



Vegetation Inventory Project

Whitman Mission National Historic Site

Natural Resource Report NPS/UCBN/NRR—2012/520



ON THE COVER

Looking southwest from Whitman Memorial Hill at the Millpond and Mission Grounds
Photograph by: Northwest Management, Inc.

Vegetation Inventory Project

Whitman Mission National Historic Site

Natural Resource Report NPS/UCBN/NRR—2012/520

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Executive Summary

Whitman Mission National Historic Site (WHMI) is located in southeast Washington near the town of Walla Walla. Established in 1939, the 100 acre site (along with a 40-acre Living Trust Area to the west of WHMI) memorializes the tragic killing of 13 Methodist missionaries by local Native Americans at the historic Waiilatpu Mission in 1847. Located near the confluence of the Walla Walla River and Mill Creek, WHMI today commemorates the United States westward expansion along the Oregon Trail while preserving many of the original mission building foundations, gravesites and memorials associated with the massacre.

The vegetation at WHMI is heavily influenced by moisture and human activity. Starting at the rivers edge long riparian corridors of cottonwood (*Populus* spp.) and willow (*Salix* spp.) forests give way to broad floodplain terraces containing a mix of tall grasses, planted trees and mowed lawns. The flat nature of WHMI's landscape is interrupted along the east boundary by the prominent Memorial Shaft Hill and its steep slopes. The dry and steep nature of the hillslopes support unique pockets of native (*Pseudoroegneria spicata*) bluebunch wheatgrass and Idaho fescue (*Festuca idahoensis*) prairie.

Revegetation of native plants at WHMI has been an important objective for park management for over fifty years and has been on-going and sustained since 1985. Recent restoration efforts strive to return the entire site to a historic condition similar to the 1800's Mission era. Restoration goals include replacing cheatgrass (*Bromus tectorum*) and other non-native grasses with Great Basin wildrye (*Leymus cinereus*) and similar tall grass species and planting native riparian plants along a natural waterway that was diverted in the past by an irrigation canal. To better understand the native, non-native and restored plant community dynamics at WHMI the NPS Vegetation Inventory Program (NVIP) funded a vegetation inventory and mapping project in 2006 as part of the larger Upper Columbia Basin Inventory and Monitoring Network (UCBN) network-wide inventory program.

A three-year, three-phase program was initiated to complete the tasks of sampling, classifying, and mapping the plant associations (i.e. communities) and vegetation alliances within WHMI. Phase-one, directed by UCBN staff in conjunction with Northwest Management Incorporated (NMI), Idaho State University (ISU), and S.M. Stoller Corporation (Stoller) resulted in the plant association and vegetation alliance classification using the National Vegetation Classification System (NVCS). Vegetation classification was based on the 2010 field sampling of 71 representative classification plots located within the boundary of WHMI and the adjoining Land Trust Area. Analysis of the classification plot data by ISU and Stoller ecologists occurred in 2010. Through this process 13 distinct plant associations were identified as were four vegetation alliances.

Phase-two, directed by NMI and Cogan Technology, Inc. (CTI) resulted in creation of the digital vegetation and land use map and project geodatabase. Mapping was conducted primarily by interpreting vegetation-specific and non-vegetated site signatures from the 2009 and 2011 National Aerial Imagery Program (NAIP) ortho-photo products. CTI reliably discerned 24 vegetation and 14 land use/land cover map units. The mapping process relied on manual digitizing of homogenous photo-signatures supported by on-site verification. All interpreted data

were converted to Geographic Information System (GIS) databases. The final map layer contains vegetation and land-use polygons with corresponding map class, NVCS, and modifier attributes.

Draft maps were printed, field tested, reviewed, and revised based on the field observations. Following verification, edits were applied to create the final vegetation map product for accuracy assessment (AA). In Phase-three the AA was conducted by NMI ecologists during the 2011 field season. Sampling required selecting 93 random point locations throughout the study area based on frequency and abundance for each vegetation map unit. AA locations were accessed by NMI field crews, the vegetation at each target was keyed to the proper association, and representative photographs of each location were acquired. The field data were compared to the electronic vegetation map and revealed an overall thematic accuracy of 92%.

Completion of the project in Phase-four included producing the standard project deliverables as described and presented in this report and the accompanying DVD. Deliverables include:

- The *Final Report* that includes keys to the vegetation types and imagery signatures, AA information, and a summary of the methods and results;
- A *Spatial GIS Database* containing spatial data for the vegetation units, classification plots, and AA points;
- *Digital Photos* from sample plots and miscellaneous park views;
- *Metadata* for all spatial data [Federal Geographic Data Committee (FGDC)-compliant];
- *Vegetation Descriptions and Photo-Signature Key* to the map units and plant associations/vegetation alliances.

A Summary of the projects statistics is included below:

Field Work:

- 2010 Plot Sampling = 71 Classification Plots
- 2011 Accuracy Assessment = 93 Points

Classification:

- 13 NVC Plant Associations and 4 Alliances

GIS Database:

- Project Size = 5,175 acres (2,096 hectares)
 - o Whitman Mission National Historic Site = 100 acres (41 hectares)
 - o Land Trust Area = 40 acres (16 hectares)
 - o Environs = 5,175 acres (2,096 hectares)
- Base Imagery = 2009 & 2011 National Agriculture Imagery Program (NAIP), True-color, 3-band, 1-meter, 1:12,000-scale ortho-images for Walla Walla County, Washington
- Thirty-eight map units (24 vegetated and 14 land-use/land-cover)
- Minimum Mapping Unit = ½ hectare (1.24 acres), modified to ¼ acre (0.1 hectare) for wetlands and riparian polygons
- Total Size = 1,050 Polygons
- Average Polygon Size = 4.9 acres (2.0 hectares)

Overall Thematic Accuracy = 92%

Acknowledgments

This unique vegetation inventory project required the enthusiasm and energy of several individuals over three years to complete. The dedication of everyone participating helped to produce the product described herein that we, the authors, thankfully acknowledge.

Foremost, we thank Lisa Garrett and the UCBN staff (including Tom Rodhouse and Gordon Dicus) who provided contracting, data management, and technical review through all aspects of this project. Special recognition is also credited to Dr. Karl Brown and Tammy Cook with the NPS Vegetation Inventory Program for prioritizing this project and providing funding. Without the financial support from the NPS Vegetation Inventory Program this project would not have been possible.

The WHMI vegetation inventory project benefited greatly from the planning and ecological expertise contributed by Amy Forman, Jeremy Shive (S.M. Stoller, Corporation), and Ken Aho (Idaho State University). We would like to especially acknowledge all of the long days and hard work put in by our field crew members including ecologists and botanists from Northwest Management Incorporated staff.

We would also like to recognize the staff at WHMI including Terry Darby (Superintendent) and Roger Trick (Chief of Interpretation and Resources Mangement) who helped review, update and approve this project.

Introduction

Background

In 1994, the U.S. Geological Survey (USGS) and National Park Service (NPS) formed the USGS-NPS Vegetation Mapping Program to cooperatively inventory and map the vegetation in the system of National Parks. Presently managed as the National Vegetation Inventory Program (NVIP) by the NPS Natural Resource Program Center, Biological Resource Management Division, program goals are to provide baseline ecological data for park resource managers, obtain data that can be examined in a regional and national context, and provide opportunities for future inventory, monitoring, and research activities (FGDC 1997, 2008 Grossman et al. 1998).

At program initiation, the NVIP adopted the U.S. National Vegetation Classification (USNVC) (The Nature Conservancy and Environmental Systems Research Institute 1994a, Grossman et al. 1998) as a basis for the *a priori* definition of vegetation units to be inventoried. The Federal Geographic Data Committee (FGDC) adopted a modified version of the upper (physiognomic) levels as a federal standard (FGDC-STD-005) (FGDC 1997, 2008). This standard was hereafter termed the National Vegetation Classification Standard (NVCS). The NVCS established a federal standard for a complete taxonomic treatment of vegetation in the U.S. at eight physiognomic levels, they are: (1) Formation Class, (2) Formation Subclass, (3) Formation, (4) Division, (5) Macrogroup, (6) Group, (7) Alliance, and (8) Association, with the finest level being the plant association. Alliances are usually aggregations of associations that are physiognomically uniform and share one or more characteristic or diagnostic species. An association is defined as a plant community or type with a consistent species composition, uniform physiognomy, and homogenous habitat conditions (Flahault and Schroter 1910). The plant association or community type is determined by environmental patterns and disturbance processes.

The NVCS established conceptual taxonomic levels for the floristic units of alliance and association, largely following the USNVC, but did not offer a taxonomic treatment for the floristic levels because of the immense scope of establishing robust floristic units for the entire U.S. The FGDC standard requires that federally funded vegetation classification efforts collect data in a manner that enables cross-walking the data to the NVCS (i.e., the physiognomic levels) and sharing between agencies, but does not require use of that standard by agencies for internal mission needs. NatureServe (2011) maintains a treatment of floristic units (alliances and associations), which, though not a federal standard, are used as classification and mapping units by the NVIP whenever feasible. For purposes of this document, the federal standard (FGDC 1997, 2008) is denoted as the NVCS; the USNVC will refer exclusively to the NatureServe treatment for vegetation floristic units (alliances and associations only).

Use of the NVCS as the standard vegetation classification system is central to fulfilling the goals of the NVIP because it:

- is vegetation based;
- uses a systematic approach to classify a continuum;
- emphasizes natural and existing vegetation;
- uses a combined physiognomic-floristic hierarchy;
- identifies vegetation units based on both qualitative and quantitative data; and
- is appropriate for mapping at multiple scales.

The use of the NVCS and the NVIP vegetation inventory protocols facilitate effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS and by other federal and state agencies. The vegetation maps and associated information support a wide variety of resource assessment, park management, and planning needs. In addition they can be used to provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental conditions and ecological processes across the landscape.

The NVCS has primarily been developed and implemented by The Nature Conservancy (TNC) and the network of State Natural Heritage Programs over the past forty years (TNC 1994a; Grossman et al. 1998). The NVCS is currently supported and endorsed by multiple federal agencies, the FGDC, NatureServe, State Heritage Programs, and the Ecological Society of America. Refinements to the classification occur in the process of application, which lead to ongoing revisions that are reviewed both locally and nationally. TNC and NatureServe have made available a two-volume publication presenting the standardized classification, providing a thorough introduction to the classification, its structure, and the list of vegetation types occurring within the U.S. as of April 1997 (Grossman et al. 1998). *Volume I: The National Vegetation Classification Standard* can be accessed electronically on the Internet at: <http://www.natureserve.org/publications/library.jsp>. NatureServe has since superseded *Volume II* of the publication (the classification listing), providing regular updates to ecological communities in the U.S. and Canada. This online database server, NatureServe Explorer®, can be accessed electronically on the Internet at: <http://www.natureserve.org/explorer> (2011).

NPS Vegetation Inventory Program

The Director of the NPS approved the Natural Resource Challenge (NRC) in 1999 to encourage the NPS to focus on the preservation of the U.S. natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). The NRC provided funding for 12 baseline inventories to be completed in each of 270 parks with significant natural resources. The vegetation inventory and mapping is considered one of the 12 baseline inventories. Through the NRC, 270 NPS units were organized into 32 networks in 2000 for the purpose of accomplishing natural resource inventory and monitoring projects.

The NVIP is a cooperative effort between the NPS and the USGS to classify, describe, and map vegetation communities in more than 270 national park units across the U.S. The scope of this effort is large and implementation is complex due to the fact that vegetation species and communities can be unique from park-to-park. When the NVIP is completed the final products will assist park managers to: 1) identify and conserve plant biodiversity; 2) better understand resources and processes including wildlife habitat relationships and wildland fires; and 3) provide the necessary tools to better manage resource issues including exotic species invasions, insect effects, and diseases.

The primary objective of the NVIP is to produce high-quality, standardized maps and associated data sets of vegetation and other land cover occurring within parks and selected adjacent environments (environs). This information fills data gaps and complements a wide variety of resource assessments, park management, and conservation needs. For example, in Sequoia and Kings Canyon National Parks, the 2007 vegetation map and digital database provided tools to better manage the foxtail pine (*Pinus balfouriana* ssp. *austrina*), an endemic species to the southern Sierra Nevada Mountains that can live for more than 1,000 years.

The NVIP uses well-established procedures that are compatible with other agencies and organizations including the NVCS, a system that is integrated with the major scientific efforts in the taxonomic classification of vegetation, and is a FGDC standard. In addition, stringent quality control procedures ensure the reliability of the vegetation data and encourage the use of resulting maps, reports, and databases at multiple scales.

A complete vegetation mapping project for an NPS unit includes the following products, at a minimum:

- Detailed vegetation report
- Digital vegetation map
- Vegetation classification plot data
- Accuracy assessment data and analysis
- Dichotomous vegetation key
- Photo-interpretation key

Maps are produced in Universal Transverse Mercator (UTM) coordinates North American Datum 1983 (NAD 83) with a 1:24,000 scale and a minimum mapping unit of 0.5 hectares (1.24 acres). The vegetation maps must meet the National Map Accuracy Standards for positional accuracy, and the minimum class accuracy goal across all vegetation and land cover classes of 80 percent.

Upper Columbia Basin Network

The specific decision to classify and map the vegetation within and adjacent to WHMI was made in response to guidelines set forth by the NPS Natural Resources Inventory and Monitoring Program and implemented by the Upper Columbia Basin Network (UCBN), which includes nine NPS units located in four states of the inland Northwest (Figure 1). The UCBN was organized to inventory and monitor status and trends for selected natural resources and the network facilitates collaboration, information sharing, and economies of scale in natural resource monitoring among its member parks. The inventory and monitoring information gathered by UCBN is used by NPS and park unit resource managers to guide management decisions, to inform scientific research, and to provide public education. One goal of the NPS service-wide monitoring program is to collect, manage, and provide resource data to better understand the dynamic nature and condition of park-managed ecosystems and to provide reference points for comparisons with other management types and possibly with altered environments. The development of a vegetation classification to the vegetation alliance/plant association level and associated GIS map and database for each park is viewed as a high priority in reaching this goal.

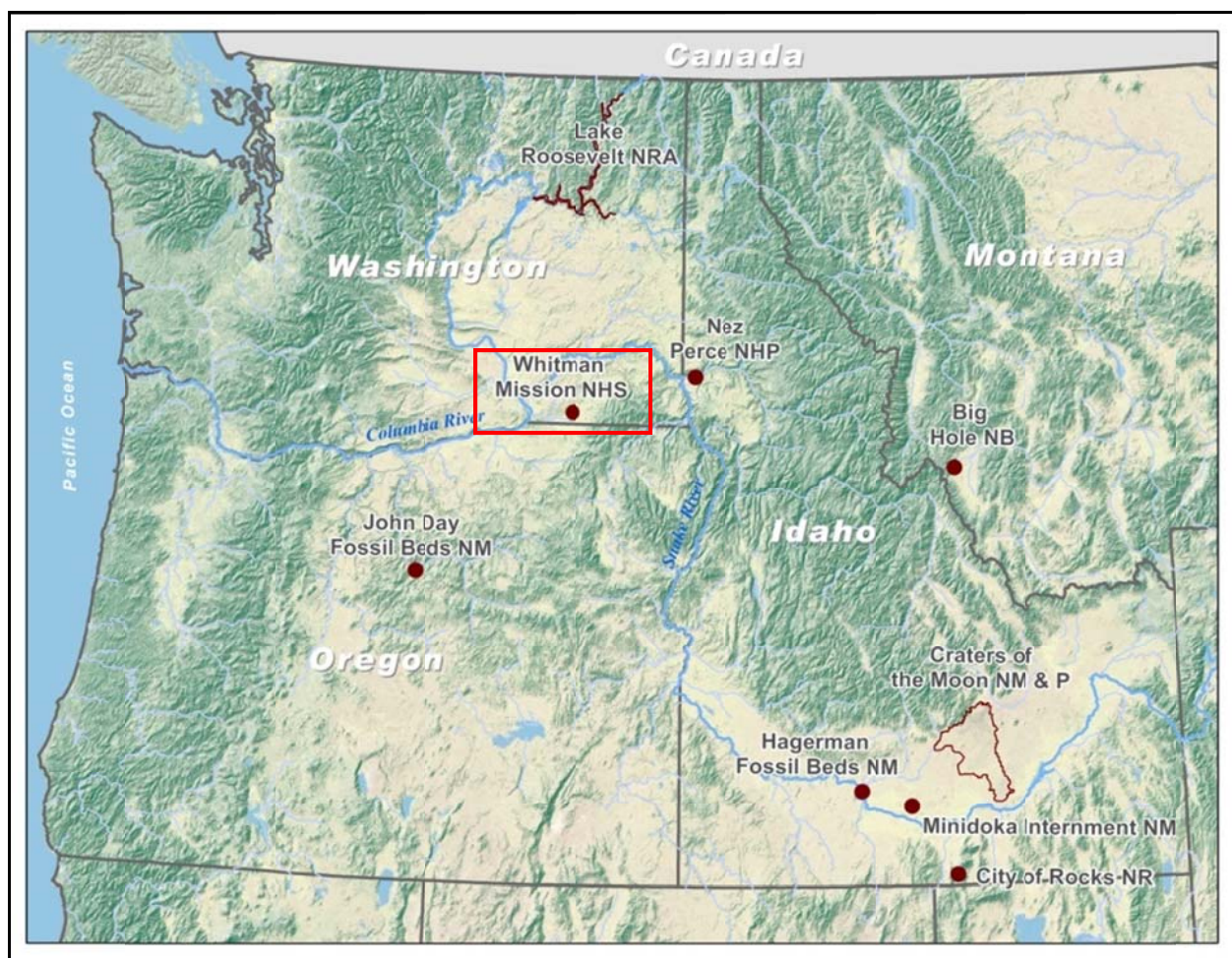


Figure 1. Map of UCBN showing the location of WHMI in the network.

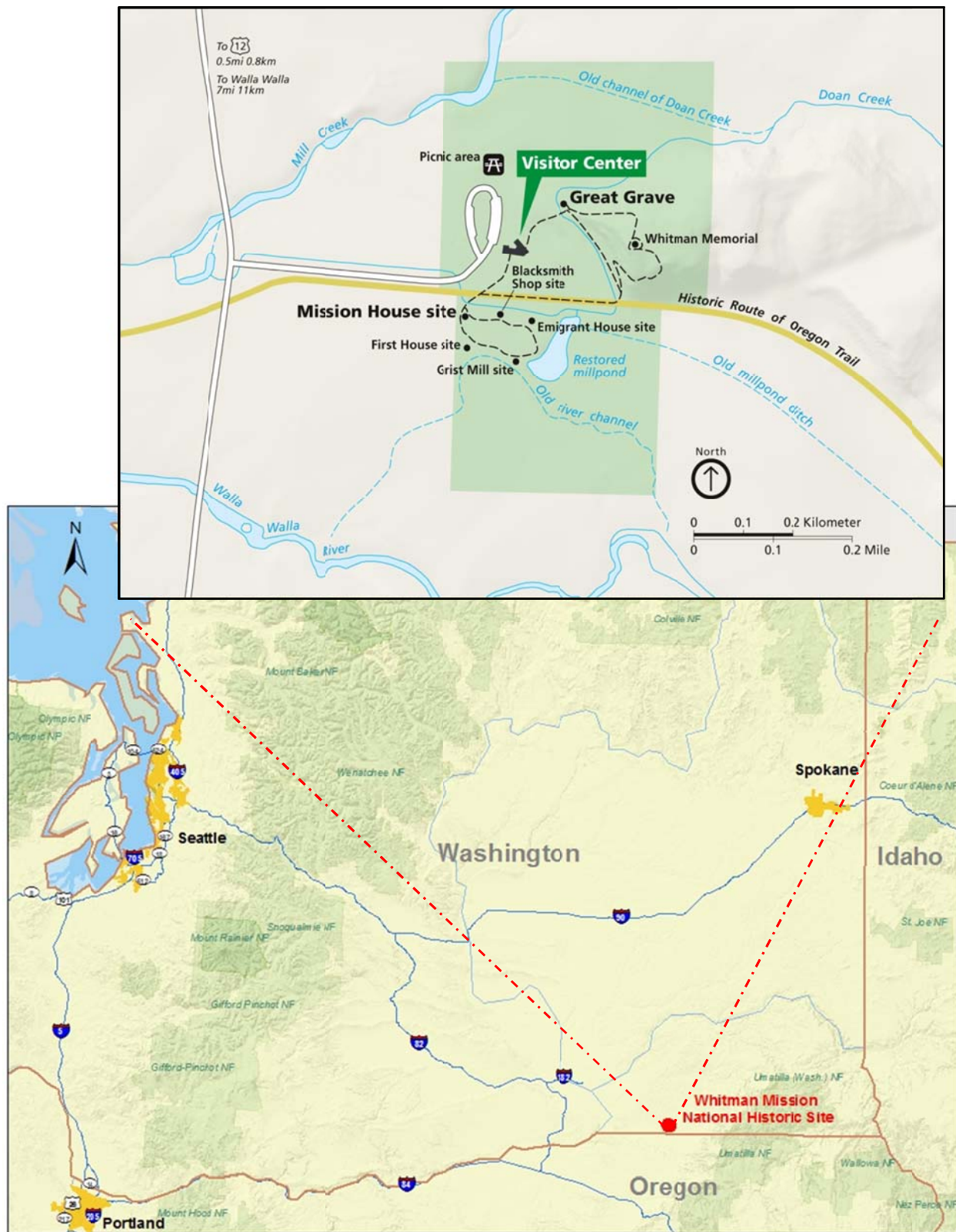
Whitman Mission National Historic Site

Whitman Mission National Historic Site (WHMI) was created by the NPS in 1936 as a public memorial to Dr. Marcus Whitman and his wife Narcissa. From 1836 to 1847 the Whitman's, along with other Methodist Church ministers and their families managed the Waiilatpu Mission near the present-day town of Walla Walla, Washington. Named as the "Place of the Rye Grass" the Waiilatpu Mission was one of three Methodist missions established in the region. While at Waiilatpu, the Whitman party ministered to the physical and spiritual needs of the Cayuse tribe of Native Americans and assisted emigrants on the Oregon Trail. As frontier missionaries the Whitman's strived to teach the Cayuse tribe how to become Christian farmers while running a small school and clinic. Unfortunately in 1847 the Whitmans along with eleven others were slain in a raid by Cayuse braves likely as a misguided reprisal for the measles epidemic that was decimating the tribe. Shortly after the massacre the Whitman's become local martyrs and their mission and gravesites became revered (Drury 1986).

After many years of local caretaking the remaining mission building foundations and gravesite along with 45.94 acres located near the Walla Walla River (southwest corner of Washington State) was deeded to the NPS for long-term preservation in 1940. In addition to the original WHMI site the NPS purchased 46.71 acres north of the mission grounds in 1960 and was deeded another narrow corridor of 5.6 acres from Walla Walla County in 1961 to act as the main park entrance from U.S. Highway 12 along Swegle Road (Figure 2). The NPS actively preserves and maintains the site of the actual Waiilatpu Mission and school, the mass grave (i.e the Great Grave) containing the massacre victim remains, the Whitman Memorial Shaft, and a Visitor Center with a small museum (Figure 3).

The NPS is also responsible for relating to the public the events that took place at the Mission and its role in western migration and settlement along the Oregon Trail. Located along the trail, WHMI is an important reminder of the western pioneer history and America's westward expansion and settlement in the 1800's. The massacre and end of the Mission led to a war between the local militia and the Cayuse in 1848 and the arrival of federal troops in 1849. The ensuing 1855 treaties resulted in opening up the territory to pioneer settlement using the Oregon Trail and other routes and did much to shape the current population demographics of the region (NPS 2011a). Today visitors to WHMI can view the Walla Walla oxbow river site chosen by the Whitmans for their mission and see remnants of the actual Oregon Trail corridor (Figure 3).

Along with the many important cultural features, WHMI also contains significant natural resources that are being actively managed by the NPS. Chief among these is the reintroduction of native plants and maintaining the overall natural character of the vegetation as it appeared during the time of the Waiilatpu Mission. The vegetation growing in this area at the time of the Whitman's likely included extensive perennial prairie grasses and riparian woodlands and shrublands. Through the years the native vegetation was gradually replaced by more semi-natural pasture grasses and orchard trees as agricultural activity in the area intensified. Through active removal, prescribed fires and plantings the vegetation is slowly being returned to a more native state that gives visitors a better sense of how the area looked in the 1840's (NPS 2011a).



Source: NPS (top), CTI (bottom)

Figure 2. Location and Park Map of Whitman Mission National Historic Site.



Great Grave



Memorial Shaft Hill



Millpond (left) and Mission Grounds (right)



Mission Site with Building Foundation Outlines



WHMI Visitor Center and Park Entrance Road



Oregon Trail Corridor at WHMI

Source: NPS and NMI

Figure 3. WHMI cultural sites and landscape photos.

Natural Setting

Whitman Mission National Historic Site is located in southeast Washington State in Walla Walla County along the confluences of the Walla Walla River, Mill Creek, and Doan Creek (all tributaries of the Columbia River located to the west of WHMI). The rivers, streams and basins are important features of this region's landscape, responsible for creating expansive floodplains, steep banks and rolling hills. As the rivers flooded and changed course they scoured broad floodplains through ancient lake beds and wind-blown (loess) deposits leaving behind sculpted knolls, hills and winding oxbows. WHMI is located on one of the dry oxbow bends of the Walla Walla River as it passes through the Columbia Basin and the Pleistocene Lake Basin ecoregions (Figure 4) of the Palouse Prairie Region of eastern Washington State. The bedrock in this area is composed of layered flows of Columbia River Basalt (Miocene and Pliocene ages) and is over 3,000 feet (915 m) thick. The uppermost layer of basalt at Whitman Mission is approximately 524 feet (160 m) below the surface and subsequent deposits above the basalt bedrock include mixtures of Pleistocene clay and gravel (NPS 2011a).



Source: CTI and U.S. Environmental Protection Agency

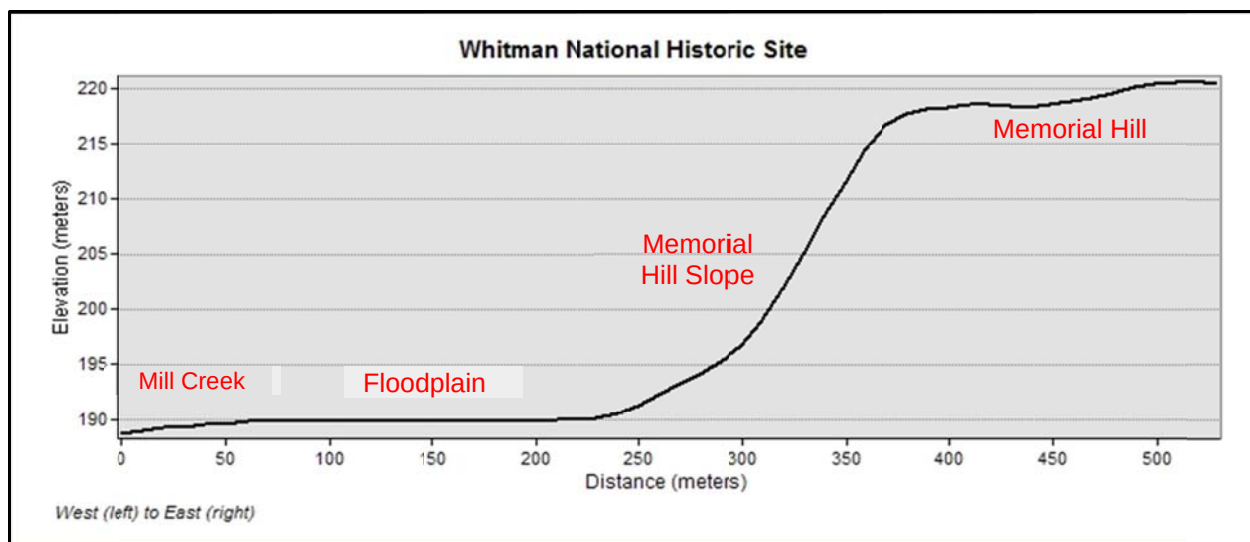
Figure 4. WHMI ecoregion location map.

Viewing WHMI from the ground reveals a very flat landscape interrupted by Memorial Shaft Hill (Figure 5) that is topped by a prominent obelisk (shaft) monument erected in memorial to the Mission victims. Memorial Shaft Hill is composed of loess and ancient sediments that escaped flooding erosion and represents the highest elevation for WHMI at 724 feet (221 meters) above sea level. The rest of the Historic Site is at 615 feet (187 meters) above sea level and generally slopes from east to west following the river and creeks (Figure 6) (NPS 2011a).



Source: USGS 10m DEM and NAIP 2009

Figure 5. WHMI 3d landscape overview map.



Source: CTI and USGS 10m DEM

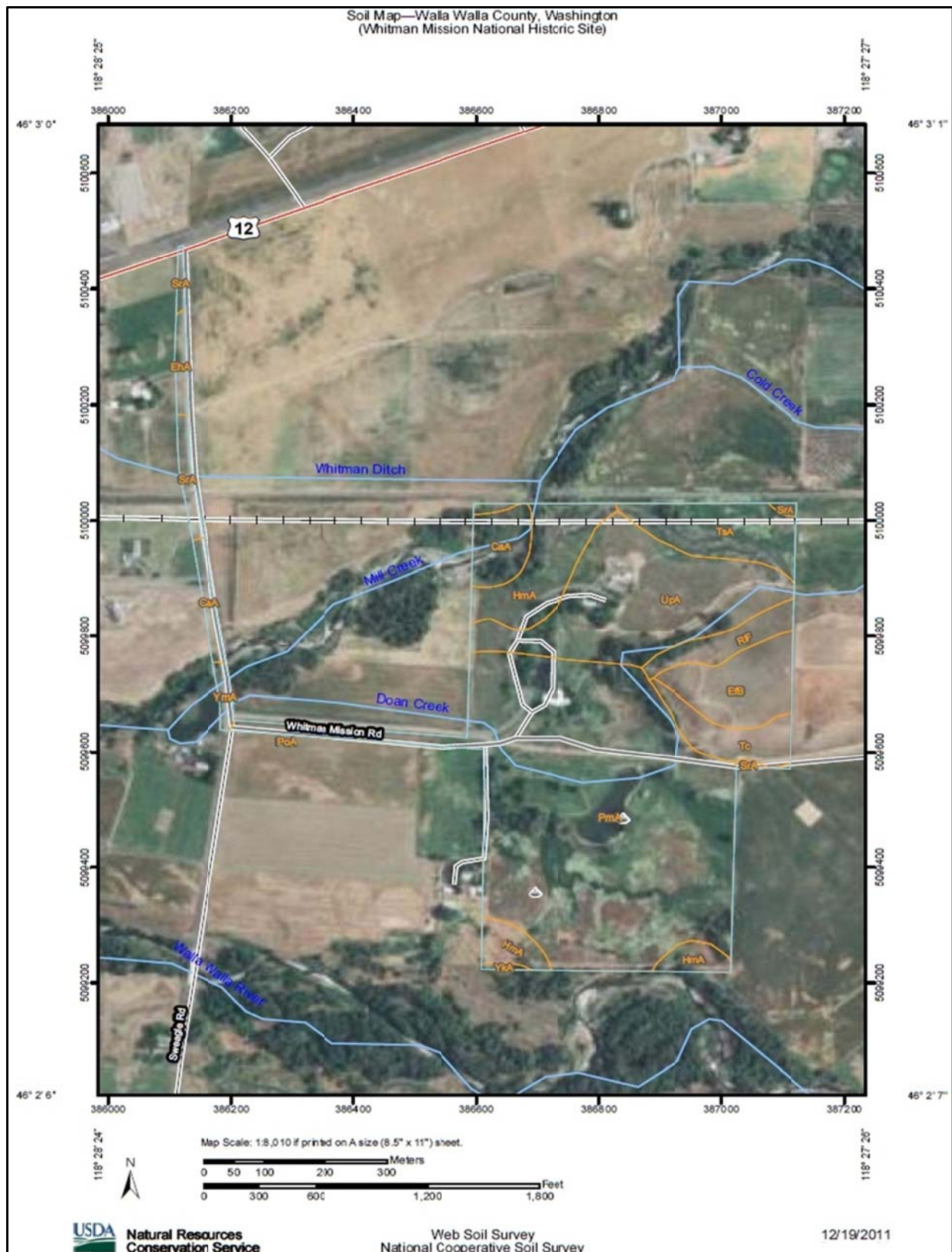
Figure 6. Representative cross-section of WHMI's topography.

WHMI's close proximity to multiple streams results in a high average water table that ranges from one to four feet (0.3 – 1.2 meters) from the surface at WHMI's lowest elevation. The climate for WHMI is relatively mild with sunny and hot summers and cloudy and cold winters. Summer temperatures vary from highs around 92° Fahrenheit (33° Celsius) and lows around 62° F (17° C) contrasted with winter average temperatures of 40°F (4° C) for highs and 20° F (-7° C) for lows (NPS 2011a).

The majority of the soils at Whitman Mission were formed from numerous flooding and sedimentation episodes (along with small remnant loess or wind-blown deposits on Memorial Hill) resulting in various layers of gravel, organic soil, silt loam, loess, hard pan, and clay. There are 13 soil types found at WHMI (Table 1) including the entrance road easement area. If you exclude the entrance road there are nine main soil types and eight are classified as silt loams with the exception being terrace escarpments found on the southside of Memorial Hill (Figure 7) (Harrison et al. 1964).

Table 1. Soil unit summary table for WHMI.

