Nature Conservancy. It is a well-established, objective methodology with a scientific basis, and is described in more detail in Appendix B.3, Threats and Sources.

Information on Clear Creek Canyon Natural Area's conservation targets, KEAs, significant threats and management actions to address those threats is summarized in Table 2 below. More detailed information is available in Appendix B.1, B.2 and B.3, and in the Clear Creek Stewardship Plan. The following section outlines short- and long-term management strategies for conservation targets.

Table 2: Clear Creek Canyon Natural Area conservation targets

Conservation target	Attributes of healthy habitat
Oak savanna (upper/middle benches)	Oak savanna is essentially prairie with a few trees per acre. Savanna is characterized by widely spaced, open canopy trees dominated by Oregon white oak. In general, the understory is relatively open with shrubs, grasses and wildflowers. In healthy oak savanna habitat, total native woody cover is typically 5 to 30 percent, and canopy architecture represents an appropriate mix of large open grown oak trees and younger tree recruitment that will replace older trees when they die. In healthy native prairie/emergent wetland habitats, native herbaceous plant species (grass and wildflower) typically compose over 90 percent of the vegetation cover, with less than 5 percent cover of woody vegetation. Emergent wetland habitat has natural vegetation structure similar to prairie. *Current cover:* Approximately 171 acres *Desired future cover:* Approximately 200 acres
Riparian Forest (lower bench)	Includes the riparian and floodplain forest along Clear Creek and its perennial tributaries, as well as associated wetlands. Riparian forests in this case are associated with streams and are relatively linear. Healthy riparian forests are relatively wide (100-200+ feet each side of stream) with few gaps and have a good mix of native trees and shrubs with good native species diversity in all layers. Downed wood and snags are important components. *Current cover:* Approximately 66 acres *Desired future cover:* Approximately 66 acres
Mixed conifer-hardwood forest	An abundant natural habitat of the region, low-elevation Pacific Northwest old-growth forests are typically dominated by Douglas fir, western red cedar, and western hemlock, with Willamette Valley ponderosa pine, grand fir and hardwood species also occurring. Plant and animal use of forests follows the changes in forests over time, with different suites of species dominating depending on forest age, canopy closure and site conditions. Biodiversity is higher in forests where some light reaches the forest floor and where standing and fallen dead wood is ample and of mixed age and size. The size of habitat (patch size) is a key consideration for wildlife diversity. *Current cover:* Approximately 256 acres *Desired future cover:* Approximately 256 acres
Native fish habitat (lower bench)	Clear Creek provides important habitat to native salmonids and lamprey because the water quality is fairly good, the riparian area is relatively intact and the flow regime has not been altered much compared with many streams in the Portland region. Healthy native fish habitat includes riffle-pool sequences, off-channel habitat, gravel and rocky substrate, and large wood in the stream. *Current cover:* Approximately 14,150 linear feet, or 2.5 miles of stream reach

SECTION 5: STRATEGIC RESTORATION AND STEWARDSHIP

5.1 Restoration

This conservation plan outlines strategic actions to be carried out at Clear Creek Canyon Natural Area over the next 10-15 years. They are based on the short- and long-term goals for the conservation targets. The strategic actions described here are general courses of action to achieve these objectives and not highly prescriptive courses of action. Specific prescriptions will be developed by Metro staff to address site-specific conditions encountered in the areas targeted for restoration action.

About 200 acres of habitat are in need of intensive restoration throughout the Clear Creek site. This primarily includes restoration of the prairie, oak savanna, riparian forest and upland closed forest

habitat areas. The information below summarizes conservation targets' key ecological attributes, significant threats to the habitat, and strategic restoration and stewardship actions that can be taken to keep or bring the KEAs into the desired range.

Conservation target: oak savanna

Short-term goals 2012-2016

- Increase presence of native grass and forb species to greater than 40 species in each of the upper and middle bench oak savanna areas.
- Expand the size of the upper bench oak savanna from 100 acres to greater than 120 acres.
- Decrease the cover of woody tree and shrub cover to less than 20 percent for both the middle and upper bench habitat areas.
- Increase extent of seasonally saturated soils in the middle bench habitat area.

Long-term goal

The long-term desired future condition is to have all condition key ecological attributes at good or very good levels and providing suitable habitat for prairie and Oregon white oak-dependent wildlife species. More specifically we hope to increase habitat for pollinators and ground nesting birds like western meadowlark.

Key ecological attributes outside normal range of variation

- *Native grass and forb species presence:* limited number of native plant species present.
- *Canopy cover vegetation structure:* trees and shrubs encroaching into the prairie.

Critical threats very high and high range

- *Altered native herbaceous species composition:* non-native species out-compete native grass and forb species.
- *Altered fire regime:* fire suppression promotes encroachment of woody shrub and tree vegetation, leading to lack of open structure and conversion to shrub.
- *Altered hydrology:* ditches and drain tiles reduce the extent of saturated soils in the wet prairie and emergent wetlands of the savanna areas.

Strategic restoration and stewardship actions

- Control non-native invasive species and increase the cover of native forb and grass species (Appendix B.4).
    - Ongoing invasive species treatments will be targeted at reducing the cover of non-native grass to less than 10 percent cover and non-native broadleaf weeds (tansy, thistle, oxeye daisy and Scot's broom) to less than 30 percent cover. Stewardship treatments would occur between 1 and 2 year intervals.
    - Plant high and medium fidelity native forb and grass species in the middle and upper bench habitat areas. Focus on grass and sedge/rush communities in the middle bench.

- Restore/mimic the natural disturbance regime by implementing a combination of mowing, grazing or prescribed fire. These strategic actions would reduce the cover of grass and shrubs and in turn release native herbaceous species. Mowing and grazing may occur on a yearly or bi-yearly basis and prescribed fire may occur between 3 and 5 year intervals.
- Restore natural hydrology by filling in man-made ditches in the middle bench.
- Remove encroaching trees and other woody vegetation.
- Plant natural shrub buffers along transitions between savanna and other habitat types.

Conservation target: riparian forest

Short-term goals 2012-2016

- Increase percent cover of native tree and shrub (vegetation structure) and native tree and shrub richness in all riparian and floodplain forest habitat areas.
- Decrease gaps in woody vegetation so no gaps exist.
- Increase floodwater access to the floodplain. Floodwaters should inundate the floodplain during moderate to high flow events in the winter.

Long-term goal

The desired future condition is to have the majority of the key ecological attributes ranked as very good thereby maintaining and restoring habitat suitable for riparian forest-dependent wildlife species. Healthy riparian areas are also linked to native fish conservation listed below.

Key ecological attributes outside normal range of variation

- *Percent cover of native trees and shrubs:* much of the area classified as riparian and floodplain habitat is dominated by reed canary grass and has limited canopy cover of trees and shrubs.
- *Gaps in wood vegetation:* numerous gaps in intact riparian vegetation exist.
- *Standing and downed dead trees:* lack of intact mature forest has resulted in limited quantities of downed wood.
- *Floodwater access to the floodplain:* floodwaters only inundate the floodplain during extreme high water events in the winter.

Critical threats very high and high range

- *Altered native species composition:* non-native species out-compete native plant species.
- *Ecosystem degradation:* historic logging on the site (and upstream in the watershed) reduced the extent of intact forests and downed wood in the system.
- *Altered hydrology:* widespread altered hydrology leads to stream bank erosion, channel damage, loss of gravel and cobble substrate and overall habitat simplification.

Strategic restoration and stewardship actions

- Restoration actions will be initiated to control non-native invasive species and increase the cover of native trees and shrubs.

    - Native tree plantings should be focused in riparian areas that have less than 30 percent canopy cover.
    - Native shrub plantings should be focused in riparian areas that have less than 25 percent canopy cover.
    - Invasive species management of reed canary grass, blackberry, thistle and other common broadleaf weeds should be focused in areas of restoration plantings.
- Early detection and treatment of invasive species should target garlic mustard, false brome and spurge laurel. Treatments would occur between 1 and 2 year intervals.

Conservation target: Mixed conifer hardwood forest (upland closed forest)

Short-term goals 2012-2016

- Increase canopy cover of native tree and shrub cover to greater than 75 percent canopy cover.
- Maintain diversity in the age and structure of young conifer stands.

Long-term goal

The desired future condition is to have all key ecological attributes ranked as good to very good thereby maintaining and restoring habitat suitable for upland conifer forest-dependent wildlife species. This habitat type is most likely to see increase in use by large migratory mammals like elk, deer, coyote and cougar.

Key ecological attribute outside normal range of variation

- Standing and downed dead trees: most upland coniferous forest areas on the site lack dead wood. This is primarily due to historic logging and the age of the trees.

Critical threats very high and high range

- *Altered native herbaceous species composition:* non-native species out-compete native species, particularly false brome, spurge laurel and garlic mustard.
- *Ecosystem conversion:* forest structure has been simplified due to historic logging. Replanting of these areas has resulted in single-aged tree stands.

Strategic restoration and stewardship actions

- Restoration actions will be initiated to control non-native invasive species and increase the cover of native trees and shrubs.
    - Native tree and shrub plantings should be focused in areas that have less than 75 percent canopy cover.
    - Invasive species management of reed canary grass, blackberry, thistle and other common broadleaf weeds should be focused in areas of restoration plantings.
- Restore stand diversity and age structure in plantations of young conifer trees.
    - Pre-commercial and commercial thin plantations of trees to maintain optimal tree growth and to increase downed wood.

    - Plant additional deciduous tree, shrub and herbaceous plantings in the understory of the plantations to increase richness.
- Restore areas with compacted soils such as old home site foundations and old logging roads.
- Early detection and treatment of invasive species should target garlic mustard, false brome and spurge laurel. Treatments would occur between 1 and 2 year intervals. Existing patches of false brome should be maintained to below 15 percent cover.

Conservation target: native fish habitat

Short-term goals 2012-2016

Increase the complexity of in-stream habitat and number of key large wood pieces in Clear Creek and off channel habitat areas.

Long-term goal

The desired future condition is to have all key ecological attributes ranked as good to very good thereby maintaining and restoring habitat suitable for native fish species present in Clear Creek. More specifically the long term goal is to support the recovery of ESA-listed coho and winter steelhead populations.

Key ecological attributes outside normal range of variation

- *Complexity of habitat:* Clear Creek lacks complex habitat that native fish require for spawning and rearing.
- *Key pieces of large wood:* historic logging on the site (and upstream in the watershed) has reduced the number of key large wood pieces in the stream and off channel habitats.

Critical threats very high and high range

- *Altered hydrology and simplified stream structure:* lack of side channel, sparse riffle-pool sequences and limited large wood that provides complex habitat for fish.
- *Impaired fish passage:* manmade structures that block fish migration including dams, weirs and culverts.

Strategic restoration and stewardship actions

Restore complex habitat in Clear Creek by installing single or multi-piece large log structures on the main channel of Clear Creek. Structures should be designed to restore long-term processes that develop and maintain complex habitats for native fish.

5.2 Prioritizing strategic restoration and stewardship actions

It is important to prioritize restoration and stewardship activities for several reasons. Budgetary or time constraints are likely to limit how much work can be accomplished at a given site. Specific actions may rise to the top due to the scarce or unique nature of a habitat type or because abating a certain threat now will save time and money in the future. Table 3 assigns priority rankings to key actions; this does not mean that the other actions are not important, simply that they are not the most important actions within the next 3-5 years.

Table 3: Priority status for Clear Creek Canyon Natural Area conservation targets

Conservation target	Priority
Savanna	High
Riparian forest	Medium
Mixed conifer hardwood forest	Low
Native fish	High

5.3 Ongoing stewardship and restoration programs

The following actions represent ongoing systems or programs that are in place and practices that will be continued and/or enhanced. These actions align with maintaining the conservation targets in good or very good condition.

Stewardship

Metro's Natural Areas Program is committed to long-term stewardship of Clear Creek Canyon Natural Area. Metro staff will conduct multiple site walks of the site per year to monitor natural resource condition and public use of the natural area. As determined necessary by staff, specific treatments or actions will be implemented to ensure that the health and condition of the natural area is maintained. Some periodic stewardship actions that are implemented by Metro staff include visits to monitor for illegal use of the site, clean up of illegal dumping, invasive species management, mowing of buffer and roadside areas for fire safety, replacing signage and response to complaints. Table 4 describes high and medium priority maintenance action at the site. Additional details about the stewardship of the site can be found in the Clear Creek Canyon Stewardship Plan.

Table 4: High and medium priority stewardship actions

Activity	Frequency/Duration	Priority
Site walk	4 times per year	High
EDRR (weed invasion treatments)	Every 1-3 years	High
Culvert and road inspections	1 time per year	Medium
Property line encroachments	1 time per year	Medium
Entry/rule sign inspection	2 times per year	Medium
Building maintenance and repair	4 times per year	Medium
Gates and fence inspection	4 times per year	High

Invasive species management

Invasive plant species can impact the habitat values for which land is conserved. Natural lands are not fully protected unless they also are managed for the features that first motivated preservation. Invasive species can change community structure, composition and ecosystem processes on these lands in ways that may not be anticipated or desirable. Careful management can minimize these negative impacts. Metro has initiated an early detection and rapid response program for invasive species including false brome, meadow knapweed and garlic mustard, which have been documented in the area. Invasive species will be controlled by hand pulling or herbicide application as they are detected in the natural area. Other invasive plant species will be controlled as part of restoration projects or ongoing management of habitat areas. See Appendix B.4 for a list of invasive species.

Wildfire response plan

Metro has developed a wildfire response plan that identifies areas where fire may be allowed to burn out to natural or established firebreaks without risk to natural resource protection areas and structures. The plan identifies on-site fire suppression resources and concerns, key Metro staff, responding agencies, partners and additional contacts, and adjacent landowner contacts. Ensuring that wildfire on the natural area does not impinge on adjacent private property is of the highest priority. Additional details about wildfire planning can be found in the Clear Creek Wildfire Response Plan (Appendix D in the Site Stewardship Plan) on file at Metro.

5.4 Long-term strategies

The following actions may be necessary to achieve the long-term goals of this site conservation plan.

- Commercial thinning in the mixed conifer and hardwood forests habitat areas.
- Acquisition of fee title or conservation easements of adjoining private lands adjacent to riparian forest and oak savanna habitat areas.
- Removal or relocation of maintenance roads and home sites in and adjacent to savanna habitat areas.

SECTION 6: RECREATION AND ACCESS

Next five years

The original goal of Metro's bond acquisition for the Clear Creek target area emphasized the idea of public access. The 1995 Clear Creek Refinement Plan goals state, "These lands could provide an opportunity for a regionally significant nature park." More recently, the 2006 Refinement Plan stated a goal of, "…protect the public investment made to date in establishing a significant, publicly accessible regional natural area." The natural area was purchased with the intention of providing some level of access and natural area experience to the residents of the region. Over the next five years actions will be taken to continue progress toward this goal.