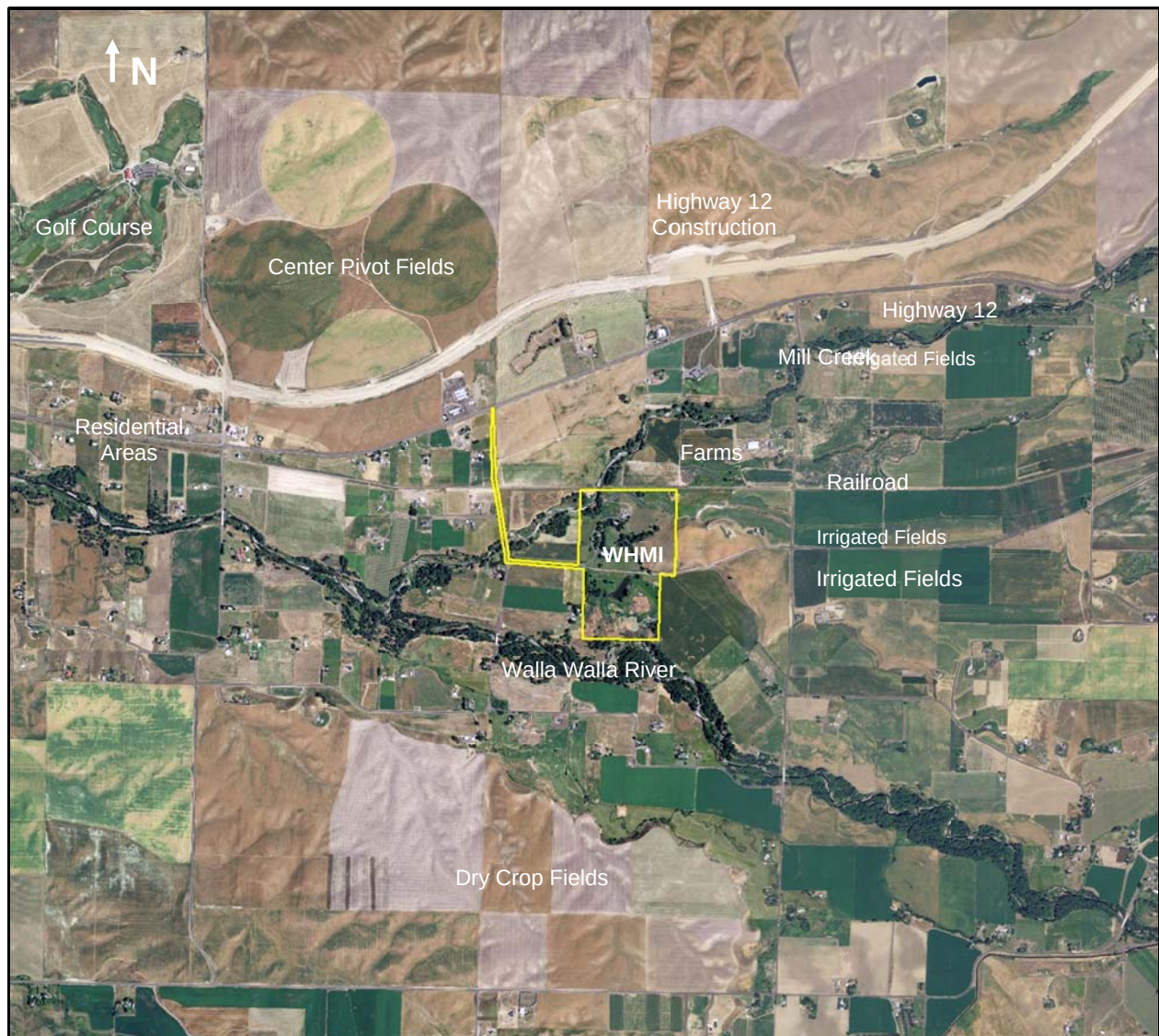
Map Unit Symbol	Map Unit Name	Topographic Position	WHMI Location	WHMI Acres	WHMI %
CaA	Catherine silt loam	0 to 3 percent slopes	Mill Creek	3.9	3.9%
EfB	Ellisforde silt loam	3 to 8 percent slopes	Memorial Hill	5.7	5.6%
EhA	Ellisforde silt loam	0 to 3 percent slopes	Entrance Road	0.8	0.8%
HmA	Hermiston silt loam	0 to 3 percent slopes	Floodplain	8.8	8.8%
PmA	Pedigo silt loam	0 to 3 percent slopes	Mission Grounds	48.6	48.4%
PoA	Pedigo silt loam, overwashed	0 to 3 percent slopes	Entrance Road	1.0	1.0%
RIF	Ritzville silt loam	45 to 60 percent slopes	Memorial Hill	2.7	2.7%
SrA	Stanfield silt loam	0 to 3 percent slopes	Entrance Road	1.7	1.7%
Tc	Terrace escarpments	escarpments	Memorial Hill	3.4	3.4%
TsA	Touchet silt loam	0 to 3 percent slopes	Northern Waterways	6.2	6.1%
UpA	Umapine silt loam, leached surface	0 to 3 percent slopes	Administrative Area	16.9	16.8%
YkA	Yakima gravelly silt loam	0 to 3 percent slopes	Southern Boundary	0.2	0.2%
YmA	Yakima silt loam	0 to 3 percent slopes	Entrance Road	0.6	0.6%



Source: USDA Web Soil Survey 2011

Figure 7. WHMI Soil Survey Map.

Today WHMI's landscape is greatly influenced by rural agricultural and residential influences and the close proximity of the historic site to the city of Walla Walla, Washington located about 7.5 miles to the east. Bisecting the park in half is the Oregon Trail corridor that joins Last Chance Road to the east and Sweagle Road to the west. The Sweagle Road intersects to the north with State Highway 12 and acts as the main entrance to the Historic Site. Surrounding WHMI on all sides are small residential acreages and large farming operations and inside the site are channels and ditches used for crop and field irrigation. Included in the 2-km mapping environs of this project are other prominent land-use features such as a railroad, golf course, circular center-pivot fields, rectangular dry crop fields, and new Highway 12 construction (Figure 8).

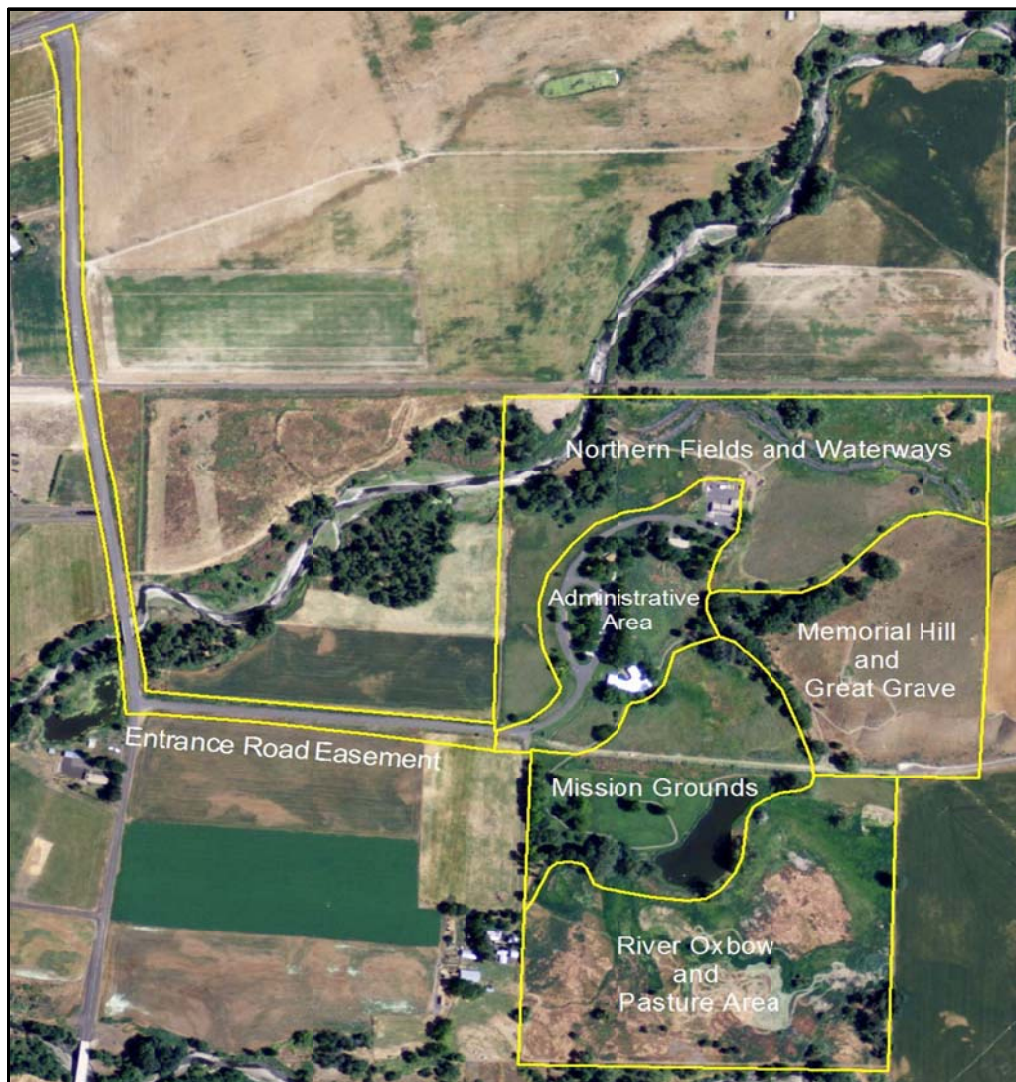


Source: NAIP 2009

Figure 8. WHMI overview map highlighting various land uses in the area.

Vegetation

WHMI vegetation is relatively diverse and includes landscaped lawns, riparian shrubs/trees, planted trees, native hillside grasses, non-native pasture grasses, disturbance-tolerant shrubs, and revegetated areas. For the purposes of this project the vegetation at WHMI can be separated into six general landscape categories based on the original vegetation restoration management units first proposed by Gilbert (1984). From north to south these include the: (1) Entrance Road Easement, (2) Northern Fields and Waterways, (3) Administrative Area, (4) Memorial Hill and Great Grave, (5) Mission Grounds, and (6) River Oxbow and Pasture Area (Figure 9). Most of the plants occurring in the various landscape categories are influenced by management and cultural activities ranging from lawn mowing to native plant restoration in former agricultural fields and drainages.



Source: NAIP 2009

Figure 9. WHMI overview map highlighting general landscape areas.

Starting with the entrance road, the roadside vegetation is primarily exotic grasses and disturbance-oriented shrub communities consisting of cheat grass (*Bromus tectorum*) and rabbitbrush (*Ericameria nauseosa* and *Chrysothamnus viscidiflorus*). Next, the Northern Fields and Waterways contain a mix of former agricultural fields now supporting annual and perennial grasses and weedy species intersected by various linear riparian corridors with shrubs and trees. Included in this area are linear restoration sites along Doan Creek that have been replanted with willows and alder using two long linear mulch cloth applications. Continuing south the Administrative Area is mostly made-up of mowed Kentucky bluegrass (*Poa pratensis*) lawns and various deciduous trees. To the east, Memorial Hill and the Great Grave is outlined by margins of deciduous trees that give way to native grasses and shrubs on the ascending slopes and summit. Common species here include bluebunch wheatgrass (*Pseudoreognaria spicata*), Idaho fescue (*Festuca idahoensis*) and rabbitbrush species. The Mission Grounds is also bordered by deciduous trees and contains manicured lawns of Kentucky bluegrass. The southern 28-acre River Oxbow and Pasture Area is another revegetation site where WHMI staff have planted native Great Basin wildrye (*Leymus cinereus*) along with two species of non-native grasses, Reed canary grass (*Phalaris arundinacea*) and tall wheatgrass (*Thinopyrum ponticum*) to better represent the historic scene of the Mission.

Occurring across all of WHMI's landscape categories are vegetation communities comprised of both native and non-native plant species in varying distributions (Figure 10). Hydrology and topology play an important role in the composition of these communities with flatter, drier areas containing more non-native or planted pasture and lawn grasses consisting of Kentucky bluegrass (lawns), cheat grass (old fields) and intermediate wheatgrass (*Thinopyrum intermedium*) (old pastures). Drier and steeper slopes on Memorial Hill contain remnant bluebunch wheatgrass and Idaho fescue native grass communities. Dry shrublands at WHMI are comprised of predominately rabbitbrush with yellow rabbitbrush (*Chrysothamnus viscidiflorus*) occurring on the flosslopes of Memorial Hill and rubber rabbitbrush (*Ericameria nauseosa*) growing throughout the floodplain on disturbed soils. Native wetland and riparian communities occur in the low-lying areas next to streams and where the water table is close to the surface. Common riparian communities at WHMI include narrow bands of willows (*Salix spp.*), cottonwoods (*Populus spp.*), dogwoods (*Cornus spp.*), blackberries (*Rubus spp.*), and elderberries (*Sambucus spp.*). Slightly drier areas on clay bottomlands and around seepage areas contain tall grass patches that were primarily composed of Great Basin wildrye but now include other non-natives such as Reed canary grass and tall wheatgrass.



Source: All Photos -NMI

Figure 10. Common WHMI vegetation types.

Mesic



Orchard and Planted Trees



Trees

Mixed Semi-natural / Landscape Trees



Great Basin Wildrye Herbaceous Vegetation



Shrubs

Blackberry and Elderberry Shrublands



Riparian

Reed Canarygrass - Tall Wheatgrass Herbaceous Vegetation and Willow Shrublands



Cottonwood and Willow Woodlands

Wet

Source: All Photos –NMI and NPS

Figure 10. Common WHMI vegetation types (continued)

Revegetation of native plants at WHMI has been an important objective for park management for over fifty years and has been on-going and sustained since 1985. Recent restoration efforts have been focused primarily along Doan Creek, the Doan Creek irrigation ditch, and the oxbow and pasture areas of the Walla Walla River (Figure 11) (Garrett and Coyner 2003). These areas are being actively managed to meet the objectives of the established natural zone along Doan and Mill Creeks and to return the entire site to a historic condition similar to the Whitman's era (Gilbert 1984). Vegetation management activities include planting, mowing, burning, and the use of herbicides to control noxious weed species such as poison hemlock, (*Conium maculatum*), yellow starthistle (*Centaurea solstitialis*), Canada thistle (*Cirsium arvense*), and Scotch thistle (*Onopordum acanthium*). The short term goal of the revegetation effort is to establish healthy stands of grass and riparian trees/shrubs that can replace weedy species. For the pasture areas both native and non-native grass species were chosen based on their ability to quickly establish healthy stands and their similarity in appearance to grasses that may have been growing here 150 years ago. For the riparian areas the tree and shrub species were planted to mimic the native shrubs and trees growing along other nearby streams.

Since the revegetation program was started, park staff has converted over 60% of WHMI from exotic grasses and weeds to more native or historically correct looking vegetation (Bell and Hinson 2009). The long-term goal is to return most of WHMI (approximately 75 acres) to an historic appearance by gradually replacing the the non-native grasses with native Great Basin wildrye and similar grasses. To this end, Great Basin wildrye has been planted in a demonstration plot next to the visitor center (Figure 11) and on 28 acres of the river oxbow area (Garrett and Coyner 2003). Also riparian shrub and tree saplings have been planted along the former Doan Creek drainageway as part of the restoration of this stream by diverting water from the irrigation canal into a re-created, meandering streambed (WWCCD 2008).



Source: NMI

Figure 11. Examples of the vegetation restoration at WHMI.

Woodlands and Forests

Deciduous forests and woodlands are relatively rare within WHMI and can be generally split into two categories, riparian woodland and forests and mixed planted or semi-natural woodlands. The riparian trees are located in stands and strips next to the millpond, the Doan and Mill Creeks, and along the Walla Walla River Channal south of WHMI. The riparian communities are comprised primarily of black and eastern cottonwoods (*Populus balsamifera* ssp. *trichocarpa* and *Populus deltoides*) and peachleah willow trees (*Salix amygdaloides*) with understories of mixed, dense deciduous shrubs consisting of dogwood, blackberry, and elderberry. Minor riparian tree species include boxelder (*Acer negundo*), birch (*Betula* spp.), and hawthorn (*Crataegus* spp.). The upland tree communities represent planted orchards, landscape trees, or escaped non-native species with mainly understories of landscaped lawns. Common trees in this category consist of Chinese elm (*Ulmus parvifolia*), Norway maple (*Acer platanoides*), Russian olive (*Elaeagnus angustifolia*), apple (*Malus* spp.), maple (*Acer* spp.), Sycamore (*Platanus* spp.), elm (*Ulmus* spp.), black locust (*Robina pseudoacacia*), English walnut (*Juglans regia*), lilac (*Syringa vulgaris*) and black ash (*Fraxinus nigra*). A planted blue spruce tree (*Picea pungens*) is the only coniferous species at WHMI; located near the main parking lot oval.

Shrublands

Shrublands at WHMI are also generally divided between those that occur in riparian settings and those that grow in uplands. Common riparian shrubs consisting of shining willow (*Salix lucida*), Himalayan blackberry (*Rubus armeniacus*), alder (*Alnus serrulata*), dogwood and blue elderberry (*Sambucus cerulea*) are found along the streambanks and minor drainages. Chokecherry (*prunus virginiana*), wild rose (*Rosa eglanteria*), mock orange (*Philadelphus lewisii*), currants (*Ribes* spp.) and sumac (*Rhus* spp.) are also found in WHMI's riparian areas but to a lesser degree. The majority of the upland shrubs consist of rabbitbrush with rubber rabbitbrush common in disturbed roadside margins and field boundaries and yellow rabbitbrush regularly occurring on dry Mission Hill slopes. Other shrub species found rarely in the uplands of WHMI include snowberry (*Symphoricarpos albus*), barberry (*Mahonia aquifolium*), greasewood (*Sarcobatus vermiculatus*) and big sagebrush (*Artemisia tridentata*).

Herbaceous Vegetation

WHMI is composed of primarily herbaceous vegetation in the form of grasslands along a broad successional and hydrologic gradient. On the drier hillslopes and hill summit are climax grass communities dominated by bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, sheep fescue (*Festuca ovina*), prairie junegrass (*Koeleria macrantha*), western wheatgrass (*Pascopyrum smithii*) and associate forbs consisting of spring draba (*Draba verna*), Queen Anne's lace (*Daucus carota*), alfilaree (*Erodium cicutarium*), and lupine (*Lupinus leucophyllus*). Transitioning to more disturbed sites, cheat grass and bulbous bluegrass (*Poa bulbosa*) become more prevalent ranging in density from sparse on footslopes to dense in bottomlands. As floodplain moisture levels increase tall, thick grasses become widespread. Great Basin wildrye likely formed the historic climax plant communities in these mesic areas but agricultural and cultural activities have greatly reduced its abundance. Some remenant and restored communities (like the ones next to the visitor center) still exist and will likely increase over time through reintroduction efforts. In most of the floodplain however large communities of non-native tall wheatgrass and reed canary grass now dominate along with thick stands of cheat grass and poison hemlock. True wetlands are rare but pockets of spikerush (*Eleocharis palustris*) and

Baltic rush (*Juncus balticus*) can be found. Plantings of pasture and turf grasses are present throughout WHMI and consist of monotypic Kentucky bluegrass lawns and former fields containing orchard grass (*Dactylis glomerata*), intermediate wheatgrass and crested wheatgrass (*Agropyron cristatum*). Early successional grassland sites around WHMI consist of weedy species like cheatgrass, thistles (*Cirsium* spp.), scotch thistle, and mountain tansy (*Descurainia richardsonii*). Native and semi-native forbs such as milkweed (*Asclepias speciosa*), nettles (*Urtica* spp.), mullen (*Verbascum* spp.), dock (*Rumex*), bindweed (*Polygonum convolvulus*), mayweed (*Anthemis cotula*), blackeyed Susan (*Rudbeckia hirta*), starwort (*Stellaria media*), and morning glory (*Convolvulus arvensis*) are rare components of most of the grassland communities at WHMI.

Sparse Vegetation#

Ture sparse vegetation communities are not found at WHMI but the natural escarpment south of Memorial Hill contains stunted cheatgrass that appears sparse when compared to denser grasslands in the surrounding areas (Figure 12). Also transisitional areas that have been recently mowed, plowed or burned may contain temporary sparse vegetation cover when compared to more established sites.



Source: NMI

Figure 12. Example of sparse cheatgrass vegetation at WHMI.

Whitman Mission Vegetation Inventory Project

WHMI is one of nine NPS units served by the UCBN Inventory & Monitoring Program. The UCBN initiated a vegetation mapping inventory for WHMI in 2006 as part of a larger effort to complete vegetation inventory maps for the network. An initial multi-year work plan was

developed for the UCBN by Cogan Technology, Inc. (CTI). This work plan provided recommendations for completing the plant community classification, digital database, and map products for each of the nine UCBN parks; it received approval from the Washington Area Service Office (WASO) Inventory Coordinator in May 2006.

In September 2007 the UCBN entered into a contract with NMI to provide all of the vegetation mapping services designated by the work plan and to administer and coordinate the UCBN vegetation mapping projects for nine park units. CTI was retained by NMI as a sub-contractor to assist on the mapping and the creation of final products. NMI started the vegetation classification plot field data collection during the summer of 2010. Following the field data collection NMI contracted with the Idaho State University and S.M. Stoller Corporation to provide the preliminary and final vegetation classification.

The classification and mapping team objectives were to secure or create the following datasets:

Spatial Data

- Aerial and ortho-photography
- Map classification based on WHMI-specific requirements
- Map classification description and key
- Spatial database of vegetation communities of WHMI
- Digital and hardcopy maps of vegetation communities
- Metadata for spatial databases
- Complete accuracy assessment of spatial data

Vegetation Information

- Vegetation classification
- Dichotomous field key of vegetation classes
- Formal description for each vegetation class
- Ground photos of vegetation classes
- Field data in database format

Scope of Work

The vegetation inventory for WHMI occurred within an approximate 5,175-acre (2,096-hectare) project area, encompassing the boundary of WHMI, the boundary of the Living Trust area west of WHMI, the entrance road (Swegle Road) easement and a general 2-km (1.25-mi) environs radius around the current WHMI Boundary (Figure 13). The final project area determination was based on management needs, financial constraints, and time limitations. The 2-km (1.25-mi) environs area was used in this project for inventory and monitoring purposes and to capture various management considerations including exotic/invasive weed locations and possible dispersal sites. Also the size of the environs corresponded to the size proposed in the work plan and matches the other vegetation mapping protocols in the UCBN.



Project Area

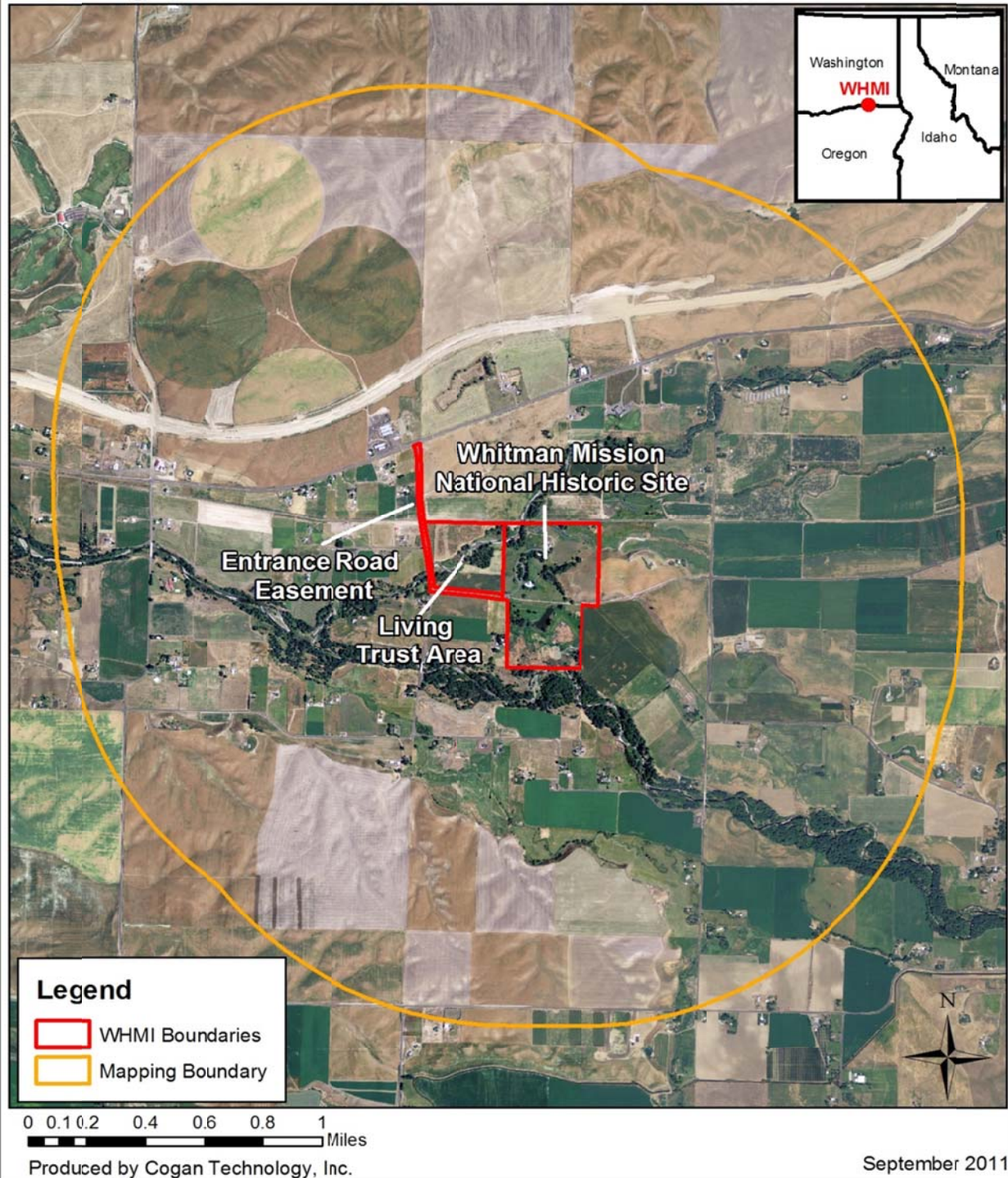


Figure 13. Map of the WHMI vegetation project boundary and land boundaries.

Methods

The vegetation mapping project at WHMI was considered to be in the “medium park” category based on the overall size of the project area (TNC 1994b). As such, the standard methodology for sampling and mapping is to visit the entire NPS site and select representative vegetation communities for sampling. The representative sites are used to characterize the vegetation types and explain their distribution across the park without having to survey each stand of vegetation. Additionally, current National Agriculture Imagery Program (NAIP) ortho-photos were used to create field maps and unique vegetation signatures were highlighted for potential sampling. In this way all of WHMI was systematically visited throughout the summer of 2010. Based on this approach the assignment of responsibilities was divided into five major steps following the 12-step guidance provided by the NVIP (NPS 2011b) and the flow chart of major steps produced for the NVIP by the USGS (Appendix A). These responsibilities included:

1. Plan, gather data, and coordinate tasks;
2. Survey WHMI to understand and sample the vegetation;
3. Classify the vegetation using the field data to NVCS standard associations and alliances and crosswalk types to recognizable map units;
4. Acquire current digital imagery and interpret the vegetation from this using the classification scheme and NVCS crosswalk;
5. Assess the accuracy of the final map product; and
6. Create the final project deliverables

All protocols for this project as outlined in the following sections are presented in documents produced by The Nature Conservancy (1994a, 1994b, and 1994c) and subsequent updates (Lea and Curtis 2010) for the NVIP and are served at: <http://biology.usgs.gov/npsveg/standards.html>.

Planning, Data Gathering and Coordination

Based on the work plan and the contract commitments by UCBN, a series of preliminary project conference calls were held in 2009 culminating in the beginning of field work in 2010. Conference calls were attended by representatives from the principle team members (including NMI, CTI, UCBN, NPS and WHMI staff). The goals of the scoping process were to: (1) provide an overview of the National Vegetation Inventory Program; (2) learn about WHMI management issues and concerns; (3) discuss availability of existing data; (4) develop a schedule; (5) discuss procedural issues and data; (6) define potential cooperators; and (7) finalize the scope of the project.

As a result of the conference calls a 2-km (1.25-mi) environs (including the entrance road easement and land trust area) was approved as the project boundary and review of the existing vegetation data and imagery yielded the following datasets to review for usefulness in this project: (1) UCBN Land cover classification and map (Wilson 2006), (2) Photo Monitoring Sites (Rodhouse (2010), and (3) all NAIP imagery for the area. A reasonable schedule was set with the project completion scheduled for 12/31/11 (Table 2).

Table 2. Project timeline for the WHMI Vegetation Inventory Project.

	2009				2010				2011			
Planning and Scoping												
Acquire Imagery												
Field Data Collection												
Image Interpretation												
Vegetation Classification												
Local & Global Descriptions												
Spatial Database												
Plant Association Field Key												
Accuracy Assessment												
Final Report and Products												

Specific work responsibilities were assigned to the following participants:

WHMI-UCBN-NPS Responsibilities

- Provide oversight and project funding;
- Provide WHMI plant list;
- Supply digital boundary files and ancillary data files;
- Assist with fieldwork and logistical considerations;
- Work with Stoller, Inc. and Idaho State University to develop the vegetation classification;
- Compile, review, and update drafts of the vegetation map, classification and report;
- Accept the final products and close the project.

NMI Responsibilities

- Provide project management;
- Coordinate the field work with WHMI staff;
- Collect representative plot data;
- Collect less detailed observations about the draft vegetation map;
- Write descriptions of the vegetation types occurring in WHMI;
- Collect accuracy assessment data;
- Provide a final report describing all aspects of the project;
- Create a DVD with reports, metadata, guides, vegetation classification, plot data, spatial data, vegetation database (map), graphics, and ground photos.

S.M. Stoller Corporation and Idaho State University Responsibilities

- Work with NPS to develop a vegetation classification for the study area based on the NVCS using quantitative analysis and ecological interpretation of the field data;
- Write a field key to the vegetation types occurring in WHMI;
- Provide guidance regarding the crosswalk of vegetation types to map units;
- Review the local vegetation descriptions;
- Review the final database containing the field data.

CTI Responsibilities

- Help with overall project facilitation and coordination;
- Develop map units linked to the NVCS;
- Provide field maps and GIS support to the field crews;
- Interpret and delineate the final vegetation and land use types;
- Transfer and automate interpreted data to a digital spatial database;
- Produce spatial layers of plot and accuracy assessment site locations;
- Assist with the accuracy assessment by picking the stratified random target points, creating field maps, and providing GIS support;
- Provide final report sections describing the mapping aspects of the project;
- Document FGDC-compliant metadata for all vegetation data (FGDC 1998);
- Assist in creating the project digital video disk (DVD).

Field Survey

Field methods used in this project followed NVIP standards (e.g., TNC 1994a, 1994b, 1994c and Lea and Curtis 2010) and UCBN guidance. Important for future projects was the ability to gather consistent data that could contribute to understanding vegetation relationships across broader landscapes within all of the park units in the UCBN. In addition to the basic vegetation data collected at each plot, the UCBN and WHMI staff defined summary data fields and made suggestions for including additional information on the forms. Plot forms and individual data field descriptions appear in Appendix B.

The sampling area included all of WHMI and the land trust area. Private lands in the environs were not visited. NMI field crews were trained and led by ecologists with experience sampling plant communities in national parks and other landscapes. The list of WHMI plant species was downloaded from the UCBN website (<http://science.nature.nps.gov/im/units/ucbn/inventory>) and known ecological systems, vegetation alliances, and preliminary plant associations were provided as a starting point for identifying and naming plant associations sampled in the field. The sampling goal was to collect between three and five classification plots in every vegetation alliance/plant association within the WHMI project area. However, some common associations were sampled more often and some rare types were sampled less often. An effort was made to achieve good spatial distribution of classification plots across the landscape and to capture the full range of variation of each plant association.

Once a representative plant community was located, a Relevé macroplot was laid out to capture stand characteristics. In this manner, transitional areas particularly ecotones were avoided. Highly disturbed areas were also avoided unless they supported a distinct or homogenous plant community. Classification plots were generally located in stands exceeding the minimum mapping unit (MMU) of 0.5 hectares. A few classification plots were sampled in smaller patches of distinctive vegetation or communities of rare species. Plot size and shape requirements were consistent with NVIP guidelines (TNC and ESRI 1994a). Classification plot size was determined by the physiognomy of the community being sampled (Table 3) and measuring tapes were used to outline the sampling area. WHMI plot shape was adjusted as needed to sample linear bands of vegetation in drainage bottoms or other confined sites. Plot size and shape were recorded for all plots and representative photographs were acquired.

Table 3. Plot sizes used for vegetation classification sampling at WHMI.

Vegetation Class	Area (m²)	Radius (m)
Forest and Woodland	400	22.6
Shrubland	400	22.6
Herbaceous	100	11.3

Following plot establishment, environmental data were recorded including: elevation, slope, aspect, landform, topographic position, soil texture and drainage, hydrologic (flooding) regime, and evidence of disturbance or wildlife use. The unvegetated surface was recorded as percent cover of each of the following types: bedrock, litter and duff, wood, bare soil, large rocks (>10 cm), small rocks (0.2-10 cm), sand (0.1-2 mm), lichens, mosses, and fungi.

Vegetation at each plot was visually divided into strata, with the height and canopy cover of all plant species estimated for each stratum. Physiognomic class, leaf phenology, and type of dominant stratum were recorded. The species comprising each stratum were listed and percent canopy cover estimated using a twelve-point cover scale (e.g. <1%, 1-5%, >5-15% ...) (Daubenmire 1959). Additional species within the vegetation unit that occurred outside of sampled plots were listed separately. No attempt was made to identify individual non-vascular plant species. Species that were not identifiable in the field were collected for later identification. Species were recorded by scientific nomenclature familiar to researchers. Finally, a provisional vegetation type name was assigned to the classification plot.

Field crews collected the information for each of the vegetation classification plots in two ways: (1) a species list was developed and recorded on field forms by the team botanist, UTM coordinates, field notes header information (Identifiers/Locators), environmental descriptions and a plot map were also recorded on this form and (2) all other field data were collected with mobile Archer Field PCs. Following collection of physiognomic and environmental information, field crews used the Garmin GPS 76CSX receiver to record the southeast corner of the plot (no permanent markers were used). UTM NAD83 X-Y coordinates and elevation were recorded both manually on the plot forms and stored as waypoints in the GPS receiver. Four representative photos were acquired facing the four cardinal directions (N, E, S, and W) from the edge of the quadrant facing plot center. Field data collection was conducted from April 19 – 23 in 2010 and 71 vegetation classification plots were sampled (Figure 14).



Field Plots

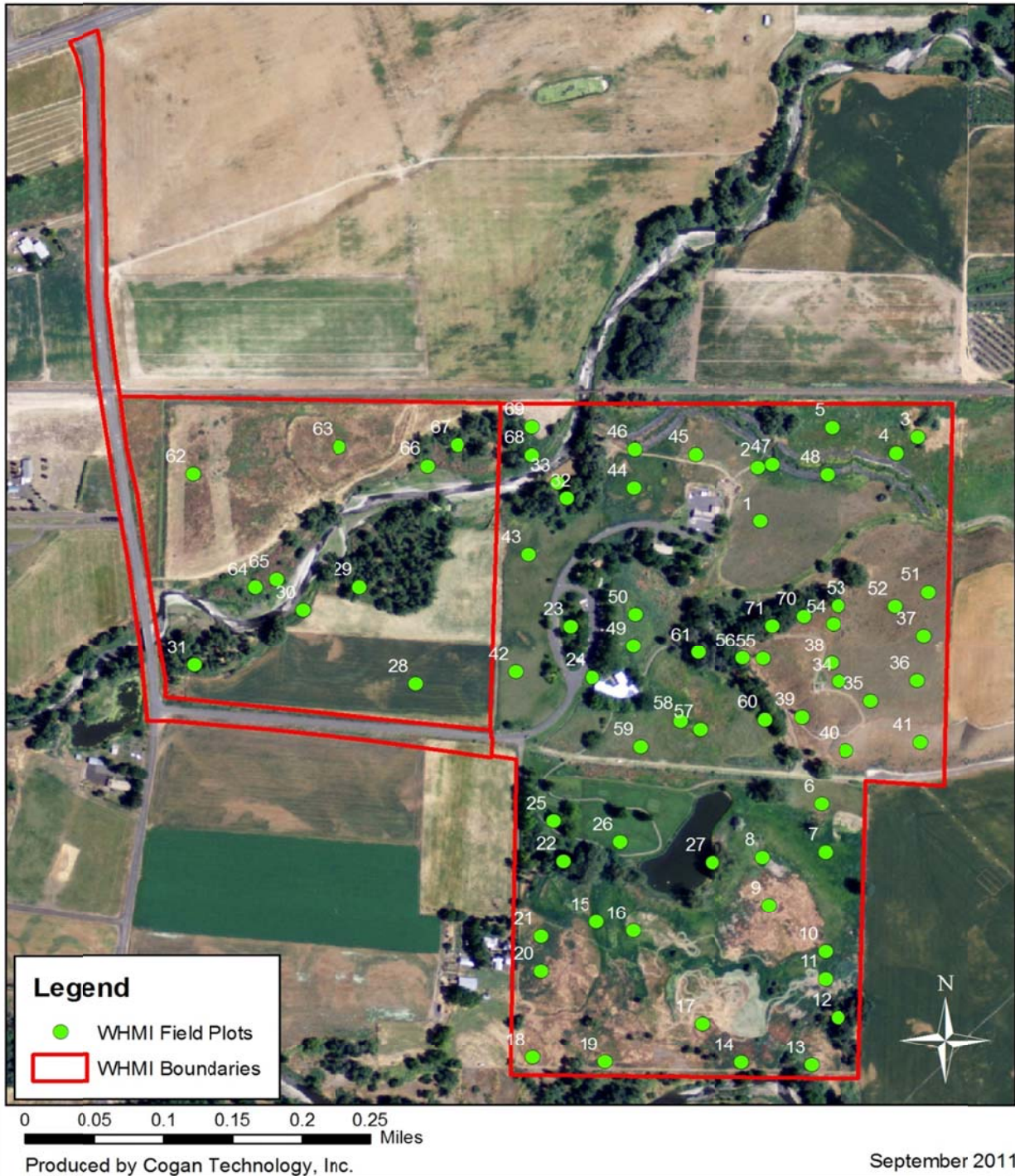


Figure 14. Vegetation classification plot locations within the WHMI project area.

Vegetation Classification

Field data were partially stored Archer Field PCs with Windows Mobile 5.0 operating systems using DataPlus software. All data from the Archer PCs were transferred and managed in a Microsoft (MS) Access database. Electronic data were transferred directly from the data recorders (NMI created data dictionaries as needed) into Database Files (DBF). DBFs were reviewed by field crews for accuracy each night, then converted and stored in the appropriate database on a laptop computer. All additional field data not recorded electronically (such as field notes) were entered manually into the database for this project and separate databases were created as necessary. Upon completion of field surveys, all recorded data were entered into a MS Access relational database. The relational database is a modified PLOTS2 database initially developed specifically for the NPS NVIP so that the electronic data entry fields mirrored the standard paper field form. Data entry was facilitated by using drop-down menus for each plant species scientific name. Scientific names were updated according to the vascular plant list provided to the field crews as found on the UCBN website and in Appendix E.

Following data entry, quality assurance was performed to minimize errors associated with duplicate entries or erroneously selected plant names. Questions regarding unknown species, especially those with high cover, were resolved, as were other taxonomic issues including grouping subspecies and varieties judged to be ecologically similar. Data were regularly compiled and at the completion of the field work the final database was supplied to S.M. Stoller and ISU statisticians for quantitative analysis. A GIS data layer was also developed to document classification plot field locations

Quantitative analyses and analytical methods were employed by ISU and S.M. Stoller statisticians to determine the plant associations at WHMI. In summary, the classification team evaluated seven classification methods to analyze the 70 plots and 107 plant species recorded in the plots. During this stage the classification team identified flexible $\beta = -0.25$ as the most appropriate classification method for the WHMI data. Using the flexible $\beta = -0.25$ method they then identified 17 optimal clusters of vegetation for WHMI using Relevé tables.

Thirteen of the seventeen plant community clusters identified using the plot data were classified at the association level and four were classified at the alliance level. Alliance-level classes were used when: (1) there wasn't enough plots in each of the representative clusters to characterize them as associations, (2) they had not been previously described at the association level in the NVC, or (3) some combination of the previous two. Eight of the seventeen plant communities (associations or alliances) resulting from this classification were represented in the NVC at the time the class list was compiled (NatureServe 2011). Many of the associations and/or alliances not previously described in the NVC were typified by the dominance of non-native species, which have historically not received much attention in the current NVC.

All plant nomenclature used in this study is that of the Integrated Taxonomic Information System (ITIS) as reflected by the PLANTS Database (USDA -NRCS 2007). ITIS nomenclature is represented in the NVCS and the WHMI plant associations described herein. Naming the plant associations used indicator (dominant or diagnostic) species for each of the vegetative strata present. The indicator species of the upper strata was listed first, followed by successively lower strata (e.g., canopy, subcanopy, tall shrub, short shrub, herbaceous vegetation, etc.). Plant species

that may only be occasionally present in the same stratum are separated by parentheses (). Species that always occurred in the same stratum (or were the same lifeform) are separated by a hyphen (-). Indicator species that occurred in different strata (or are a different lifeform) were separated by a slash (/). Alliance names were concluded with the word “Alliance” to differentiate them from association names. Plant association names incorporated the physiognomic class in which the association was classified (e.g., Forest, Woodland, or Herbaceous (FGDC 1997, 2008 and Forman et al. 2011)).

The final products of the classification task included a field key and local plant association descriptions. The dichotomous field key to the WHMI plant associations was developed to assist users in identifying vegetation associations in the field, particularly during the accuracy assessment task (Appendix C). The local descriptions were based on the field data and provide WHMI characteristics for each plant association within the NatureServe template (Appendix D).

Digital Imagery and Mapping

Existing sources of imagery were evaluated for vegetation mapping and geodatabase development for BIHO. Among the current sources of imagery were NAIP ortho-photography products from 2009 and 2011. Since the mapping portion of this project was started in 2010, the 2009 1-meter resolution NAIP ortho-photo (Figure 15) was deemed adequate for starting the vegetation mapping. The 2009 image for Walla Walla County were accessed and downloaded from the U.S. Department of Agriculture’s Geospatial Gateway website (<http://datagateway.nrcs.usda.gov/>). The entire 2009 NAIP county image was clipped to the project boundary and the clipped image (Figure 15) was used to conduct the preliminary delineation and vegetation interpretation in anticipation of the accuracy assessment (AA) work to begin in the summer of 2011.

Subsequent to the completion of the AA, the 2011 NAIP image was made available and this 1-meter, true-color product was downloaded and processed for WHMI (Figure 15). Since the 2011 image highlighted recent changes in the vegetation at WHMI, the 2011 NAIP basemap was used to update the vegetation mapping. All previous interpreted linework was modified accordingly and the final map product for WHMI is primarily based on the 2011 NAIP ortho-imagery.

Starting with the 2009 NAIP image and transitioning to the similar 2011 NAIP product, the mapping and photo-signature interpretation at WHMI involved a four-step process consisting of: (1) field reconnaissance; (2) map class development; (3) image processing and interpretation; and (4) spatial database development. Field reconnaissance was conducted by NMI staff during the field plot data collection. Paper field maps of the NAIP imagery were printed and vegetation notes were made on these by the field teams (Figure 16). The goal of the field reconnaissance was to provide site-specific data to familiarize the mapping team with WHMI vegetation patterns, plant community distribution, and land-use types. As the vegetation mapping progressed in 2010 and 2011 additional feedback on the dominant and characteristic plant species was solicited from the field crews as needed.



Source: NAIP

Figure 15. Example of the 2009 and 2011 NAIP true-color base-map imagery for WHMI.



Source: NMI and NAIP

Figure 16. Example of the WHMI field reconnaissance maps.

All classification plot information sampled in 2010 was documented, summarized, and geo-processed into a GIS shapefile that could be overlain on the NAIP ortho-imagery. CTI created preliminary map classes (also known as map units) based largely on whether the vegetation surrounding the plot locations could be readily identified and delineated on the NAIP imagery (i.e. photo signature development). Once the photo signatures were inventoried they were matched or cross-walked back to the preliminary list of plant associations prepared in the project work plan. Supplemental land-use and land-cover classes (Anderson 1976, amended 2002) were added to classify non-vegetated areas such as developments, roads, streams, ponds, bare ground, and active agricultural areas. All obvious land-use features were manually digitized and incorporated with the project boundary into a draft GIS layer. Initial interpretation and mapping focused only on delineating obvious landforms (e.g., geologic exposures and land use) and physiognomic features (e.g., grasslands versus shrublands versus woodlands).

In 2010, CTI compared the initial map classes to both the 2009 NAIP imagery and a draft of the final WHMI vegetation classification. New map classes were added as necessary with emphasis placed on the ability to accurately delineate homogenous polygons from the base ortho-imagery. In general, the level of detail possible in a vegetation map is limited by the imagery, the skill and experience of the interpreter and mapper, and the availability of supporting information. The relationships between the map classes and plant associations are often complex. In most cases, the WHMI map classes were derived on a 1 plant association or 1 vegetation alliance to 1 map class basis. However due to the limitations of the imagery and the lack of ground data on the surrounding private lands some of the photo signatures could not be accurately matched to existing associations.

Mapping ambiguity was addressed by scaling up the NVCS to the alliance level, combining similar associations/alliances into complexes or mosaics, or creating a new “woodland stand” map class for small wooded patches. Complexes were used when associations/alliances could not be discerned from each other. Conversely, mosaics were used when associations/alliances could be discerned but were so small and interspersed that individual polygon mapping would prove to be impractical. Woodland stands were used when different species of trees were identified but did not cover enough area to be considered a plant association.

All map classes were reviewed by CTI and NMI staff and based on the resulting suggestions some additional park-specific or “Park Specials” were defined as follows:

- Created *Acer platanoides*, *Elaeagnus angustifolia*, and *Robina pseudoacacia* Semi-natural Woodland Stands to address small stands of these trees in the project area;
- Added *Polulus balsamifera* ssp. *trichocarpa* Temporarily Flooded Forest Alliance to address riparian woodlands dominated by this tree species;
- Created a Mixed Riparian Forest Complex map unit to address indistinguishable riparian forests in the environs that likely contain either willow or cottonwood trees;
- Created a Mixed Planted and Semi-natural Woodland Complex to address mixed wooded areas in the environs that did not appear to be dominated by willow or cottonwood trees;
- Placed emphasis on non-native vegetation by adding a Mixed Planted or Semi-natural Grassland Complex and a Mixed Weedy Semi-natural Herbaceous Vegetation Complex for areas in the environs that appeared to have either a mixture of pasture grasses or disturbed annual vegetation (respectively);
- Extended the delineation of wetland and riparian stands below the minimum mapping unit (mmu) of 0.5 hectares (1.24 acres).

For some map classes like the *Acer platanoides*, *Elaeagnus angustifolia*, and *Robina pseudoacacia* Semi-natural Woodland Stands, existing NVC alliances used at other UCBN park units were later matched to the park special map units for reference based on the dominant species. In addition to the park specials small areas of either non-native vegetation or barren streambanks were also delineated.

WHMI vegetation mapping continued in 2011 by importing the preliminary WHMI vegetation layer into eCognition software for segmentation comparisons. Automated imagery segments (polygons) were based in part on pixel reflectance and their relationship to neighboring pixels. By incrementally increasing segmentation size within the program, small image objects (i.e. preliminary polygons) were continuously merged into larger polygons. Completion of the segmentation was based on visual judgment of the analyst when obvious, distinct features were lost the previous segmentation was adopted as the final treatment.

Following segmentation, only those lines/polygons that matched the vegetation patterns within the WHMI project area were exported as ArcInfo shapefiles and converted into ArcInfo coverages. The resulting coverages were refined through a series of smoothing routines until no obvious artificial or relict breaks in the lines were visible. Following smoothing, the line-work was manually cleaned to remove extraneous lines, very small polygons (<0.25 acre), and polygons that obviously split a homogenous stand of vegetation. The cleaned lines were overlain on the new 2009 NAIP imagery (and later the 2011 NAIP imagery) and visually inspected for completeness.

At this stage the mapping approach was switched from an automated process back to a manual interpretation effort. Using the classification plot data, field notes, and ancillary data final vegetation polygons were edited, split, and merged through on-screen digitizing to create consistent, homogenous polygons that matched the mapping units. Mapping progressed by first delineating known areas within WHMI and the Land Trust area and then into unsampled areas in the environs.

When the interpretation effort was considered complete, topology for the final polygon layer was built and attributed and then imported into a spatial database (geodatabase). Each polygon was attributed with a dedicated map unit name, code, and modifier. Polygon-specific modifiers included additional data on the height, density, and patterns of the dominant vegetation. Also polygons of disturbed sites were identified in a comments field along with any notable dominate understory or locally common plant species. Finally other map class data including the NVCS crosswalk and the land-use classes were added (Table 4).

Table 4. Polygon attribute items and descriptions.

<u>ATTRIBUTE</u>	<u>DESCRIPTION</u>
AREA*	Surface area of the polygon in meters squared
PERIMETER*	Perimeter of the polygon in meters
WHMI_VEG#*	Unique code for each polygon
WHMI_VEG-ID*	Unique identification code for each polygon
VEG_CODE	Final Map Unit Codes – Project specific
MAP_DESC	Map Unit Common Description Name – Project specific
DENS_MOD	Modifier - Percent cover of the upper stratum layer in the polygon Percent cover classes: Very Sparse < 10% , Sparse 10 - 25% , Open 25 - 60% , Discontinuous - Closed > 60%
PTRN_MOD	Modifier - Vegetation pattern within the polygon Vegetation pattern classes: Evenly Dispersed = Homogeneous Grouped Stands of Vegetation = Bunched / Clumped , String of Vegetation = Linear
HT_MOD	Modifier - Height range of the dominant vegetation layer Height classes: < 1, 1-5, 5-15, 15-30 & >30 meters
CES_CODE	Ecological Systems Code – NVCS derived (NatureServe)
CES_NAME	Ecological Systems Name – NVCS derived (NatureServe)
NVC_ELCODE	Corresponding Association Code – NVCS derived (NatureServe) Association = Community Element Global Code – Elcode link to the NVCS
ASSN_NAME	Project Community Name - NVCS Association(s)
ASSN_CNAME	Project Common Community Name - synonym name of Association(s)
NVCS_CODE	NVCS Code - to NVCS Formation level
ALL_CODE	Alliance Name Code – NVCS derived (NatureServe) Alliance = Alliance Global Code – Alliance Link to the NVCS
ALL_NAME	Project Alliance Name = NVCS Alliance(s)
ALL_CNAME	Project Common Alliance Name = NVCS Alliance(s)
FORMATION	NVCS Formation = Formation name NVCS Code – Formation name
SUBGROUP	NVCS Formation Subgroup = NVCS Code – Subgroup name
GROUP	NVCS Formation Group = NVCS Code – Group name
SUBCLASS	NVCS Formation Subclass = NVCS Code – Subclass name
CLASS	Formation Class = NVCS Code – Class name
LUC_II_GEN	General Land Use and Land Cover Classification System Name Project specific based on Level I or II of Anderson et al. (1976)
LUC_II	Specific Land Use and Land Cover Classification System Name Project specific Level II or Level III of Anderson et al. (1976)
COMMENTS	Additional Comments about the Vegetation in Individual Polygons
ACRES	Surface area of the polygon in acres
(*ArcInfo [®] default items)	

Accuracy Assessment

Following the vegetation map completion the accuracy assessment (AA) was conducted. AA is a statistical test of how well the vegetation map represents the vegetation on the ground. The AA compares field observations with the map class assignment. Errors occur when mapped polygon labels differ from field observations. Results of the AA allow users to evaluate the utility of the vegetation mapping data for particular applications. Accuracy assessment results are expressed in two forms (Hop et al. 2005): “producer’s accuracy” (the probability that an AA point was mapped correctly, also referred to as “errors of omission”), and “user’s accuracy” (the probability that the map represents what was found on the ground, also referred to as “errors of commission”). High producer’s accuracy combined with low user’s accuracy indicates that the map class is under-mapped or that it was confused with other map units and not sufficiently delineated. Conversely, low producer’s accuracy combined with high user’s accuracy indicates that a type is over-mapped or that more of this type was mapped than actually occurs on the ground.

The thematic accuracy of the vegetation map was assessed using the methodology and standards provided by the NVIP Accuracy Assessment Procedures manual (TNC 1994c) and subsequently updated in version 2.0 (Lea and Curtis 2010). Assessment methodology included a four-step process consisting of a sample design, sample site selection, data collection, and data analysis. The design of the AA process followed the five possible scenarios provided in the first version of the field methods with stratified random targets placed in each map class based on their respective frequency and abundance. The AA included most vegetation map classes and was limited to managed lands within WHMI and the Land Trust area. Sample sizes for each evaluated map class were selected using the NVMP guidelines (TNC et al. 1994b). The design of the AA process followed the five possible scenarios with stratified random targets placed in each map class based on their respective frequency and abundance (Table 5).

All AA parameters were uploaded into a custom GIS program along with the vegetation layer. Following some reformatting of the data, the program automatically picked the various random target locations, buffered each 10 meters (33 feet) away from any polygon boundary, and 50 meters (164 feet) away from other AA points. Being able to choose minimum distance to polygon boundaries helped to minimize confusion and accounted for the horizontal error typically encountered in common GPS receivers (± 5 m; [16 ft]). The resulting target locations were restricted to within the WHMI and the Land Trust area boundaries by masking out the environs and any private in-holdings. Fourteen land-use and geologic/bare rock map classes were excluded since they are essentially unvegetated.

Table 5. Sampling protocol for AA points.

Scenario	Description	# Polygons	Area (ac)	Recommended # of Samples
A	The class is abundant. It covers more than 50 hectares (124 acres) of the total area and consists of at least 30 polygons. In this case, the recommended sample size is 30.	> 30	> 125	30
B	The class is relatively abundant. It covers more than 50 hectares (124 acres) of the total area but consists of fewer than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.	< 30	> 125	20
C	The class is relatively rare. It covers less than 50 hectares (124 acres) of the total area but consists of more than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.	> 30	< 125	20
D	The class is rare. It has more than 5 but fewer than 30 polygons and covers less than 50 hectares (124 acres) of the area. In this case, the recommended number of samples is 5. The rationale for reducing the sample size is that the class consists of small polygons and the frequency of the polygons is low. Specifying more than 5 sample sites will therefore probably result in multiple sample sites within the same (small) polygon. Collecting 5 sample sites will allow an accuracy estimate to be computed, although it will not be very precise.	5-30	< 125	5
E	The class is very rare. It has fewer than 5 polygons and occupies less than 50 hectares (124 acres) of the total area. In this case, it is recommended that the existence of the class be confirmed by a visit to each sample site. The rationale for the recommendation is that with fewer than 5 sample sites (assuming 1 site per polygon) no estimate of level of confidence can be established for the sample (the existence of the class can only be confirmed through field checking).	< 5	< 125	Visit all and confirm

Accuracy assessment point data were collected at WHMI during the 2011 field season. Following target location selection, ecologists were provided with draft field maps, overview maps, map unit definitions, the field key to the plant associations (Appendix C), and digital GPS files containing the location of the AA targets. The ecologists traveled to the AA target sites and determined the vegetation association using the field key. At each target they recorded the primary, secondary, or tertiary associations that occurred within a roughly 50-meter radius. They also recorded height and cover of vegetation strata, environmental data, and percent canopy cover of the major species (see field form Appendix B). Other nearby vegetation types outside the 50-meter radius and any recent disturbance were also recorded. To better assist the analysis 4 digital photographs were acquired at each AA point, in the sequence of cardinal directions, N-E-S-W.

Data from 93 sampled AA sites were imported from the database into a GIS layer (Figure 17) then were visually compared in two steps to the vegetation map. The first step was to compare the AA points to the original target locations to check for erroneous points and remove these from further analysis. General errors in the data were recorded at this time, including documenting points that had GPS and location errors. The initial review confirmed that all WHMI AA sites were in the right target polygon and had the correct UTM coordinates associated with them. Nomenclature standards and other data management procedures were the same as for the classification plot data. Nomenclature standards and other data management procedures were the same as for the classification plot data.

The second review step involved deciding between the primary and secondary call for the plant association as recorded by the field crew. In larger vegetation mapping projects such as Rocky Mountain National Park (Salas et al. 2004), AA analysis involved fuzzy logic which assigns different levels of accuracy based on the primary, secondary, and tertiary calls. However due to the confusion that fuzzy logic can cause, a simple binary assessment was conducted with the WHMI data. CTI assigned a final map unit for every point by choosing between the primary and secondary calls. Assignment was accomplished by first adding a new attribute to the point layer labeled "Final_Code" and then by comparing the assigned field names of the point with its corresponding location on the digital imagery. In most cases the primary vegetation map unit name assigned by the field crew was used. However some points were assigned the secondary field call based on one of the following reasons: (1) it appeared that the second call was the better choice due to the overhead perspective (e.g., a stand judged to be sparse woodland on the imagery vs. herbaceous vegetation in the field), (2) the data were actually recorded in a stand that was too small (i.e. inclusion), or (3) the second call better matched the ecological context (e.g. riparian woodland located next to a stream vs. upland woodland).



Accuracy Assessment Points

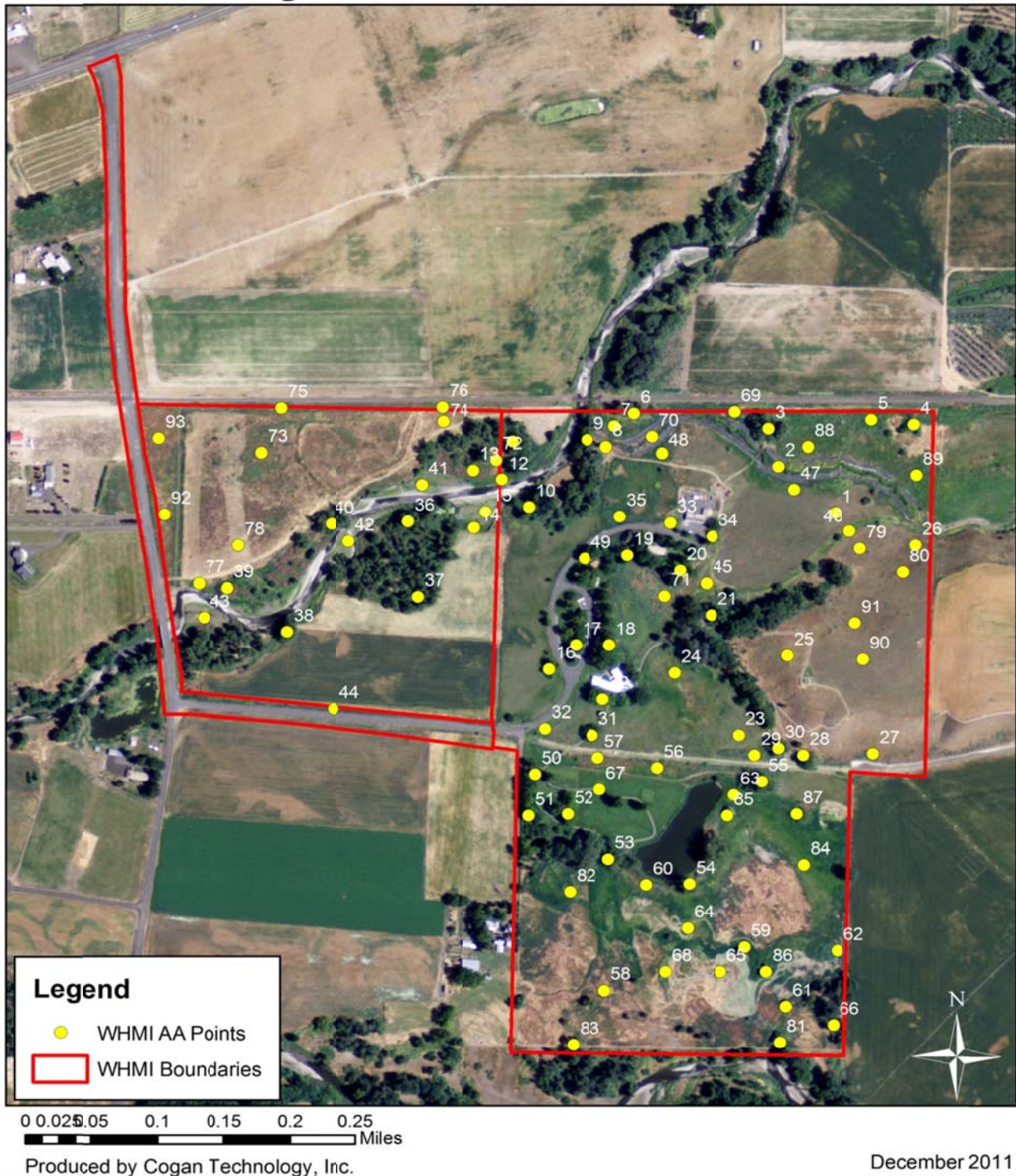


Figure 17. Location of the accuracy assessment (AA) points in WHMI.

Following AA data review the accuracy analysis was conducted. For WHMI the process was streamlined using methods developed from previous studies at Rocky Mountain National Park (Salas et al. 2004) and Wupatki National Monument (Hansen et al. 2004). Specifically many of the in-house GIS programs developed for these projects were used to compare the AA data, generate confidence intervals, Kappa statistics, and error matrices (contingency tables). Through this automated process, the final map units in the AA layer were compared to the map unit designations for their corresponding polygons. All statistics and calculations used to analyze these data are described at length in the program manuals (TNC 1994c, Lea and Curtis 2010) and are summarized in Table 6. Final assessments for each point were recorded using an error matrix.

Table 6. Statistics used in AA analysis.

Statistic	Formula	Description
User's - accuracy:	$\frac{n_{ii}}{n_{i+}}$	Where i is the land cover type, n_{ii} is the number of matches between map and reference data and n_{i+} is the total number of samples of i in the map. This formula is the number of "correct" observations divided by the sum of the row.
Producer's accuracy	$\frac{n_{ii}}{n_{+i}}$	Where n_{+i} = total number of sample of i in the reference data. This formula is the number of "correct" observations divided by the sum of the column.
Confidence Interval	$\hat{p} \pm \left\{ z_{\alpha} \sqrt{\frac{\hat{p}(1 - \hat{p})}{n} + \frac{1}{(2n)}} \right\}$	Where $z_{\alpha} = 1.645$ (this comes from a table of the z-distribution at the significance level for a two-sided limit with a 90% confidence interval). The term $1/(2n)$ is the correction for continuity. The correction should be applied to account for the fact the binomial distribution describes discrete populations $\hat{p}$ = the sample accuracy (0 -1.0), n = the number of sites sampled.
Kappa Index	$k = \frac{N \sum_{i=1}^r x_{ii} - \sum_{i=1}^r (x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^r (x_{i+} \times x_{+i})}$	Where N is the total number of sites in the matrix, r is the number of rows in the matrix, x_{ii} is the number in row i and column i , x_{+i} is the total for row i , and x_{i+} is the total for column i .

Results

Vegetation Classification

Over 107 plant species and varieties were documented during taxonomic inventories and classification plot and accuracy assessment field data collection (NPS 2011) (Appendix E). Based on the dominant/characteristic plant species and other factors the WHMI vegetation was further classified into 17 community types (13 plant associations and four vegetation alliances) (Forman et al. 2011) (Table 7). Forty-seven percent of associations identified within WHMI are currently listed in the NVC (NatureServe 2011). Associations described but not recognized by the NVC include three semi-natural vegetation associations and nine plant associations that have not been described previously at the association level. Distinctive plant associations that should be considered for inclusion in the NVC include:

1. *Ulmus parvifolia* Semi-natural Woodland;
2. *Ericameria nauseosa* - *Chrysothamnus viscidiflorus* Shrubland;
3. *Rubus armeniacus* Semi-natural Shrubland;
4. *Bromus tectorum* Semi-natural Herbaceous Vegetation;
5. *Phalaris arundinacea* - *Bromus tectorum* Herbaceous Vegetation;
6. *Phalaris arundinacea* - *Thinopyrum ponticum* Herbaceous Vegetation;
7. *Pseudoroegneria spicata* - *Festuca ovina* Herbaceous Vegetation;
8. *Thinopyrum ponticum* Semi-natural Herbaceous Vegetation.

Table 6 lists the 13 plant associations and four vegetation alliances by scientific name, common name, code, and number of plots/association-alliance; they are ordered by physiognomy: forests and woodlands, shrublands and herbaceous vegetation.

Forest and Woodland Associations

Only deciduous woodland and forest associations were documented at WHMI. Forests were mainly found in the riparian and wetland corridors associated with the various streams and rivers in the area. Cottonwood and peachleaf willow species made-up the majority of the riparian forest associations growing in these mesic areas where they contained various deciduous shrub species in the understory. Upland woodlands varied in composition throughout the project area and most of the upland trees are likely a result of past plantings or represent escaped non-native species. Of these, only Chinese elm was common enough to be considered a true plant community.

Shrubland Associations

Shrublands, mainly deciduous riparian species, were common at low elevations along the floodplain on streambanks or in canopy openings. Only two shrubs species consisting of Himalayan blackberry and Shining willow were considered to be common enough to be classified as true shrub associations. In the uplands only rubber and yellow rabbitbrush were found at WHMI in sufficient quantities to be considered a shrub association.

Table 7. List of 35 plant associations and two vegetation alliances for WHMI.

Scientific Name	Common Name	Key Code	NVC Code	N
Forest and Woodland				
<i>Populus deltoides</i> - <i>Platanus occidentalis</i> Forest	Eastern Cottonwood - American Sycamore Forest	PODE - PLOC	CEGL002095	1
<i>Salix amygdaloides</i> Woodland	Peachleaf Willow Woodland	SAAM	CEGL000947	4
<i>Ulmus parvifolia</i> Semi-natural Woodland	Chinese Elm Semi-natural Woodland	ULPA	N/A	4
Shrubland				
<i>Ericameria nauseosa</i> - <i>Chrysothamnus viscidiflorus</i> Shrubland	Rubber Rabbitbrush - Yellow Rabbitbrush Shrubland	ERNA - CHVI	N/A	2
<i>Rubus armeniacus</i> Semi-natural Shrubland	Himalayan Blackberry Semi-natural Shrubland	RUAR	N/A	3
<i>Salix lucida</i> Temporarily Flooded Shrubland Alliance	Shining Willow Temporarily Flooded Shrubland Alliance	SALU	A.979	3
Herbaceous Vegetation				
<i>Bromus tectorum</i> Semi-natural Herbaceous Vegetation	Cheatgrass Semi-natural Herbaceous Vegetation	BRTE	N/A	15
<i>Festuca idahoensis</i> Herbaceous Alliance	Idaho Fescue Herbaceous Alliance	FEID	A.1251	2
<i>Leymus cinereus</i> Herbaceous Vegetation	Great Basin Wildrye Herbaceous Vegetation	LECI	N/A	2
<i>Phalaris arundinacea</i> Western Herbaceous Vegetation	Reed Canarygrass Western Herbaceous Vegetation	PHAR	CEGL001474	8
<i>Phalaris arundinacea</i> - <i>Bromus tectorum</i> Herbaceous Vegetation	Reed Canarygrass - Cheatgrass Herbaceous Vegetation	PHAR - BRTE	N/A	2

Scientific Name	Common Name	Key Code	NVC Code	N
<i>Phalaris arundinacea</i> - <i>Thinopyrum ponticum</i> Herbaceous Vegetation	Reed Canarygrass - Tall Wheatgrass Herbaceous Vegetation	PHAR - THPO	N/A	2
<i>Poa pratensis</i> Semi-natural Herbaceous Alliance	Kentucky Bluegrass Semi-natural Herbaceous Alliance	POPR	A.3562	4
<i>Pseudoroegneria spicata</i> - <i>Festuca ovina</i> Herbaceous Vegetation	Bluebunch Wheatgrass - Sheep Fescue Herbaceous Vegetation	PSSP - FEOV	N/A	5
<i>Sisymbrium altissimum</i> - <i>Bromus tectorum</i> Semi- natural Herbaceous Vegetation	Tall Tumblemustard - Cheatgrass Semi-natural Herbaceous Vegetation	SIAL - BRTE	N/A	3
<i>Thinopyrum intermedium</i> Semi-natural Herbaceous Alliance	Intermediate Wheatgrass Semi-natural Herbaceous Alliance	THIN	A.2529	1
<i>Thinopyrum ponticum</i> Semi-natural Herbaceous Vegetation	Tall Wheatgrass Semi-natural Herbaceous Vegetation	THPO	N/A	9

Herbaceous Associations

Various semi-natural and native reintroduced grass associations including those dominated by reed canarygrass, Great Basin wildrye and tall wheatgrass were common at WHMI on the floodplain terraces. All of the floodplain grasslands were likely influenced by past treatment and agricultural activities including seeding, herbicide spraying, burning and plowing. The lawn areas around the Mission Site, picnic area and visitor center were comprised of Kentucky bluegrass that has been maintained through mowing. Native grasslands consisting of bluebunch wheatgrass and Idaho fescue were only found on top of, or on the slopes leading up to Memorial Hill. Non-native grasses including cheatgrass and other weedy annual vegetation were common outside of WHMI on fallow fields, roadsides and around agricultural fields.

In addition to the NVC associations and alliances the vegetation data at WHMI was also placed into the ecological system classification to provide managers a broader landscape perspective. The ecological system classification addresses natural landscapes and developed areas were not included. Based on the current vegetation data 6 ecological systems currently occur within the WHMI vegetation mapping project area (Forman et al. 2011) (Table 8).

Table 8. List of 6 ecological systems within WHMI.

Ecological System	NVC Code
North-Central Interior Floodplain	CES202.694
North American Arid West Emergent Marsh	CES300.729
Columbia Basin Foothill Riparian Woodland and Shrubland	CES304.768
Inter-Mountain Basins Big Sagebrush Shrubland	CES304.777
Columbia Basin Palouse Prairie	CES304.792
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland	CES306.821

Digital Imagery and Interpretation

For WHMI, 38 map units (24 vegetated and 14 land-use/land-cover) were developed. The final list of map classes/units was directly cross-walked or matched to corresponding plant associations and land-use classes (Table 9). WHMI map classes represent a compromise between the detail of the NVCS, the needs for park management, and the limitations of the imagery. As a result, the mapping legend does not exactly match the NVCS. When the NVCS link was not feasible, descriptive local map units or park specials were created.