6.1 Public access

Presently, public access to Clear Creek Canyon Natural Area is neither discouraged nor actively promoted by Metro. There is very limited use of the natural area by the public, primarily along the existing road network. Springwater Environmental Science School students, volunteers and education programs use the network of existing maintenance roads for access to the site for science education-related projects. A very short 200-foot trail links the Springwater School to the natural area. No other identifiable trails currently exist at the site.

In 2011, Metro staff conducted an internal process to consider an appropriate level of access for each of its natural areas at a site scale. That process looked at determining, from a working staff perspective, what an appropriate level of access (low, medium, high or no access) would be to Metro natural area properties. The access designation is offered here as a starting point, with the understanding that judgment will always be needed on a case-by-case basis, and indicates that some

part of that site can accept people at the stated level. It does not suggest that the entire site should have that level of access.

At the end of that process, it was determined that in regards to Clear Creek Canyon Natural Area, the level of access is "Natural Area, High:"

> Access at these sites is allowed and may be modestly promoted on a site by site basis. Gravel parking areas may or may not be developed at these sites to facilitate access if necessary. Portable or vault restrooms may be installed on a site-by-site basis. Basic rules and site identification signage are standard. Soft surface, mineral soil or gravel trails are formalized and wayfinding signage may be posted to channel access and protect sensitive habitat. These sites are visited weekly or bi-weekly by Metro staff to inspect for unauthorized use and to conduct maintenance. These sites could move to a Nature Park designation in the future.

This designation indicates the highest level of access that is appropriate for some portion of the site. Where, precisely – and how this would be accomplished – will be determined through a future planning process. Some of the issues include the 2006 refinement plan goals stating access to the site and an expectation already set for regional nature park development, extremely sensitive habitats, transport of invasive weeds, and the potential for habitat fragmentation.

Within the life of this conservation plan Metro expects to make significant progress toward planning for future public access at the site. One goal is to engage the public in a future master plan process. This process would seek stakeholder input to help guide future access and infrastructure investments.

During the planning process, thoughtful consideration will go in to the balance of access and conservation of the natural resource area. Some of the potential opportunities/constraints that will be discussed include the natural area experience, environmental education and stewardship, local recreational demand, resource impacts, patch fragmentation, wildlife corridor disruption, public right-of-way access, land use and development permit requirements, long term operations and maintenance, as well as capital development and maintenance funding.

6.2 Programmatic (education and volunteers)

Metro's regional parks and natural areas were created to intentionally give residents within our region opportunities to enjoy, experience, participate in and understand the natural world. Conservation education staff at Metro work with schools, civic organizations and the general public to provide nature programs that thoughtfully connect people to Metro's parks and natural areas. Schools and civic groups who are interested in programs contact Metro to request a program. Public walks are advertised in Metro's quarterly "GreenScene" publication. Information about conservation education programming is also available on Metro's website, www.oregonmetro.gov.

Education program

Currently Clear Creek Canyon Natural Area is utilized two to three times per year for nature walks that are open to the public. The themes that have encompassed these programs have included salmon lifecycles, mushrooms, bird identification, prairie ecology and open house tours to showcase

Metro's natural areas program. From an education perspective, Clear Creek Canyon Natural Area's unique natural and cultural history holds strong potential for education programming. Metro has no plans for significant expansion of Clear Creek Canyon Natural Area as an educational site beyond its current usage.

Volunteer program

The primary goal of the volunteer program is to provide a variety of high-quality, meaningful volunteer opportunities that add value and capacity to Metro's work. Through these opportunities, community members are able to learn about and enjoy Clear Creek Canyon Natural Area, work alongside fellow community members, learn new skills or polish existing ones and gain the satisfaction of contributing to the long-term health and livability of their communities.

Wildlife monitoring volunteers

Metro's volunteer wildlife monitoring program provides valuable information about Metro's natural areas while offering a unique and in-depth service opportunity for community members. By focusing on indicator species, such as amphibians and birds, volunteers provide data to help Metro's science and stewardship team gauge the progress of its restoration efforts and track the effects of public use on wildlife.

Native Plant Center volunteers

Metro's Native Plant Center, located near Wanker's Corner in Tualatin, provides an important supply of rare locally adapted native seeds and plant stock to support Metro's natural area restoration projects. Staff and volunteers collect, grow and distribute native species for planting at restoration sites throughout the region. The Clear Creek site is the focus of collections for camas and other forb species in the prairie and wetland habitats. Each year these plant species are re-seeded back into Clear Creek Canyon Natural Area as well as other natural areas across the region.

Restoration volunteers

The restoration volunteer program focuses on providing groups of all kinds the opportunity to contribute to the health and vitality of our parks, natural areas and cemeteries. Primarily involving a short-term commitment of one day, restoration volunteers experience an engaging, hands-on learning opportunity with immediate, tangible results.

Volunteer site stewards

The natural area site steward volunteer program enhances Metro's parks and natural areas for community members and creates healthy habitat for fish and wildlife through active monitoring of site conditions and use by both people and wildlife, and personal and group restoration, stewardship and educational activities. The steward program provides opportunities for committed volunteers to take an active, leadership role in Metro's natural areas. The steward engages in hands-on small restoration projects for the site as well as monthly monitoring. Stewards can take on crew leader roles with volunteer groups for restoration educational projects at the site.

6.3 Site management

Metro's management of the site will include enforcement of the posted rules to provide protection for wildlife and water quality, and to protect the safety and enjoyment of any person visiting these facilities.

Special use permits

Special use permits are required for certain regulated and non-traditional uses of parks and natural areas to ensure public health and safety and to protect natural resources, properties and facilities owned or managed by Metro. Special use permits are required for commercial film, video or photography; educational activities or educational events; festivals and organized sports activities; use of amplified sound; equipment or other elements posing a safety threat or public nuisance; concession services; site restoration or alteration, biological research, scientific collection (soil, wildlife or vegetation disturbance of any kind); any organized activity, event or gathering involving 25 or more people.

Archeological resources

Clear Creek Canyon Natural Area is steeped in history and may contain archeological resources. To date, there have been no formal archaeological investigations. If, during any site investigation, alteration or improvement, an archaeological resource is discovered, Metro will work with the State Historic Preservation Office to sensitively address the find. If any damage or unlawful use is identified, Metro would partner with the Clackamas County Sheriff to investigate.

Dogs

One of the most difficult management issues for public access is the introduction of dogs by visitors. Research shows that even if dogs stay on the trails, they are perceived as predators by wildlife. The zone of influence of a dog, even on leash, can be several hundred feet on either side of a trail. Because of the potential disturbance to wildlife and wildlife habitat, dogs are not allowed within Clear Creek Canyon Natural Area. Educational signage, self-policing and strict enforcement are all needed to effectively manage this sensitive issue.

Signage

As part of the integration of people into a natural area the need for regulatory, wayfinding and interpretive signage becomes necessary. The development of a signage plan for Clear Creek Canyon Natural Area would be part of the future master plan and subsequent design/development process. Typically, interpretive themes are identified during the planning effort and those themes are further vetted during design/development. Wayfinding and regulatory signage is developed once the trail network is finalized. As aspects of the master plan are implemented, i.e., formalized access points, new trails, gates, etc., signage would be added to help inform and orient the visitor.

In the interim, regulatory signs and gates should be installed to alert the public to the level of access currently provided at Clear Creek Canyon Natural Area. With the desire to formalize the access from the Springwater Environmental Science School, the installation of boot wipes and educational signage should be added at the entry as part of Metro's invasive weed education program.

Any future signage developed for the natural area should utilize Metro's signage standards manual. The manual establishes a graphic standard that will be integrated into the entire signage plan. The manual addresses each of the three types of signs: regulatory, wayfinding and interpretive.

6.4 Strategic actions (access and site management)

The following actions describe the proposed access and site management improvements over the life of this plan. The projects were established as part of the development of this plan and should be revisited every two to three years for additions and updates. Cost estimates for these actions are included in Section 6.3 of this document. Coordination with the Springwater Environmental Sciences School will be required to implement some of these actions.

Construct new trails

A permanent connector trail will be created between the maintenance road and the Springwater Environmental Sciences School. This trail will be approximately 350 feet long, aligned to avoid the wetland and sensitive habitats. The trail will be 4 feet wide with a soft surface. Construction will include 2 inches of ¾" minus compacted base rock with 1 inch top dressing of ¼" minus rock, wetted and rolled for compaction.

Install new signage

Regulatory and information signs will be installed, including natural area rules, maintenance road/fire lane identification, sensitive habitat and additional signs as needed. Signs will be placed at strategic locations throughout the natural area.

Maintenance roads

In order to continue using the existing maintenance roads some improvements will need to be made during the life of this plan. These improvements may include surfacing with ¾" minus top dressing to 10 feet wide, brushing and ditching of roadside areas, replacement of failing culverts and restoration of slope failures. This action is more fully described in the site conservation plan.

A new gate will be installed at the main entry point at Springwater Road. The gate should have the ability to provide access to multiple partners including vegetation management contractors and emergency responders.

6.5 Beyond five years or as needed

In the future there may be increased demand to access and recreate at Clear Creek Canyon Natural Area. Future access improvements will need a more in-depth analysis of opportunities and constraints for trails and public access, including meetings with neighbors and the public and developing a detailed trails master plan. This is likely to be initiated within 5-10 years.

SECTION 7: COORDINATION

The conservation plan has laid out the history and context of Clear Creek Canyon Natural Area, along with the conservation and recreation projects for the next five years. For those projects to be realized, coordination will be needed on a number of fronts. Important coordination points include:

- Balancing public access with natural resource (habitat) improvements.
- Monitoring restoration efforts to track effectiveness and make changes to the priorities and goals as needed.
- Coordinating with neighbors and local stakeholders to implement projects.
- Funding to realize the strategic restoration and access actions identified in this plan.

7.1 Monitoring framework

Monitoring at the Clear Creek site is an integral part of an adaptive management approach to restoration and stewardship. Based on the monitoring plan developed by Metro, a feedback loop is created between monitoring and management decisions. Monitoring will be done to evaluate habitat, population responses to management action, as well as progress toward achieving habitat and population objectives.

The monitoring strategy is based on threats and key ecological attributes associated with conservation targets. Generally the greatest threats to Clear Creek Canyon Natural Area are traced to:

- Altered native plant species composition: non-native species out-compete native species.
- Altered hydrology: ditches and drain tiles reduce the extent of saturated soils in prairie habitat.
- Ecosystem degradation: historic logging on the site (and upstream in the watershed) reduced the extent of intact forests and downed wood in the system.

Monitoring addresses threats directly and indirectly, by tracking changes in certain ecological attributes. It implements techniques that are well-established and continues many monitoring efforts already in place. Recent and current monitoring activities have included remote sensing/GIS, informal amphibian and bird surveys, and monitoring the success of revegetation efforts. The monitoring plan is likely to change over time, including monitoring of key ecological attributes.

Monitoring techniques

Some monitoring techniques are used to monitor more than one conservation target. This discussion is intended to provide a general introduction but not detailed methods.

Remote sensing/GIS

Several metrics for health of conservation targets relate to canopy cover and size of a habitat. Where a desired condition is a minimum canopy cover, it can be estimated with GIS software using current aerial photography. Similarly, important connections within the natural area and to off-site habitat can be inspected with aerial photographs.

Transects

These are lines or strips of ground along which measurements are made of plant species presence or absence. Permanent transects can be installed and tracked over the years to track progress toward goals. They are useful in tracking the cover and composition of native plants and invasive species in prairie and Oregon white oak savanna habitat areas.

Avian point counts

Avian (bird) surveys during breeding season follow an established and widely used protocol that allows data sharing with other scientists. By tracking changes in the bird community, Metro can detect changes in habitat function as restoration projects mature. The species present can indicate if a suitable habitat for sensitive species is present.

Ocular estimates

Ocular (visual) estimates can be used to determine the presence or absence of a species within a short timeline and at a very low cost. This method of monitoring is typically used to determine intervals for treatments or success of a planting.

Photos

Permanent photo points are established to provide long term documentation of changes to habitats over time. Typically photo points are marked by a permanent landscape feature or metal stakes and photos are taken at a landscape scale over long term periods of time.

Conservation targets and monitoring techniques

Oak savanna

A combination of transects, avian point counts and GIS work will be used to monitor key ecological attributes of this conservation target. Avian point counts will be focused on the upper bench oak savanna habitat areas.

Riparian forest

A combination of photo points, GIS work and ocular estimates of plant and wildlife species will be used to monitor key ecological attributes of this conservation target. Metro will rely on the Clackamas River Basin Council to provide these monitoring services.

Mixed conifer hardwood forest

A combination of photo points and ocular estimates of plant and wildlife species will be used to monitor key ecological attributes of this conservation target.

Native fish

Metro will rely on the Oregon Department of Fish and Wildlife to provide monitoring data for this conservation target. Monitoring is part of their annual stream survey of Clear Creek and is subject to staff availability and allocation of resources in annual budgets.

7.2 Funding

Costs in Tables 5 and 6 are general estimates for the purpose of understanding the magnitude of costs to implement the structural elements of the plan, as described in Sections 4 and 5. The costs are estimated on hiring contractors to complete the work and include a construction contingency for time and materials. In addition to these project implementation costs we have included staff time and annual stewardship costs for Clear Creek Canyon Natural Area in Table 7.

Table 5: Access and recreation strategic action cost estimates

Strategic action	Cost
Improve existing trail to Springwater School	$5,500
Maintenance road improvements	$15,000
New entry gate	$25,000
Signs (regulatory and entry)	$4,500
Total	**$50,000**

Table 6: Conservation target strategic restoration action cost estimates

Strategic action	Cost
Savanna	
Invasive species treatments and herbaceous plantings	$90,500
Restore natural hydrology (middle bench)	$150,000
Plant natural shrub buffers	$25,000
Riparian forest	
Plant native tree and shrubs + Invasive species treatments	$50,000
Upland forest	
Invasive species treatments + additional plantings	$63,000
Pre-commercial thinning	$55,000
Rehabilitation of old home sites	$21,500
Native fish	
Install log structure(s?) in Clear Creek	$350,000
Total	**$805,000**

Table 7: Annual stewardship cost estimates

Annual stewardship*	Cost
Mowing in Savanna habitat area	$2,000
Mowing of roadside vegetation and treatment of invasive weeds	$2,500
EDRR surveys and invasive weed treatments (entire site)	$2,500
Maintenance of existing Infrastructure (average of multiple small actions)	$1,000
Total (per year cost)	**$8,000**

* Stewardship actions and costs are described in more detail in the Clear Creek Canyon Stewardship Plan

7.3 Public involvement

As projects are developed and the master plan process is initiated, Metro will provide local stakeholders and residents near Clear Creek Canyon Natural Area with pertinent information about the work before it is implemented. Project information may include background on the project, timing, cost, materials types and other information as necessary for the public to be aware of the project and its implications.

MAPS

Map 1 – Ownership and planning area

Map 2 – Soils

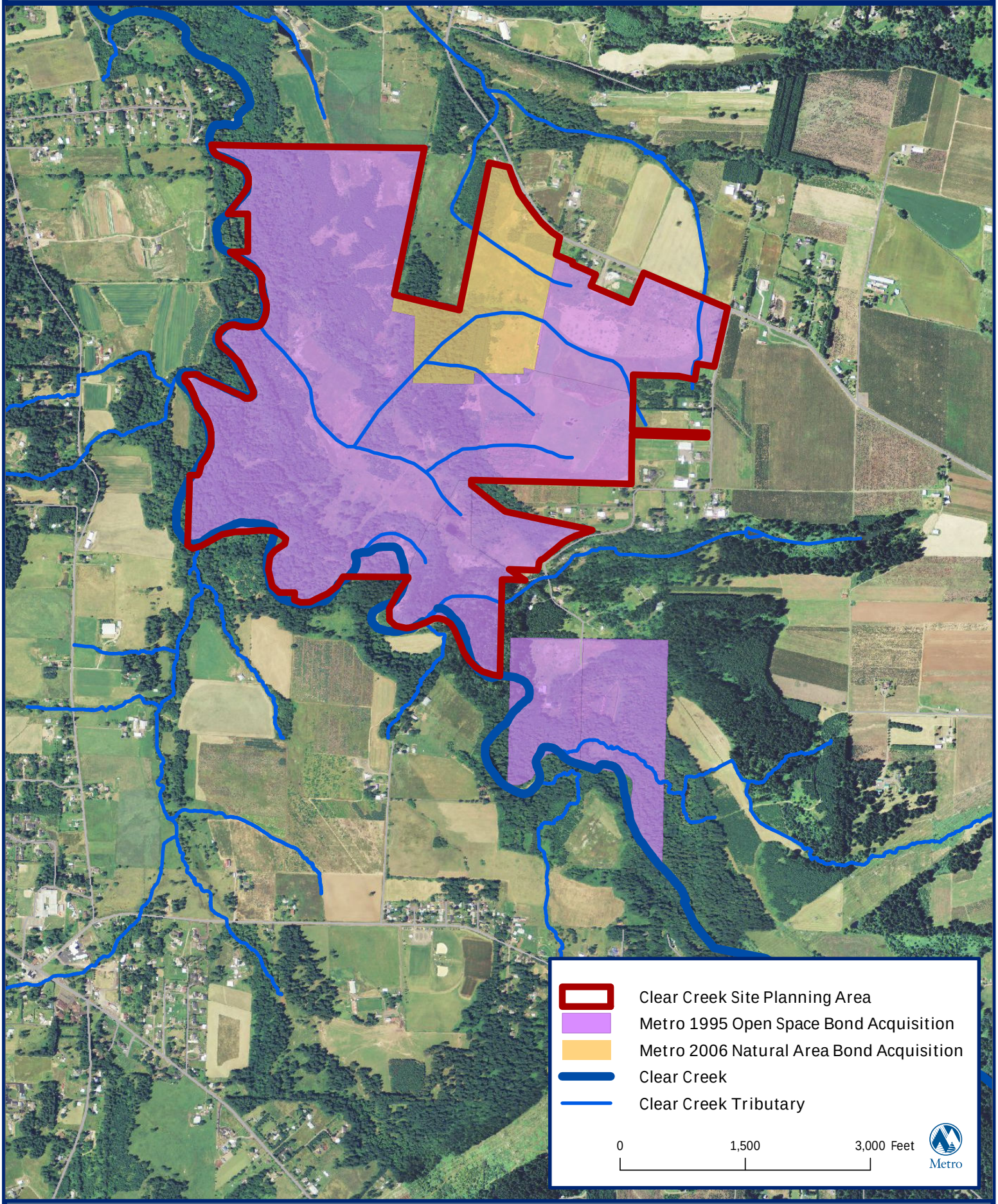
Map 3 – Physical conditions

Map 4 – Vegetation habitat types

Map 5 - Access

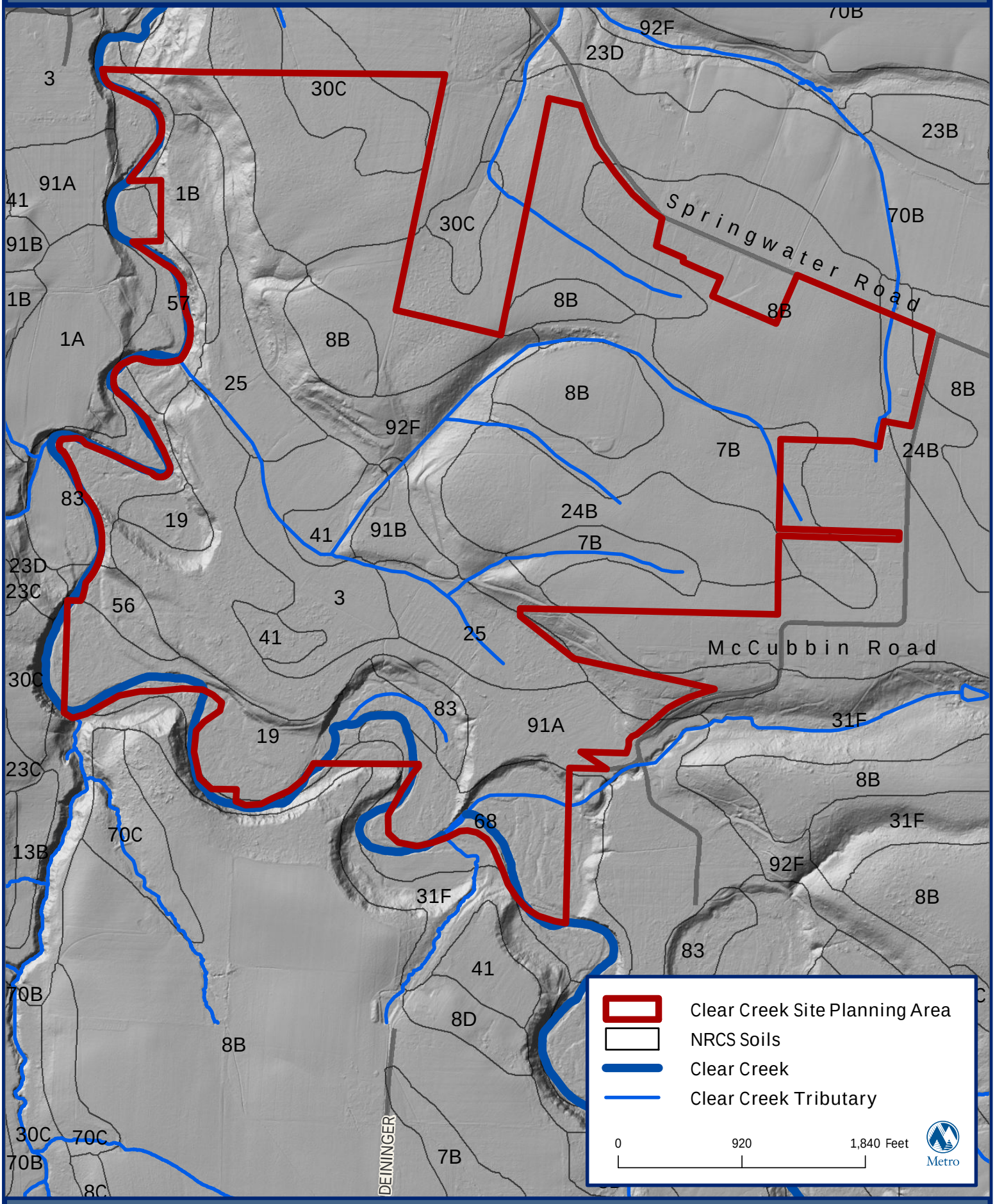
Map 1

Ownership and Planning Area



Map 2

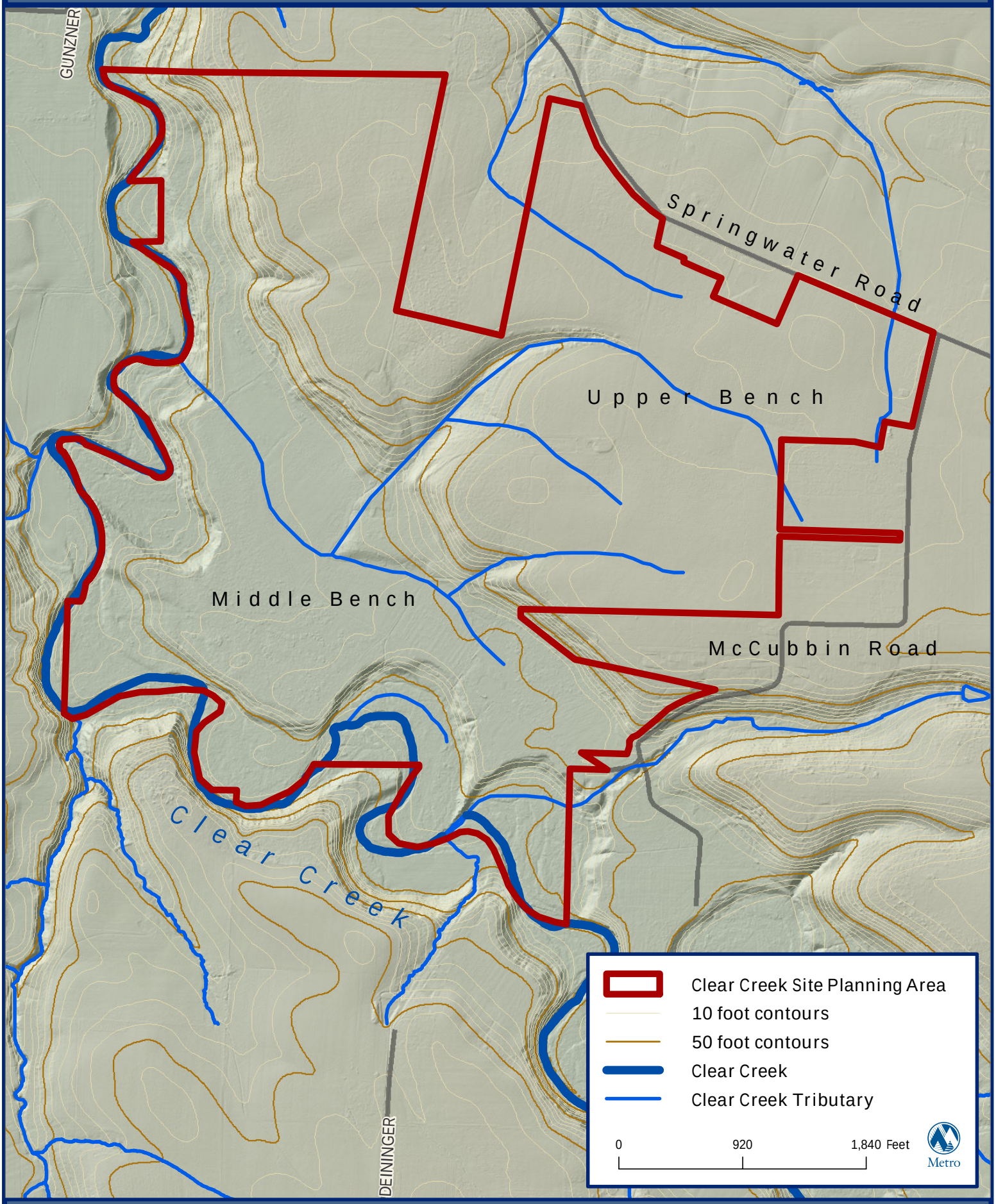
Soils



Clear Creek Canyon Site Conservation Plan

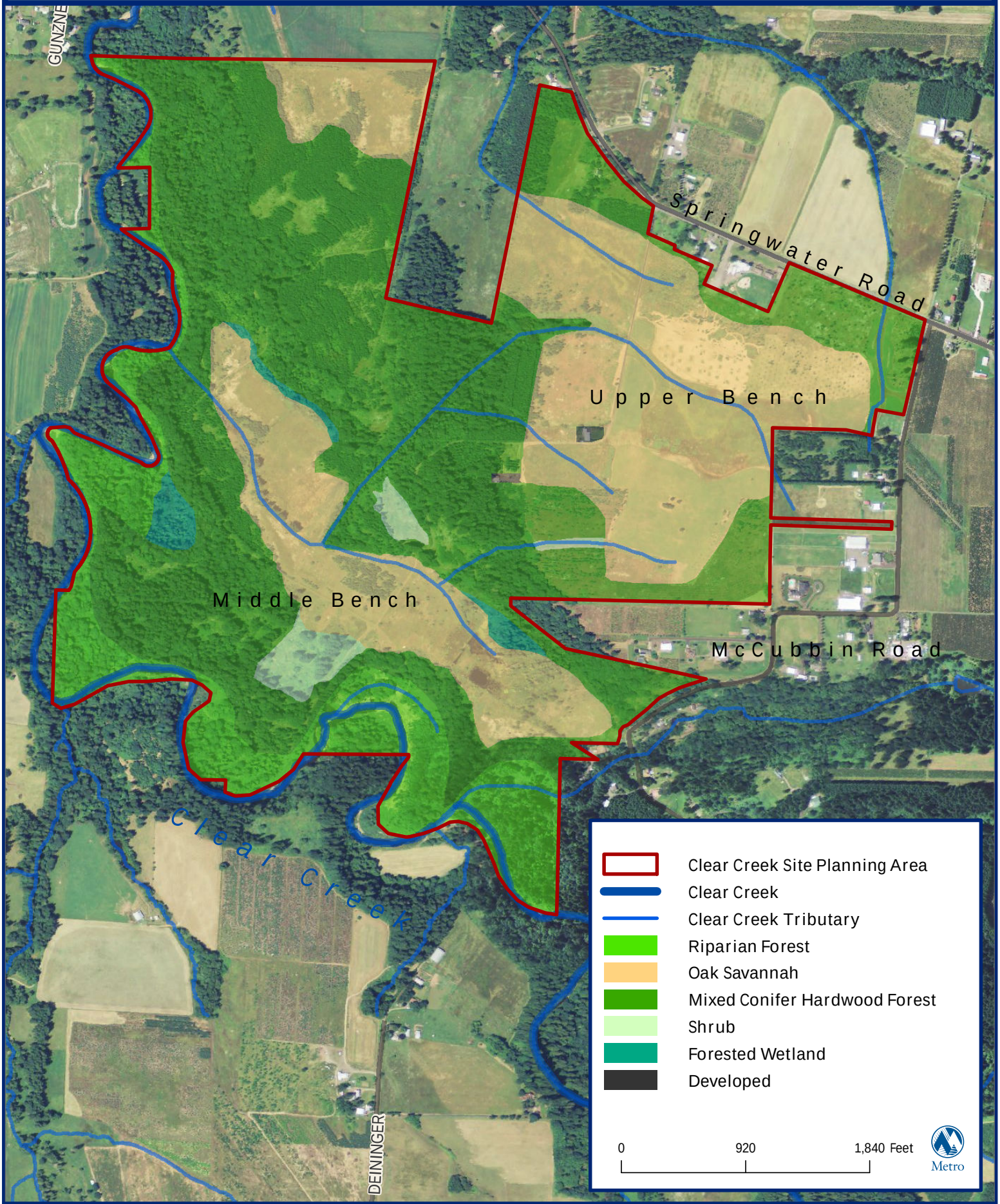
Map 3

Physical Conditions



Map 4

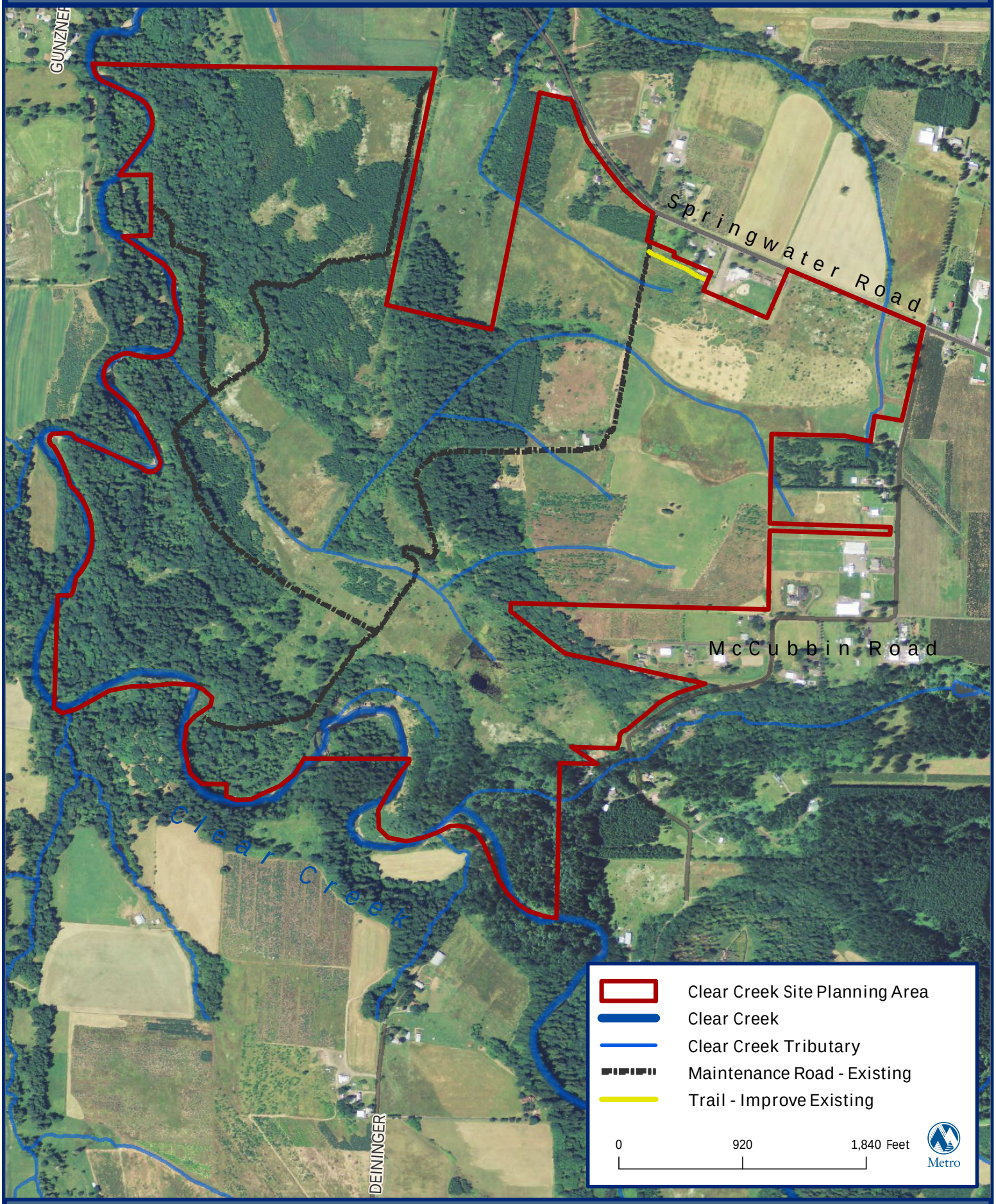
Vegetation Habitat Types



Clear Creek Canyon Site Conservation Plan

Map 5

Access


GUNZNER
Springwater Road
McCubbin Road
Clear Creek
DEININGER
Clear Creek Site Planning Area
Clear Creek
Clear Creek Tributary
Maintenance Road - Existing
Trail - Improve Existing
0
920
1,840 Feet
Metro

APPENDICES

Appendix A – Physical environment

Appendix B – Conservation

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B.2 Key ecological attributes

B.3 Threats and sources

B.4 Invasive species

Appendix C – References and additional resources

APPENDIX A | PHYSICAL ENVIRONMENT

The following excerpt is from the Clear Creek and Foster Creek Watershed Assessment that was developed by the Clackamas River Basin Council in September of 2002.

Geology: rocks and landforms

The geologic history of the lower Clackamas region, spanning about 15 million years (15 Ma), has been characterized by the interaction of volcanic and depositional processes along the border between the Cascade Range and the Portland Basin (part of the Willamette structural trough).

The materials include volcanic and sedimentary rocks, poorly-inundated to unconsolidated fluvial and mudflow deposits, and the soils formed on them. Four major geologic units include the Sardine Formation, the Troutdale Formation, the Boring Lava, and Alluvial Deposits: Terraces and Floodplains. These units are briefly described below, and in greater detail in the Sediment Sources Section.

The Goat Mountain highlands are built of the oldest rocks in the study region, Western Cascade volcanic rocks named the Sardine Formation or Rhododendron Formation by various workers. Andesitic lava flows erupted from vents at Goat Mountain, Soosap Peak, and other sites east and south of the study area, about 15-5 Ma. Along with associated flow breccias, the lavas built thick volcanic piles around the vents; mudflows carried some of the material north and west, where it was deposited in the lowlands (and is exposed in the bottom of Clear Creek almost to Viola). All of these rocks are now well cemented.

As the Cascade Range rose (after about 4 Ma), the ancestral Columbia River and streams flowing off the growing mountains deposited sediments in the trough to the west. These fluvial conglomerates, sandstones, and siltstones form one of the thickest layers of materials in the Portland Basin. In the study area, they lap onto the Goat Mountain highlands near Dodge and Elwood, and thicken northwestward; as much as 500 ft is exposed in the canyon of Clear Creek.

High Cascade-like volcanic activity extended across the Portland Basin in the late Pliocene and Pleistocene (about 3.2-0.5 Ma), creating the Boring Lava formation. Named for the Boring Hills, these basaltic flows and associated agglomerates and tuff-breccias erupted intermittently from dozens of vents in the region, forming cinder cones, shield volcanoes, and some extensive lava plateaus. In the Clear-Foster area, the main sources were in the Outlook buttes (3.15 Ma, among the oldest Boring Lavas yet dated), in the hills between Redland and Four Corners, and at Highland Butte. The Clackamas River, Clear Creek, and their tributaries later eroded into and broke up the nearly continuous surface of Boring Lavas and cones that probably once stretched from Oregon City to the Cascade foothills.

The site's terraces and floodplains arise, in part, from alluvial deposits. Erosion and deposition processes continued throughout occasional eruption of the Boring Lavas. There are some breccias that were probably formed by mudflows coming off the volcanoes; meanwhile, streams continued to bring sediment down from the Cascades. The highest surface in the study area, called the Springwater surface, is mantled with fluvial conglomerate (with lesser sands, silts, and debris flows), deposited over Troutdale sediments and interbedded with Boring Lavas. The Springwater is thickest

next to the Cascades near Dodge, and thins westward toward Logan, where it laps against the Boring volcanic plateau; it probably once formed a near continuous piedmont or bajada surface at the foot of the Cascades. Now about 2 Ma old, it is commonly highly weathered to about 75 ft depth.

Geologic channel forming processes

Channel characteristics in the Clear and Foster Creek basins reflect the geologic and geomorphic processes that have been active in the region, especially over the past couple of million years. Uplift of the Cascades, volcanic eruptions, and deposition of fluvial sediments created the materials and relief of the area; abundant rainfall has generated surface and subsurface runoff that stimulated mass wasting and stream erosion. The channels in the basin can be sorted into a small number of landform types based on their combinations of geologic materials, terrain, and history.

The terrain in about two-thirds of the Clear Creek Watershed is dominated by a series of plateaus and terraces, built up by a combination of local volcanic eruptions (from Boring Lava vents) and the deposition of fluvial sands, silts, and gravels by streams flowing off the Cascades. The weathered soils and rocks of the lava plateaus and the older/higher terraces have been eroded into rolling surfaces by small tributary streams, flowing away from the volcanic centers or down the inherited terrace slopes at gentle gradients. But where they flow over the terrace edges into the deeper canyons, these streams have eroded ravines of varying lengths and depths. The channels in these ravines are typically narrow and steep, and local gradients are controlled by the rocks' resistance to incision. In many places, hard layers of basalt, conglomerate, sandstone, or mudstone form ledges, waterfalls, and step-pools (such as on Swagger Creek); in others, stream incision has left narrow slices into bedrock (as at the mouth of Foster Creek).