The following types represent the possible map scenarios that were encountered in the WHMI project:

1. **One-to-one relationship** = When a plant association or vegetation alliance had a unique photo signature and could be readily delineated on the imagery, the map unit adopted the plant association/vegetation alliance name or similar synonym.
2. **One-to-many relationship** = When related plant associations shared the same signature and could not be distinguished on the imagery, several plant associations were combined into a single complex.
3. **Park Specials** = When unique stands of vegetation did not have a corresponding NVCS plant association or vegetation alliance.
4. **Land Use – Land Cover** = Non-vegetated areas and vegetation types not recognized by the NVCS received Anderson et al. (1976, updated 2002) map unit designations.

Additional park special map units were used for the WHMI to address the lack of ground-based data in the environs, the mixed nature of some of the vegetation, and the presence of individual planted trees and tall shrubs. As a result the following WHMI map classes were added:

- Mixed Riparian Forest Complex – was added to address undocumented riparian forests and woodlands in the environs that likely contain mixes of various cottonwood and willow species;
- Mixed Planted and Semi-natural Woodland Complex – was added to attribute unknown trees in the environs and some of the individual stands of planted trees on the Mission Grounds;
- *Acer platanoides* Semi-natural Woodland Stand – was added based on documented locations of this species at WHMI;
- *Elaeagnus angustifolia* Semi-natural Woodland Stand– was added based on documented locations of this species at WHMI;
- *Populus balsamifera* ssp. *trichocarpa* Temporarily Flooded Forest Alliance – was added based on documented locations of this species at WHMI;
- *Robinia pseudoacacia* Semi-natural Woodland Stand– was added based on documented locations of this species at WHMI;
- Mixed Planted and Semi-natural Grassland Complex – was added to account for undocumented grasslands in the environs on private land that did not show active cultivation;
- Mixed Weedy Semi-natural Herbaceous Vegetation Complex - was added for highly disturbed vegetated sites in the environs.

Please reference Appendix F for detailed descriptions and representative photographs for all vegetation map units.

Table 9. Assignment of map classes to NVC plant associations/alliances.

Map Class Code	Map Class Name	NVC Association/Alliance(s) Assigned to Map Class (or Map Unit Description)	Relationship
Forest and Woodland			
ACPL	<i>Acer platanoides</i> Semi-natural Woodland Stand	- <i>Acer platanoides</i> Planted Woodland Alliance	1 : 1
ELAN	<i>Elaeagnus angustifolia</i> Semi-natural Woodland Stand	- <i>Elaeagnus angustifolia</i> Semi-natural Woodland Alliance	1 : 1
MXRP	Mixed Riparian Forest Complex	N/A	Park Special
MXWD	Mixed Planted and Semi-natural Woodland Complex	N/A	Park Special
POBA	<i>Populus balsamifera</i> ssp. <i>trichocarpa</i> Temporarily Flooded Forest Alliance	- <i>Populus balsamifera</i> ssp. <i>trichocarpa</i> Temporarily Flooded Forest Alliance	1 : 1
PODE-PLOC	<i>Populus deltoides</i> - <i>Platanus occidentalis</i> Forest	- <i>Populus deltoides</i> - <i>Platanus occidentalis</i> Forest	1 : 1
ROPS	<i>Robinia pseudoacacia</i> Semi-natural Woodland Stand	- <i>Robinia pseudoacacia</i> Semi-natural Forest	1 : 1
SAAM	<i>Salix amygdaloides</i> Woodland	- <i>Salix amygdaloides</i> Woodland	1 : 1
ULPA	<i>Ulmus parvifolia</i> Semi-natural Woodland	- <i>Ulmus parvifolia</i> Semi-natural Woodland	1 : 1
Shrubland			
ERNA-CHVI	<i>Ericameria nauseosa</i> - <i>Chrysothamnus viscidiflorus</i> Shrubland	- <i>Ericameria nauseosa</i> – <i>Chrysothamnus viscidiflorus</i> Shrubland	1 : 1
RUAR	<i>Rubus armeniacus</i> Semi-natural Shrubland	- <i>Rubus armeniacus</i> Semi-natural Shrubland	1 : 1
SALU	<i>Salix lucida</i> Temporarily Flooded Shrubland Alliance	- <i>Salix lucida</i> Temporarily Flooded Shrubland Alliance	1 : 1

Herbaceous Vegetation			
BRTE	<i>Bromus tectorum</i> Semi-natural Herbaceous Vegetation	<i>Bromus tectorum</i> Semi-natural Herbaceous Vegetation	1 : 1
FEID	<i>Festuca idahoensis</i> Herbaceous Alliance	<i>Festuca idahoensis</i> Herbaceous Alliance	1 : 1
LECI	<i>Leymus cinereus</i> Herbaceous Vegetation	<i>Leymus cinereus</i> Herbaceous Vegetation	1 : 1
MXGRS	Mixed Planted and Semi-natural Grassland Complex	N/A	Park Special
PHAR	<i>Phalaris arundinacea</i> Western Herbaceous Vegetation	<i>Phalaris arundinacea</i> Western Herbaceous Vegetation	1 : 1
PHAR-GRS	<i>Phalaris arundinacea</i> Seasonally Flooded Herbaceous Alliance	- <i>Phalaris arundinacea</i> - <i>Bromus tectorum</i> Herbaceous Vegetation - <i>Phalaris arundinacea</i> - <i>Thinopyrum ponticum</i> Herbaceous Vegetation	1 : Many
POPR	<i>Poa pratensis</i> Semi-natural Herbaceous Alliance	<i>Poa pratensis</i> Semi-natural Herbaceous Alliance	1 : 1
PSSP-FEOV	<i>Pseudoroegneria spicata</i> - <i>Festuca ovina</i> Herbaceous Vegetation	<i>Pseudoroegneria spicata</i> - <i>Festuca ovina</i> Herbaceous Vegetation	1 : 1
SIAL-BRTE	<i>Sisymbrium altissimum</i> - <i>Bromus tectorum</i> Semi-natural Herbaceous Vegetation	<i>Sisymbrium altissimum</i> - <i>Bromus tectorum</i> Semi-natural Herbaceous Vegetation	1 : 1
THIN	<i>Thinopyrum intermedium</i> Semi-natural Herbaceous Alliance	<i>Thinopyrum intermedium</i> Semi-natural Herbaceous Alliance	1 : 1
THPO	<i>Thinopyrum ponticum</i> Semi-natural Herbaceous Vegetation	<i>Thinopyrum ponticum</i> Semi-natural Herbaceous Vegetation	1 : 1
WEED	Mixed Weedy Semi-natural Herbaceous Vegetation Complex	N/A	Park Special

Land-Use / Land-Cover			
AGRI	Agricultural Business	Ranch and farm facilities	N/A
BARE	Bare Rock / Sand / Other Bare Ground	Unvegetated rock, cleared land, etc...	N/A
CANL	Canal / Ditch	Man-made linear water conveyance systems	N/A
FACL	Facilities	Visitor center, Housing, Maintenance Yard, etc.	N/A
FILD	Planted / Cultivated	Tilled and cropped agricultural fields	N/A
LIND	Commercial / Light Industry	Businesses and surrounding lands in environs	
MINE	Quarries / Strip Mines / Gravel Pits	Sites disturbed by humans to extract sand, gravel, rock or other minerals	N/A
ORCH	Orchards, Groves, Vineyards, Nurseries, and Horticultural Areas	Planted woody vegetation used for fruit production	N/A
POND	Lake / Pond	Natural and small human-made water impoundments	N/A
RECR	Entertainment / Recreation	Golf Course, Parks, schools, etc...	N/A
RESD	Residential	Single-family housing	N/A
ROAD	Transportation	Paved and earthen roads	N/A
STRM	Stream / River	Natural linear drainage features	N/A
TRANS	Transitional	Previously developed land, fallow fields, roadsides, slash piles, etc...	N/A

Vegetation Map

The final WHMI vegetation map (Appendix G) consisted of 1,050 polygons totaling 5,175 acres (2,096 hectares) (Table 10). Average polygon size was 4.9 acres (2.0 hectares) that includes adjacent polygons that have the same map code but different density, height, pattern or other attributes. The area within the supplied WHMI boundary totaled 100 acres (41 hectares) or 2% of the total project area. The area within the Living Trust Area (adjacent to WHMI) boundary totaled 40 acres (16 hectares) or 1% of the total project area. Of the total number of polygons, 65% represented vegetation map classes and 35% were land use classes. The most common WHMI map class was the *Thinopyrum ponticum* Semi-natural Herbaceous Vegetation class (20 acres) (8 hectares) and *Bromus tectorum* Semi-natural Herbaceous Vegetation had the largest number of polygons (26 polygons). Within The Living Trust Area the most prevalent map class was Mixed Planted and Semi-natural Grassland Complex (12 acres) (5 hectares) and the *Bromus tectorum* Semi-natural Herbaceous Vegetation was also the most frequent (9 polygons). Across the entire project area the Planted / Cultivated Field land-use class was the most abundant (3,806 acres) (1,542 hectares) and the *Bromus tectorum* Semi-natural Herbaceous Vegetation map class had the highest frequency with 96 polygons.

Normally the standard minimum mapping unit for NPS vegetation mapping projects is defined as 0.5 hectare (1.24 acres). However, this is a nominal unit and due to the resolution of the imagery, it was reduced to ¼ acre (0.1 hectare) for wetland and other rare classes. This MMU size allowed for more detail in the mapping and allowed for better delineation of sites deemed important for WHMI management. The ability to recognize small patches of vegetation is reflected in the high number of polygons created and the average size of the polygons for some of the rarer types.

The WHMI vegetation map should more appropriately be considered a spatial database that also contains many additional polygon attributes not presented in the preceding table (i.e. density, height, and pattern). These data are difficult to convey in a table or on a two-dimensional map, but the different attributes can be combined in many ways and at different scales and resolutions to produce other products representing the full spectrum of vegetation diversity. For example, older, more mature stands of riparian tree can quickly be located by querying the GIS vegetation layer for the specific vegetation type and then reselecting only those polygons with high density (> 60%) and the tallest height class (15 – 30 meters).

Figure 18 is an example of a fine scale (1:6,000-scale) WHMI vegetation map created from the GIS spatial database with the 2011 NAIP imagery as the background.

Table 10. Summary statistics for the WHMI map class polygons.

Map Code	Map Unit Description	Whitman Mission NHS			Living Trust Area			Total Project Area		
		Polygon Count	Acres	Hectares	Polygon Count	Acres	Hectares	Polygon Count	Acres	Hectares
ACPL	<i>Acer platanoides</i> Semi-natural Woodland Stand	3	0.4	0.2	0	0	0	3	0.5	0.2
ELAN	<i>Elaeagnus angustifolia</i> Semi-natural Woodland Stand	4	0.5	0.2	0	0	0	6	0.7	0.3
MXRP	Mixed Riparian Forest Complex	0	0	0	0	0	0	61	95.1	38.5
MXWD	Mixed Planted and Semi-natural Woodland Complex	8	0.8	0.3	0	0	0	91	77.7	31.5
POBA	<i>Populus balsamifera</i> ssp. <i>trichocarpa</i> Temporarily Flooded Forest Alliance	10	2.2	0.9	0	0	0	10	5.8	2.3
PODE-PLOC	<i>Populus deltoides</i> - <i>Platanus occidentalis</i> Forest	7	2.4	1.0	0	0	0	7	2.5	1.0
ROPS	<i>Robinia pseudoacacia</i> Semi-natural Woodland Stand	15	3.2	1.3	0	0	0	15	3.3	1.3
SAAM	<i>Salix amygdaloides</i> Woodland	6	3.3	1.3	8	6.6	2.7	39	46.2	18.7
ULPA	<i>Ulmus parvifolia</i> Semi-natural Woodland	3	2.9	1.2	0	0	0	5	3.3	1.3
ERNA-CHVI	<i>Ericameria nauseosa</i> - <i>Chrysothamnus viscidiflorus</i> Shrubland	5	3.8	1.5	0	0	0	17	24.1	9.8
RUAR	<i>Rubus armeniacus</i> Semi-natural Shrubland	0	0	0	5	1.9	0.8	6	3.0	1.2
SALU	<i>Salix lucida</i> Temporarily Flooded Shrubland Alliance	1	0.9	0.4	0	0	0	17	11.3	4.6
BRTE	<i>Bromus tectorum</i> Semi-natural Herbaceous Veg	26	14.1	5.7	9	2.3	0.9	96	115.2	46.7
FEID	<i>Festuca idahoensis</i> Herbaceous Alliance	2	0.5	0.2	0	0	0	2	1.7	0.7
LECI	<i>Leymus cinereus</i> Herbaceous Vegetation	10	6.0	2.4	0	0	0	20	13.1	5.3
MXGRS	Mixed Planted and Semi-natural Grassland Complex	5	0.4	0.2	3	11.8	4.8	46	130.4	52.8
PHAR	<i>Phalaris arundinacea</i> Western Herbaceous Vegetation	16	8.4	3.4	8	2.4	1.0	73	35.8	14.5
PHAR-GRS	<i>Phalaris arundinacea</i> Seasonally Flooded Herbaceous Alliance	10	3.3	1.3	0	0	0	53	36.6	14.8
POPR	<i>Poa pratensis</i> Semi-natural Herbaceous Alliance	12	4.6	1.9	0	0	0	25	33.2	13.4
PSSP-FEOV	<i>Pseudoroegneria spicata</i> - <i>Festuca ovina</i> Herbaceous Vegetation	2	4.1	1.7	0	0	0	2	4.2	1.7
SIAL-BRTE	<i>Sisymbrium altissimum</i> - <i>Bromus tectorum</i> Semi- natural Herbaceous Vegetation	5	1.8	0.7	0	0	0	17	32.2	13.0
THIN	<i>Thinopyrum intermedium</i> Semi-natural Herbaceous Alliance	3	2.7	1.1	0	0	0	3	2.8	1.1
THPO	<i>Thinopyrum ponticum</i> Semi-natural Herbaceous Vegetation	20	19.8	8.0	3	0.8	0.3	37	55.6	22.5
WEED	Mixed Weedy Semi-natural Herbaceous Vegetation Complex	3	0.2	0.1	0	0	0	34	109.2	44.2

Map Code	Map Unit Description	Whitman Mission NHS			Living Trust Area			Total Project Area		
		Polygon Count	Acres	Hectares	Polygon Count	Acres	Hectares	Polygon Count	Acres	Hectares
AGRI	Agricultural Business	1	0.1	0.1	0	0	0	60	119.6	48.4
BARE	Bare Rock / Sand / Other Bare Ground	0	0	0	7	0.9	0.4	51	8.3	3.3
CANL	Canal / Ditch	0	0	0	1	0.4	0.2	4	2.0	0.8
FACL	Facilities	5	1.1	0.4	0	0	0	5	1.0	0.4
FILD	Planted / Cultivated	10	2.7	1.1	1	10.0	4.1	92	3,806.2	1,541.5
LIND	Commercial / Light Industry	0	0	0	0	0	0	2	13.5	5.5
MINE	Quarries / Strip Mines / Gravel Pits	0	0	0	0	0	0	2	3.0	1.2
ORCH	Orchards, Groves, Vineyards, Nurseries, & Horticultural Areas	2	0.4	0.2	0	0	0	26	25.7	10.4
POND	Lake / Pond	2	1.4	0.6	0	0	0	7	4.1	1.7
RECR	Entertainment / Recreation	0	0	0	0	0	0	4	9.9	4.0
RESL	Residential	0	0	0	0	0	0	52	83.4	33.8
ROAD	Transportation	5	5.9	2.4	2	2.0	0.8	9	192.6	78.0
STRM	Stream / River	3	0.3	0.1	1	1.3	0.5	11	29.4	11.9
TRANS	Transitional	3	2.0	0.8	0	0	0	40	33.1	13.4
Total Vegetation		176	86.3	35.0	36	25.8	10.4	685	843.4	341.6
Total Land-Use/Land Cover		31	13.9	5.7	12	14.6	5.9	365	4,331.8	1,754.4
Totals		207	100.2	40.6	48	40.4	16.4	1,050	5,175.2	2,096.0

Accuracy Assessment

The 2010 AA yielded 93 points distributed throughout WHMI and the Living Trust Area. Using the AA GIS point file created from the AA point coordinates, one point was found to be located in the apple tree orchard on the Mission Grounds and since the orchard class is a land-use type this point was removed from the vegetation map analysis. Also two map classes: MXRP - Mixed Riparian Forest Complex and WEED – Mixed Weedy Semi-natural Herbaceous Vegetation Complex were not assessed since both types only occurred outside of WHMI and the Living Trust Area, in the project environs.

A total of 92 points were then used for further analysis and a preliminary error matrix was created and reviewed by CTI. During the review process all of the AA points whose primary plant association did not match their corresponding map class designation in the GIS layer were highlighted. These mis-matches were further investigated to see if the second, third or other vegetation call matched. Upon completion of the review a final error matrix was created (Table 11). The final assessment revealed an overall accuracy of 92%.

Examination of the final error matrix showed concentrations of user's error among three map classes, likely reasons for this error are presented below:

- 1) *Ericameria nauseosa* - *Chrysothamnus viscidiflorus* Shrubland (ERNA-CHVI) – this rare type only had three sample points and one was actually cheatgrass. This confusion was likely caused by the mixing of dominant species and/or borderline ERNA-CHVI cover.
- 2) *Bromus tectorum* Semi-natural Herbaceous Vegetation (BRTE) – was confused with some of the other grassland map units, likely a result of mixing of the dominant species and the difficulty in distinguishing grass species from aerial photography.
- 3) *Phalaris arundinacea* Western Herbaceous Vegetation (PHAR) – was confused with the PHAR-GRS, RUAR, and THPO map classes. This confusion was likely caused by the mixing of dominant grass species and the difficulty in distinguishing grass species from aerial photography.

Also the *Rubus armeniacus* Semi-natural Shrubland (RUAR) had a lower than expected producer's error likely indicating that more of this type likely occurs at WHMI and the Living Trust Area but could be discerned from the 2011 NAIP imagery.

General trends in the AA reveal the difficulty in obtaining sufficient numbers of AA points for very rare or small vegetation stands. Having few AA points decreases the confidence levels and makes it difficult to assume the accuracy of these classes with any certainty. Other trends in the AA are a result of using the true-color base imagery, including: (1) the difficulty in separating deciduous woodland/forest types with similar canopies, (2) the complexity of trying to accurately separate different grass species (especially in treated and managed areas), and (3) attempting to reliably delineate different native and semi-native herbaceous vegetation types. Additionally, the differences/confusion between shrubland and herbaceous vegetation types can probably be explained by the difficulty in resolving the difference in scale and perspective between viewing vegetation on the imagery and assessing it on the ground. For example, field sampling could have occurred in very sparse shrub communities or on a shrub inclusion that were actually part of a larger grassland polygon.

Table 11. Final Contingency Table (Error Matrix) for WHMI.

Map Class	Observed AA Point (Reference AA Ground Data)																					Total	Users Accuracy	90% Conf. Interval	
	ACPL	ELAN	MXWD	POBA	PODE-PLOC	ROPS	SAAM	ULPA	ERNA-CHVI	RUAR	SALU	BRTE	FEID	LECI	MXGRS	PHAR	PHAR-GRS	POPR	PSSP-FEOV	SIAL-BRTE	THIN	THPO		-	+
ACPL	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	100%	75%	100%
ELAN	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100%	50%	100%
MXWD	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	100%	75%	100%
POBA	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	100%	83%	100%
PODE-PLOC	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	100%	90%	100%
ROPS	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	100%	93%	100%
SAAM	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	100%	94%	100%
ULPA	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	100%	83%	100%
ERNA-CHVI	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	3	67%	5%	100%
RUAR	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	100%	75%	100%
SALU	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	100%	75%	100%
BRTE	0	0	0	0	0	0	0	0	0	0	0	6	0	1	0	0	1	0	0	0	0	9	67%	35%	98%
FEID	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	100%	50%	100%
LECI	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	100%	90%	100%
MXGRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	100%	90%	100%
PHAR	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	9	1	0	0	0	0	12	75%	50%	100%
PHAR-GRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	100%	83%	100%
POPR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4	100%	88%	100%
PSSP-FEOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	100%	75%	100%
SIAL-BRTE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	100%	50%	100%
THIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	100%	50%	100%
THPO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	100%	95%	100%
Total	2	1	2	3	5	7	9	3	2	3	2	7	1	6	5	9	5	4	2	1	1	12	92% Overall Accuracy		
Producers Accuracy	100%	100%	100%	100%	100%	100%	100%	100%	100%	67%	100%	88%	100%	83%	100%	100%	60%	100%	100%	100%	100%	83%	92 Total Points	91% 93%	
90% Conf. -	75%	50%	75%	83%	90%	93%	94%	83%	75%	5%	75%	57%	50%	50%	90%	94%	14%	88%	75%	50%	50%	61%	85 Correct Points	Overall 90% Conf. Intervals	
Level +	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	91% Kappa Index		

Notes: One point was removed from analysis and two vegetation map classes were not included as they only occurred in the environs.

Instruction on Using the Accuracy Assessment Contingency Table: The contingency table or error matrix presents an array of numbers set out in rows and columns corresponding to a particular vegetation map unit relative to the actual vegetation type as verified on the ground. The column headings represent the vegetation classification as determined in the field and the row headings represent the vegetation classification taken from the vegetation map. The highlighted diagonal indicates the number of points assessed in the field that agree with the map label. Conversely, the inaccuracies of each map unit are described as both errors of inclusion (user's or commission errors) and errors of exclusion (producer's or omission errors). By reading across this table (i.e., rows) one can calculate the percent error of commission, or how many polygons for each map unit were incorrectly labeled when compared to the field data. By reading down the table (i.e., columns) one can calculate the percent error of omission, or how many polygons for that type were left off the map. Numbers "on the diagonal" tell the user how well the map unit was interpreted and how confident they can be in using it. Numbers "off the diagonal" yield important information about the deficiencies of the map including which types were: 1) over-mapped - commission errors on the right –more of this type was mapped than occurs at the site or 2) under-mapped - omission errors on the bottom – some of this type was mapped as other map units.

Discussion

Whitman Mission National Historic Site located in southeastern Washington features many native and non-native plant communities occurring in riparian corridors, flat floodplains and dry hill slopes and ridges. Adjacent to the park is a mix of private residences, farms, fields, and mixed urban lands. The human influences and the land use patterns resulted in moderate challenges to the classification and mapping effort. Challenges included some logistical considerations for field work due to working on exposed geologic formations, steep slopes, and negotiating passage through the Reserve. The inventory process described in this report although largely successful revealed opportunities for improvement that are discussed herein.

Approaches that worked well: Field data and local descriptions of the plant associations provided by project ecologists were extremely important ancillary data sources used by the GIS contractor to delineate map classes. The high-quality field data provided valuable on-site information for photo signature development and the high to moderate density of the plots provided a strong baseline to build the entire mapping model. Timely and high resolution base imagery is also essential to produce detailed and accurate maps. For mapping, the 2009 and 2011 NAIP imagery products were important to this project, providing a timely, high resolution basemap that resulted in a recent final map and likely increased the overall accuracy.

Areas for Improvement: Inherent to all vegetation mapping projects is the need to produce both a consistent vegetation classification and a comprehensive set of map units. Typically, the systems are very similar, but when using a national classification such as the NVCS there is usually not a strict 1:1 correspondence. Nonconformity is due to the remote sensing nature of the interpretation and its ability to delineate map units based only on photo signatures. Subtle vegetation characteristics that can be seen on the ground are not necessarily the same as those apparent on the imagery. Canopy closure, shadows, soil reflections and the timing of the imagery acquisition can all impact the vegetation signatures. In the future if a more detailed map or classification is needed, especially for the complex grass and herbaceous types, more field-based ground-truthing work could be concentrated or focused within selected units. Similarly, if more precision is needed for the delineation of the non-native versus native woodland/forest vegetation types, new imagery (preferably color infrared) could be acquired at specific times to capture the highest degree of contrast between these types (i.e. autumn to capture leaf color change).

Field Survey

The vegetation classification data driving this project should be used as the baseline from which to begin future vegetation studies. New field survey work in a judicious timeframe would improve both the classification (plant association descriptions) and mapping (refined linework) efforts. Using the accuracy assessment as a guide, map classes with lower accuracy could be further surveyed and boundaries delineated in the field to create a more accurate GIS layer. While it may appear that there are a large number of plant associations and vegetation alliances described for the study area, some were only minimally sampled likely due to access limitations. For example, some of the herbaceous vegetation types could be examined throughout the growing season to document both the cool and warm season species in order to refine their stand composition. Also, accessing neighboring lands would allow new classification plot samples to be obtained increasing the confidence in these types, thereby strengthening the classification.

Vegetation Classification

The main classification challenge within WHMI is documenting changes to plant life caused by clearing, planting, mowing, seeding, prescribed burns, agricultural pressures (grazing, non-native plantings), and other anthropogenic disturbance. Changes can include reduction of non-native tree, shrub, and grass cover or the spread of new undocumented invasive plant species. At all times, but especially after these events, new data should be collected to document vegetation changes over time. Overall, more specialized and targeted data collection in affected areas would help to document any changes and would greatly increase the understanding of the landscape in general.

Of special consideration for future WHMI classification refinement would be the interesting mix of native and non-native grasses and how the active restoration efforts are affecting their distribution. All of the grass species at WHMI form intricate associations/ecotones with much species overlap among the dominants. From a management perspective it is likely that broader groupings are desirable since the characteristic species in each type exhibit similar growth patterns and would respond similarly to preservation and control efforts. The complex nature of these types makes it more difficult to accurately classify the dominant species into discrete and meaningful associations. More classification work concentrating on abiotic and environmental aspects including characteristic soil types, habitats, and disturbance patterns may improve the ability to determine when single species should form separate associations and when they should be grouped with other similar species.

Since WHMI is relatively small in size the presence of individual tree and shrub species and their importance to the landscape is magnified. An effort was made in this study to separate map most of the larger, different shrubland, woodland and forest types but most were grouped into broader classification units due to limits in the NVCS. A site specific census of all the planted shrubs and trees at WHMI might be warranted in the future to better document their distribution and how they fit into the existing plant associations at WHMI.

Digital Imagery and Mapping

The vegetation map for WHMI was based primarily on the 2011 NAIP ortho-imagery. Therefore, all of the resulting mapping products correspond to the summer of 2011 timing of the image acquisition (i.e. snapshot in time). As the data are used, it should be remembered that fires and other changes to the landscape since 2011 are not included in this product. In the future it might be beneficial to update the map with newer imagery and GPS coordinates (perimeters) for major events (e.g. prescribed fire perimeters, clearings, mowings, etc).

Accuracy Assessment

An important and necessary aspect of this project is the accuracy assessment; collecting independent ground data determines the usefulness of the vegetation map. As such, users of this product should remember that the GIS mapping and the classification portions of this project were conducted separately from both the plot and AA field data collection. Employing divisions in completing tasks created some challenges related to communication among the teams, including: (1) adequately conveying changes to the vegetation classification based on finding potentially new vegetation types during the field portion of the AA, (2) thoroughly testing and adjusting the field key to remove confusing splits among similar types, (3) insuring that adequate sample sizes are collected for rare and infrequent types, and (4) avoiding having to collect more than the estimated 30 data points for common types.

Actual errors in the mapping likely stemmed from limitations within the ortho-photography as previously described, natural changes in the vegetation between sampling and the acquisition date of the imagery, errors in the field key, or the difficulty in establishing an overhead perspective to exactly match the ground view. Although the accuracy for WHMI assessed high, improvements can be made and users should fully explore and understand the sources of error as presented in the error matrix.

It is also important to understand that the mapping portion of this project is primarily a remotely sensed exercise and the field work was conducted on site, therefore all resulting products are scale dependent. In general the mapping portions should be viewed as a broader overview and the field data as site-specific. An analyst can enlarge the imagery beyond the 1:12,000-scale using GIS software and see more detail; however the actual interpretation/mapping was conducted at this scale. As such, any work performed with this product at a finer scale (enlarged image) could lead to some uncertainty. In contrast, the field work was conducted at individual locations at one specific time and extrapolation using these locations to represent out-lying areas or using them to determine species presence at different times/seasons is less reliable. Database users should recognize scale limitations and balance research and modeling projects accordingly.

Future Recommendations

This project represents the best efforts of a multi-disciplinary team over a short time period. In order to create the best possible “long-term” vegetation classification for WHMI and the most accurate and detailed GIS layer, this project should be viewed as a place to start or baseline rather than an end product. In other words, present and future NPS staff should be encouraged to scrutinize this project, building from its strengths and bolstering its weaknesses. One example would be to periodically perform field checking by examining the map in the field (use qualified NPS or contract staff), document changes, and incorporate changes into newer versions. Realizing that this project represents a snapshot in time, future research can help to better understand the vegetation in and around WHMI and how it changes over time.

The products presented herein can greatly help direct future vegetation and land-use monitoring and management as follows:

1. The diversity of plant species and dynamic nature of WHMI with respect to restoration efforts, mowing, outside influences, and prescribed fire warrants periodic **field surveys** by experienced ecologists. Working with, and sampling plant communities established in the project environs would also be beneficial allowing for new plant associations to be discovered, existing vegetation types to be updated, and integrated pest management strategies could be expanded. All new information could be used to update both the GIS map layer (i.e. better delineation) and the classification (i.e. new associations).
2. Remote sensing does not replace on-the-ground knowledge provided by GPS-linked plots, observations, photographs, and ground verification. Time, topographic features, and funding limitations curtailed the amount of map **ground-truthing** performed. As research opportunities arise, maps should be examined in the field by experienced crews. Also GPS receiver data and other GIS layers (such as soils and geology) should be used to improve and update the spatial data. Data could be collected on a standard field form, stored, and then used to update the GIS layer on an annual basis. The vegetation map layer should not be viewed as static but should be updated with more current and accurate information.
3. To better understand the limitations of the map, the **accuracy assessment** data presented in the error matrices should be thoroughly reviewed by NPS staff. Map classes with low accuracy should be examined to determine if they could be improved with future studies using ground-truthing or other remote-sensing formats (i.e. fine-scale imagery, hyperspectral, etc). Also, landscape modeling may help to tease out the location of specific types based on specific habitat information. For some applications it may make sense to combine map classes into higher units, such as alliances or ecological systems to improve their accuracy.
4. For monitoring purposes, **change over time** could be addressed by similar remote sensing projects. New imagery acquired at regular intervals could be used to create up-to-date vegetation layers that could be overlain on this vegetation and land-use baseline layer. Any changes between the two layers could be extracted and analyzed. Also periodically and immediately following events causing vegetation change, new data should be collected and analyzed. New vegetation map layers should also be prepared as the base map becomes out-dated over time. Overall more specialized and targeted data collection in affected areas would also greatly help to document any changes to WHMI's vegetation.
5. In the future, resource management personnel could link the habitat for **species of concern** to specific associations and map units. These map units could be used to help locate potential sites of rare, endangered, or threatened species and communities in the field or identify areas for non-native plant removal or treatment. Known populations and individual species of concern locations can be overlain using point or small polygon layers.

Research Opportunities

Having an accurate and current vegetation classification and map in a geodatabase presents many new and exciting research opportunities. Research could include expanding or linking the GIS layer to derive other information including fire models, habitat monitoring locations, guides for rare plant surveys, wildlife habitat structural analyses, and inventorying areas that are likely vectors for invasive species. The map could also be enhanced by overlaying other existing GIS layers including geology, hydrology, elevation, and soils. In this manner complex interactions between these layers could be examined and yield important information about growth rates, regeneration after disturbance, biomass distribution, and stream morphology, among others. Through innovative analyses the vegetation layer could be used as a baseline for other ecological and climate-related studies including examining how the vegetation interacts with soil chemistry, pollution, paleontological/archeological sites, weather patterns, etc.

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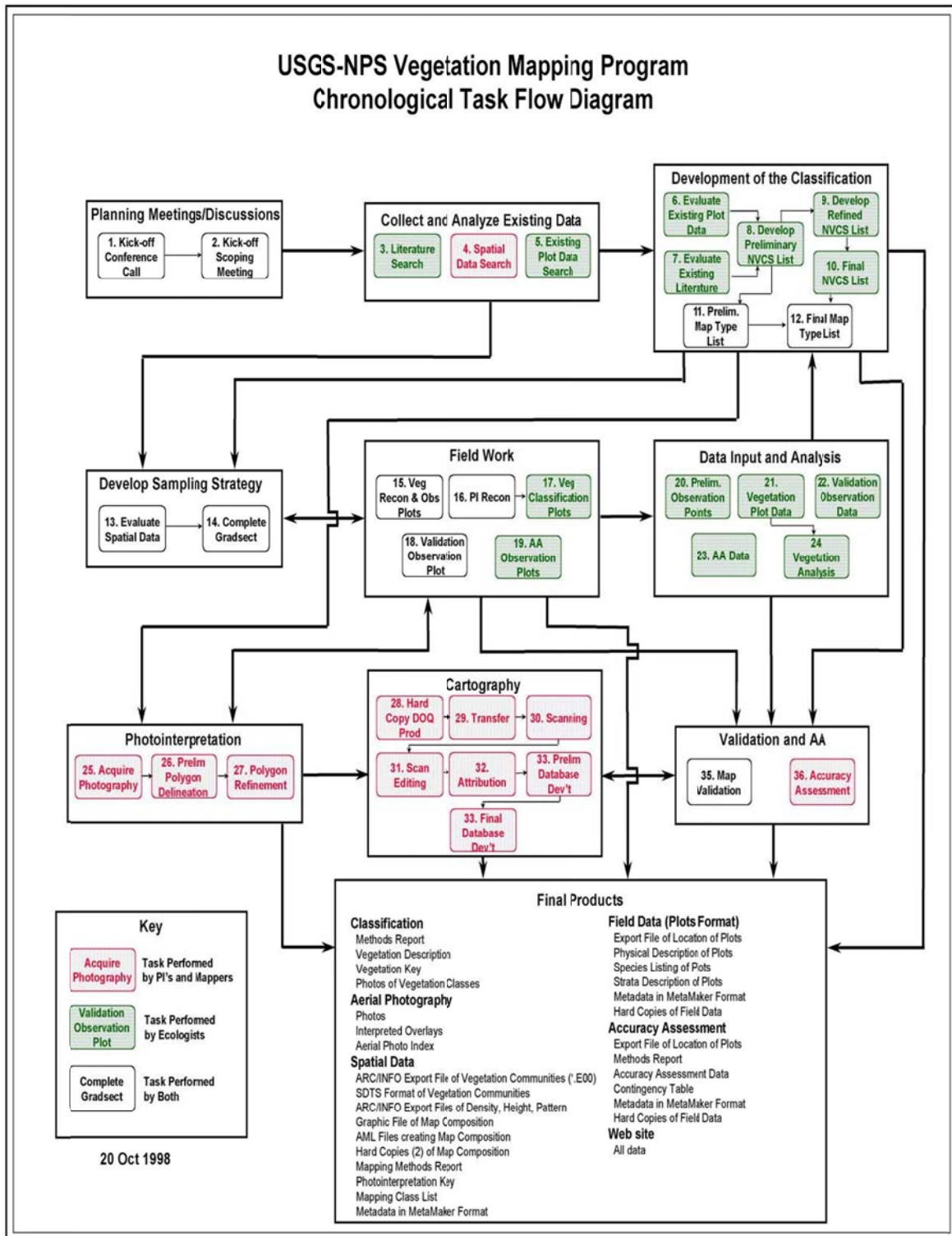
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Appendix A - Components and Flow Diagram of the Vegetation Inventory Program



Source: Tom Owens, USGS

Appendix B - Field Data Forms and Instructions

IDENTIFIERS/LOCATORS

Plot Code

Code indicating the specific plot within the vegetation polygon.