The Clackamas River, Clear Creek, and their major tributaries have eroded deeply into the old upland surfaces, while stream meandering (particularly by the Clackamas) shaped the terraces and left steep terrace scarps. Along Clear Creek (especially from Dodge-Elwood to Fischer's Mill) and the major tributaries (Mosier, Little Clear, Little Cedar, and Bargfeld Creeks, etc.), the combination of stream incision and land sliding has produced deep, complex ravines. Almost all of the scarps have been affected by shallow mass movement to one degree or another, and most show evidence of deep-seated land sliding, with some slide complexes hundreds of acres in area. Where the ravines are narrow, such sliding has on occasion blocked the creeks (at least temporarily), altering local base levels and depositional patterns. Even in the wider Clear Creek canyon, sliding has deflected the stream toward the opposite wall in places, changing local erosional patterns and channel behavior. The smaller tributaries that cross or originate on the irregular surfaces of the large landslide bodies typically have gentle gradients, commonly interrupted by small ponds and wetlands. The landslides are major contributors to the supplies of coarse sediment (including boulders and cobbles, locally) and large woody debris to the streams.

Although terrace scarps and bluffs remain important elements, in terms of constraining channel migration and supplying sediment from landslides, downstream of Springwater Clear Creek flows dominantly on alluvium (as opposed to bedrock) in a generally wider valley bottom. There, low-gradient streams meander across their valley bottoms, occasionally abandon channel segments, and inundate their floodplains and low terraces during high flows. The younger/lower terraces of the

north end of the area (including most of the Foster Creek basin) are typically flatter than the rolling higher surfaces in the south. Consequently, the tributaries flowing on them tend to have very gentle gradients, except where they have eroded ravines into the terrace scarps, as near the mouth of Foster Creek. On the lower terraces and floodplains, small streams can flow into abandoned channels or onto the inboard edges of lower terraces, or originate there from seepage. These small back-terrace or wall-base channels provide important rearing and refuge habitat.

Soils

The properties of soils found within a watershed influence to a large extent the movement of water through and within the soil layers. Information on soils in the Clear and Foster Creek watersheds is available from the soil survey of the Clackamas area (NRCS, 1985; 1998) published by the USDA Natural Resources Conservation Service (NRCS; formerly the Soil Conservation Service). The NRCS has classified soils into hydrologic soil groups (HSGs) to indicate the rates of infiltration and transmission (rate at which the water moves within the soil).

Table 1: Descriptions of hydrologic soil group properties

Soil symbol	Soil name	Description
68	Newberg Loam	This deep, somewhat excessively drained soil is on flood plains. It formed in mixed alluvium. Slope is 0 to 3 percent.
92F	Xerochrepts	This map unit is on terrace escarpments. Slope is 20 to 60 percent.
71B	Quatama	This deep, moderately well drained soil is on terraces. It formed in stratified glaciolacustrine deposits.
30C	Delena	This deep, poorly drained soil is on high terraces and rolling uplands. It formed in silty alluvium.
1B	Aloha Silt Loam	This deep, somewhat poorly drained soil is on broad valley terraces. It formed in stratified glaciolacustrine deposits.
57	McBee variant	This deep, somewhat poorly drained soil is on flood plains. It formed in mixed alluvium. Slope is 0 to 3 percent.
1A	Aloha	This deep, somewhat poorly drained soil is on broad valley terraces. It formed in stratified glaciolacustrine deposits.
25	Cove Silty Clay Loam	This deep, poorly drained soil is on flood plains. It formed in clayey alluvium. Slope is 0 to 2 percent.
7B	Borges Silty Clay Loam	This deep, poorly drained soil is in concave areas on rolling uplands and high terraces. It formed in mixed clayey alluvium.
8B	Bornstedt	This deep, moderately well drained soil is on high terraces and rolling uplands. It formed in mixed old alluvium.
83	Wapato	This deep, poorly drained soil is on flood plains. It formed in mixed alluvium. Slope is 0 to 3 percent.
24B	Cottrell	This deep, moderately well drained soil is on high terraces and rolling uplands. It formed in old alluvium.
3	Amity	This deep, somewhat poorly drained soil is on broad valley terraces. It formed in stratified glaciolacustrine deposits.
41	Huberly	This deep, poorly drained soil is in swales of valley terraces. It formed in stratified glaciolacustrine deposits. Slope is 0 to 3 percent.
56	McBee	This deep, moderately well drained soil is on flood plains. It formed in mixed alluvium. Slope is 0 to 3 percent.

Soil symbol	Soil name	Description
31F	Dystrochrepts	These deep, well drained soils are on terrace escarpments. They formed in colluviums derived dominantly from basalt and andesite.
19	Cloquato	This deep, well drained soil is on flood plains. It formed in mixed alluvium. Slope is 0 to 3 percent.
91A	Woodburn	This deep, moderately well drained soil is on broad valley terraces. It formed in stratified glaciolacustrine deposits.
91B	Woodburn	This deep, moderately well drained soil is on broad valley terraces. It formed in stratified glaciolacustrine deposits.

APPENDIX B-1 | CONSERVATION TARGETS

Introduction

Conservation targets are composed of a suite of species, communities and ecological systems that represent and encompass the full array of native biodiversity of the site, reflect local and regional conservation goals, and are viable or at least feasibly restorable (The Nature Conservancy 2007). Priority conservation targets represent species or habitats that are the conservation focus for a given area or management unit.

Conservation targets establish the basis for setting goals, carrying out conservation actions, and measuring conservation effectiveness. They are the foundation of conservation planning. Key ecological attributes (KEAs) for each conservation target will be evaluated. KEAs are aspects of a conservation target's biology or ecology that, if missing or altered, would lead to the loss of that target over time (The Nature Conservancy 2007). Viability of the conservation target is inferred by the condition of the KEAs. Analysis of threats affecting conservation targets inform the development of action plans to abate serious threats and monitoring plans to gauge success of the action plans. Conservation targets then should consist of species or communities that will provide the focus of management actions and monitoring. Species or communities that for whatever reason are too expensive to manage or monitor are not good candidates for conservation targets.

Background

Historically, the Willamette Valley was dominated by extensive prairie, oak savanna and woodland habitats totaling approximately 2 million acres that supported a wide diversity of plant and animal species, including several endemic to the Willamette Basin (Floburg et al 2004). These habitats were primarily maintained by Native American-ignited fires. Agricultural and residential development in the Willamette Subbasin and the cessation of widespread prescribed fires has resulted in a substantial loss of native habitat especially at the lowest elevations, leaving less than two percent of all historic prairies and seven percent of oak habitat extant today.

Methods

Regional conservation plans were referenced to align the conservation goals of the Clear Creek Canyon Site Conservation Plan (see Table 1). These plans included the Oregon Department of Fish and Wildlife's Oregon Conservation Strategy (ODFW 2006), The Nature Conservancy's Ecoregional Assessment of the Willamette Valley – Puget Trough-Georgia Basin (Floburg et al 2004), the Northwest Power and Conservation Council's Willamette Subbasin Plan (NWPCC 2005), and Partners in Flight's Conservation Strategy for Landbirds in Lowlands and Valleys of Western Oregon and Washington (Altman 2000). These plans identify both focal habitats and focal species as conservation targets.

The Clear Creek site is large with diverse habitats and species. Reflecting this complexity, several sensitive species and onsite habitats as mapped by Metro staff were used as the foundation for selecting conservation targets.

Results

Using onsite habitat types and regional conservation planning efforts as guides, conservation targets were selected that encompass the site's most threatened biodiversity values as well as regional

conservation targets (Table 1). Each of the conservation targets are represented in one or more of the regional conservation plans listed in Table 1.

Table 1: Clear Creek site conservation targets and relationships to other conservation strategies

Clear Creek Canyon Natural Area conservation targets	**Oregon Conservation Strategy** *(ODFW 2006)*	**Willamette Basin Subbasin Plan** *(Primozich 2004)*	**Landbird Conservation Strategy** *(Altman 1999, 2000)*	**Ecoregional Assessment** *(Floburg et al 2004)*
Savannah	Grasslands and oak habitats are priorities for the Willamette Valley	Upland and wet prairie	Grassland – savanna	Upland and wet prairie; savanna
Riparian forest	Freshwater aquatic, riparian and wetland habitats are all priorities for the Willamette Valley	Basinwide priority	Riparian	Riparian forests and shrublands
Upland conifer-hardwood forest	Late successional conifer forests	Old growth conifer forest	Low elevation western hemlock/western redcedar	Douglas fir-western hemlock-western redcedar forests
Native fish habitat	All are strategy species in the Willamette Valley ecoregion[1]	Anadromous fish species and their habitats are basin-wide priorities	N/A	Ecoregional target species

While not elevated to the level of "conservation targets," certain fish and wildlife species that depend on savannah and riparian habitats are integrated into these habitats' Key Ecological Attributes. These species are rare or declining, and implementing specific management practices may aid their conservation. Some Clear Creek Canyon Natural Area species with special state or federal status are listed in Table 2.

Table 2: Federal and state status for species of conservation interest at Clear Creek Canyon Natural Area

Species of conservation interest	**Federal status**	**State status**	**OR Conservation strategy species?**	**Notes**
Western Meadowlark (as a surrogate for many grassland-associated birds)	None	Sensitive–Critical	Yes	Partners in Flight focal species
Coho, Lower Columbia River ESU	Threatened	Endangered	Yes	
Steelhead, Lower Columbia River ESU	Threatened	Sensitive–Critical	Yes	Winter runs
Chinook, Lower Columbia River ESU	Threatened	Sensitive–Critical	Yes	Fall and spring runs
Coastal cutthroat trout, SW WA/Columbia River ESU	Species of Concern	Sensitive–Vulnerable	Yes	
Pacific lamprey	Species of Concern	Sensitive–Vulnerable	Yes	Clear Creek and its tributaries may also have Western brook lamprey, but Pacific are documented on the site
Northern Red Legged Frog	Species of Concern	Sensitive–Vulnerable	Yes	

[1] Coho salmon Oregon Coast ESU not native above Willamette Falls.

Habitat descriptions

Savannah

Savannah habitat at the Clear Creek Canyon natural area includes mosaic of Oregon white oak and Douglas fir trees, prairie and emergent wetland habitats. For the purpose of this conservation plan these habitats are combined into a single conservation target. Oregon white oak habitats are identified as conservation priorities within both the Oregon Conservation Strategy and the Regional Conservation Strategy for the Greater Portland-Vancouver Metropolitan Area. Native dominated oak savanna and prairie have largely disappeared in the metro region.

Oak savanna is essentially prairie with a few trees per acre. Savanna is characterized by widely spaced, open canopy trees dominated by Oregon white oak. In general, the understory is relatively open with shrubs, grasses and wildflowers. In healthy oak savanna habitat, total native woody cover is typically 5 to 30 percent, and canopy architecture represents an appropriate mix of large open grown oak trees and younger tree recruitment that will replace older trees when they die. In healthy native prairie and emergent wetland habitats, native herbaceous plant species (grass and wildflower) typically compose over 90 percent of the vegetation cover, with less than 5 percent cover of woody vegetation. Emergent wetland habitat has natural vegetation structure similar to prairie.

Savannah habitat at the Clear Creek Canyon Natural Area includes mosaic of Oregon white oak and Douglas fir trees, prairie and emergent wetland habitats. For the purpose of this conservation plan these habitats are combined into a single conservation target.

Key plants

Native forbs found in this habitat may include camas, brodiaea lily, Oregon sunshine, large rose mallow (Sidalcea), Oregon saxifrage, large leaf lupine, tarweed, collinsia and bracken fern. Native grass species found in this habitat may include Roemer's fescue, California oat grass, tufted hairgrass, slender hairgrass and blue wildrye. Shrubs found in this habitat may include poison oak, spiraea, snowberry and tall Oregon grape.

Key wildlife

Partners in Flight identifies the following focal species occurring in our area for grassland or savanna habitats: western meadowlark, streaked horned lark, common nighthawk, American kestrel and northern harrier. Oak focal species include white-breasted (slender-billed) nuthatch, acorn and downy woodpecker, western wood-peewee, bushtit, chipping sparrow, Bewick's wren and house wren. Other birds utilizing oak, savanna and emergent wetland habitats may include white-crowned sparrow, rufous hummingbird, western bluebird, lazuli bunting and red-tailed hawk, as well as waterfowl, rails, herons and shorebirds in wetter habitats. Other wildlife utilizing this mix of habitats may include Pacific tree and red-legged frogs, garter snake, rubber boa, butterflies, black-tailed deer, coyote, fox and various native rodents.

Current extent and attributes

The Clear Creek Canyon Natural Area includes 171 acres of Oregon white oak savannah habitat over three separate areas of the site. Native wildflowers can be found in bloom from March to July.

Riparian forest

River mainstem and tributary native fish habitat conditions are moderately to severely degraded within much of the region. Widespread development and land use activity affect habitat quality and complexity, water quality and watershed processes in lower Willamette and Columbia tributaries. Stream habitat degradation is primarily due to past and current land-use practices that have affected properly functioning stream channels, riparian areas and floodplains, as well as watershed processes. The Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan identifies the Clackamas River and its tributaries as primary habitat necessary to the recovery of coho and winter steelhead, and as important contributing habitat for fall Chinook and chum salmon (Primozich and Bastash, *Willamette Subbasin Plan* 2004).

Key plants

Native forbs found in this habitat may include Pacific waterleaf, false hellebore, nodding beggartick and skunk cabbage. Sedge and rush species found in this habitat may include slough sedge, awl-fruited sedge, dewy sedge, slender rush, common rush and spreading rush. Shrubs and trees found in this habitat may include red alder, Oregon ash, Western red cedar, cottonwood, big leaf maple, Pacific ninebark, red-osier dogwood, Sitka and Pacific willow, red elderberry and Douglas' spiraea.

Key wildlife

Partners in Flight identifies the following focal species for bottomland shrub and tree habitats: willow flycatcher, red-eyed vireo, yellow warbler, Swainson's thrush, downy woodpecker and yellow-billed cuckoo. Other birds utilizing this habitat may include green heron, great blue heron, Wilson's and other warblers, yellow-breasted chat, black-headed grosbeak, common yellowthroat, song sparrow, ruby-crowned kinglet, downy woodpecker and red-breasted sapsucker. Some of the wildlife species that regularly use this habitat include Pacific tree frog, northern red-legged frog, various salamanders, common garter snake, black-tailed deer, elk, coyote and fox.

Current extent and attributes

The Clear Creek Canyon Natural Area includes approximately 66 acres of forested riparian habitat. Some variations of canopy structure in this habitat type include big leaf maple, red alder/western red cedar and big leaf maple/Douglas fir community types.

Upland conifer-hardwood forest

Upland coniferous and mixed conifer/deciduous forests are the dominant natural habitat of the region. Low-elevation Pacific Northwest old-growth forests typically are dominated by the conifers Douglas fir, western red cedar and western hemlock, with grand fir and hardwood species also occurring. Under natural conditions, trees of many of the dominant species live to be 350 to 750 years old or older and frequently have diameters of 8 feet or more. Plant and animal use of forests follows the changes in forests over time, with different suites of species dominating depending on forest age, canopy closure and site conditions. Biodiversity is higher in forests where some light reaches the forest floor and where standing and fallen dead wood is ample and of mixed age and size. Forests younger than 60 years dominate western Oregon due to current forestry practices, and old growth associated species' declines reflect these changes in overall forest structure across the region.

Stands of forest can be categorized by the age of trees, species and composition of understory species. Upland forests in the greater Portland-Vancouver region provide primary habitat for at least 94 species and are used by at least 129 more species (Portland-Vancouver *Regional Conservation* Strategy 2012).

Key plants

Native forbs found in this habitat may include sword fern, licorice fern, false Solomon's seal, false lily of the valley, trillium, fairy bells, miner's lettuce, stinging nettle, hedge-nettle and heal-all. Shrubs and trees found in this habitat may include Pacific yew, Pacific madrone, bigleaf maple, red alder, Douglas fir, Grand fir, Western red cedar, black hawthorn, Western serviceberry, tall and dull Oregon grape, mock orange, blue and red elderberry, salal, red huckleberry, Indian plum and snowberry.

Key wildlife

Partners in Flight identifies the following focal species for coniferous forests in western Oregon: Vaux's swift, brown creeper, red crossbill, pileated woodpecker and varied thrush (old growth and mature forests); hermit warbler, Pacific-slope flycatcher, Hammond's flycatcher, winter (Pacific) wren, black-throated gray warbler and Hutton's vireo (mature/young/pole forests); and olive-sided flycatcher, western bluebird, orange-crowned warbler and rufous hummingbird (young forests). Other birds utilizing this habitat may include Townsend's warbler, evening grosbeak, Swainson's thrush, Anna's hummingbird, cedar waxwing, bushtit, chestnut-backed and black-capped chickadee, American robin, Steller's jay, Bewick's wren, golden-crowned kinglet and Cooper's hawk. Other species may include Douglas' squirrel, common garter snake, rubber boa, elk, black-tailed deer, mountain lion, bobcat, coyote, fox, weasel and a variety of small mammals.

Current extent and attributes

The site includes 256 acres of upland coniferous forest habitat, with tree age in the range of 2-100+ years. A large portion of the site was planted as part of a carbon sequestration experiment and these conifer forested areas are relatively young compared to other stands at the site. Some variations of canopy structure in this habitat type include Grand fir/big leaf maple, Douglas fir/big leaf maple/red alder and big leaf maple/Douglas fir community types.

Forested wetlands

Sometimes called swamps, forested wetlands occur on seasonally or perennially wet flats, depressions, or stream terraces. Hydration occurs via precipitation, groundwater discharge or inflowing streams. Forested wetlands sometimes are located within riparian zones but differ from riparian and floodplain habitat in their higher water tables and longer duration of surface water. Forested wetlands typically are flooded for several weeks during the growing season (seasonal flooding), and are differentiated from riparian stands that may have surface water for only a few days during a temporary flood.

Key plants

Native forbs found in this habitat may include false lily of the valley, false hellebore, star-flowered Solomon's seal and skunk cabbage. Sedge and rush species found in this habitat may include slough sedge, awl-fruited sedge, dewy sedge, slender rush, common rush and spreading rush. Shrubs and

trees found in this habitat may include cottonwood, Sitka alder, Oregon ash, Pacific ninebark, red-osier dogwood, red elderberry, twinberry and Douglas spirea.

Key wildlife

Birds utilizing this habitat may include green heron, great blue heron, Wilson's warbler, song sparrow, cedar waxwing, bushtit, black-capped chickadee, orange-crowned warbler and fed-breasted sapsucker. Other wildlife utilizing this habitat include Pacific tree frog, Northern red-legged frog, Northwestern salamander, common garter snake, black-tailed deer, coyote and fox.

Current extent and attributes

The site includes six acres of forested wetland over three separate areas of the site.

Shrub wetland

Shrub (commonly called scrub shrub) wetlands include areas dominated by woody vegetation less than 6 meters (20 feet) tall (Portland-Vancouver Biodiversity Guide 2012). Characteristic species include shrubs, young trees and trees or shrubs that are small or stunted because of environmental conditions. Shrubs add complexity to other habitats, greatly increasing the amount of area available for cover and nesting. Numerous studies in the Pacific Northwest document the importance of shrubs to a wide variety of arthropods, amphibians, small mammals and birds. The fruit and flowers of shrubs – particularly deciduous ones – host abundant pollinator and prey species. The diets of deer and elk consist largely of shrub browse. Shrubs also provide important habitat connectivity and may effectively widen a forested biodiversity corridor.