Surveyors

Names of surveyors, with principal surveyor listed first.

Date

Date the survey was taken; year, month and day.

BPU Code

The biophysical unit identified.

Provisional Community Name

Using the provisional classification of the park that was provided, assign the name of the vegetation type which most closely resembles this type. Enter the finest level of the classification possible. If it's a new type, name it based on the two or three most dominant species in the plot.

Quad Name

Appropriate name/scale from survey map used; use 7.5-minute quadrangle if possible.

Park Site Name

Provisional name assigned by field worker that describes where the data were collected. It should represent an identifiable feature on a topographic map.

GPS Rover File

Record the number of the file from the GPS unit.

Field UTM X

Use GPS; do not estimate. If you can't get a GPS reading, estimate coordinates from a topo map and note on the form that this method was used.

Field UTM Y

Use GPS; do not estimate. If you can't get a GPS reading, estimate coordinates from a topo map and note on the form that this method was used.

Error

Error is recorded from the GPS unit.

Plot Length and Plot Width

Enter width and length dimensions for square or rectangular plots. Choose the appropriate plot size based on the following:

Vegetation Class	Standard Plot Dimensions	PLOT AREA
Forest	20 m x 20 m	400 m ²
Woodland	20 m x 20 m	400 m ²
Shrubland	20 m x 20 m	400 m ²
Dwarf-shrubland (heath)	10 m x 10 m	100 m ²
Herbaceous	10 m x 10 m	100 m ²
Nonvascular	5 m x 5 m	25 m ²

Photo numbers

If photos of the plot have been taken at the time of sampling, indicate their numbers from the ones the camera assigns.

Plot Permanent

Note if the plot has been permanently marked.

Plot Representativeness

Does this plot represent the full variability of the polygon? If not, were additional plots taken?

Note: we distinguish in this section the plot's ability to represent the stand or polygon you are sampling as one component and the ability of this sample to represent the range of variability of the association in the entire mapping area. The former comment may be ascertained by reconnaissance of the stand. The latter comment comes only after some familiarity with the vegetation type throughout the mapping area and may be left blank if you have no opinion at this time.

ENVIRONMENTAL DESCRIPTION

Elevation

Elevation of the plot obtained from the GPS

Slope

Measure the slope in percent using a clinometer.

Aspect

Measure the aspect using a compass (be sure compass is set to correct for the magnetic declination).

Topographic Position

Choose one:

INTERFLUVE (crest, summit, ridge). Linear top of ridge, hill, or mountain; the elevated area between two fluves (drainageways) that sheds water to the drainageways.

SHOULDER (shoulder slope, upper slope, convex creep slope).
Geomorphic component that forms the uppermost inclined surface at the top of a slope. Includes the transition zone from backslope to summit. Surface is dominantly convex in profile and erosional in origin.

BACKSLOPE. Subset of midslopes that are steep, linear and may include cliff segments (fall faces).

FOOTSLOPE (lower slope, foot slope, colluvial footslope). Inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between backslope and toeslope.

TOESLOPE (alluvial toeslope). Outermost gently inclined surface at base of a slope. In profile, commonly gentle and linear and characterized by alluvial deposition.

TERRACE Valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.

CHANNEL (narrow valley bottom, gully, arroyo). Bed of single or braided watercourses commonly barren of vegetation and formed of modern alluvium.

BASIN FLOOR (depression). Nearly level to gently sloping, bottom surface of a basin.

Describe Topographic Position (Optional)

Give more details here, if needed.

Cowardin System

Indicate “upland” if the system is not a wetland. If the system is a wetland, check off the name of the USFWS system which best describes its hydrology and landform.

- Riverine: Below the high water mark on a moving water system (a creek bed). A community of *Eleocharis* on a sand bar would be in this category.
- Palustrine: In the riparian zone. Plants regularly have wet roots through much of the summer. A community of willows and sedges would be in this category.
- Lacustrine: Below the high water mark of a lake. The marshy debris on the edge of a lake would be in this category.

Assess the hydrologic regime of the plot using the descriptions below (adapted from Cowardin et al. 1979).

PERMANENTLY FLOODED - Water covers the land surface at all times of the year in all years. Equivalent to Cowardin's “permanently flooded.”

SEMIPERMANENTLY FLOODED - Surface water persists throughout growing season in most years except during periods of drought. Land surface is normally saturated when water level drops below soil surface. Includes Cowardin's Intermittently Exposed and Semipermanently Flooded modifiers.

SEASONALLY FLOODED - Surface water is present for extended periods during the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases and is very variable, extending from saturated to a water table well below the ground surface. Includes Cowardin's Seasonal, Seasonal-Saturated, and Seasonal-Well Drained modifiers.

SATURATED - Surface water is seldom present, but substrate is saturated to surface for extended periods during the growing season. Equivalent to Cowardin's Saturated modifier.

TEMPORARILY FLOODED - Surface water present for brief periods during growing season, but water table usually lies well below soil surface. Often characterizes floodplain wetlands. Equivalent to Cowardin's Temporary modifier.

INTERMITTENTLY FLOODED - Substrate is usually exposed, but surface water can be present for variable periods without detectable seasonal periodicity. Inundation is not predictable to a given season and is dependent upon highly localized rain storms. This modifier was developed for use in the arid West for water regimes of Playa lakes, intermittent streams, and dry washes, but can be used in other parts of the U.S. where

appropriate. This modifier can be applied to both wetland and non-wetland situations. Equivalent to Cowardin's Intermittently Flooded modifier.

UNKNOWN - The water regime of the area is not known. The unit is simply described as a non-tidal wetland.

Unvegetated Surface

Estimate the approximate percentage of the *total* surface area covered by each category.

Soil Texture

Using the key below, assess average soil texture.

Simplified Key to Soil Texture

Soil does not remain in a ball when squeezed.....sand

Soil remains in a ball when squeezed.....2

Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you can push up over your finger.

2. Soil makes no ribbon.....loamy sand

2. Soil makes a ribbon (may be very short).....3

3. Ribbon extends less than 1 inch before breaking.....4

Add excess water to small amount of soil:

4. Soil feels smooth.....silt loam

4. Soil feels at least slightly gritty.....5

Squeeze a moistened ball:

5. Cast is formed which can be handled CAREFULLY without breaking..... sandy loam

5. Cast is formed which can be handled FREELY without breaking.....loam

3. Ribbon extends 1 inch or more before breaking.....6

5. Soil makes a ribbon that breaks when 1 to 2 inches long;
cracks if bent into a ring.....7

Add excess water to small amount of soil:

7. Soil feels at least slightly gritty.....clay loam

7. Soil feels smooth.....silt

6. Soil makes a ribbon 2+ inches long;
does NOT crack when bent into a ring..... 8

Add excess water to a small amount of soil:

8. Soil feels at least slightly gritty.....clay

8. Soil feels smooth.....silty clay

HANDBOOK ON SOILS

In the field, soil texture is determined by the feel of a moist soil when it is rubbed between the thumb and fingers. While sand particles feel gritty, silt particles have a smooth velvety feel and clay is both sticky and plastic, an estimate of the relative proportions of the separates may be made. This procedure, of course, will not give the exact percentage of sand, silt, and clay, but, with a little practice on samples of known composition, the relative proportions of the individual separates can be closely estimated. Practice with known samples is the only way to acquire this knowledge.

The outstanding physical characteristics of the main textural grades as determined by the feel of the soil are described below.

1. Sandy Soil. A sandy soil is loose and single grained. The individual grains can be seen readily or felt. Squeezed in the hand when dry, it will fall apart when pressure is released. Squeezed when moist, it will form a cast, but will crumble when touched.
2. Sandy Loam Soil. A sandy loam soil contains much sand, but has enough silt and clay to make it somewhat coherent. Individual sand grains can be easily seen and felt. Squeezed when dry, it will form a cast which will readily fall apart; but if squeezed when moist a cast can be formed which will bear careful handling without breaking.
3. Loam Soil. A loam soil is about an equal mixture of the sand and silt with the clay content being between 7 and 27 percent. A loam is mellow with a somewhat sandy feel, yet fairly smooth and slightly plastic. Squeezed when moist, it will form a cast which can be handled freely without breaking.
4. Silt Loam Soil. A silt loam soil, when dry, may appear cloddy, but lumps are readily broken, and when pulverized, it feels soft and floury. When wet, the soil readily runs together. Either dry or moist, it will form casts which can be handled freely without breaking, but when moistened and extruded between the thumb and fingers, it will not form a ribbon, but will give a broken appearance.
5. Clay Loam Soil. A clay loam soil is fine-textured and usually breaks into clods or lumps that are hard when dry. When moist and extruded between the thumb and fingers, it will form a thin "ribbon" which will break readily, barely sustaining its own weight. The moist soil is plastic and will form a cast that will bear much handling. When kneaded in the hand, it does not crumble readily, but tends to work into a heavy, compact mass.
6. Clay Soil. A clay soil is fine-textured and usually forms very hard lumps or clods when dry and is plastic and sticky when wet. When the moist soil is ribboned out between the thumb and fingers, it will form a long flexible strip. A clay soil leaves a "slick" surface on the thumb and fingers when rubbed together and tends to hold the thumb and fingers together due to the stickiness of the clay.

The characteristics described above are suggestive only, and will only apply to a group of similar soils. The characteristics of clay vary with the kind of clay mineral. For this reason, textural grades may exhibit different properties from region to region. For instance, clays of the montmorillonite group are very sticky and plastic; those of the oxide group are plastic and waxy with relatively little stickiness.

The preceding discussion has been directed to those soil particles whose diameters are less than 2 millimeters--the sands, silts, and clays. Soils may also contain larger sized particles that may be collectively called coarse fragments. These large particles may on occasion exceed the smaller soil particles in volume.

Soil Drainage

The soil drainage classes are defined in terms of (1) actual moisture content (in excess of field moisture capacity) and (2) the extent of the period during which excess water is present in the plant-root zone. It is recognized that permeability, level of groundwater, and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot generally be used as criteria of moisture status. It is further recognized that soil profile morphology, for example mottling, normally, but not always, reflects soil moisture status. Although soil morphology may be a valuable field indication of moisture status, it should not be the overriding criterion. Soil drainage classes cannot be based solely on the presence or absence of mottling. Topographic position and vegetation as well as soil morphology are useful field criteria for assessing soil moisture status.

WELL DRAINED - The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year.

MODERATELY WELL DRAINED - The soil moisture content is in excess of field capacity for a small but significant period of the year.

POORLY DRAINED - The soil moisture content is in excess of field capacity in all horizons for a large part of the year.

VEGETATION DESCRIPTION

Leaf Phenology

Select the value which best describes the leaf phenology of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

EVERGREEN - Greater than 75% of the total woody cover is never without green foliage.

COLD DECIDUOUS - Greater than 75% of the total woody cover sheds its foliage in connection with an unfavorable season mainly characterized by winter frost.

MIXED: EVERGREEN & COLD DECIDUOUS - Evergreen and deciduous species generally contribute 25-75% of the total woody cover. Evergreen and cold-deciduous species are mixed.

PERENNIAL - Herbaceous vegetation composed of more than 50% perennial species.

ANNUAL - Herbaceous vegetation composed of more than 50% annual species.

Leaf Type

Select the value which best describes the leaf form of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

BROAD-LEAVED - Woody vegetation primarily broad-leaved (generally contributes greater than 50 percent of the total woody cover).

NEEDLE-LEAVED - Woody vegetation primarily needle-leaved (generally contributes greater than 50 percent cover).

GRAMINOID - Herbaceous vegetation composed of more than 50 percent graminoid/stipe leaf species.

FORB (BROAD-LEAF-HERBACEOUS) - Herbaceous vegetation composed of more than 50% broad-leaf forb species.

PTERIDOPHYTE - Herbaceous vegetation composed of more than 50 percent species with frond or frond-like leaves. (Ferns)

Physiognomic Class

Choose one:

Forest: Trees with their crowns overlapping (generally forming 60-100% cover).

Woodland: Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover.

Shrubland: Shrubs generally greater than 2.5 feet tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover.

Dwarf-Shrubland: Low-growing shrubs usually under 2.5 feet tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and

tall shrubs generally less than 25% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover.

Herbaceous: Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover.

Nonvascular: Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover.

Sparse Vegetation: Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 25% and greater than 0%).

Strata, Height Class, Cover Class, Diagnostic Species

Visually divide the community into vegetation layers (strata). Indicate the average height class of the stratum in the first column, using the Height Scale on the form. Enter the average percent cover class of the whole stratum in the second column, using the Cover Scale on the form. Height and Cover classes are also listed below.

Trees are defined as single-stemmed woody plants, generally 15 feet in height or greater at maturity and under optimal growing conditions. Shrubs are defined as multiple-stemmed woody plants generally less than 15 feet in height at maturity and under optimal growing conditions.

List the dominant species in each stratum.

Animal Use Evidence

Comment on any evidence of wildlife (i.e., tracks, scat, gopher or prairie dog mounds, etc.). Notes on domestic animals should be made in the field below.

Natural and Anthropogenic Disturbance

Comment on any evidence of natural or anthropogenic disturbance and specify the source.

Environmental Comments

Enter any additional noteworthy comments on the environmental setting. This field can be used to describe site history such as fire events (date since last fire or evidence of severity) as well as other disturbance or reproduction factors

Other Comments

Any miscellaneous comments.

Species/Strata/Percent Cover Table

The main use of the strata information is to categorize the plots by life form, in order to subset the data into forest, woodland, shrublands, and herbaceous plots for analysis. It is imperative that things be called the same throughout the data set.

Starting with the uppermost stratum, list all the species present and their cover class using the scale provided below. If a species is in the tree layer (single-stemmed woody plants, generally 15 feet in height or greater at maturity), list whether it is T1 (emergent tree), T2 (tree canopy), or T3 (tree sub-canopy). If a species is in the shrub layer, note if S1 (tall shrub), or S2 (short shrub), or S3 (dwarf shrub). If in the ground layer, note if H (herbaceous) or N (nonvascular). Some species will be in more than one layer. For example, Cottonwoods might have one or two especially tall specimens, which would be in the T1 (emergent tree) layer. Then the majority of the mature trees would be in T2 (tree canopy). The saplings that are coming up in the understory would be in the T3.

Seedlings are defined as trees less than “breast height” or less than 4.5 feet tall. Seedlings between knee height and breast height should be labeled as being in the short shrub layer (S2), and those below knee height should be labeled as being in the dwarf shrub layer (S3).

Cover Scale for Species Percent Cover

Use the cover scales provided on the forms.

NATIONAL PARK VEGETATION MAPPING PROGRAM: PLOT SURVEY FORM

IDENTIFIERS/LOCATORS

Plot Code _____	Polygon Code _____
Provisional Community Name _____	
State _____	Park Name _____
Park Site Name _____	
Quad Name _____	Quad Code _____
GPS file name _____	Field UTM X _____
	m E Field UTM Y _____ m N
	Error +/- _____ m
<i>please do not complete the following information when in the field</i>	
Corrected UTM X _____	m E Corrected UTM Y _____ m N
UTM Zone _____	
Survey Date _____	Surveyors _____
Directions to Plot _____	
Plot length _____	Plot width _____
Plot Photos (y/n) _____	Roll Number _____
Frame Number _____	Plot Permanent (y/n) _____
Plot representativeness _____	

ENVIRONMENTAL DESCRIPTION

Elevation _____	Slope _____	Aspect _____
Topographic Position _____		
Landform _____		
Surficial Geology _____		

Cowardin System	<u>Non-Tidal</u>	
____ Upland	____ Permanently Flooded	____ Saturated
____ Riverine	____ Semipermanently Flooded	____ Seasonally Flooded/Saturated
____ Palustrine	____ Seasonally/Temporarily Flooded	____ Intermittently Flooded
____ Lacustrine		

Environmental Comments:	Soil Taxon/Description
	Unvegetated Surface: <i>(please use the cover scale on next page)</i>
	____ Bedrock ____ Litter, duff ____ Wood (> 1 cm)
	____ Large rocks (cobbles, boulders > 10 cm)
	____ Small rocks (gravel, 0.2-10 cm)
	____ Sand (0.1-2 mm) ____ Bare soil
	____ Other: _____
Soil Texture	Soil Drainage
____ sand ____ loamy sand ____ sandy loam ____ loam	____ Rapidly drained ____ Well drained
____ silt loam ____ silt ____ clay loam ____ silty clay	____ Moderately well drained ____ Somewhat poorly drained
____ clay ____ peat ____ muck	____ Poorly drained ____ Very poorly drained

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	Cover Scale for Strata & Unvegetated Surface		Height Scale for Strata	
<u>Trees and Shrubs</u>	<u>Broad-leaved</u>	<u>Forest</u>	01	5%	01	<0.5 m
<u>Evergreen</u>	<u>Needle-leaved</u>	<u>Woodland</u>	02	10%	02	0.5-1m
<u>Cold-deciduous</u>	<u>Microphyllous</u>	<u>Shrubland</u>	03	20%	03	1-2 m
<u>Drought-deciduous</u>	<u>Graminoid</u>	<u>Dwarf Shrubland</u>	04	30%	04	2-5 m
<u>Mixed evergreen - cold-deciduous</u>	<u>Forb</u>	<u>Herbaceous</u>	05	40%	05	5-10 m
<u>Mixed evergreen - drought-deciduous</u>	<u>Peridophyte</u>	<u>Nonvascular</u>	06	50%	06	10-15 m
		<u>Sparse Vegetated</u>	07	60%	07	15-20 m
			08	70%	08	20-35 m
			09	80%	09	35 - 50 m
			10	90%	10	>50 m
			11	100%		
<u>Herbs</u>						
<u>Annual</u>						
<u>Perennial</u>						

Strata	Height Class	Cover Class	Diagnostic species (if known)
T1 Emergent			
T2 Canopy			
T3 Sub-canopy			
S1 Tall shrub			
S2 Short Shrub			
H Herbaceous			
N Non-vascular			
V Vine/iana			
E Epiphyte			
<i>please see above table for height and cover scales</i>			
Animal Use Evidence			
Natural and Anthropogenic Disturbance Comments			
Other Comments			

Species/percent cover: Starting with the uppermost stratum, list all species with % cover for each species in the stratum. For each tree species estimate seedling, sapling, mature and total cover indicating stratum. Also for forests and woodlands, on a separate page or line below each tree species, list the DBH of all trees above 5 cm diameter. Separate measurements with a comma (note if measurements are from multi-stemmed tree). Put an asterisk next to any species that are known diagnostics for a particular community in the classification. Also list species outside the plot at the end of the table or designate with a 0 in Cover Class column.

[illegible]

T = >0-1%	5 = >45-55%
P = >1-5%	6 = >55-65%
1 = >5-15%	7 = >65-75%
2 = >15-25%	8 = >75-85%
3 = >25-35%	9 = >85-95%
4 = >35-45%	10 = >95%

ACCURACY ASSESSMENT POINT FORM
UPPER COLUMBIA BASIN NETWORK VEGETATION MAPPING PROJECT

IDENTIFIERS/LOCATORS

AA Plot Number: _____		AA Point Shape: circle other	
Park Site Name _____			
Survey Date _____		Surveyor(s) _____	
GPS Unit: <u>Garmin Map 76</u>		Datum NAD 83	UTM Zone: <u>11</u> Error +/-: _____ m
Camera Name and Model (circle one): <u>Olympus Stylus FE-210</u> Other: _____			
Camera #	Frame #	Photographer	Direction/Comments

PLANT ASSOCIATION INFORMATION

ASSOCIATIONS AT AA POINT		MAP UNIT AT AA POINT	New?	OTHER ASSOCIATIONS WITHIN 50 M OF AA POINT
Primary Name/Code	Map Code		1.	
Secondary Name/Code			2.	
Tertiary Name/Code			3.	
Representativeness of point within polygon: Good Fair Poor Unk of association to description: Good Fair Poor				
Classification Comments: (complications, uncertainties, explanation of fair/poor representativeness)				

ENVIRONMENTAL DESCRIPTION

Elevation _____ m/ft	Front GPS	Slope _____	Aspect _____
Topographic Position: <u>Circle One</u>			
Interfluvial	Shoulder	Backslope	Footslope Toeslope Step in slope Valley floor Terrace Channel
Environmental Comments:			
			

Unvegetated Surface Cover: (please use the cover scale below)		
_____ Bedrock	_____ Large rocks (cobbles, boulders > 10 cm)	_____ Sand (0.1-2 mm)
_____ Litter, duff	_____ Small rocks (gravel, 0.2-10 cm)	_____ Bare soil
_____ Wood (> 1 cm)	_____ Nonvascular	_____ Other: _____

ACCURACY ASSESSMENT POINT FORM
UPPER COLUMBIA BASIN NETWORK VEGETATION MAPPING PROJECT

VEGETATION DESCRIPTION

Leaf phenology (dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic Class	Height Class (m)	Cover Class
<u>Trees and Shrubs</u>		<u>Pick one</u>	T < 1ft.	t < 0.5%
_____ Evergreen	_____ Broad-leaved	_____ Forest	01 1-5ft.	T 0.5-0.99%
_____ Deciduous	_____ Needle-leaved	_____ Woodland	05 5-15ft.	01 1-1.9%
_____ Mixed evergreen - deciduous	_____ Graminoid	_____ Shrubland	15 15-30ft.	02 2-4.9%
	_____ Forb		30 > 30ft.	05 5-9.9%
<u>Herbs</u>	_____ Pteridophyte	_____ Dwarf shrubland		10 10-14%
_____ Perennial	_____ Non Vascular	_____ Herbaceous		15 15-24%
_____ Annual	_____ Mixed	_____ Nonvascular		25 25-34%
		_____ Sparsely vegetated		35 35-49%
				50 50-74%
				75 75-94%
				95 > 95%

Strata	Height Class	Cover Class	2 - Dominant species (mark any known diagnostic species with a *)	Individual Species Cover
T1 Emergent	_____	_____	_____	_____
T2 Canopy	_____	_____	_____	_____
			_____	_____
			_____	_____
T3 Sub-canopy	_____	_____	_____	_____
			_____	_____
S1 Tall shrub	_____	_____	_____	_____
			_____	_____
			_____	_____
S2 Short Shrub	_____	_____	_____	_____
			_____	_____
			_____	_____
S3 Dwarf-shrub	_____	_____	_____	_____
			_____	_____
H Herbaceous	_____	_____	_____	_____
			_____	_____
			_____	_____
N Non-vascular	_____	_____	_____	_____

Please check this box if AA point has more than one plant association (e.g. two or more species list at a point recorded on form)

Appendix C - Dichotomous Key to WHMI Plant Associations

Dichotomous Key to the Classification

The field key to plant communities for WHMI and environs follows. The key is structured into physiognomic classes (or lifeform groups). These classes do not constraint the classification *per se*; rather they are employed to assist in applying the classification. In the field, different expressions of a given plant association may occur as different physiognomic classes. Given this, associations may be found through multiple pathways within the key.

Use of the Key

To use the field key most effectively, identify a representative, homogeneous stand of vegetation. Work through the entire hierarchy of the key, beginning with *Key to Lifeform Groups*, to each sequential dichotomous lead. Estimate plant cover on an area of approximately 405 m². If a satisfactory determination is not made in stands with low total cover consider adjusting diagnostic species cover break-points downward. Assignment of individual species to lifeform follows USDA, NRCS (2007).

In the key the term *relative cover* is used. In this context relative cover refers to the proportional abundance of the given species (or group of species) with respect to the total abundance of the associated group. The value is calculated by dividing the percent cover of the species under consideration by the total cover of the respective group of species. For example, the relative cover of native graminoid species is calculated as follows: (sum of native graminoid species cover within the sample) / (total cover of all graminoids within the sample) = (relative native graminoid composition).

Key to Lifeform Groups

1a Trees are common to abundant, providing at least 10% absolute canopy cover

Forest and Woodland Vegetation Classes pg 1

1b Trees are absent to sparse; when present, individuals are scattered with less than 10% absolute canopy cover

2a Shrubs are common to dominant; herbaceous species may range from sparse to co-dominant

Shrubland Vegetation Classes pg 1

2b Herbaceous species clearly dominate the plant community; shrubs may be present, but don't contribute substantial cover

Herbaceous Vegetation Classes pg 1

Forest and Woodland Vegetation Classes

1a *Salix amygdaloides* is the dominant tree species

Vegetation Class 8: SAAM

1b The dominant tree species are introduced or are not otherwise endemic to the area

2a *Populus deltoides* and/or *Platanus occidentalis* dominate the canopy

Vegetation Class 7: PODE - PLOC

2b *Ulmus parvifolia*, *Acer platanoides*, and/or *Populus alba* dominate the canopy

Vegetation Class 15: ULPA

Shrubland Vegetation Classes

1a Native shrubs dominate the plant community

2a *Salix lucida* is the most abundant shrub species

Vegetation Class 10: SALU

2b *Ericameria nauseosa* and/or *Chrysothamnus viscidiflorus* are the most abundant shrub species

Vegetation Class 13: ERNA - CHVI

1b *Rubus armeniacus* is the dominant shrub species

Vegetation Class 17: RUAR

Herbaceous Vegetation Classes

- 1a The most abundant species is a graminoid
 - 2a The dominant species is native
 - 3a Upland species dominate the plant community
 - 4a *Pseudoroegneria spicata* is the most abundant grass species
Vegetation Class 9: PSSP - FEOV
 - 4b *Festuca idahoensis* is the most abundant grass species
Vegetation Class 12: FEID
 - 3b *Leymus cinereus*, which favors low-lying topography where water accumulates, dominates the plant community
Vegetation Class 11: LECI
 - 2b The dominant species is introduced or is not otherwise endemic to the area
 - 5a The dominant species is perennial
 - 6a Bunch grasses dominate the plant community
 - 7a *Thinopyrum ponticum* is the most abundant grass species
 - 8a *Phalaris arundinacea* ranges from common to co-dominant in the plant community and contributes substantial cover
Vegetation Class 5: PHAR - THPO
 - 8b *Phalaris arundinacea* is sparse to absent from the plant community
Vegetation Class 1: THPO
 - 7b *Festuca ovina* is the most abundant grass species
Vegetation Class 9: PSSP - FEOV
 - 6b Rhizomatous grasses dominate the plant community
 - 9a *Phalaris arundinacea* is abundant, contributes substantial cover to the plant community
 - 10a *Phalaris arundinacea* clearly dominates the plant community; other species may be present, but do not contribute substantial cover
Vegetation Class 2: PHAR
 - 10b Other species are abundant to dominant and contribute substantial cover to the plant community
 - 11a *Thinopyrum ponticum* is abundant in the plant community
Vegetation Class 5: PHAR - THPO
 - 11b *Bromus tectorum* is abundant in the plant community
Vegetation Class 4: PHAR - BRTE
 - 9b *Phalaris arundinacea* is sparse or absent from the plant community
 - 12a *Poa pratensis* dominates the plant community
Vegetation Class 6: POPR
 - 12b *Thinopyrum intermedium* dominates the plant community
Vegetation Class 14: THIN

5b *Bromus tectorum* dominates the plant community

13a *Bromus tectorum* clearly dominates the plant community; other species may be present, but do not contribute substantial cover

Vegetation Class 3: BRTE

13b Other species are abundant to co-dominant and contribute substantial cover to the plant community

14a *Phalaris arundinacea* is abundant and contributes substantial cover to the plant community

Vegetation Class 4: PHAR – BRTE

14b *Sisymbrium altissimum* is abundant and contributes substantial cover to the plant community

Vegetation Class 16: SIAL - BRTE

1b The most abundant species is a forb

15a *Sisymbrium altissimum* is abundant and contributes substantial cover to the plant community

Vegetation Class 16: SIAL - BRTE

15b *Sisymbrium altissimum* is sparse or absent from the plant community

16a *Dipsacus fullonum* is abundant and contributes substantial cover to the plant community

Vegetation Class 4: PHAR - BRTE

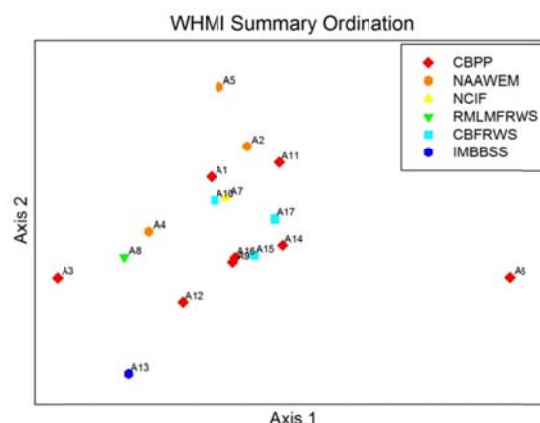
16b *Conium maculatum* is abundant and contributes substantial cover to the plant community

Vegetation Class 5: PHAR – THPO

Appendix D - WHMI Plant Association Descriptions

A1 Tall Wheatgrass Semi-natural Herbaceous Vegetation

Thinopyrum ponticum Semi-natural Herbaceous Vegetation



Description

An introduced, perennial, bunch grass, *Thinopyrum ponticum*, dominates this herbaceous vegetation type. There are few, if any other species found in stands of this monotypic association. If other species occur, non-natives may be expected. *Thinopyrum ponticum* is often planted as a cover crop or as an erosion control measure. It is not expected to linger with competitive native species, however, under certain soil conditions, it may be hard to replace once established.

Thinopyrum ponticum is adapted to a wide range of soil types and climates. It establishes well on wet, alkaline soils such as greasewood and saltgrass sites where the water table is from a few inches to several feet below ground surface. Tall wheatgrass has been planted as forage on saline and sodic soils where few other species will survive.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 9, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Thinopyrum ponticum (tall wheatgrass) V.64

Forb

None

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

Tall wheatgrass is originally from Turkey, Asia Minor and Russia. It was introduced to the U.S. from Turkey in 1909 and is now found throughout all western and central states of the U.S. and most Canadian provinces.

COMMENTS

Tall wheatgrass is used for hay and pasture in the northern Great Plains and intermountain region. It produces high yields of good quality forage. However, it is typically less palatable than other wheatgrasses and is best suited for early season rotational grazing.

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.



A2

Reed Canarygrass Western Herbaceous Vegetation

Phalaris arundinacea Western Herbaceous Vegetation



Description

This association is characterized by a dense, tall herbaceous stratum that is dominated by *Phalaris arundinacea*, which tends to form nearly monotypic stands. Associated species such as *Mentha arvensis*, *Polygonum amphibium*, *Solidago canadensis*, and *Urtica dioica* may occur with very sparse cover values. Introduced species such as *Daucus carota*, *Cirsium arvense*, *Dipsacus fullonum*, *Bromus inermis*, *Bromus tectorum*, *Euphorbia esula*, and *Poa pratensis* are common in disturbed stands that dry out mid-summer.

This association is reported across a wide elevation range. Stands are found along riparian areas, pond and lake margins, wet meadows, and intermittent drainages. Sites are flat to rolling. The poorly drained soils are derived from alluvium and are commonly fine-textured but can also be coarser in texture. Sites are generally flooded from brief to extended periods, and soils remain saturated throughout much of the the growing season.

CONSERVATION RANK G5

DATABASE CODE CEG001474

CHARACTERISTIC SPECIES (n = 8, xx)

Tree

None

Shrub

None

Dwarf-shrub

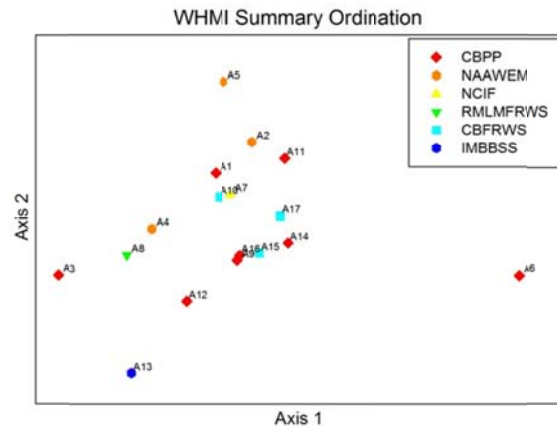
None

Graminoid

Phalaris arundinacea (reed canarygrass) V.56

Forb

Dipsacus fullonum (Fuller's teasel) IV.1



RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

This association is described from Colorado, Nebraska, Montana, Idaho, Washington and northeastern Utah and is likely more widespread in the western United States. It has been documented to occur in British Columbia and Alberta, Canada, and is probably widespread elsewhere in southern parts of Canadian provinces. Its distribution as a natural type is complicated because this native species is widely cultivated as a forage crop and has escaped and established in many wetlands and riparian areas.

COMMENTS

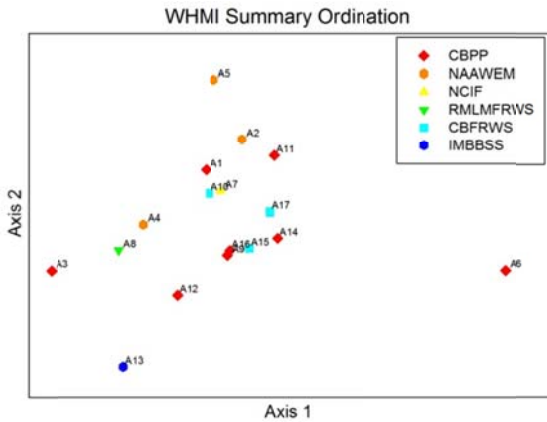
Phalaris arundinacea produces abundant herbage and was planted for livestock forage. It is tolerant of moderate grazing by livestock, although heavy grazing will reduce density. *Phalaris arundinacea* is a threat to riparian and wetland areas because it spreads rapidly from rhizomes, dominating sites, and is extremely difficult to remove once established. Fire has been used with limited success to control the spread of *Phalaris arundinacea*, but the high water table where it grows makes it difficult to burn during the growing season.