Key plants

Willow, spirea, ninebark and red twig dogwood are common dominant shrub species found in scrub wetlands in this region. May include stands on gravel or sand bars. This habitat may also contain small amounts of Oregon ash. Deeper or more year-round water areas may include wapato, pond lily, bulrushes, and bur-reed.

Key wildlife

Partners in Flight identifies willow flycatcher as a focal species for Willamette Valley floodplain shrub. Other species associated with scrub-shrub wetlands include beaver, otter, yellow-breasted chat, common yellowthroat, green heron, yellow warbler, Pacific chorus frog and other amphibians. Scrub wetlands often intergrade with herbaceous wetlands, particularly in floodplain habitats; the two types of wetlands share many of the same wildlife species, and both may serve as important habitat for rearing or overwintering salmonids.

Current extent and attributes

The Clear Creek Canyon Natural Area includes approximately 10 acres of scrub wetlands, often intergrading in a mosaic with the other conservation target habitats.

APPENDIX B-2 | KEY ECOLOGICAL ATTRIBUTES

Key ecological attributes (KEAs) are aspects of a conservation target's biology or ecology that, if missing or altered, would lead to the loss of that target over time (The Nature Conservancy 2007). KEAs define the conservation target's viability. They are the biological or ecological components that most clearly define or characterize the conservation target, limit its distribution or determine its variation over space and time. They are the most critical components of biological composition, structure, interactions and processes, and landscape configuration that sustain a target's viability or ecological integrity. For each KEA, one or more indicators were selected to assess the health of the KEA.

Indicators are measurable entities related to the condition of the KEA (The Nature Conservancy 2007). A good indicator should be:

- **Biologically relevant:** The indicator should represent an accurate assessment of target health.
- **Sensitive to anthropogenic stress:** The indicator should be reflective of changes in stress.
- **Measurable:** The indicator should be capable of being measured using standard procedures.
- **Cost-effective:** The indicator should be inexpensive to measure using standard procedures.
- **Anticipatory:** The indicator should indicate degradation before serious harm has occurred.
- **Socially relevant:** The indicator's value should be easily recognizable by stakeholders.

KEA indicators were categorized by type: size, condition or landscape context:

- **Size:** A measure of the area or abundance of the conservation target's occurrence.
- **Condition:** A measure of the biological composition, structure and biotic interactions that characterize the occurrence.
- **Landscape context:** An assessment of the target's environment including ecological processes and regimes that maintain the target occurrence such as flooding, fire regimes and many other kinds of natural disturbance, and connectivity such as species targets having access to habitats and resources or the ability to respond to environmental change through dispersal or migration.

The status of an indicator will vary over time either within an acceptable range of variation that sustains the conservation target or beyond a critical threshold that threatens the viability of the conservation target. The range is described as very good, good, fair or poor. The very good and good ratings mean that the indicator is functioning within its acceptable range of variation. Fair and poor ratings mean an indicator is outside its acceptable range of variation. When information was lacking to define all four categories then only a subset of the four categories was defined.

Definitions for the four categorizes follow those used by The Nature Conservancy:

- **Very Good**: The indicator is functioning within an ecologically desirable status, requiring little human intervention for maintenance within the natural range of variation (i.e., is as close to "natural" as possible and has little chance of being degraded by some random event).
- **Good:** The indicator is functioning within its range of acceptable variation, although it may require some human intervention for maintenance.

- **Fair:** The indicator lies outside of its range of acceptable variation and requires human intervention for maintenance. If unchecked, the target will be vulnerable to serious degradation.
- **Poor:** Allowing the indicator to remain in this condition for an extended period will make restoration or prevention of extirpation of the target practically impossible (e.g., too complicated, costly and/or uncertain to reverse the alteration).

KEAs and their indicators for the Clear Creek Canyon Natural Area's conservation targets are provided in the following tables.

Table 1: Key ecological attributes for oak savanna

Category	KEA	Indicator	---------- Indicator rating ----------				Current rating	DFC* for this SCP	Long term DFC	Comments
			Poor	Fair	Good	Very good				
Size	Western Meadowlark and grassland bird habitat	Number of potential male meadowlark territories (8 ha, or 20 acre units)	<16 contiguous ha (40 acres) of a mix of suitable habitat such as prairie and degraded prairie, savanna or appropriate pasture habitat, i.e. insufficient habitat for 2 male meadowlark territories.	16-49 ha (40-120 ac) of contiguous prairie or other suitable habitat, i.e. enough suitable habitat for 2 to 5 male meadowlark territories.	49-162 ha (120-400 ac) of suitable contiguous/connected habitat, i.e. enough for 6 to 20 male territories. Alternatively, 3 patches of closely associated suitable habitat, each >16 ha (40 acres) in size.	>162 ha (400 ac) of suitable contiguous or connected habitat, i.e. enough suitable habitat for >20 male meadowlark territories. Alternatively, 3 patches of suitable contiguous or connected habitat, each >57 ha (140 acres) in size.	Fair	Fair	Good	Estimate via GIS. Western meadowlark territories used as a surrogate for all grassland birds specifically and prairie and savanna system size in general. Literature territory size range avg. 6 ha (14 acres), range 2-14 ha (5-35 acres). Can be a mixture of upland prairie, wet prairie, and possibly suitable savanna habitat as well. The ratings are aimed at improving population viability, but do not necessarily ensure the specified level of viability, as larger areas may be needed if other habitat features are less suitable (Vesely and Rosenberg 2010; Alverson 2009).
Condition	Native Grass and Forb Presence	Native species richness	<20 native herbaceous plant species with high fidelity to the system types present within the patch.	20-39 native herbaceous plant species with high fidelity to the system types present at the patch.	40-59 native herbaceous plant species with high fidelity to the system types present at the patch.	> 60 native herbaceous plant species with high fidelity to the system types present at the patch.	Fair	Fair	Good	Estimate based on habitat inspection. Fidelity is a term that describes the degree to which a native plant species is associated with prairie or oak systems; high fidelity species are always or almost always found in prairie or oak habitats in the WPG ecoregion (Alverson 2009).
Condition	Native grass and forb abundance	Frequency of native herbaceous species in 1 sq m (11 sq ft) quadrats	<2 native high fidelity herbaceous prairie species occurring with >50% frequency and <9 additional species occurring with at least 10% frequency	At least 2 native high fidelity herbaceous prairie species occurring with >50% frequency and at least 9 additional species occurring with at least 10% frequency	At least 3 native high fidelity herbaceous prairie species occurring with >75% frequency and at least 9 additional species occurring with at least 25% frequency	At least 7 native high fidelity herbaceous prairie species occurring with >75% frequency and at least 15 additional species occurring with at least 25% frequency	Fair	Good	Good	The Nature Conservancy's recommendations to measure prairie/savanna habitat quality (Alverson 2009).
Condition	Native forb and grass abundance	Percent cover native forbs & grasses	<20%	20-30%	30-50%	>50%	Fair	Good	Very Good	The Nature Conservancy's recommendations to measure prairie/savanna habitat quality (Alverson 2009).
Condition	Vegetation Structure (Upper Bench)	Canopy cover (5-30%) and architecture of woody vegetation	Total native woody cover is outside the preferred range (5-30%) over more than half the habitat area.	Total native woody cover is within the preferred range (5-30%) over 50-90% of the habitat area.	Total native woody cover is within the preferred range (5-30%) over at least 90% of the habitat area, but young oak tree recruitment is limited or absent.	Total native woody cover is within the preferred range (5%-30%) over at least 90% of the habitat area, and canopy includes appropriate mix of large open-grown trees and younger tree recruitment.	Fair	Good	Very Good	Estimate based on site walk or aerial photos when trees are leafed out. If cover is estimated from aerial photography threshold cover categories should be increased by at least 5-10 percentage points. (Alverson 2009)
Condition	Vegetation Structure (Middle Bench)	Canopy cover (5-30%) and architecture of woody vegetation	Total native woody cover is outside the preferred range (5-30%) over more than half the habitat area.	Total native woody cover is within the preferred range (5-30%) over 50-90% of the habitat area.	Total native woody cover is within the preferred range (5-30%) over at least 90% of the habitat area, but young oak tree recruitment is limited or absent.	Total native woody cover is within the preferred range (5%-30%) over at least 90% of the habitat area, and canopy includes appropriate mix of large open-grown trees and younger tree recruitment.	Poor	Fair	Good	Estimate based on site walk or aerial photos when trees are leafed out. If cover is estimated from aerial photography threshold cover categories should be increased by at least 5-10 percentage points. (Alverson 2009)
Landscape context	Proximity (distance) to other target habitat patches	Number of habitat patches ≥ 40 (16 ha) acres within 2 km (1.25 mi)	No patches within 2 km (1.25 mi)	1 patch within 2 km (1.25 mi)	2 patches within 2 km (1.25 mi)	At least 3 patches within 2 km (1.25 mi)	Good	Good	Good	This KEA covers the issue of meta-populations and value of having other patches of target habitat within dispersal/pollinator distance. The 2 km (1.25 mi) distance may be greater than dispersal of many prairie species, and should be modified when specific dispersal distances for species of interest can be identified (Alverson 2009).
Landscape context	Edge condition	% of edge bordered by natural habitats and/or managed for conservation	Patch surrounded by non-natural habitats (0-25% natural habitat)	25%+ of patch bordered by natural habitats	50-75% of patch bordered by natural habitats or managed for conservation	75-100% of patch bordered by natural habitats or managed for conservation	Good	Very Good	Very Good	Assess via aerial photographs. The intactness of the edge can be important to biotic and abiotic aspects of the site. Derived from Washington DNR's *Ecological integrity assessment: North Pacific dry Douglas-fir forest and woodland* (Crawford 2011).

Table 2: Key ecological attributes for riparian forest

Category	KEA	Indicator	---------- Indicator rating ---------- Poor	Fair	Good	Very good	Current Rating	DFC* for this SCP	Long term DFC	Comments
Size	Riparian forest width	Avg. width of riparian forest	<15 m (50 ft) each side of stream	15-30 m (50-100 ft) each side of stream	30-61 m (100-200 ft) each side of stream	>61 m (200 ft) each side of stream	Good	Good	Very Good	Total width, both sides of stream. Estimate using GIS. Riparian forest width positively correlates with water and wildlife habitat quality, including biodiversity corridors. Width includes both sides of the stream or one side for larger rivers (effective wildlife movement corridor). Title 13 Class I riparian, which accounts for 5 primary ecological functions, is typically within 30-61 m (100-200 ft) on either side of the stream; steep slopes are encompassed in the wider distances. Optimum width won't always be achievable – e.g., could interact with other priority habitats such as prairie. (Environmental Law Institute 2003; Metro's *Technical Report for Fish and Wildlife* Habitat, 2005; Hennings and Soll 2010; Shandas and Alberti 2009; Cole and Hennings 2006)
Condition	Vegetative structure: shrub layer	% native shrub cover	<10% cover	10-25% cover	25-50% cover	>50% cover	Fair	Fair	Very Good	Estimate via site walk. Indicator categories based on data from local study at 54 riparian study sites. Abundance and species richness of many bird and mammal species is associated with native shrub cover and woody vegetation volume. Puget Sound studies suggest that the fragmentation of upland vegetation and the total amount of riparian vegetation explain the greatest amount of variability in riparian bird communities. (Carey and Johnson 1995; Hennings 2001; Hagar 2003; Shandas and Alberti 2009; Hagar 2011)
Condition	Vegetative structure: tree layer	% native tree canopy cover	<20% cover	20-30% cover	30-40% cover	40% or more	Fair	Fair	Very Good	Estimate via site walk. Based on data from local study at 54 riparian study sites. In these sites, the best mix of native tree and shrub cover occurred when both were in the 40-60% range. Tree cover In this tended to support healthy shrub communities and helped control European starlings. Note that some species, such as yellow-breasted chat, rely on native shrub habitat rather than forest, therefore if specific species are involved separate KEAs should be developed. (Hennings 2001)
Condition	Native herbaceous layer richness	# native species of grasses, herbs, forbs and ferns, at least half of which are riparian-associated, per 0.4 ha (1 ac)	<5 species	5-12 species	12-18 species	>18 species	Poor	Good	Good	Estimate via site walk. Species numbers based on field experience of Marsha Holt-Kingsley and Lori Hennings; currently using species list from McCain and Christy 2005, Technical Paper R6-NR-ECOL-TP-01-05.
Condition	Native tree and shrub richness	# native tree and shrub species per 0.4 ha (1 ac)	<5 species	5-10 species	10-15 species	>15 species	Fair	Good	Very Good	Estimate via site walk. Some studies show that native wildlife species diversity (particularly Neotropical migratory songbirds) is associated with native deciduous shrub diversity. (Muir et al. 2002; Hagar 2003; Hagar 2011)
Condition	Standing and downed dead trees	Average # snags and large wood (> 50 cm, or 20 in, DBH) per 0.4 ha (1 ac)	< 5 snags and <5% down wood	5-11 snags and 5-10% down wood	12-18 snags and 10-20% down wood with moderate variety of size and age classes	> 18 snags and >20% cover down wood in a good variety of size and age classes	Poor	Poor	Good	Estimate via site walk. Rankings distilled from multiple references and particularly from *Habitat Conservation for Landbirds in Lowlands and Valleys of Western Oregon and Washington* (Altman and Alexander 2012) and DecAID results for species' use of dead wood in Westside Lowland Conifer-hardwood forests.

Category	KEA	Indicator	---------- Indicator rating ----------				Current Rating	DFC* for this SCP	Long term DFC	Comments
			Poor	Fair	Good	Very good				
Condition	Floodwater access to the floodplain	Degree of connection between stream/ floodplain during high water events	Extensively disconnected by channel incision, dikes, tide gates, elevated culverts, etc.	Moderately disconnected by channel incision, dikes, tide gates, elevated culverts, etc.	Minimally disconnected by channel incision, dikes, tide gates, elevated culverts, etc.	Completely connected (backwater sloughs, channels)	Good	Very Good	Very Good	Measure based on field walk, aerials. Adapted from Washington DNR's *Ecological Integrity Assessment for North Pacific Lowland Riparian Forest and Shrubland*, "Hydrologic Connectivity (Riverine)." Added channel incision. Not appropriate for higher gradient streams. (Stanford et al. 1996; Rocchio 2011)
Landscape context	Offsite riparian habitat condition	% rating at least "fair" for both width and gaps (see above), within 2.5 km (1.6 mi) up- and down-stream of property.	0-25%	25-50%	50-75%	75-100%	Good	Very Good	Very Good	Measure using aerial photos for 2.5 km (1.6 mi) stream length, up- and downstream. Several studies suggest the importance of riparian buffer contiguity to water quality, fish and benthic organisms. A 2006 study in and near Damascus, OR found that benthic biotic integrity was significantly correlated with % forested area for 1,500 m (1,640 ft) upstream at 50, 100, and 200 m (55, 109, and 219 ft) wide. Ontario researchers found that the combination of % of forested stream bank and forest width within 2.5 km (1.6 mi) upstream of a site accounted for 90% of the observed variation in water temperatures. (Barton et al. 1985; Wang et al. 2001; Cole and Hennings 2006; Freeman et al. 2007; Olsen et al. 2007)

**Desired future condition.

** This KEA may not be appropriate where native turtles are present, because nesting turtles require some open habitat. Patches of bare ground may accommodate turtles and are important to native ground-nesting bees.