A3

Cheatgrass Semi-natural Herbaceous Vegetation

Bromus tectorum Semi-natural Herbaceous Vegetation



Description

The vegetation in this herbaceous association is dominated by *Bromus tectorum*, an introduced, annual grass species. The herbaceous stratum may range from moderate to dense. Native species persist in some stands, however cover and diversity are typically low, and component native species can be quite variable depending on the plant community that was present prior to the conversion to introduced herbaceous species. Native shrubs may occur sporadically with low densities. *Thinopyrum ponticum* and *Poa bulbosa*, both of which are introduced species, are the most frequently occurring and abundant additional grasses in this community type. Several forb species may occur with sparse cover and variable species composition across stands of this type. *Sisymbrium altissimum*, *Convolvulus arvensis*, and *Lactuca serriola* occur with the greatest frequency.

This association can occur across a wide range of environmental conditions in semi-arid ecosystems and is not tightly constrained by slope, aspect, soil texture, or soil depth. This association often occurs on or near sites that have been disturbed.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 15, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Bromus tectorum (cheatgrass) V.36, *Thinopyrum ponticum* (tall wheatgrass) III.8, *Poa bulbosa* (bulbous bluegrass) III.2

Forb

Sisymbrium altissimum (tall tumbled mustard) V.1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

The range the *Bromus tectorum* Semi-natural Herbaceous Alliance occurs throughout much of western North America from the western Great Plains to the intermountain and southwestern U.S.

COMMENTS

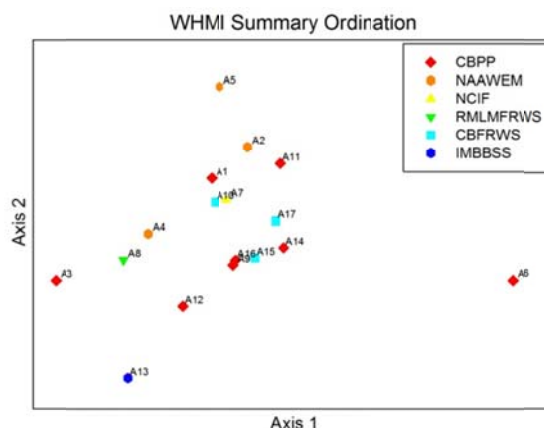
The unique life history characteristics of *Bromus tectorum* and the altered ecological process associated with this species have promoted the spread of it and other exotic annual bromes at the expense of sagebrush shrublands and related assemblages in large parts of the western U.S. Consequently, this species tends to dominate or co-dominate primarily on sites that have been severely impacted.

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from the Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.

A4

Reed Canarygrass - Cheatgrass Herbaceous Vegetation

Phalaris arundinacea - *Bromus tectorum* Herbaceous Vegetation



Description

This association is characterized by a dense, tall herbaceous layer that is dominated by *Phalaris arundinacea*, which occurs as small linear patches within a matrix of other invasive grasses, primarily *Bromus tectorum*. *Bromus tectorum* cover ranges from sparse to moderate. The spatial pattern of this community type is a patchy co-dominance rather than a homogenous mix the most abundant species. Tree and shrub species are rare in this vegetation type. Other introduced herbaceous species such as *Daucus carota*, *Cirsium arvense*, *Dipsacus fullonum*, *Thinopyrum ponticum*, *Nepeta cataria* *Conium maculatum*, and *Poa pratensis* are also common in disturbed stands of this type.

This dominant species in this association are reported to occur across a wide elevation range. Stands are found along riparian areas, pond and lake margins, wet meadows, and intermittent drainages. Sites are flat to rolling. The poorly drained soils are derived from alluvium and are commonly fine-textured but can also be coarser in texture. Sites are generally flooded from brief to extended periods, and soils remain saturated throughout the growing season but may dry out in the mid to late summer, which would lead to emergence of the drier grassland species.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 4, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Bromus tectorum (cheatgrass) V.15, *Phalaris arundinacea* (reed canarygrass) V.6, *Thinopyrum ponticum* (tall wheatgrass) V.3

Forb

Dipsacus fullonum (Fuller's teasel) V.8, *Daucus carota* (Queen Anne's lace) V.1, *Nepeta cataria* (catnip) V.1, *Conium maculatum* (poison hemlock) V.<1, *Cirsium arvense* (Canada thistle) III.13

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

This association is probably widespread in the western United States. It is also likely to occur widespread elsewhere in southern parts of Canadian provinces. The distribution of *Phalaris arundinacea* communities as a natural type is complicated because this native species is widely cultivated as a forage crop and has escaped and established in many wetlands and riparian areas.

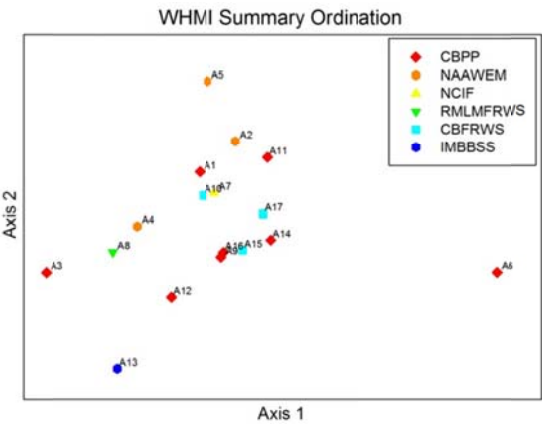
COMMENTS

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from the Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.

A5

Reed Canarygrass – Tall Wheatgrass Herbaceous Vegetation

Phalaris arundinacea – *Thinopyrum ponticum* Herbaceous Vegetation



Description

This association is characterized by a dense, tall herbaceous layer that is dominated by *Phalaris arundinacea*, and *Thinopyrum ponticum*. The tall native bunchgrass, *Leymus cinereus* is also abundant in many stands of this vegetation type. Tree and shrub species are rare. Forbs common to this community type are often introduced and may include; *Daucus carota*, *Cirsium arvense*, *Nepeta cataria* and *Conium maculatum*. Sites that support this community are often disturbed or in close proximity to past disturbance.

Associations dominated by these species are reported across a wide elevation range. Stands are found along riparian areas, pond and lake margins, wet meadows, and intermittent drainages. Sites are flat to rolling. The poorly drained soils are derived from alluvium and are commonly fine-textured but can also be coarser in texture. Sites are generally flooded from brief to extended periods, and soils remain saturated throughout the growing season but may dry out in the mid to late summer, which would lead to emergence of the drier grassland species.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 2, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Phalaris arundinacea (reed canarygrass) V.20, *Thinopyrum ponticum* (tall wheatgrass) V.15, *Leymus cinereus* (basin wildrye) III.8

Forb

Conium maculatum (poison hemlock) V.6, *Daucus carota* (Queen Anne's lace) V.3, *Cirsium arvense* (Canada thistle) V.2, *Nepeta cataria* (catnip) V.1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

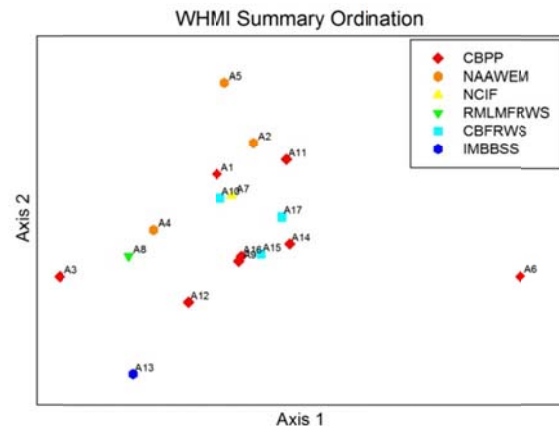
This association is probably widespread in the western United States. It is also likely to occur widespread elsewhere in southern parts of Canadian provinces. The distribution of *Phalaris arundinacea* as natural community type is complicated because this native species is widely cultivated as a forage crop and has escaped and established in many wetlands and riparian areas.

COMMENTS

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from the Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.

A6 **Kentucky Bluegrass Semi-natural Herbaceous Alliance**

Poa pratensis Semi-natural Herbaceous Alliance



Description

This semi-natural vegetation alliance is characterized by a moderate to dense herbaceous stratum that is dominated by the introduced perennial, sod-forming grass, *Poa pratensis*. Other graminoids, particularly other non-native species, also occur regularly in this vegetation type. *Robinia pseudoacacia*, occurs intermittently in stands of this type, but can be abundant where present. Other trees also occur sporadically in and around the edges of this vegetation type, though they do not contribute substantially to cover. Forbs are common to this alliance, but they are highly variable and occur at very low cover. *Trifolium repens* and *Taraxacum officinale* appear to be the most common across many regional variances, including this one.

This association typically occupies seasonally flooded swales and wet, low- to mid-elevation sites. Habitats are often alkaline meadows and may have long-term grazing disturbance. Sites are typically gently sloping on all aspects. Soils are mineral with dark surface horizons containing large amounts of well-decomposed organic matter. Soil texture ranges from silt to sandy loam. Water tables are often at or near the soil surface in early summer but may drop below 50 cm by late August. Arid sites receive enough moisture to support at least some wetland species.

CONSERVATION RANK N/A

DATABASE CODE A.3562

CHARACTERISTIC SPECIES (n = 4, xx)

Tree

Robinia pseudoacacia (black locust) III.18

Shrub

None

Dwarf-shrub

None

Graminoid

Poa pratensis (Kentucky bluegrass) V.75

Forb

Trifolium repens (white clover) V.2, *Taraxacum officinale* (common dandelion) V.1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

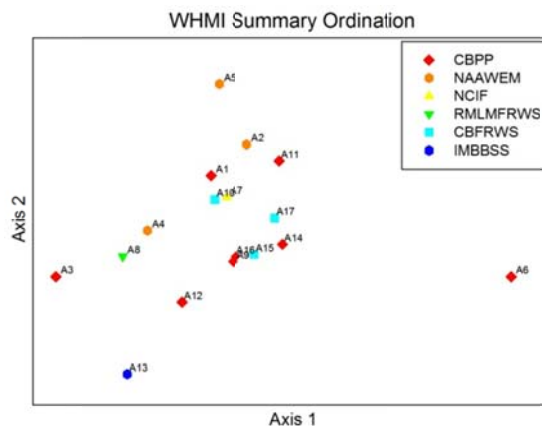
The *Poa pratensis* Semi-natural Herbaceous Alliance is reported to occur in Washington, Oregon, Montana, Wyoming, Idaho, Utah, and California, but is likely widespread in the western U.S. and northern Great Plains.

COMMENTS

Poa pratensis is widespread in the western U.S. where, following disturbance, its extensive rhizome system allows it to spread and establish, outcompeting many native graminoids. It is tolerant of heavy grazing and burning and increases at the expense of less tolerant native species.

A7 Eastern Cottonwood – American Sycamore Forest

Populus deltoides – *Platanus occidentalis* Forest



Description

The structure of this association is characterized by a nearly-closed to closed tree canopy. Dominant species are *Populus deltoides* and *Platanus occidentalis*. Other common trees may include; *Acer negundo*, *Celtis occidentalis*, and *Salix nigra*. Shrubs are typically not abundant in this community type and the herbaceous stratum ranges from moderate to dense. The most abundant and frequently occurring herbaceous species are introduced. *Thinopyrum ponticum* is generally the most abundant grass species and *Cardaria draba* is the most abundant forb. This forest vegetation type is likely associated with ornamental/agricultural plantings during settlement of the area.

Stands occur on nearly level to undulating soils on floodplains along major rivers and streams. Soils are deep, poorly drained to well-drained, and formed in silty and clayey alluvium.

CONSERVATION RANK G1

DATABASE CODE CEG002095

CHARACTERISTIC SPECIES (n = 1, xx)

Tree

Populus deltoides (eastern cottonwood) V.50, *Platanus occidentalis* (American sycamore) V.15

Shrub

None

Dwarf-shrub

None

Graminoid

Thinopyrum ponticum (tall wheatgrass) V.25, *Bromus tectorum* (cheatgrass) V.5, *Poa pratensis* (Kentucky bluegrass) V.1

Forb

Cardaria draba (whitetop) V.15, *Cirsium arvense* (Canada thistle) V.1, *Conium maculatum* (poison hemlock) V.<1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

United States, primarily Kansas.

COMMENTS

There are probably fewer than 20 occurrences in Kansas, the only state from which this community is reported, although it probably occurs across a broader landscape scale. This community is restricted to floodplains, and is currently known from a restricted range in four ecoregion subsections from six counties in Kansas. Most of the documented occurrences are at least somewhat degraded or disturbed.

A8 Peachleaf Willow Woodland

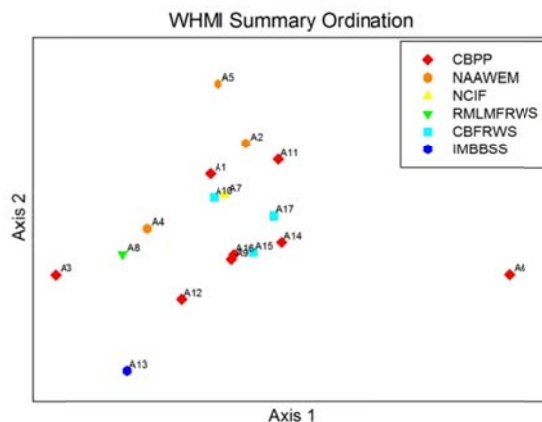
Salix amygdaloides Woodland



Description

Salix amygdaloides provides a low, multi-stemmed canopy which ranges from open to nearly closed in this woodland vegetation type. *Salix exigua* and *Symphoricarpos occidentalis* may occur sporadically, but are not locally abundant. The understory varies considerably depending on the hydrologic regime and past disturbance of the site. There is usually a well-developed herbaceous understory, which locally, is dominated by introduced graminoids. *Bromus tectorum* and *Phalaris arundinacea* are the most abundant graminoid species. Forbs provide little vegetative cover to the herbaceous stratum; *Conium maculatum* and *Cirsium arvense* occur with the greatest frequency.

This riparian community type occurs as linear patches in a variety of locations such as backwater areas, old meander channels and wetland margins or as clumps along water courses. Soils are usually Regosols or Chernozems, and the water table typically stays within 1 m of the soil surface during the growing season.



CONSERVATION RANK G3

DATABASE CODE CEGL000947

CHARACTERISTIC SPECIES (n = 4, xx)

Tree

Salix amygdaloides (peachleaf willow) V.43

Shrub

None

Dwarf-shrub

None

Graminoid

Bromus tectorum (cheatgrass) V.45, *Phalaris arundinacea* (reed canarygrass) III.8

Forb

Conium maculatum (poison hemlock) V.2, *Cirsium arvense* (Canada thistle) IV.1, *Urtica dioica* (stinging nettle) III.6

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

This peachleaf willow woodland type is found in the northern Rocky Mountains, ranging from Idaho to Montana and into parts of the western Great Plains and north into southern Alberta.

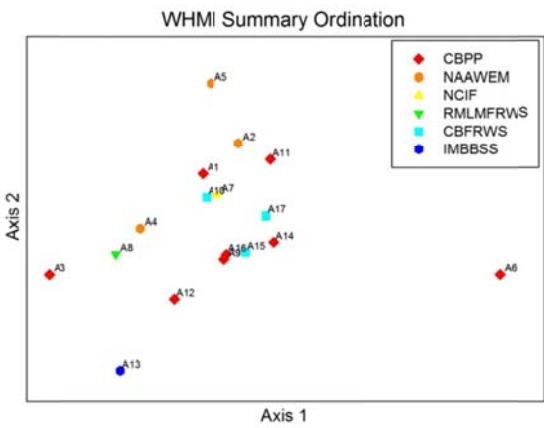
COMMENTS

None.

A9

Bluebunch Wheatgrass – Sheep Fescue Herbaceous Vegetation

Pseudoroegneria spicata – *Festuca ovina* Herbaceous Vegetation



Description

This association is a bunchgrass grassland with minor cover of forbs and occasionally sparse cover of trees and/or shrubs. *Pseudoroegneria spicata* dominates or co-dominates the moderate to dense herbaceous stratum of this plant community; *Festuca ovina* is also abundant and sometimes co-dominant. Other grasses may occur with low cover, and species composition is variable from one stand to another. On or near disturbed sites, the graminoid component is likely to include species such as *Poa pratensis*, *Bromus tectorum*, and *Poa bulbosa*. Forbs are typically weeds and contribute little to total herbaceous cover.

Sites where this plant community occurs include ridges and slopes, occasionally alluvial fans, scree slopes, sloped rocky cliff faces, and bedrock outcrops of any aspect, although southerly and westerly aspects are most common in the northwestern part of the geographic range. This community type occupies a very broad elevational range. Stands grow on well-drained, often shallow, and frequently gravelly or rocky soils generally of loam, clay loam, silt loam, or sandy loam textural classes.

CONSERVATION RANK N/A DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 5, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Pseudoroegneria spicata (bluebunch wheatgrass) V.35, *Festuca ovina* (sheep fescue) V.15, *Leymus cinereus* (basin wildrye) V.<1, *Bromus tectorum* (cheatgrass) IV.4

Forb

Draba verna (spring draba) V.<1, *Erodium cicutarium* (redstem stork's bill) V.<1, *Lupinus leucophyllus* (velvet lupine) V.<1, *Sisymbrium altissimum* (tall tumblemustard) V.<1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

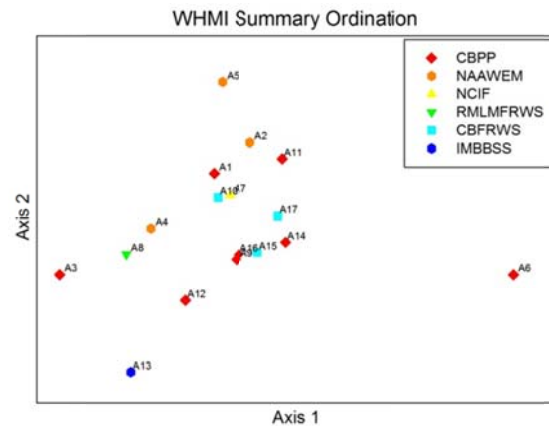
Global

This association likely occurs across the range of bluebunch wheatgrass, which is found in Piceance Basin and Dinosaur National Park in western Colorado and the Cache Valley of northeastern Utah. Stands are reported from Fossil Butte National Monument and Grand Teton National Park in Wyoming and Rocky Mountain National Park in Colorado.

COMMENTS

Grazing has a negative effect on bluebunch wheatgrass associations, and it is believed that they now occupy a very small portion of their original range. The size of most occurrences is very small, most under 60 acres.

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.

A10**Shining Willow Temporarily Flooded Shrubland Alliance***Salix lucida* Temporarily Flooded Shrubland Alliance**Description**

This mesic community type is dominated by *Salix lucida*, with a relatively open canopy. Tree saplings and shrubs may occur sporadically. The shrub species with the highest constancy in communities of this type is *Prunus virginiana*, though it occurs with low mean cover. Herbaceous cover is sparse to moderate and the composition of the herbaceous layer can vary greatly. Species often found in the herbaceous stratum of this community locally are introduced and may include; *Phalaris arundinacea*, *Thinopyrum ponticum*, *Bromus tectorum*, *Bassia scoparia*, *Brassica juncea*, and *Cirsium arvense*.

The type is common on low alluvial bars that are subject to repeated flooding. The parent material is alluvial sand, although silt, clay, or gravel may be present as well. Soils are somewhat deep and consist of a layer of sandy loam at the surface overlying deep deposits of sand, gravel, or cobble. Rock fragments are extensive. These well-drained soils provide good aeration and rapid movement of water through the profile.

CONSERVATION RANK N/A

DATABASE CODE A.979

CHARACTERISTIC SPECIES (n = 3, xx)

Tree*Salix lucida* (shining willow) V.22**Shrub***Prunus virginiana* (chokecherry) V.<1**Dwarf-shrub**

None

Graminoid

Phalaris arundinacea (reed canarygrass) V.6, *Bromus tectorum* (cheatgrass) V.4, *Thinopyrum ponticum* (tall wheatgrass) IV.2

Forb

Bassia scoparia (burningbush) V.2, *Brassica juncea* (India mustard) V.1, *Lemna minor* (common duckweed) V.1, *Nepeta cataria* (catnip) V.<1, *Cirsium arvense* (Canada thistle) IV.1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

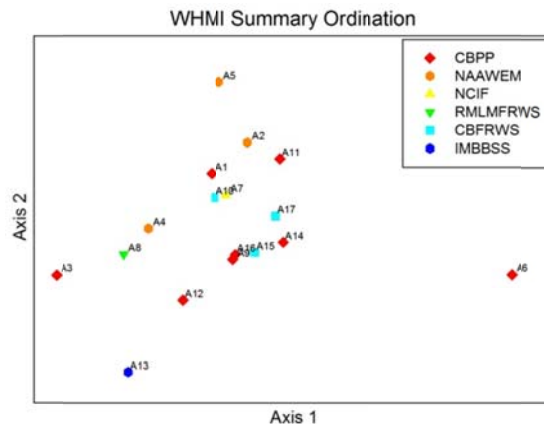
The range of this alliance includes the Great Basin, between the Sierra Nevada, the Rocky Mountains, and the deserts of the southwestern U.S.

COMMENTS

None.

A11 **Great Basin Wildrye Herbaceous Vegetation**

Leymus cinereus Herbaceous Vegetation



Description

This association is a tall, moderately dense grassland dominated by *Leymus cinereus*. Other herbaceous species are found primarily between clumps of *Leymus cinereus* or on the edges of dense stands. Scattered shrubs may occur sporadically, although species composition is variable. Associated graminoid species occurring with low cover values may include *Phalaris arundinacea* and other locally common species. Forbs are variable with low diversity and low cover and species composition varies from one stand to another.

This association is found along lower elevation riparian corridors and some moderately alkaline valley bottomlands. Stands tend to be patchy and grow on mesic sites with more soil moisture than is available to the surrounding vegetation. Sites are flat to steep and occur on all aspects. Soils are rapidly drained, often with a shallow water table. Soil texture is variable and ranges from silty clays to deep loamy sands.

CONSERVATION RANK G2

DATABASE CODE CEGL001479

CHARACTERISTIC SPECIES (n = 2, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Leymus cinereus (basin wildrye) V.43, *Phalaris arundinacea* (reed canarygrass) V.9

Forb

Galium aparine (stickywilly) V.<1, *Nepeta cataria* (catnip) V.<1

RANGE

Whitman Mission National Historic Site

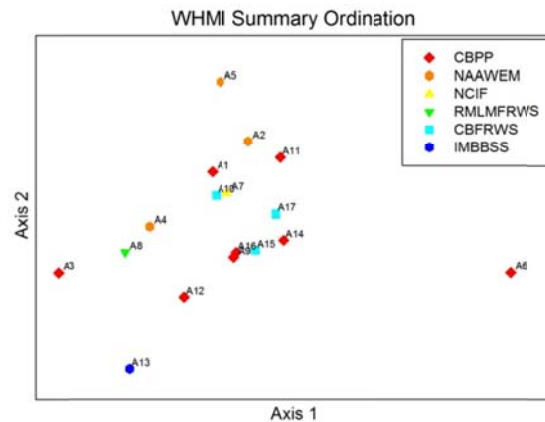
Enter WHMI specific data.

Global

This vegetation type is found mainly in the Great Basin and the Intermountain Region, and just reaches the western part of the Northern Great Plains. Although it occupies only a relatively small total area, it has a fairly large range.

COMMENTS

The conservation status of this association has been ranked as imperiled because few high-quality sites remain. This is a very widespread community type, and is found in many western states, but it is degraded throughout most of its range. This association was formerly very abundant in interior valleys, but most of these sites have been converted to agriculture. More knowledge of its distribution is needed, but it should remain a priority for conservation since most remaining sites are threatened by livestock grazing, agriculture, altered stream hydrology, and altered fire regime.



Description

This grassland association is characterized by a moderate herbaceous layer which is dominated by *Festuca idahoensis*. Cover of sub-dominant graminoids may vary widely across stands of this vegetation type, but the introduced species, *Poa bulbosa* and *Bromus tectorum* tend to be locally abundant. Shrubs, particularly *Chrysothamnus viscidiflorus* and *Ericameria nauseosa* are often occur as widely scattered individuals throughout the plant community. Forb species composition varies, depending on aspect and geographic distribution. Invasive, non-native species are may also be present and even abundant in or adjacent to heavily disturbed stands. Common forb species include: *Sisymbrium altissimum*, *Daucus carota*, and *Centaurea solstitialis*.

This grassland is found mostly on flat to gently rolling topography, but can be found on relatively steep slopes as well. It tends to occur more on northerly exposures at the lower elevations and on southerly exposures at the higher elevations. Soils are primarily Mollisols, deep and dark-colored, with varying degrees of calcium carbonate buildup.

CONSERVATION RANK N/A

DATABASE CODE A.1251

CHARACTERISTIC SPECIES (n = 2, xx)

Tree

None

Shrub

Chrysothamnus viscidiflorus (green rabbitbrush) V.1, *Ericameria nauseosa* (gray rabbitbrush) V.<1

Dwarf-shrub

None

Graminoid

Festuca idahoensis (Idaho fescue) V.35, *Bromus tectorum* (cheatgrass) V.10, *Poa bulbosa* (bulbous bluegrass) V.4, *Poa secunda* (Sandberg bluegrass) V.2

Forb

Centaurea solstitialis (yellow star-thistle) V.2, *Achillea millefolium* (common yarrow) V.1, *Daucus carota* (Queen Anne's lace) V.1, *Linum lewisii* (Lewis flax) V.1, *Sisymbrium altissimum* (tall tumbled mustard) V.1, *Claytonia perfoliata* (miner's lettuce) V.<1, *Draba verna* (spring draba) V.<1, *Holosteum umbellatum* (jagged chickweed) V.<1, *Lupinus leucophyllus* (velvet lupine) V.<1

RANGE

Whitman Mission National Historic Site

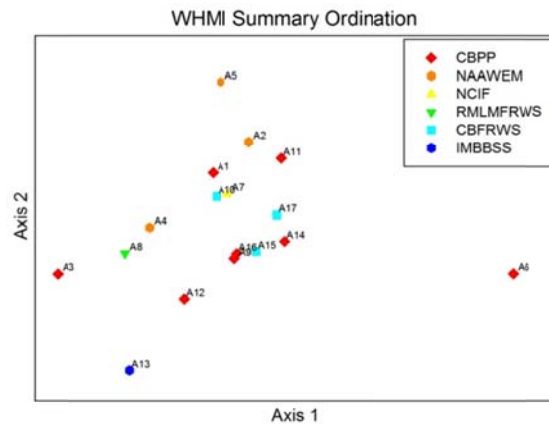
Enter WHMI specific data.

Global

This type is documented in Montana, Wyoming and Alberta, Canada, but is likely to occur across the Rocky Mountain Range.

COMMENTS

None.

A13**Rubber Rabbitbrush – Yellow Rabbitbrush Shrubland***Ericameria nauseosa* – *Chrysothamnus viscidiflorus* Shrubland**Description**

Total vegetation cover of this association is generally low to moderate and the plant community is characterized by an open shrub canopy dominated by *Ericameria nauseosa*, *Chrysothamnus viscidiflorus*, or a combination of both. Other shrubs may occur sporadically in the shrub stratum, although species composition is variable and cover is sparse. Cover of the herbaceous layer is low to moderate and occasionally approaches cover levels equal to those of the shrub stratum. Invasive grasses generally dominate the patchy understory and include *Bromus tectorum* and *Poa bulbosa*. Forbs tend to be sparse and variable and often include both introduced and native species. *Daucus carota*, *Centaurea solstitialis*, and *Achillea millefolium* are common in local stands.

This association generally occurs in areas that have experienced disturbance. *Chrysothamnus viscidiflorus*-dominated communities often result from wildland fires in sagebrush steppe ecosystems. Slopes range from gentle to moderately steep. Soils have textures ranging from silt loam to sandy loam to loamy sand, and bare soil is often conspicuous.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 2, xx)**Tree**

None

Shrub*Chrysothamnus viscidiflorus* (green rabbitbrush) V.15, *Ericameria nauseosa* (gray rabbitbrush) V.15**Dwarf-shrub**

None

Graminoid*Bromus tectorum* (cheatgrass) V.25, *Poa bulbosa* (bulbous bluegrass) V.15, *Poa secunda* (Sandberg bluegrass) V.1**Forb***Daucus carota* (Queen Anne's lace) V.2, *Achillea millefolium* (common yarrow) V.1, *Centaurea solstitialis* (yellow star-thistle) V.1, *Clematis ligusticifolia* (western white clematis) V.<1, *Sisymbrium altissimum* (tall tumbled mustard) V.<1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

This association likely occurs as isolated patches throughout the western U.S. as all of the diagnostic species are common and widespread. The range of this association is probably restricted to areas that have been impacted by disturbance as indicated by the abundance of cheatgrass and the absence of non-resprouting shrubs.

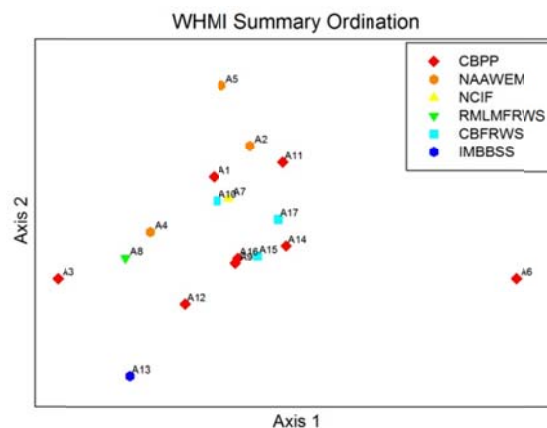
COMMENTS

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from the Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.

A14

Intermediate Wheatgrass Semi-natural Herbaceous Alliance

Thinopyrum intermedium Semi-natural Herbaceous Alliance



Description

The vegetation of this alliance is strongly dominated by *Thinopyrum intermedium*, an introduced grass species. The herbaceous stratum is typically dense as *Thinopyrum intermedium* may be sod-forming with little interspace for other species. Native species persist in some stands, however cover and diversity are typically low, and component native species can be quite variable depending on the plant community that was present prior to the conversion to introduced herbaceous species. Native shrubs may occur sporadically with low densities in some stands. Several native perennial and annual forb species may also occur with sparse cover and variable species composition across stands of this type. *Verbascum thapsus* occurs with the greatest frequency locally.

This alliance can occur across a wide range of environmental conditions in cool ecosystems with moderate rainfall and is not tightly constrained by slope, aspect, or soil texture; although minimum a soil depth of at least 16 inches is required for the community to persist. This alliance often occurs on or near sites that have been disturbed.

CONSERVATION RANK N/A

DATABASE CODE A.2529

CHARACTERISTIC SPECIES (n = 1, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Thinopyrum intermedium (intermediate wheatgrass) V.75, *Carex spp.* (sedge) V.<1

Forb

Verbascum thapsus (common mullein) V.1, *Dipsacus fullonum* (Fuller's teasel) V.<1, *Galium aparine* (stickywilly) V.<1

RANGE

Whitman Mission National Historic Site

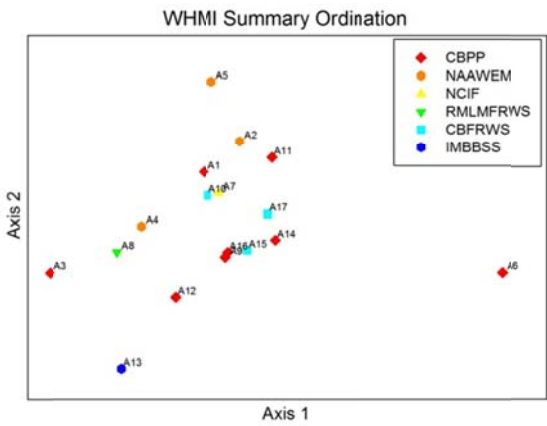
Enter WHMI specific data.

Global

Intermediate wheatgrass can be found throughout the western half of the United States and Canada.

COMMENTS

This species is among the most productive forage species for the western United States. Because it seeds relatively late, it can be grown effectively in mixture with alfalfa to increase its productivity, longevity, and forage quality. It regrows slowly after grazing or cutting, making it best suited to management with a single harvest per year or as a rehabilitation species for stabilizing disturbed soil. Intermediate wheatgrass is not often considered an invasive as it tends to intermix with native species. If managed well, stands can persist for up to 50 years.



Description

This woodland association is dominated by the ornamental tree, *Ulmus pumila*, which forms a relatively open canopy. Other trees are uncommon in the canopy of this vegetation type. There is generally no distinct shrub stratum, and the herbaceous stratum may range from sparse to moderate. The most frequently occurring and abundant herbaceous species in this community type tend to be non-native. Common grasses and forbs include: *Bromus diandrus*, *Bromus tectorum*, *Daucus carota*, *Thinopyrum ponticum*, and *Asperugo procumbens*. Chinese elm will grow in full sun on a wide range of soils, adapting easily to extremes in pH or moisture, and tolerates urban heat, and wind. Trees will look their best when grown in moist, well-drained, fertile soil but they can acclimate to drought and the extremes of urban sites.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 4, xx)

Tree

Ulmus pumila (Chinese elm) V.30

Shrub

None

Dwarf-shrub

None

Graminoid

Bromus diandrus (ripgut brome) V.23, *Bromus tectorum* (cheatgrass) III.8, *Thinopyrum ponticum* (tall wheatgrass) III.2

Forb

Daucus carota (Queen Anne's lace) V.9, *Asperugo procumbens* (German-madwort) V.1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

The Chinese elm is found on all continents except Antarctica.

COMMENTS

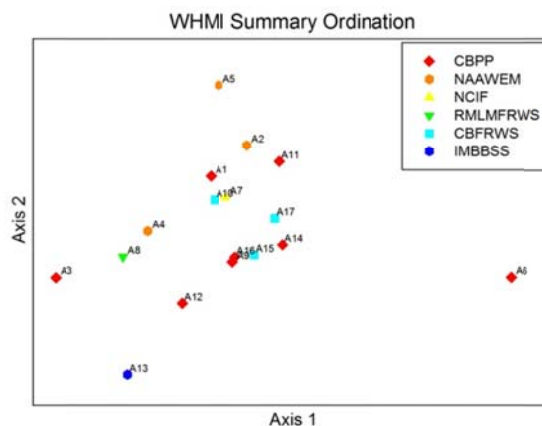
The Chinese elm is a tough landscape tree, hardy enough for use in harsh planting situations such as parking lots, in small planters along streets and in plazas or patios. In addition, due to its versatility and ability to tolerate a wide range of temperatures, light, and humidity conditions.

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from the Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.



Tall Tumblemustard - Cheatgrass Semi-natural Herbaceous Vegetation

Sisymbrium altissimum - *Bromus tectorum* Semi-natural Herbaceous Vegetation



Description

This herbaceous plant community is characterized by sparse cover of introduced species. The herbaceous stratum is dominated by *Sisymbrium altissimum*, an annual forb, *Bromus tectorum*, an annual grass, or a combination of both species. This class often occurs on or near sites that have been disturbed. Total vegetation is generally very low. Native species persist in some stands, however cover and diversity are typically very low, and component native species can be quite variable depending on the plant community that was present prior to the conversion to introduced species. Several forb species may also have sparse cover and variable species composition across stands of this vegetation type, although locally, *Onopordum acanthium* occurs the most frequently.

This class can occur across a wide range of environmental conditions in semi-arid ecosystems but is likely to be found in low-lying areas that have fine soil-textures and experience occasional seasonal flooding.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 3, xx)

Tree

None

Shrub

None

Dwarf-shrub

None

Graminoid

Bromus tectorum (cheatgrass) V.3

Forb

Sisymbrium altissimum (tall tumblemustard) V.4, *Onopordum acanthium* (Scotch thistle) V.2

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

This global distribution of this class coincides with the range the *Bromus tectorum* Semi-natural Herbaceous Alliance, which occurs throughout much of western North America from the western Great Plains to the intermountain and southwestern U.S.

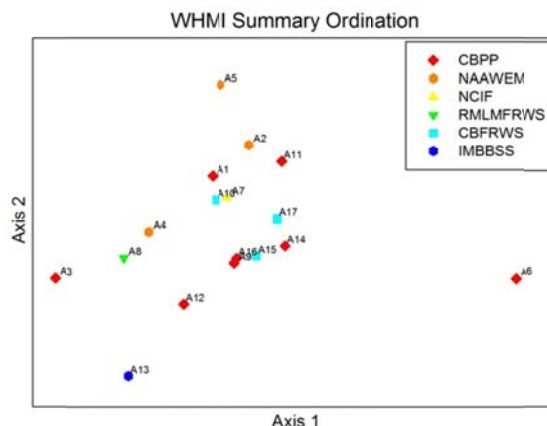
COMMENTS

The unique life history characteristics of cheatgrass and the altered ecological process associated with this species have promoted the spread of it and other exotic annual bromes at the expense of sagebrush shrublands in large parts of the western U.S. Tall tumbled mustard is also characteristic of disturbed areas. Consequently, these species tend to codominate on or around sites that have been severely impacted.

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from the Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.

A17 Himalayan Blackberry Semi-natural Shrubland

Rubus armeniacus Semi-natural Shrubland



Description

This association is characterized by a dense, often impenetrable stratum of short-statured shrubs. Stands are often nearly monotypic and are dominated by the non-native species, *Rubus armeniacus*. Herbaceous species are sparse in this vegetation type and many component graminoid and forb species are also introduced. The most common graminoid species is *Phalaris arundinacea*, and *Brassica juncea*, *Brassica rapa*, and *Dipsacus fullonum* are among the most frequently occurring forb species.

Himalayan blackberry forms dense thickets in wastelands, pastures, and forest plantations. It grows along roadsides, creek gullies, river flats, fence lines, and right-of-way corridors. It is common in riparian areas, where it establishes and persists despite periodic inundation by fresh or brackish water. Himalayan blackberry prefers disturbed and wet sites even in relatively wet climates. It prefers areas with an average annual rainfall greater than 76 cm and occurs on both acidic and alkaline soils including a variety of barren, infertile soil types.

CONSERVATION RANK N/A

DATABASE CODE N/A

CHARACTERISTIC SPECIES (n = 3, xx)

Tree

None

Shrub

None

Dwarf-shrub

Rubus armeniacus (Himalayan blackberry) V.50

Graminoid

Phalaris arundinacea (reed canarygrass) V.3

Forb

Brassica juncea (India mustard) V.1, *Brassica rapa* (field mustard) V.<1, *Dipsacus fullonum* (Fuller's teasel) V.<1, *Polygonum lapathifolium* (curlytop knotweed) V.<1, *Conium maculatum* (poison hemlock) IV.1

RANGE

Whitman Mission National Historic Site

Enter WHMI specific data.

Global

Himalayan blackberry is native to western Europe and found its way to the United States in 1885 as a cultivated crop. By the 1940's, it had become naturalized along the West Coast, and has since spread to other temperate climates across the United States including the East Coast and in some central states as well.

COMMENTS

This association was not recognized in the National Vegetation Classification (NVC) and had not been documented or described by NatureServe (2011) at the time this document was produced. Therefore, the plant community description is based on limited data from the Whitman Mission National Historic Site and on related plant communities that have been previously described. The descriptions provided herein may vary slightly from similar plant communities found elsewhere due to the local scale at which data were collected and the lack of a published standard in the NVC.

Appendix E – Plant Species List for WHMI

[Source: UCBN 2008]

APP E.1

Family	Scientific Name	Common Name
Apiaceae	Conium maculatum	Poison Hemlock
Apiaceae	Daucus carota	Queen Anne's Lace, Wild Carrot, Queen Ann's Lace
Apiaceae	Lomatium canbyi	Canby's Desert Parsley
Apiaceae	Lomatium cous	Biscuit root, Bisquit root
Asteraceae	Achillea millefolium	Yarrow
Asteraceae	Acroptilon repens	hardheads, Russian knapweed, Turestan thistle
Asteraceae	Anthemis cotula	Mayweed
Asteraceae	Artemisia ludoviciana	Cud sage
Asteraceae	Artemisia tridentata	big sagebrush, big sagebush
Asteraceae	Balsamorhiza sagittata	arrowleaf balsamroot
Asteraceae	Centaurea biebersteinii	spotted knapweed
Asteraceae	Centaurea diffusa	diffuse knapweed, diffuse knaweed, white knapweed
Asteraceae	Centaurea solstitialis	Yellow Star Thistle
Asteraceae	Chrysothamnus nauseosus	Rabbitbrush
Asteraceae	Chrysothamnus viscidiflorus	Rabbit Brush, Rabbit-brush
Asteraceae	Cichorium intybus	Blue Sailors
Asteraceae	Cirsium arvense	Canada Thistle, Canadian Thistle
Asteraceae	Cirsium vulgare	Bull Thistle
Asteraceae	Conyza canadensis	Conyza
Asteraceae	Gaillardia aristata	common gaillardia, gaillardia, great blanket-flower
Asteraceae	Helianthus cusickii	Little Sunflower
Asteraceae	Hemizonia pungens	common spikeweed, common tarweed, spikeweed
Asteraceae	Lactuca serriola	Prickly lettuce
Asteraceae	Onopordum acanthium	Scotch Thistle
Asteraceae	Rudbeckia hirta	blackeyed Susan, blackeyedsusan
Asteraceae	Tragopogon dubius	Yellow Salsify

Family	Scientific Name	Common Name
Brassicaceae	<i>Brassica juncea</i>	Brown mustard
Brassicaceae	<i>Brassica rapa</i>	bird's rape, birdsrape mustard, field mustard
Brassicaceae	<i>Cardaria draba</i>	Hear-podded Hoarywort
Brassicaceae	<i>Cardaria pubescens</i>	Globpodded Hoary cress
Brassicaceae	<i>Descurainia richardsonii</i>	Mountain Tansey, Mountain Tansy
Brassicaceae	<i>Draba verna</i> ssp. <i>verna</i>	
Brassicaceae	<i>Lepidium perfoliatum</i>	Pepperweed
Amaranthaceae	<i>Amaranthus retroflexus</i>	Pigweed
Caryophyllaceae	<i>Stellaria media</i>	Starwort
Chenopodiaceae	<i>Kochia scoparia</i>	common kochia, fireweed, kochia
Chenopodiaceae	<i>Salsola kali</i>	Russian thistle
Chenopodiaceae	<i>Sarcobatus vermiculatus</i>	black greasewood, greasewood
Celastraceae	<i>Euonymus nana</i>	Wahoo
Cornaceae	<i>Cornus stolonifera</i>	red-osier dogwood
Cyperaceae	<i>Eleocharis palustris</i>	common spikerush, creeping spikerush, spikesedge
Cyperaceae	<i>Schoenoplectus americanus</i>	American bulrush, chairmaker's bulrush, Olney bulrush
Cyperaceae	<i>Schoenoplectus tabernaemontani</i>	great bulrush, softstem bulrush, soft-stem bulrush
Poaceae	<i>Achnatherum hymenoides</i>	Indian ricegrass
Poaceae	<i>Aegilops cylindrica</i>	Jointed goatgrass
Poaceae	<i>Agropyron cristatum</i>	Crested Wheatgrass
Poaceae	<i>Agropyron riparium</i>	
Poaceae	<i>Agropyron spicatum</i>	Bluebunch grass
Poaceae	<i>Agrostis capillaris</i>	colonial bent, colonial bentgrass
Poaceae	<i>Apera interrupta</i>	dense silkybent, dense silky-bent, silky bentgrass
Poaceae	<i>Aristida longiseta</i>	Red threeawn
Poaceae	<i>Bromus carinatus</i>	California brome, mountain brome
Poaceae	<i>Bromus rigidus</i>	Ripgut brome
Poaceae	<i>Bromus tectorum</i>	Cheat grass
Poaceae	<i>Cynodon dactylon</i>	Bermuda Grass
Poaceae	<i>Dactylis glomerata</i>	Orchard Grass

Family	Scientific Name	Common Name
Poaceae	<i>Distichlis spicata</i>	desert saltgrass, inland saltgrass, marsh spikegrass
Poaceae	<i>Elymus lanceolatus</i>	streambank wheatgrass, streamside wild rye
Poaceae	<i>Elymus lanceolatus wawawai</i>	Snake River Wheatgrass (renamed variety of bluebunch wheatgrass)
Poaceae	<i>Elymus macrourus</i>	thickspike wheatgrass
Poaceae	<i>Elymus repens</i>	quackgrass
Poaceae	<i>Elytrigia pontica inermis</i>	Alkar variety Tall Wheatgrass
Poaceae	<i>Eremopyrum triticeum</i>	annual false wheatgrass, annual wheatgrass
Poaceae	<i>Festuca idahoensis</i>	Idaho fescue
Poaceae	<i>Festuca ovina</i>	sheep fescue
Poaceae	<i>Festuca rubra</i>	ravine fescue, red fescue
Poaceae	<i>Festuca trachyphylla</i>	hard fescue
Poaceae	<i>Hordeum jubatum</i>	foxtail barley
Poaceae	<i>Hordeum leporinum</i>	Charming Barley
Poaceae	<i>Koeleria macrantha</i>	junegrass, prairie Junegrass
Poaceae	<i>Leymus cinereus</i>	basin wildrye
Poaceae	<i>Leymus condensatus</i>	giant wildrye
Poaceae	<i>Lolium arundinaceum</i>	<i>Lolium arundinaceum</i> , tall fescue
Poaceae	<i>Lolium multiflorum</i>	annual ryegrass, Italian ryegrass
Poaceae	<i>Pascopyrum smithii</i>	pubescent wheatgrass, western wheatgrass
Poaceae	<i>Phalaris arundinacea</i>	Reed Canary Grass
Poaceae	<i>Poa bulbosa</i>	Bulbous bluegrass
Poaceae	<i>Poa pratensis</i>	Kentucky bluegrass
Poaceae	<i>Poa secunda</i>	big bluegrass, Sandberg bluegrass, Sandberg's bluegrass
Poaceae	<i>Polypogon monspeliensis</i>	Rabbits foot
Poaceae	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass, bluebunch-wheat grass
Poaceae	<i>Secale cereale</i>	cereal rye, common rye, Cultivated annual rye
Poaceae	<i>Spartina gracilis</i>	alkali cordgrass
Poaceae	<i>Sporobolus cryptandrus</i>	sand dropseed
Poaceae	<i>Thinopyrum intermedium</i>	intermediate wheatgrass
Poaceae	<i>Thinopyrum ponticum</i>	rush wheatgrass, tall wheatgrass

Family	Scientific Name	Common Name
Caprifoliaceae	<i>Sambucus cerulea</i>	Blue Elderberry
Caprifoliaceae	<i>Sambucus nigra</i> ssp. <i>cerulea</i>	blue elderberry, elderberry
Caprifoliaceae	<i>Symphoricarpos albus</i>	snow berry
Dipsacaceae	<i>Dipsacus fullonum</i>	common teasel, Fuller's teasel, teasel
Dipsacaceae	<i>Dipsacus sylvestris</i>	Gypsy Combs, Theasel, Gypsy Combs
Equisetaceae	<i>Equisetum laevigatum</i>	Horse tails
Fabaceae	<i>Astragalus gracilis</i>	Milkvetch, slender milkvetch
Fabaceae	<i>Lupinus laxiflorus</i>	
Fabaceae	<i>Lupinus leucophyllus</i>	Lupine
Fabaceae	<i>Lupinus sericeus</i>	Pursh's silky lupine, silky lupine
Fabaceae	<i>Medicago sativa</i>	alfalfa, lucerne
Fabaceae	<i>Melilotus officinalis</i>	Common yellow sweat clover
Fabaceae	<i>Robinia pseudoacacia</i>	black locust, false acacia, yellow locust
Fabaceae	<i>Robinia pseudo-acacia</i>	Robina
Fabaceae	<i>Thermopsis montana</i>	mountain goldenbanner
Betulaceae	<i>Alnus serrulata</i>	Smooth Alder
Betulaceae	<i>Betula alba</i> var. <i>macrophylla</i>	White birch
Betulaceae	<i>Betula occidentalis</i>	Water Birch
Betulaceae	<i>Betula pubescens</i>	downy birch
Apocynaceae	<i>Vinca major</i>	Periwinkle
Asclepiadaceae	<i>Asclepias speciosa</i>	Milkweed
Geraniaceae	<i>Erodium cicutarium</i>	alfilaree, alfilaria, California filaree
Platanaceae	<i>Platanus hybrida</i>	London planetree
Platanaceae	<i>Platanus occidentalis</i>	Sycamore
Juncaceae	<i>Juncus balticus</i>	Baltic rush
Boraginaceae	<i>Amsinckia lycopsoides</i>	Tarweed
Lamiaceae	<i>Lamium amplexicaule</i>	Common Dead Nettle
Lamiaceae	<i>Lamium purpureum</i>	Red Dead Nettle, Red-Dead Nettle, Self-heal, common mint
Lamiaceae	<i>Nepeta cataria</i>	Catnip
Iridaceae	<i>Iris missouriensis</i>	Rocky Mountain iris, western blue flag, wild iris

Family	Scientific Name	Common Name
Iridaceae	<i>Iris pseudacorus</i>	Yellow Flag
Liliaceae	<i>Allium douglasii</i>	Wild Onion
Liliaceae	<i>Asparagus officinalis</i>	Asparagus
Liliaceae	<i>Calochortus macrocarpus</i>	greenband mariposa lily, sagebrush mariposa lily
Liliaceae	<i>Fritillaria pudica</i>	yellow bells, yellow fritillary, yellow missionbells
Linaceae	<i>Linum bienne</i>	pale flax
Linaceae	<i>Linum lewisii</i>	blue flax, Lewis blue flax, Lewis flax
Linaceae	<i>Linum perenne</i>	blue flax
Malvaceae	<i>Malva neglecta</i>	Mallow, cheeseweed
Papaveraceae	<i>Eschscholzia californica</i>	California Poppy
Polygonaceae	<i>Eriogonum compositum</i>	Buckwheat
Polygonaceae	<i>Eriogonum niveum</i>	snow buckwheat
Polygonaceae	<i>Polygonum convolvulus</i>	Ivy bind weed, Ivy bindweed
Polygonaceae	<i>Polygonum lapathifolium</i>	curltop ladythumb, curlytop knotweed, curlytop smartweed
Polygonaceae	<i>Rumex crispus</i>	Curly dock
Polygonaceae	<i>Rumex paucifolius</i>	Mountain Sorrel
Berberidaceae	<i>Mahonia aquifolium</i>	hollyleaved barberry
Elaeagnaceae	<i>Elaeagnus angustifolia</i>	Russian Olive
Grossulariaceae	<i>Ribes aureum</i>	Golden current
Grossulariaceae	<i>Ribes oxycanthoides</i>	Northern gooseberry
Hydrangeaceae	<i>Philadelphus lewisii</i>	Mock Oragne, Mock orange, Syringa
Rosaceae	<i>Crataegus chrysocarpa</i>	fireberry hawthorn, hawthorn
Rosaceae	<i>Crataegus columbiana</i>	Hawthorn
Rosaceae	<i>Crataegus dilatata</i>	a hawthorn, black hawthorn, broadleaf hawthorn
Rosaceae	<i>Crataegus douglasii</i>	Hawthorn
Rosaceae	<i>Crataegus phaenopyrum</i>	Hawthorn
Rosaceae	<i>Prunus virginiana</i>	Choke cherry
Rosaceae	<i>Prunus virginiana</i> var. <i>melanocarpa</i>	Choke cherry
Rosaceae	<i>Rosa canina</i>	Wild Rose
Rosaceae	<i>Rosa eglanteria</i>	Rose, Wild Rose

Family	Scientific Name	Common Name
Rosaceae	<i>Rosa nutkana</i>	Nootka rose
Rosaceae	<i>Rosa woodsii</i>	woods rose, Wood's rose, Woods' rose
Rubiaceae	<i>Galium aparine</i>	Bed Straw, Bedstraw
Salicaceae	<i>Populus alba</i>	Silver poplar
Salicaceae	<i>Populus angustifolia</i>	Black, Narrow-leaf cottonwood
Salicaceae	<i>Populus balsamifera</i> ssp. <i>trichocarpa</i>	balsam poplar, black cottonwood
Salicaceae	<i>Populus deltoides</i>	black cottonwood
Salicaceae	<i>Populus tremuloides</i>	quaking aspen
Salicaceae	<i>Populus trichocarpa</i>	Black Cottonwood
Salicaceae	<i>Salix lasiandra</i>	Willow
Aceraceae	<i>Acer negundo</i>	Box elder
Aceraceae	<i>Acer platanoides</i>	Norway Maple
Anacardiaceae	<i>Rhus glabra</i>	smooth sumac
Anacardiaceae	<i>Rhus hirta</i>	staghorn sumac
Anacardiaceae	<i>Rhus typhina</i> var. <i>dissecta</i>	Staghorn sumac
Oleaceae	<i>Forsythia suspensa</i>	Forsythia
Oleaceae	<i>Syringa vulgaris</i>	Common Lilac, Lilac
Scrophulariaceae	<i>Penstemon palmeri</i>	Palmer penstemon, Palmer's penstemon
Scrophulariaceae	<i>Verbascum blattaria</i>	Moth Mullien
Scrophulariaceae	<i>Verbascum thapsus</i>	Woolly Mullien, Woolly mullien
Convolvulaceae	<i>Convolvulus arvensis</i>	Morning Glory, Field bindweed
Solanaceae	<i>Solanum dulcamara</i>	Bittersweet Nightshade
Urticaceae	<i>Urtica dioica</i>	California nettle, slender nettle, stinging nettle
Urticaceae	<i>Urtica dioica</i> var. <i>californica</i>	Stinging Nettle
Violaceae	<i>Viola adunca</i>	violet

Appendix F - Photo Interpretation Mapping Conventions and Visual Key

Whitman Mission National Historic Site - Map Units

This appendix describes the map units for the Whitman Mission National Historic Site (WHMI) Vegetation Inventory Project. Its purpose is to:

- Describe the vegetation of each map unit;
- Provide a representative ground photograph/image for each map unit;
- Describe the link between each map unit and the revised U.S. National Vegetation Classification System (NVCS);
- Provide visual examples of each map unit with digital overhead images and delineated overlays.

The map units for WHMI were based on a combination of NVCS plant associations, unique plant stands (i.e. Park Specials), the limitations of the digital imagery, and land use / land cover classes. The vegetation described in this section reflects the classification designed specifically for this project. Non-vegetated and land-use map units are not described in this key but polygon distribution maps are provided. For more information on the development of the mapping convention for WHMI please reference the mapping sections of this report and the digital information (i.e. lookup tables, metadata, etc.) included on the project DVD.

This key uses the physiognomic grouping of each map unit starting with forest and woodland types. Each map unit is fully described by a variety of characteristics and features: (1) common species found in the individual map classes, (2) the NVCS crosswalk (if applicable) to associations and/or alliance(s), (3) a description of the mapping concept, (4) a representative ground photograph, (4) a distribution map for each mapping unit across the study area, and (5) an imagery snapshot with representative polygon outlines on the 2011 National Agriculture Imagery Program (NAIP) true-color basemap. Many of the map unit descriptions rely on the vegetation classification plot data collected in 2010. The sample ground photographs were taken during the 2010 classification plot data collection or during the 2011 accuracy assessment by Northwest Management, Inc. (NMI) field crews.

Forests and Woodlands

Map Code	<i>Acer platanoides</i> Semi-natural Woodland Stand
ACPL	Norway Maple Planted Woodland Stand

Common Species

Acer platanoides, *Poa pratensis*, *Robinia pseudoacacia*, *Trifolium repens*, *Malus sylvestris*, *Veronica arvensis*

NVCS Alliance

- *Acer platanoides* Planted Woodland Alliance

Description

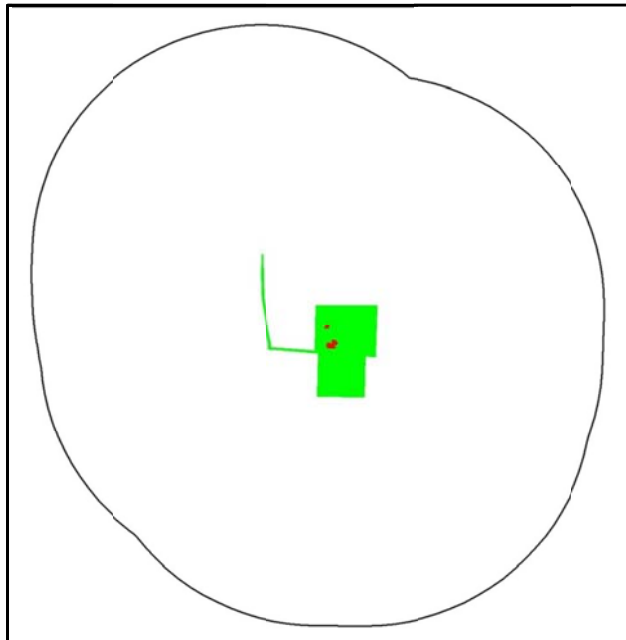
Norway maple trees were found around the visitor center and main parking lot at WHMI. An emphasis was placed on distinguishing the various large deciduous trees in WHMI instead of grouping them into broader mapping units. Based on verification efforts this alliance was added to the classification to help separate Norway maple trees from Chinese elm, black locust, and other tree species on the Mission grounds. Although the Norway maple trees were identified they did not occur in large enough stands to consider them a true plant association. Vegetation in this map unit was characterized by closed tree canopies dominated by Norway maple with a lawn-like herbaceous layer consisting of Kentucky bluegrass. For this map class, mapping was based primarily on where Norway maples were known to occur. On the 2011 National Agriculture Imagery Program (NAIP) ortho-photography, Norway maple trees had a light green, coarse signature surrounding by maintained lawns. It is likely that some confusion exists in the mapping between this type and the cottonwood(s), black locust and Chinese elm map units.

Representative Ground Photo



Photo Signature Example

Range and Distribution



Map Unit	<i>Elaeagnus angustifolia</i> Semi-natural Woodland Stand
ELAN	Russian-olive Semi-natural Woodland Stand

Common Species

Elaeagnus angustifolia, *Thinopyrum ponticum*, *Phalaris arundinacea*

NVCS Alliance

- *Elaeagnus angustifolia* Semi- natural Woodland Alliance

Representative Ground Photo



Description

Russian olive trees were rare in the study area and were only found in small stands and as single trees. Due to Russian olive's invasive tendency an emphasis was placed on mapping these trees and separating them from the other tree map classes. Based on verification efforts the *Elaeagnus angustifolia* Semi- natural Woodland Alliance was added to the classification to provide more detail and assist with management efforts. Russian olive trees had a very distinct pale, blue-green signature and individual trees could be discerned on the 2009 and 2011 NAIP imagery.

Range and Distribution

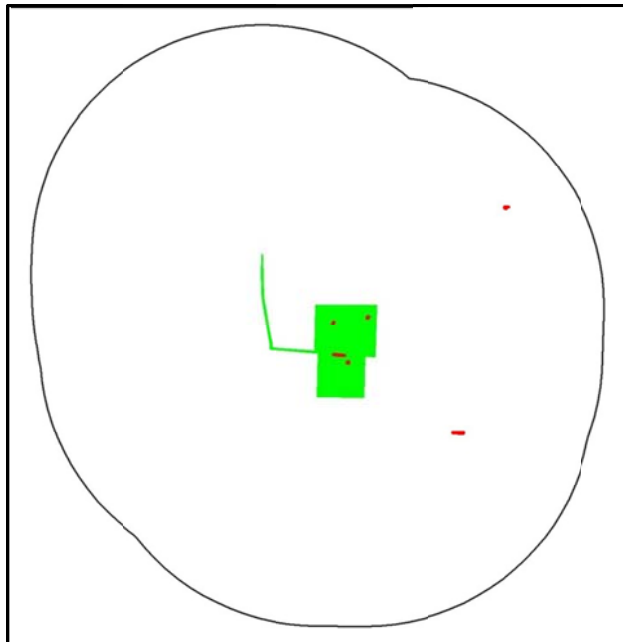


Photo Signature Example



Map Unit	Mixed Riparian Forest Complex
MXRP	

Common Species

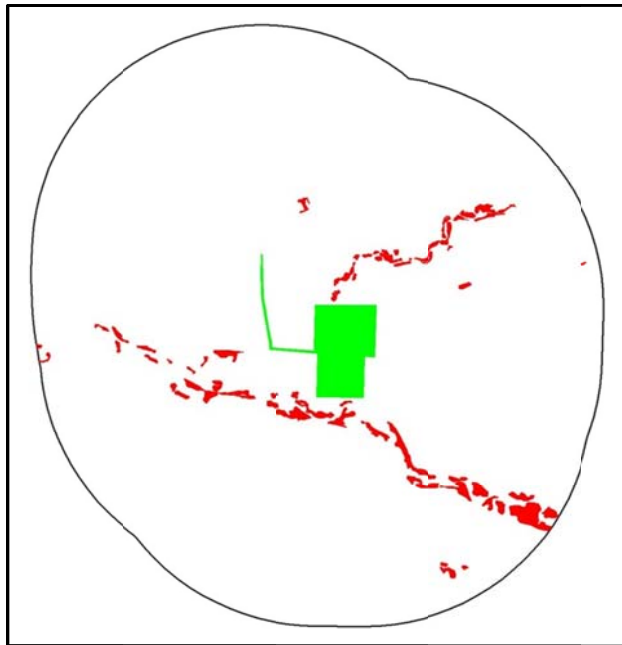
Populus balsamifera ssp. *trichocarpa*
Populus deltoides, *Platanus occidentalis*, *Salix amygdaloides*,
Sambucus cerulea, *Eleagnus angustifolia*,
Crataegus douglasii, *Rhus glabra*, *Mahonia aquifolium*, *Poa pratensis*, *Leymus cinereus*,
Phalaris arundinacea, *Bromus rigidus*,
Thinopyrum ponticum, *Conium maculatum*

NVCS Alliance

- [No Alliance – Park Special]

Description

Mixed deciduous trees in riparian settings were found throughout the environs of the WHMI project area growing around major streams and rivers. Since no ground data collection efforts were conducted in the environs outside of the Mission, separating individual tree species on the 2011 NAIP imagery was not viable. Instead this map unit was added to help delineate mixed riparian stands of primarily peachleaf willow and cottonwoods from other mixed tree species. The mixed riparian deciduous trees were mapped from their photo signature consisting of a coarse dark green color that differed from the lighter green color of non-native and planted deciduous trees. It is likely that some confusion exists in the mapping between this type and the other woodland and forest map units. More ground-truthing would greatly improve the accuracy and distribution of this type

Representative Ground Photo**Range and Distribution****Photo Signature Example**

**Map Unit
MXWD**

Mixed Planted and Semi-natural Woodland Complex**Common Species**

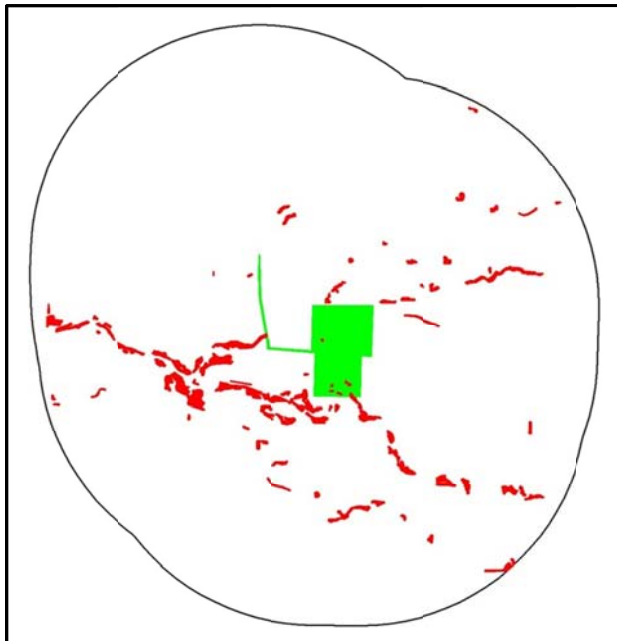
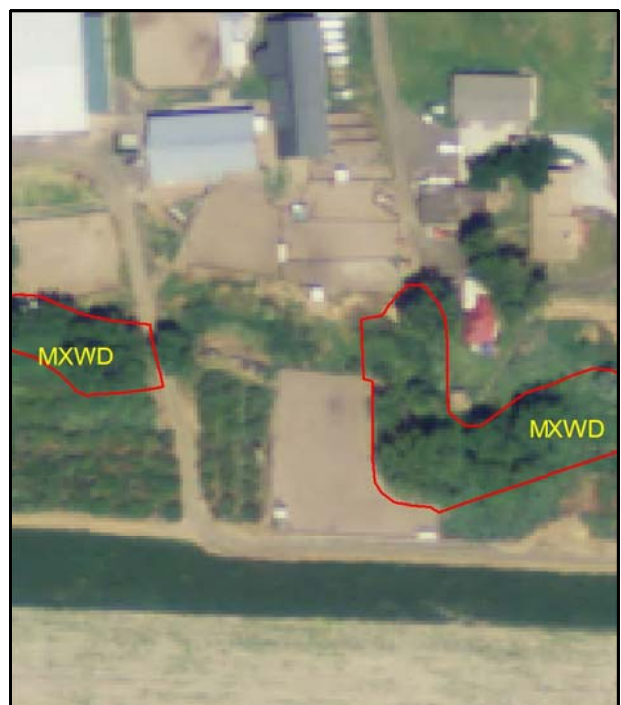
Picea pungens, *Poa pratensis*, *Sambucus cerulea*, *Phalaris arundinacea*, *Bromus rigidus*

NVCS Alliance

- [No Alliance – Park Special]

Description

Planted and escaped trees were found throughout the WHMI project area in and around agricultural and developed areas. In these settings the deciduous trees were mapped from known locations and by their obvious photo signature consisting of a coarse, green color that differed from the darker native deciduous trees. This map unit was also used to delineate small conifer trees, like the blue spruce tree growing in parking lot loop and elderberry tall shrubs/small trees growing in the river oxbow and pasture area of WHMI. Since the composition of the dominate species varied by location this map unit was used as a catch-all in an effort to provide more detail. It is likely that some confusion exists in the mapping between this type and the other forest and woodland map units. More ground-truthing would greatly improve the accuracy and distribution of this type.

Representative Ground Photo**Range and Distribution****Photo Signature Example**

Map Unit	<i>Populus balsamifera</i> ssp. <i>trichocarpa</i> Temporarily Flooded Forest Alliance
POBA	Black Cottonwood Temporarily Flooded Forest Alliance

Common Species

Populus balsamifera ssp. *trichocarpa*,
Sambucus cerulea, *Eleagnus angustifolia*,
Crataegus douglasii, *Conium maculatum*,
Bromus rigidus, *Thinopyrum ponticum*,
Phalaris arundinacea

NVCS Alliance

- *Populus balsamifera* ssp. *trichocarpa*
Temporarily Flooded Forest Alliance

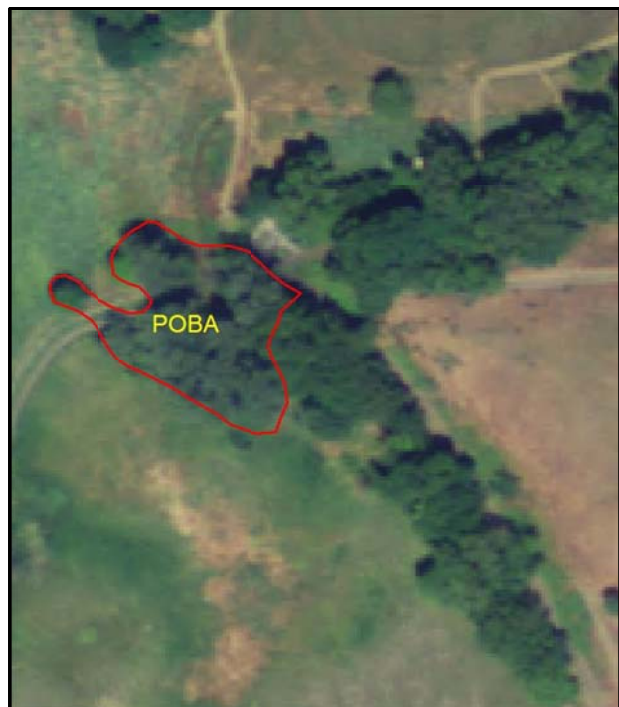
Description

Black cottonwood forest stands were small in size and rare in the mapping area, occurring along some of the terraced drainages and as forest groves close to the visitor center and in the river oxbow and pasture area of WHMI. An emphasis was placed on separating the black cottonwood trees from the Eastern cottonwood stands and the black cottonwood alliance was added to the classification. Vegetation in this map unit was characterized by closed tree canopies dominated by black cottonwood trees with some deciduous shrubs and mixed herbaceous understory. On the 2011 NAIP orthophotography, black cottonwood trees had a dark green, coarse signature. It is likely that some confusion exists in the mapping between this type and the Eastern cottonwood, peachleaf willow, and mixed riparian tree map units.