Table 3: Key ecological attributes for upland conifer-hardwood forests

Category	KEA	Indicator	---------- Indicator rating ----------				Current status	DFC* for this SCP	Long term DFC	Comments
			Poor	Fair	Good	Very good				
Size	Forested habitat patch size	Patch size (includes native shrub patches or natural clearings)	< 12 ha (30 ac)	12-40 ha (30-100 ac)	40-61 ha (100-150 ac)	>61 ha (150 ac)	Very Good	Very Good	Very Good	Calculate by delineating forest patch in GIS. If more than one patch present, rank based on a composite. In the Puget Sound, most native forest birds were present in patches ≥ 42 ha (104 ac). Local studies suggest a lowest threshold for birds and mammals of about 12 ha (30 ac) (Environmental Law Institute 2003; Donnelly and Marzluff 2004; Soll and Hennings 2010).
Condition	Native tree and shrub richness	Number of native tree and shrub species per ac	<5 species per 0.4 ha (1 ac)	5-8 species 0.4 ha (1 ac)	8-12 species per 0.4 ha (1 ac)	>12 species per 0.4 ha (1 ac)	Good	Good	Very Good	Estimate overall via site walk. Native wildlife species diversity is associated with native vegetation. A diversity of shrubs is more likely to provide food and shelter for species over the seasons. Shrub diversity is particularly important to pollinators and songbirds. (Hagar 2003; Hennings 2006; Burghardt et al. 2009).
Condition	Vegetative structure: native tree and shrub layer	% native tree and shrub canopy cover (combined)	<25% cover	25-50% cover	50-75% cover	>75% cover	Good	Good	Very Good	Estimate overall via site walk. Native bird species richness is associated with the amount of native shrub cover. (Hagar 2003; Hennings 2006). Numbers based on data analysis from local studies at 54 riparian study sites (Hennings 2001). Native shrub cover was as high as ~60%, with highest native shrub cover in the 50-60% tree canopy cover range.
Condition	Mature trees	Number and size (dbh) of species such as Douglas fir, western red cedar, western hemlock and grand fir	Mature trees lacking	<3 per ac with dbh >24 in	3-5 per ac with dbh >24 in	>5 per ac with dbh >24 in	Fair	Fair	Good	Recruitment of native trees necessary for long-term health of upland forests. Saplings are < 2m tall. Based on PIF (2000) biological objective for WV large-canopy trees in riparian deciduous woodland.
Condition	Standing and downed dead trees	Average # snags and large wood (> 50 cm, or 20 in, DBH) per acre	< 5 snags and <5% down wood	5-11 snags and 5-10% down wood	12-18 snags and 10-20% down wood with moderate variety of size and age classes	>18 snags and >20% cover down wood in a good variety of size and age classes	Fair	Fair	Good	Etimate via site walk. Rankings distilled from multiple references and particularly from *Habitat Conservation for Landbirds in Lowlands and Valleys of Western Oregon and Washington* (Altman and Alexander 2012) and DecAID results for species' use of dead wood in Westside Lowland Conifer-hardwood forests.
Landscape context	Edge condition	% of edge bordered by natural habitats and/or managed for conservation	Patch surrounded by non-natural habitats (0-25% natural habitat)	25%+ of patch bordered by natural habitats	50-75% of patch bordered by natural habitats or managed for conservation	75-100% of patch bordered by natural habitats or managed for conservation	Good	Good	Good	Assess via aerial photographs. The intactness of the edge can be important to biotic and abiotic aspects of the site. Derived from *Ecological integrity assessment: North Pacific dry Douglas-fir forest and woodland* (Crawford/WDNR 2011).

*Desired future condition.

Table 4: Key ecological attributes for native fish habitat (instream)

Category	KEA	Indicator	---------- Indicator rating ----------				Current rating status	DFC* for this SCP	Long term DFC	Comments
Condition	Complexity of Habitat	# of different stream habitat units per 305 m (1,000 foot) reach	Less than 2 habitat units	Between 2-5 habitat units	Between 5-10 habitat units	Greater than 10 habitat units	Fair	Good	Very Good	The number of different habitat units indicates the complexity of the stream reach. Complex stream reaches provide high quality habitat for all life stages of native fish. Habitat units may include glides, riffles, runs, pools, step pools, alcoves, side channels, etc. (Independent Multidisciplinary Science Team, 2002, *Recovery of Wild Salmonids in Western Oregon Lowlands*).
Condition	Key pieces and # of pieces of large wood in wetted areas of the stream and adjacent streambank	# key pieces and large wood per 305 m (1,000 ft) reach	<10 large wood pieces and 0-1 key pieces	10-20 large wood pieces and 2-5 key pieces	20-40 large wood pieces and 6-10 key pieces	>40 large wood pieces and >10 key pieces	Fair	Good	Very Good	Large wood is defined as logs greater than 46 cm (18 inch) diameter and 6 m (20 ft) in length. Note that optimum diameter and length depends on bankfull width; see DSL/ODFW's 2010 *Guide to Placement of Wood, Boulders and Gravel for Habitat Restoration*. Key pieces resist downstream transport as well as anchor and retain other pieces of large wood.
Condition	Substrate in wetted areas of stream	% area of fines and gravel substrate per 305 m (1,000 ft) reach	Fines >30% and gravel <10% of area	Fines 20-30% and gravel 10-20% of area	Fines 10-20% and gravel 20-35% of area	Fines <10% and gravel >35% of area	Good	Good	Good	Visually assess for a stream reach(es) of interest or for entire stream on site. If preferred, measure quantitatively using cross-sections ODFW methods. Fines are defined as sand, silt or organics. Gravels are defined as particles that range in size from a small pea to roughly baseball sized substrate. Derived from *2000 Reference Site Selection and Survey Results, Report No. OPSW-ODFW-2001-6*, Oregon Plan for Salmon and Watersheds, 2000.
Landscape context	Fish passage	Fish able to move to and from mainstem and tributaries	Complete blockage	Blocked more than half the year	Blocked less than half the year	Passage open year-round	Very Good	Very Good	Very Good	*Could be adjusted for seasonal movement.*

*Desired future condition.

APPENDIX B-3 | THREATS AND SOURCES

Introduction

A stress is the "impairment or degradation of the size, condition and landscape context of a conservation target, and results in reduced viability of the target," (The Nature Conservancy 2007) or, in other words, a degraded key ecological attribute (KEA) that is outside its acceptable range of variation. Stresses may also reduce the viability of nested conservation targets such as grassland birds. A source of stress is an extraneous factor, either human (e.g., policies, land use) or biological (e.g., non-native species) that infringes upon a habitat or species target in a way that results in stress. Put together, stresses and their sources constitute a threat.

Analysis of threats to conservation targets at Clear Creek Canyon Natural Area involves three parts:

- Identify stresses and apply stress-rating criteria.
- Identify sources of stress, rank and assign threat-to-system rank.
- Assign overall threat rank.

Background on methods

Identify stresses and apply stress-rating criteria

In identifying stresses, we applied the concept that a stress is any alteration of a KEA that can result or has resulted in a KEA declining below a "good" rating. For each conservation target, KEA indicators with ratings of "poor" or "fair" were analyzed by asking the question "*What types of destruction, degradation or impairment are responsible for the 'poor' or 'fair' rating?*" We also considered those KEA indicators with "good" and "very good" ratings but likely to degrade to "poor" or "fair" if no management actions are taken.

Stresses are ranked according to two criteria: **severity** and **scope** of the anticipated damage.

Severity

The level of damage to the conservation target that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation).

- **Very high:** The threat is likely to destroy or eliminate the conservation target over some portion of the target's occurrence at the site.
- **High:** The threat is likely to seriously degrade the conservation target over some portion of the target's occurrence at the site.
- **Medium:** The threat is likely to moderately degrade the conservation target over some portion of the target's occurrence at the site.
- **Low:** The threat is likely to only slightly impair the conservation target over some portion of the target's occurrence at the site.

Scope

The geographic extent of impact on the conservation target at the site that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation).

- **Very high:** The threat is likely to be widespread or pervasive in its scope and affect the conservation target throughout the target's occurrences at the site.
- **High:** The threat is likely to be widespread in its scope and affect the conservation target at many of its locations at the site.
- **Medium:** The threat is likely to be localized in its scope and affect the conservation target at some of the target's locations at the site.
- **Low:** The threat is likely to be very localized in its scope and affect the conservation target at a limited portion of the target's location at the site.

Once severity and scope ratings are determined, they are combined to develop a stress ranking using the following stress ranking table (The Nature Conservancy 2007).

Table 1: Stress ranking

	SCOPE			
Severity	**Very high**	**High**	**Medium**	**Low**
Very high	Very high	High	Medium	Low
High	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
Low	Low	Low	Low	Low

Identify sources of stress and apply threat to system rank

Sources of stresses are the proximate cause of the stress. A source of stress may be either human activities or biological (e.g., non-native species). Sources of the stress are rated in terms of **contribution** and **irreversibility** as defined below:

Contribution

The expected contribution of the source, acting alone, under current circumstances (i.e., given the continuation of the existing management/conservation situation).

- **Very high:** The source is a very large contributor of the particular stress.
- **High:** The source is a large contributor of the particular stress.
- **Medium:** The source is a moderate contributor of the particular stress.
- **Low:** The source is a low contributor of the particular stress.

Irreversibility

The degree to which the effects of a source of stress can be restored.

- **Very high:** The source produces a stress that is irreversible (e.g., wetlands converted to a shopping center).
- **High:** The source produces a stress that is reversible, but not practically affordable (e.g., wetland converted to agriculture).
- **Medium:** The source produces a stress that is reversible with a reasonable commitment of resources (e.g., ditching and draining of wetland).

- **Low:** The source produces a stress that is easily reversible at relatively low cost (e.g., off-road vehicles trespassing in wetland).

The contribution and irreversibility of each source across all the stresses to each conservation target is ranked using Table 5, resulting in a source of stress rank for each contribution/ irreversibility combination.

Table 2: Source ranking

	CONTRIBUTION			
Irreversibility	**Very high**	**High**	**Medium**	**Low**
Very high	Very high	High	High	Medium
High	Very high	High	Medium	Medium
Medium	High	Medium	Medium	Low
Low	High	Medium	Low	Low

In a similar fashion stress and source rankings are combined to develop a threat ranking specific to that conservation target (Table 6).

Table 3: Threat ranking

	CONTRIBUTION			
Stress	**Very high**	**High**	**Medium**	**Low**
Very high	Very high	Very high	High	Medium
High	High	High	Medium	Low
Medium	Medium	Medium	Low	Low
Low	Low	Low	Low	low

Threat-to-system rank

A threat-to-system rank is a summary ranking for all threats associated with a particular source of stress to a conservation target. Where multiple threats related to the same source of stress occurred, the threat-to-system rank is adjusted by using the "3-5-7" rule as follows:

- Three high rankings equal a very high.
- Five medium rankings equal a high.
- Seven low rankings equal a medium.

Table 7 illustrates the threat-to-system ranking.

Table 4: Conservation target A

	Stress 1	**Stress 2**	**Stress 3**	**Threat to system rank**
Stress rank	High	Medium	Medium	
Source A rank	High	Medium	N/A	High*
Source B rank	Low	N/A	Medium	Medium**

N/A = Not applicable: stress/source combination does not affect conservation target
**, ** - See Table4*

Overall threat rank

The last step in the process is to summarize threats across the system and apply an overall threat rank to each threat (source/stress combination). Overall threat ranks are determined by combining threat-to-system ranks across all system/targets affected by that threat. For each threat, DEA will

combine the threat-to-system ranks across all conservation targets into an overall threat rank of very high, high, medium or low as determined by the "2 Prime" rule which is as follows:

- Two very high threat rankings yield an overall threat rank of very high.
- One very high or two high threat rankings yield an overall threat rank of high.
- One high or two medium threat rankings yield an overall threat rank of medium.
- Less than two medium threat rankings yield an overall threat rank of low.

The overall threat rank represents the degree to which a particular source causes stress to the conservation target.

Table 5: Overall threat rank

	Target 1	Target 2	Target 3	Overall threat rank
Threat A	*High**	Very high	High	High
Threat B	*Medium***	Medium	High	Medium
Threat C	N/A	Medium	Low	Low

**, ** from Tables 5,6*

Threats and source analysis for the Clear Creek Canyon Natural Area

Threats for the Clear Creek Canyon Natural Area conservation targets are listed in Tables 9-12 below.

Table 6: Oak Savanna

Stress	Stress rank	Source of stress	Source rank	Threat rank	Comments
Increased competition from invasive species	High	Extensive non-native grasses and broadleaf weeds	High	High	Non-native broadleaf weeds include black-berry, Scots broom, ivy, thistle spp., and foxglove. Tied to native species abundance and richness KEAs.
Altered fire (disturbance) regime	High	Lack of regular fires	High	High	Build up of fuels degrades habitat and increases risk of a high intensity fire. Tied to native species abundance, richness, and woody species KEAs.
Altered hydrology	Medium	Ditching, colonization by shrub and tree species	Medium	Medium	Ditching/encroachment of ash trees has substantially dried out the seasonal wetlands embedded within the wet prairie. Specific to wet prairie and emergent wetland.
Human disturbance (recreational activities)	Medium	Demand trails, camping, dogs	Low	Low	Demand trail users trample vegetation, spread invasive weed; humans and dogs disturbing ground-nesting birds. Tied to vegetation structure, native grass and forb KEAs.

Table 7: Riparian forest

Stress	Stress rank	Source	Source rank	Threat rank	Comments
Increased competition from invasive species	High	Extensive non-native grasses, broadleaf weeds; limited invasive woody vegetation	High	High	Non-native broadleaf weeds include black-berry, Scots broom, ivy, thistle, and foxglove. Tied to native vegetation and structure KEAs.

Stress	Stress rank	Source	Source rank	Threat rank	Comments
Lack of down and standing dead wood	Medium	Previous forest management practices and altered hydrology	Medium	Low	Due to previous forest management practices and altered hydrology (see related stress), which can erode streambanks and near-stream plants and remove sources of dead wood. Tied to dead wood KEAs.
Altered hydrology	Medium	Primarily logging, development in upstream portions of the watershed	Medium	Low	Widespread altered hydrology leads to stream bank erosion, riparian vegetation loss, channel damage, loss of gravel and cobble substrate and overall habitat simplification.
Human disturbance (recreational activities)	Medium	Demand trails, camping, dogs, fishing	Low	Low	Demand trail users trample vegetation, spread invasive weed; humans and dogs disturb ground-nesting birds. Tied to structure, native plant KEAs.

Table 8: Upland conifer-hardwood forest

Stress	Stress rank	Source	Source rank	Threat rank	Comments
Increased competition from invasive species	High	Encroachment of non-native invasive species	High	High	Extensive invasive grasses and broadleaf weeds, esp. false brome and garlic mustard, and invasive shrubs such as Himalayan blackberry. Tied to native species KEAs.
Habitat conversion	High	Conversion from natural forest, prairie or savanna to single age young forest.	High	High	Thinning is needed. Complete canopy closure stunts trees and prevents development of native herbaceous and shrub layers. Tied to native plant and vegetative structure KEAs.
Lack of downed and standing dead wood	High	Previous forest management practices.	High	High	Snags and down wood are critical habitat elements used by more than 150 species of wildlife in Northwest conifer forests (Hagar 2007). Tied to dead wood KEAs.
Altered fire regime	Medium	Suppression of fire frequency outside natural range of variation	Medium	Low	Increased risk of stand-replacing fires in Douglas-fir forest, where a build up of fuels would increase risk of a high intensity fire. Tied to all KEAs.
Human disturbance (recreational activities)	Medium	Demand trails, camping, dogs, fishing	Low	Low	Stress to wildlife species utilizing this habitat. Potential loss of habitat and vegetation structure by escaped fire. Disturbance reduces habitat value. Tied to structure/patch size (interior habitat) KEAs.

Table 9: Native fish habitat

Stress	Stress rank	Source	Source rank	Threat rank	Comments
Simplified stream structure, sparse side channel refugia & riffle-pool sequences	High	Altered hydrology, channel morphology due to previous practices and upstream development, deforestation and disturbance	High	High	Salmon require off-channel habitat for rearing. Adult salmon need riffle-pool habitat for spawning, refugia, prey habitat and water oxygenation. Tied to all but fish passage KEAs.
Lack of logs and dead wood in streams	Medium	Previous forest management practices; narrow buffer in some areas	Medium	Low	Large logs provide critical habitat for juvenile fish and form the matrix of large wood jams and structure that provides complexity in the stream. Tied to habitat complexity and large wood KEAs.
Impaired fish passage	Low	Manmade structures that block fish migration including: dams, weirs, culverts	Low	Low	Currently no barriers at the Clear Creek site. Fish passage barriers do exist upstream and should be addressed to improve native fish habitat in the Clear Creek watershed.

APPENDIX B-4 | INVASIVE SPECIES

The table below summarizes a preliminary list of invasive plants requiring control in all or parts of Clear Creek Canyon Natural Area, including focus areas and timing for control. Invasive species, with the exception of Early Detection Rapid Response (EDRR) species, will be controlled as part of restoration projects or ongoing management of habitat areas. Photos of EDRR species for identification are listed below. A list of noxious weeds for Oregon, including descriptions and photos, can be found at: www.oregon.gov/ODA/PLANT/WEEDS/statelist2.shtml.

Table 1: Working list of priority non-native species for control at Clear Creek Canyon Natural Area (EDRR species common names are bolded in red)

Genus	Species	Common name	Focus area for detection/control	Control timing
Allarium	*petiolata*	**Garlic Mustard**	All	Spring
Brachypodium	*sylvaticum*	**False Brome**	All	Spring/Fall
Centaurea	*pratensis*	**Meadow knapweed**	Savannah	Summer
Cirsium	*arvense*	Canada thistle	Savannah	Spring
Clematis	*vitalba*	Old man's beard	Upland forest	Spring/Fall
Conium	*maculatum*	Poison hemlock	Savannah	Spring
Crataegus	*monogyna*	Common hawthorn	Prairie	Fall
Cytisus	*scoparius*	Scotch broom	Prairie	Fall
Daphne	*laureola*	**Spurge Laurel**	All	Spring/Fall
Dipsacus	*fullonum*	Teasel	All	Spring
Hedera	*Helix*	English Ivy	All	Winter
Hypericum	*perforatum*	St John's wort	Savannah	Spring
Ilex	*aquifolium*	Holly	Upland forest	Fall
Iris	*pseudacorus*	Yellow iris	Forested wetland	Fall
Lunaria	*Annua*	Money Plant	Savannah	Spring
Lythrum	*salicaria*	**Purple loosestrife**	Forested wetland	Summer
Mentha	*pulegium*	Pennyroyal	Savannah	Summer
Phalaris	*arundinacea*	Reed canarygrass	Savannah, Forested Wetland	Fall
Polygonum	*cuspidatum*	Japanese knotweed	All	Summer
Robinia	*pseudoacacia*	Black locust	savannah	Fall
Rubus	*armenianus*	Himalayan blackberry	All	Fall
Solanum	*dulcamara*	Bittersweet nightshade	All	Spring

Photo 1: Garlic mustard


Images courtesy of Glenn Miller, Oregon Dept. of Agriculture

Photo 2: False brome


Images courtesy of Glenn Miller, Oregon Dept. of Agriculture

Photo 3: Meadow knapweed


Images courtesy of Dan Sharratt, Oregon Department of Agriculture

Photo 4: Purple Loosestrife


Images courtesy of Bonnie Rasmussen (left) and Eric Coombs (right), Oregon Dept. of Agriculture

Photo 5: Spurge Laurel


Images courtesy of *Randy Westbrooks* (left) and King County noxious weed program (right)

APPENDIX C | REFERENCES AND ADDITIONAL RESOURCES

References and additional resources

Altman B, Alexander JD. 2012. Habitat conservation for landbirds in coniferous forests of western Oregon and Washington. Version 2.0. Oregon-Washington Partners in Flight (www.orwapif.org) and American Bird Conservancy and Klamath Bird Observatory.

Altman B. 1999. Status and conservation of state sensitive grassland bird species in the Willamette Valley. Corvallis, OR, Oregon Department of Fish and Wildlife.

Altman B. 2000. Conservation strategy for landbirds in lowlands and valleys of western Oregon and Washington. Version 1.0. Corvallis, OR, Oregon-Washington Partners in Flight and the American Bird Conservancy.

Alverson E. 2009. Key ecological attributes and indicators for Willamette Valley prairie and oak systems. Excel spreadsheet. Eugene, OR, The Nature Conservancy.
Ref Type: Generic

Barton DR, Taylor WD, Biette RM. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management 5:364-378.

Bauer S, Salminen E, Runyon J. 2005. Clackamas River Basin Action Plan. Clackamas, OR, Clackamas River Basin Council.

Burghardt KT, Tallamy DW, Shriver WG. 2009. Impact of native plants on bird and butterfly biodiversity in suburban landscapes. Conservation Biology 23:219-224.

Carey AB, Johnson ML. 1995. Small mammals in managed, naturally young, and oldgrowth forests. Ecological Applications 5:336-352.

Cole MB, Hennings LA. 2006. Baseline assessment of stream habitat and macroinvertebrate communities in and adjacent to the Damascus area urban growth boundary expansion, Oregon. Portland, OR, Metro Regional Government.

Crawford R. 2011. Ecological integrity assessment: North Pacific dry Douglas-fir forest and woodland. Olympia, WA, Washington Department of Natural Resources, Natural Heritage Program.

Donnelly R, Marzluff JM. 2004. Importance of reserve size and landscape context to urban bird conservation. Conservation Biology 18:733-745.

Environmental Law Institute. 2003. Conservation thresholds for land use planners. ELI project code 003101, Washington, D.C., Environmental Law Institute.

Floberg J, Goering M, Wilhere G, MacDonald C, Chappell C, Rumsey C, Ferdana Z, Holt A, Skidmore P, Horsman T, Alverson E, Tanner C, Bryer M, Iachetti P, Harcombe A, McDonald B, Cook T, Summers M, Rolph D. 2004. Willamette Valley - Puget Trough - Georgia Basin Ecoregional Assessment. The Nature Conservancy, with support from the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.

Foster SC, Stein CH, Jones KK. 2001. A guide to interpreting stream survey records. Portland, OR, Oregon Department of Fish and Wildlife. Aquatic Inventories Project, Natural Production Program.

Freeman MC, Pringle CM, Jackson CR. 2007. Hydrologic connectivity and the contribution of stream headwaters to ecological integrity at regional scales. Journal of the American Water Resources Association 43:5-14.

Gerig AJ. 1985. Soil survey of Clackamas County area, Oregon. Natural Resource Conservation Service.

Goklany ME, Johnson BR, Tomaszewski T, Pfeifer-Meister L, Bridgham SC. 2011. How will climate change affect the physiology, productivity, and fitness of the invasive grass, *Agrostis capillaris* L., in Pacific Northwest prairies? Program for 96th ESA Annual Meeting (August 7-12, 2011)

Hagar J. 2003. Functional relationships among songbirds, arthropods, and understory vegetation in Douglas-fir forests, western Oregon. Corvallis, OR, Oregon State University.

Hagar JC. 2007. Key elements of stand structure for wildlife in production forests west of the Cascade Mountains. Harrington TB, Nicholas GE, editors. PNW-GTR-695. Portland, OR, USDA Forest Service, Pacific Northwest Research Station.

Hagar JC. 2011. Partial harvesting can enhance foraging habitat for birds associated with understory vegetation in western Oregon forests. Jones SL, editor. Biological Technical Publication BTP-R1014-2011. Washington, DC, US Department of the Interior, Fish and Wildlife Service.

Hennings LA, Soll J. 2010. Wildlife corridors and permeability. A literature review. Portland, OR, Metro.

Hennings LA. 2001. Avian communities in riparian reserves in an urban landscape. M.S. thesis, Oregon State University, Corvallis, OR.

Hennings, LA. 2006. State of the watersheds monitoring report. Portland, OR, Metro Regional Government.

Independent Multidisciplinary Science Team. 2002. Recovery of wild salmonids in western Oregon lowlands. Technical Report 2002-1 to the Oregon Plan for Salmon and Watersheds. Salem, OR, State of Oregon, Governor's Natural Resources Office.

Lower Columbia Fish Recovery Board. 2004. Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan.

Lower Columbia Fish Recovery Board. 2010. Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (updated from 2004 draft).

McCain C, Christy JA. 2005. Field guide to riparian plant communities in northwestern Oregon. Technical Paper R6-NR-ECOL-TP-01-05. Portland, OR, USDA Forest Service, Pacific Northwest Region.

Metro Regional Government. 2005. Metro's Technical Report for Fish and Wildlife Habitat. Exhibit F, Ordinance No. 05-1077C, Attachment 2. Portland, OR, Metro Regional Government.

Moore K, Jones K, Dambacher J, Stein C et al. 2012. Methods for stream habitat surveys. Corvallis, OR, Oregon Department of Fish and Wildlife, Conservation and Recovery Program. Aquatic Inventories Project.

Muir PS, Mattingly RL, Tappeiner JC II, Bailey JD, Elliott WE, Hagar JC, Miller JC, Peterson EB, Starkey EE. 2002. Managing for biodiversity in young Douglas-fir forests of western Oregon. USGS/BRD/BSR-2002-0006. Corvallis, OR, US Department of the Interior, US Geological Survey, Forest and Rangeland Ecosystem Science Center.

Olson DH, Anderson PD, Frissell CA, Hartwell HW Jr., Bradford DF. 2007. Biodiversity management approaches for stream–riparian areas: Perspectives for Pacific Northwest headwater forests, microclimates, and amphibians. Forest Ecology and Management 246:81-107.

Oregon Department of Fish and Wildlife. 2006. Oregon Conservation Strategy. Salem, OR, Oregon Department of Fish and Wildlife.

Oregon Department of State Lands, Oregon Department of Forestry, Oregon Watershed Enhancement Board, and Oregon Department of Fish and Wildlife. 2010. Guide to placement of wood, boulders and gravel for habitat restoration. Final draft January 1, 2010. Portland, OR, Oregon Department of Forestry and Oregon Department of Fish and Wildlife.

Primozich, D, Bastasch R. Draft Willamette Subbasin Plan. 2004. Portland, OR, Northwest Power and Conservation Council (prepared by the Willamette Restoration Initiative).

Rocchio J. 2011. Ecological integrity assessment: North Pacific lowland riparian forest and shrubland. Olympia, WA, Washington Department of Natural Resources.

Runyon J, Salminen E. 2005. Clackamas basin summary fish populations and aquatic riparian habitat. Boise, ID, Watershed Professionals Network, prepared for the Clackamas River Basin Council.

Salminen E. 2005. Clackamas Basin summary watershed overview. Clackamas, OR, Clackamas River Basin Council.

Shandas V, Alberti M. 2009. Exploring the role of vegetation fragmentation on aquatic conditions: Linking upland with riparian areas in Puget Sound lowland streams. Landscape and Urban Planning 90:66-75.

Stanley AG, Kaye TN, Dunwiddie PW. 2008. Regional strategies for restoring invaded prairies: Observations from a multi-site, collaborative research project. Native Plants Journal 9:247-254.

The Intertwine Alliance. 2012. Biodiversity guide for the greater Portland-Vancouver region. Portland, OR, The Intertwine Alliance.

The Intertwine Alliance. 2012. Regional Conservation Strategy for the Greater Portland-Vancouver Region. Portland, OR, The Intertwine Alliance.

The Nature Conservancy. 2003. The Five-S Framework for site conservation. Third edition.

The Nature Conservancy. 2007. Conservation action planning handbook. Arlington, VA, The Nature Conservancy.

Thom BA, Kavanagh PS, Jones KK. 2000. Reference site selection and survey results 2000, Oregon Plan for Salmon and Watersheds. Monitoring Report No. OPSW-ODFW-2001-6. Portland, OR, Oregon Department of Fish and Wildlife. Aquatic Inventories Project.

US Fish and Wildlife Service. 2010. Recovery plan for the prairie species of western Oregon and southwestern Washington. Portland, OR, US Fish and Wildlife Service.

Vesely DG, Rosenberg DK. 2010. Wildlife conservation in the Willamette Valley's remnant prairie and oak habitats: A research synthesis. Corvallis, OR, Oregon Wildlife Institute.

Wang L, Lyons J, Kanehl P, Bannerman R. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. Environmental Management 28:255-266.