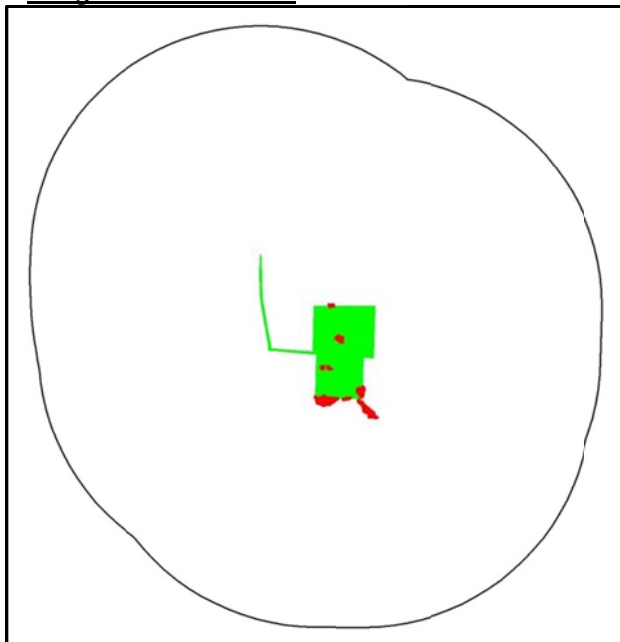
Representative Ground Photo



Photo Signature Example



Range and Distribution



Map Unit	<i>Populus deltoides</i> - <i>Platanus occidentalis</i> Forest
PODE-PLOC	Eastern Cottonwood - American Sycamore Forest

Common Species

Populus deltoides, *Platanus occidentalis*, *Salix amygdaloides*, *Rhus glabra*, *Mahonia aquifolium*, *Poa pratensis*, *Leymus cinereus*, *Phalaris arundinacea*, *Bromus rigidus*, *Thinopyrum ponticum*

NVCS Association

-*Populus deltoides* - *Platanus occidentalis* Forest

Description

Eastern cottonwood trees with American sycamore stands were common around the visitor center and the mill pond areas. Stands of this forest type were small in size but fairly common in the project area occurring along streams and drainages and in planted or landscaped settings. The mapping signature for this class includes large trees with light green canopies. Understory composition varied by location with Kentucky bluegrass lawns in landscaped settings and a mix of tall grasses and forbs in more natural areas. In some stands black cottonwood and peachleaf willow trees were also common components of the canopy and some confusion may have occurred between these similar deciduous forest map units.

Representative Ground Photo



Range and Distribution

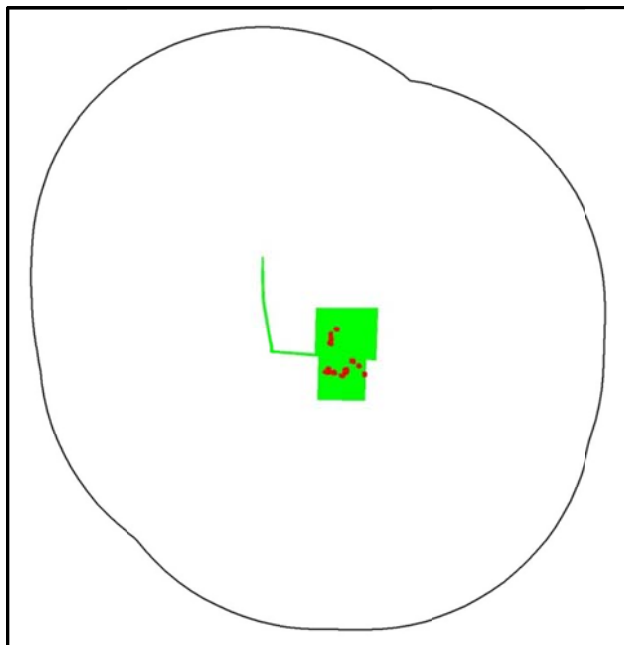
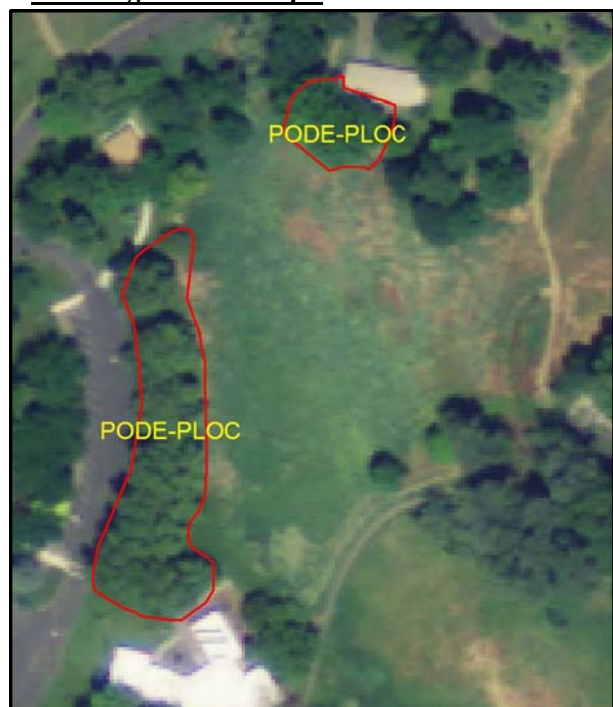


Photo Signature Example



Map Code	<i>Robinia pseudoacacia</i> Semi-natural Woodland Stand
ROPS	Black Locust Semi-natural Woodland Stand

Common Species

Robinia pseudoacacia, *Acer platanoides*,
Eleagnus angustifolia, *Poa pratensis*,
Leymus cinereus, *Thinopyrum ponticum*,
Trifolium repens, *Cirsium arvense*

NVCS Association

-*Robinia pseudoacacia* Semi-natural Forest

Description

Black locust trees were common in the landscaped grounds of WHMI and nearby restoration areas. An emphasis was placed on distinguishing the various large deciduous trees in WHMI instead of grouping them into broader mapping units. Based on verification efforts this map class was added to help separate black locust trees from Chinese elm, Norway maple, and other planted tree species on the Mission grounds. Although the black locust trees were identified they did not occur in large enough stands to consider them a true plant association. Vegetation in this map unit was characterized by open tree canopies with either a Kentucky bluegrass herbaceous layer in landscaped areas or a mix of tall grasses in more natural settings. Mapping of this type was based primarily on where black locust trees were known to occur. On the 2011 NAIP ortho-photography, black locust trees had a smooth dark light signature. It is likely that some confusion exists in the mapping between this type and the cottonwood(s), Norway maple and Chinese elm map units.

Representative Ground Photo



Range and Distribution

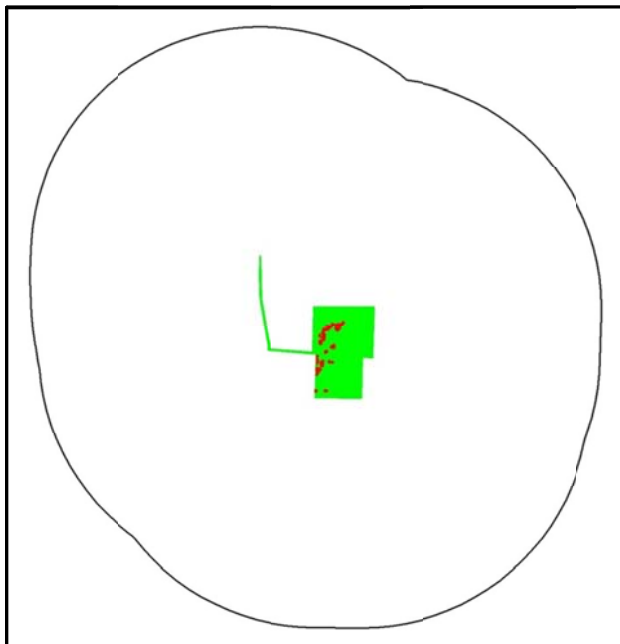
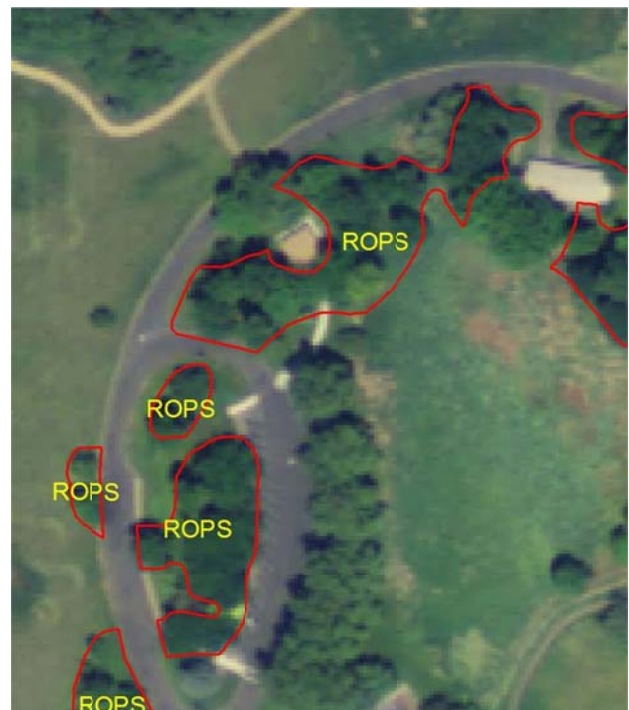


Photo Signature Example



Map Code	<i>Salix amygdaloides</i> Woodland
SAAM	Peachleaf Willow Woodland

Common Species

Salix amygdaloides, *Populus balsamifera* ssp. *trichocarpa*, *Rubus armeniacus* *Phalaris arundinacea*, *Conium maculatum*, *Rosa nutkana*, *Dactylis glomerata*

NVCS Association

-*Salix amygdaloides* Woodland

Representative Ground Photo



Description

This is a common forest map class found at WHMI extensively along the Walla Walla River and its tributaries. Peachleaf willow trees occurred on riparian banks and terraces and the plant species composition of this community varied with some areas containing black and Eastern cottonwood trees that appeared similar on the NAIP imagery. This similarity may have led to some confusion in the mapping and more undocumented peachleaf willow stands likely occur in the environs. Small thickets of blackberry and Shining willow often intermixed with this forest class and the understory layer included a mix of tall grasses and weedy species. On the imagery this type had slightly smaller trees than the cottonwood stands and exhibited a representative dark green, textured signature.

Range and Distribution

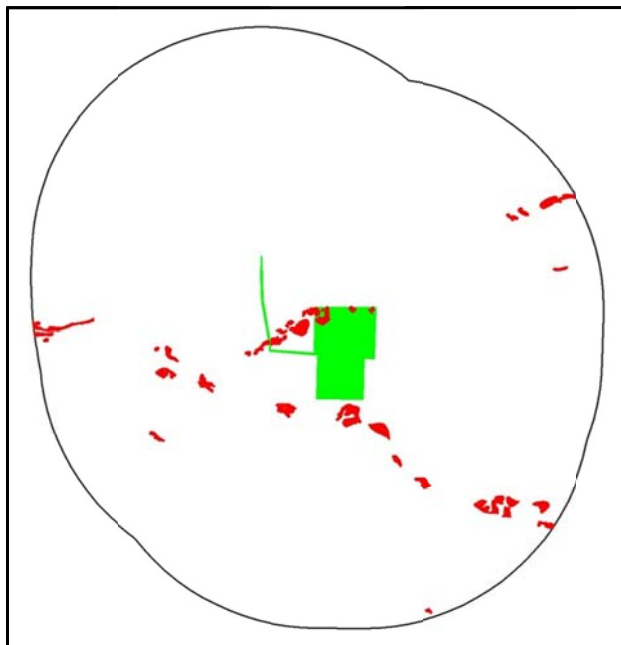
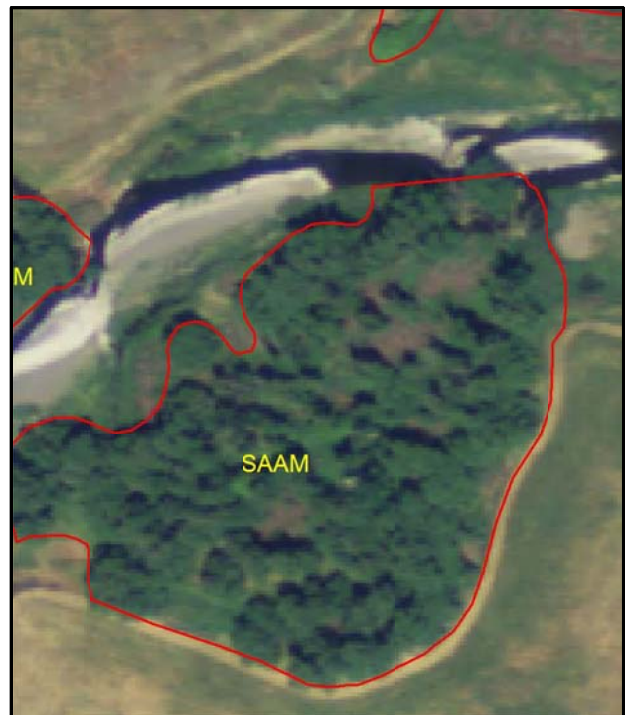


Photo Signature Example



Map Unit	<i>Ulmus parvifolia</i> Semi-natural Woodland
ULPA	Chinese Elm Semi-natural Woodland

Common Species

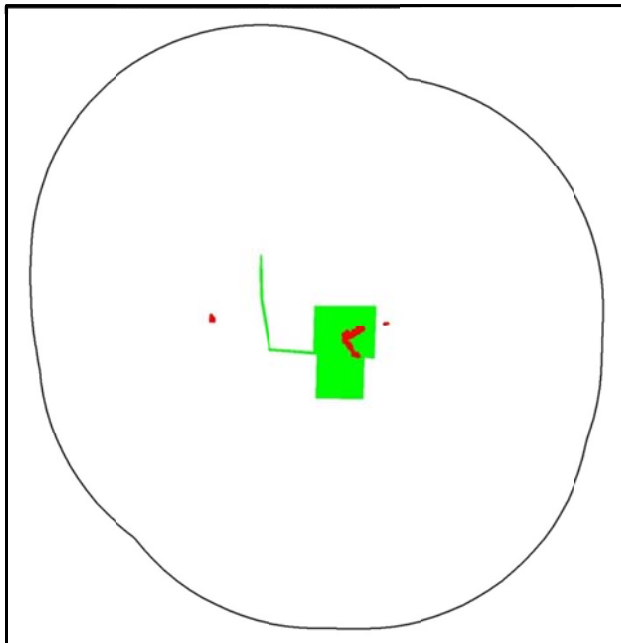
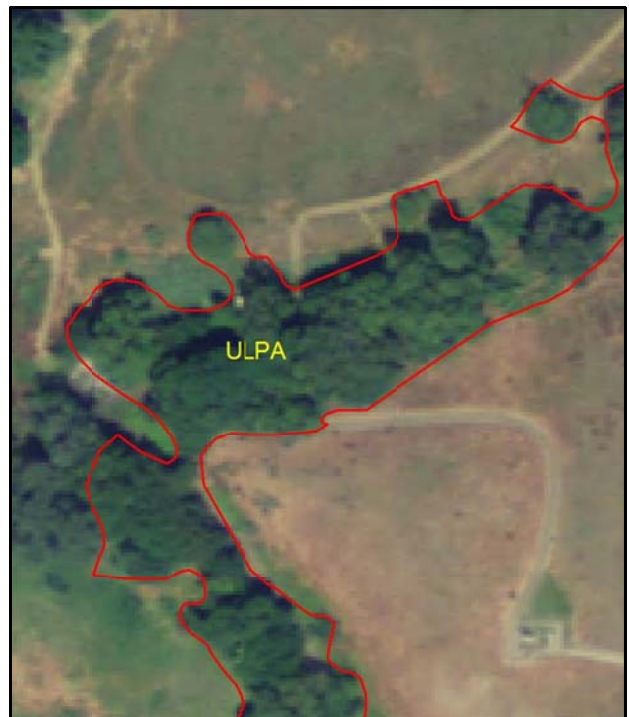
Ulmus parvifolia, *Acer platanoides*,
Syringa vulgaris, *Mahonia aquifolium*,
Symphoricarpos albus, *Bromus rigidus*,
Anthriscus scandicina, *Leymus cinereus*

NVCS Association

-*Ulmus parvifolia* Semi-natural Woodland

Representative Ground Photo**Description**

Chinese elm woodlands were found at WHMI primarily in a drainage and slope at the base of Memorial Hill. More stands of this woodland type likely occur in the environs but were not mapped due to lack of ground data. Chinese elm occurred as trees, saplings and seedlings depending on the age of the stand. Trees of this type mimicked the cottonwood(s) type on the imagery and some confusion likely occurred between this type and the other deciduous forest and woodland map units. Overall the signature ranged from a light green for young stands to a dark green for mature trees.

Range and Distribution**Photo Signature Example**

Shrublands

Map Unit	<i>Ericameria nauseosa</i> - <i>Chrysothamnus viscidiflorus</i> Shrubland
ERNA-CHVI	Rubber Rabbitbrush - Yellow Rabbitbrush Shrubland

Common Species

Chrysothamnus nauseosus,
Chrysothamnus viscidiflorus,
Bromus tectorum, *Centaurea solstitialis*

NVCS Associations

-*Ericameria nauseosa* - *Chrysothamnus viscidiflorus* Shrubland

Representative Ground Photo



Description

This upland short shrub type was found on Memorial Hill and similar dry slopes and hills in the environs. Rubber and yellow rabbitbrush were the dominant shrubs along with a mix of grasses including cheatgrass. Of the two species, rubber rabbitbrush tended to be associated with disturbed locations such as roadways and fallow fields in the environs and yellow rabbitbrush was found in more natural grassland settings. On the NAIP imagery, rabbitbrush short shrubs presented as olive-green to brown flecks with a tan background color. The short stature and tan color of the ERNA-CHVI map unit made it very similar in appearance to grasslands and may have led to some mapping confusion between them.

Range and Distribution

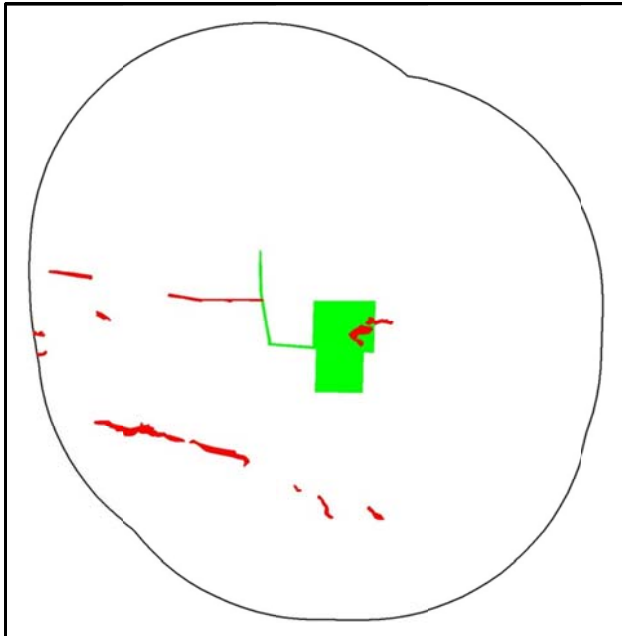
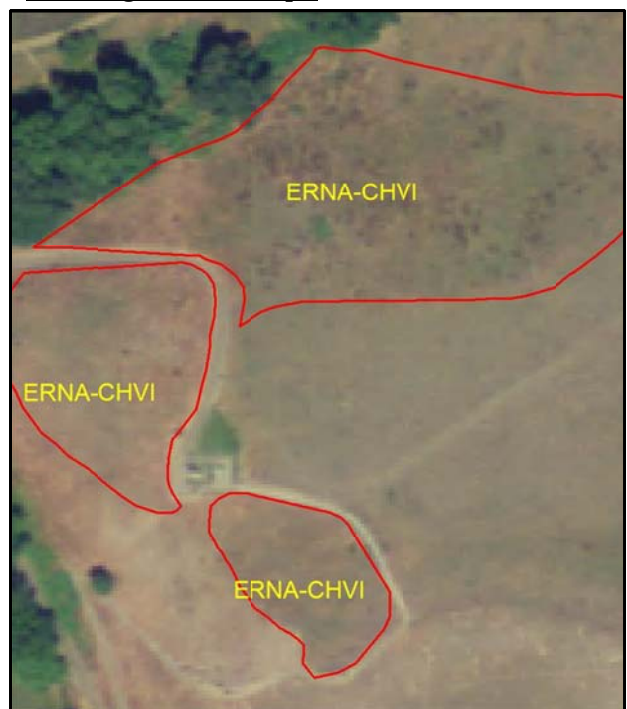


Photo Signature Example



Map Unit	<i>Rubus armeniacus</i> Semi-natural Shrubland
RUAR	Himalayan Blackberry Semi-natural Shrubland

Common Species

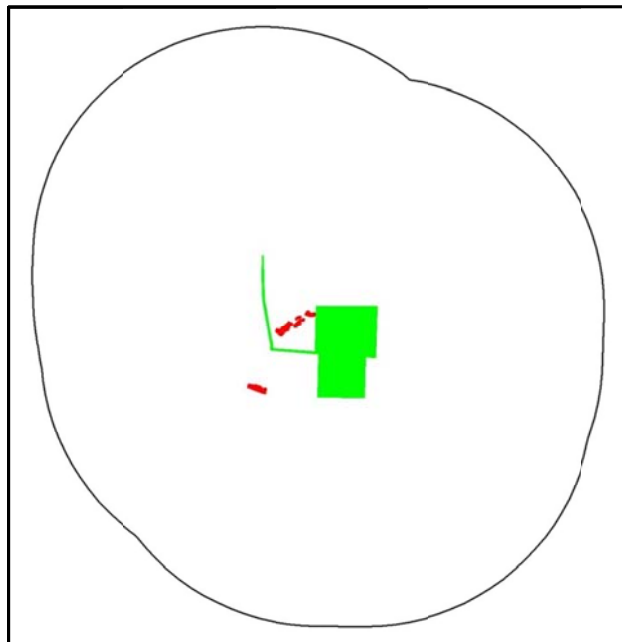
Rubus armeniacus, *Salix amygdaloides*,
Urtica dioica, *Bromus tectorum*,
Rubus armeniacus, *Phalaris arundinacea*

NVCS Association

-*Rubus armeniacus* Semi-natural Shrubland

Representative Ground Photo**Description**

Himalayan blackberry thickets were common along the Mill Creek portion of the Living Trust Area just east of WHMI. Located in the riparian zone, this map unit was commonly interspersed among tall peachleaf willow trees and often formed a transition between the perennial stream and adjacent uplands. Polygons representing this map unit exhibited a characteristic dark green mottled color with large brown areas representing dead plant material. The similar texture and color of living blackberry stands closely mimicked tall riparian grassland types and some mapping confusion may have occurred between them. Other blackberry pockets likely occur in the vicinity of WHMI but were either not documented or were not large enough to be recognizable on the NAIP imagery.

Photo Signature Example**Range and Distribution**

Map Unit	<i>Salix lucida</i> Temporarily Flooded Shrubland Alliance
SALU	Shining Willow Temporarily Flooded Shrubland Alliance

Common Species

Salix lucida, *Ribes aureum*,
Phalaris arundinacea, *Nepeta cataria*,
Salix amygdaloides, *Phalaris arundinacea*

NVCS Alliance

- *Salix lucida* Temporarily Flooded Shrubland Alliance

Representative Ground Photo



Description

Shining and similar willow species formed linear bands of riparian tall shrubland along Mill Creek and the Walla Walla River and was found primarily at WHMI in the Doan Creek restoration area. Willow shrubs at WHMI varied in density from thick stands with little understory to open stands with mixes of wetland and upland graminoids in the ground layer. Willow shrubs appeared as light green pebbles with black shadows against a smooth tan to green understory signature on the 2011 NAIP ortho-imagery.

Range and Distribution

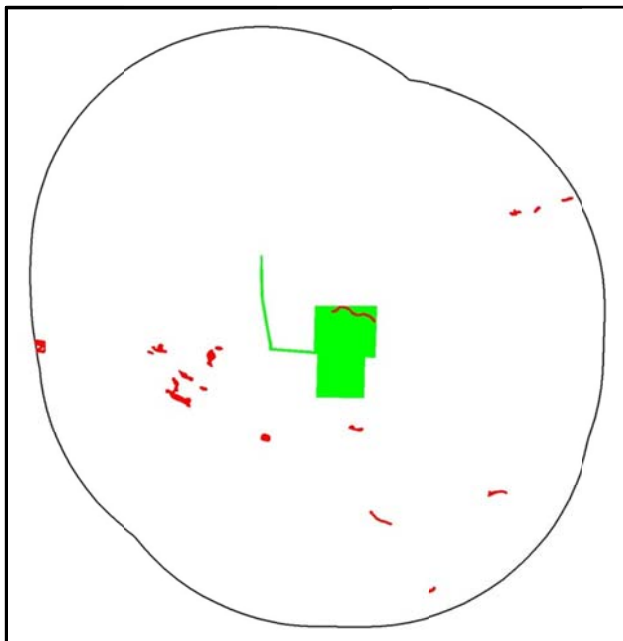
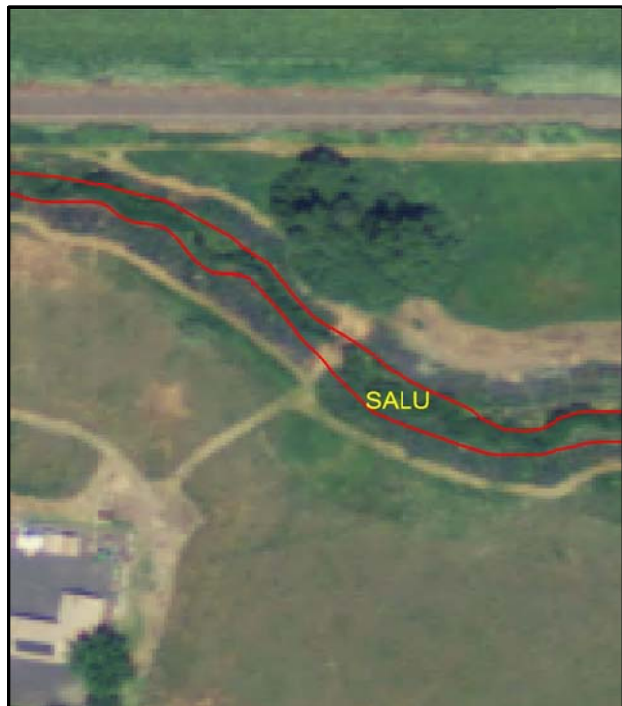


Photo Signature Example



Herbaceous Vegetation

Map Unit	<i>Bromus tectorum</i> Semi-natural Herbaceous Vegetation
BRTE	Cheatgrass Semi-natural Herbaceous Vegetation

Common Species

Bromus tectorum, *Chrysothamnus viscidiflorus*, *Poa bulbosa*, *Chrysothamnus nauseosus*, *Centaurea solstitialis*

NVCS Association

- *Bromus tectorum* Semi-natural Herbaceous Vegetation

Representative Ground Photo



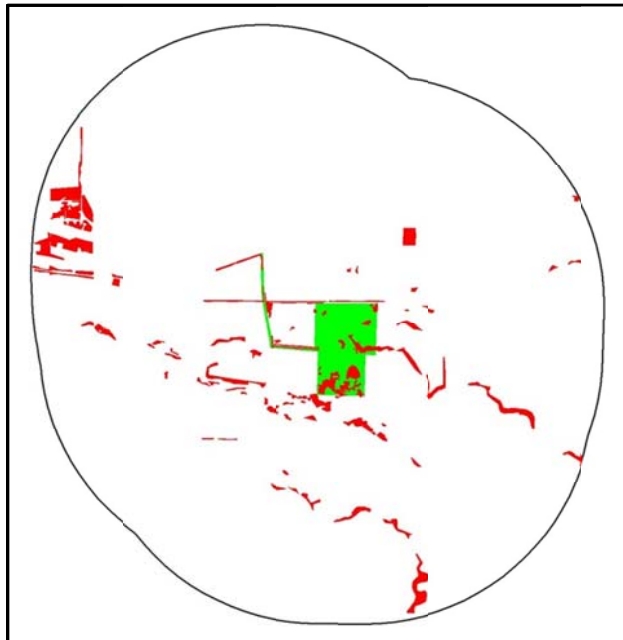
Description

Non-native annual cheatgrass vegetation occurred on disturbed floodplain sites and on the southwest slopes of Memorial Hill. Cheatgrass was also common in Oxbow and Pasture site in southern WHMI where it intermixed with other grasses. Cheatgrass grasslands were also found in the project environs around agricultural and ranching operations. Stands of cheatgrass ranged from dense and tall on floodplains to low or sparse cover on dry sites on Memorial Hill. On the 2011 NAIP imagery stands of cheatgrass with moderate cover (>20%) had a characteristic smooth, orange-tan color and there may have been some confusion with rabbitbrush stands and other grass types, especially in areas that have been actively managed.

Photo Signature Example



Range and Distribution



Map Unit	<i>Festuca idahoensis</i> Herbaceous Alliance
FEID	Idaho Fescue Herbaceous Alliance

Common Species

Festuca idahoensis, *Bromus tectorum*,
Chrysothamnus nauseosus, *Chrysothamnus*
viscidiflorus

NVCS Alliance

- *Festuca idahoensis* Herbaceous Alliance

Description

This rare native grassland type was very similar to the bluebunch wheatgrass –sheep fescue, the rabbitbrush shrubland and the non-native cheatgrass map units in both appearance and composition. This type was separated from the others due its high cover of Idaho fescue and its unique location on north-facing, steep slopes on Memorial Hill. In the two polygons mapped as this type, Idaho fescue was the dominant grass forming moderate to thick stands with little shrub cover. Other native grasslands likely occur in the mapping environs but were not mapped due to lack of verification data. On the 2011 NAIP imagery this map unit appeared as a rich, smooth tan signature due to the lack of shrubs and juniper trees.

Representative Ground Photo



Range and Distribution

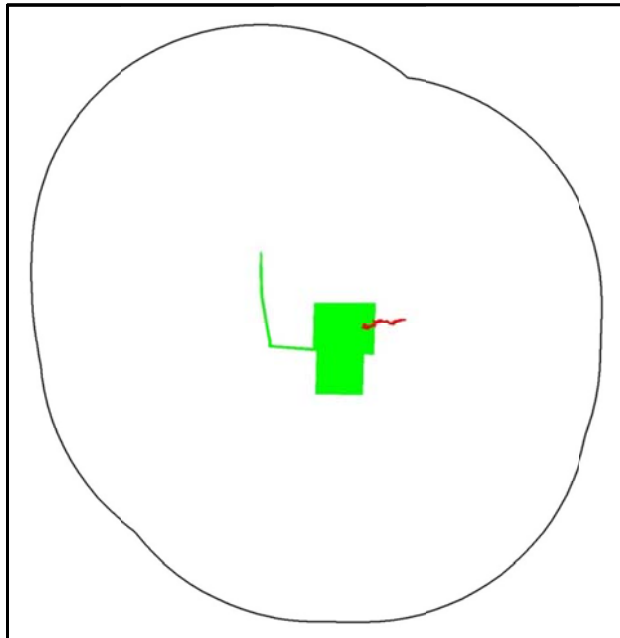
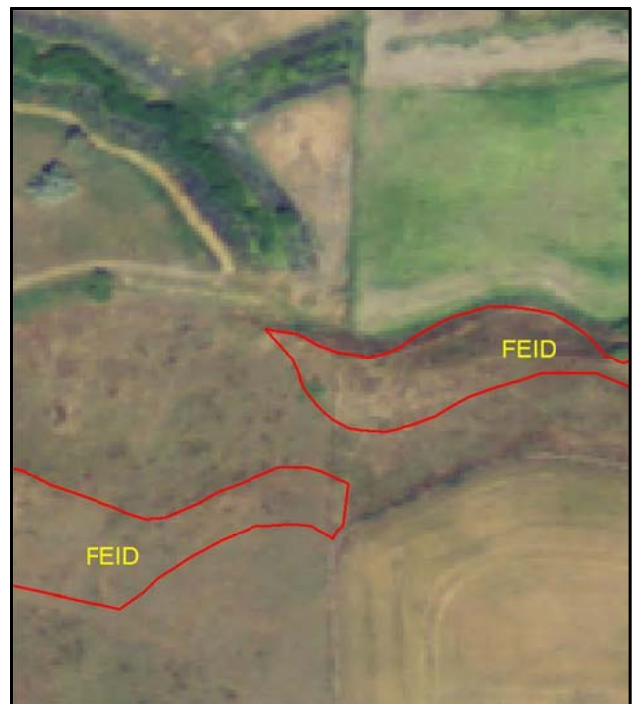


Photo Signature Example



Map Unit	<i>Leymus cinereus</i> Herbaceous Vegetation
LECI	Great Basin Wildrye Herbaceous Vegetation

Common Species

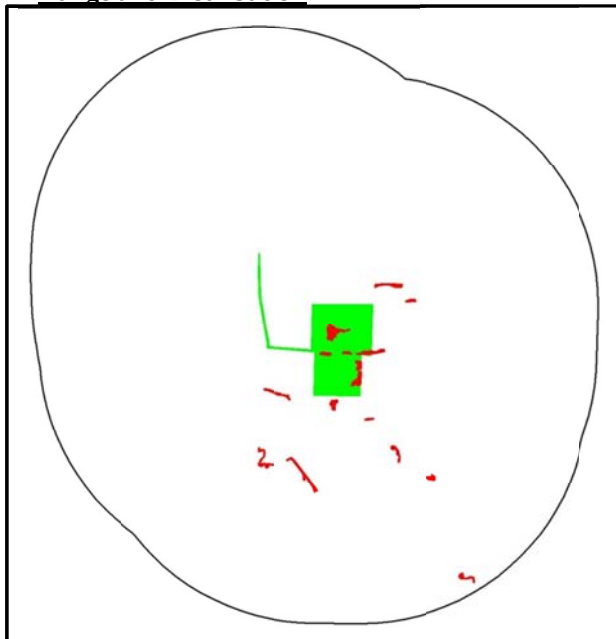
Leymus cinereus, *Bromus tectorum*
Thinopyrum ponticum, *Phalaris arundinacea*

NVCS Association

- *Leymus cinereus* Herbaceous Vegetation

Representative Ground Photo**Description**

Great Basin wildrye is an important historical grass species to the landscape of WHMI and communities of this type are actively being restored and maintained throughout the Mission area. Density of this grass type can be high and recent restoration sites can contain high levels of cheatgrass, reed canarygrass and tall wheatgrass. On the 2011 NAIP imagery the Great Basin wildrye exhibited a characteristic lime green color that was smooth and continuous with undertones of browns and tans relating to the presence of cheatgrass and other non-native grasses. Mapping of this type included splitting pure stands from mixed cheatgrass stands and polygons were attributed as such in the comments field.

Range and Distribution**Photo Signature Example**

**Map Unit
MXGRS**

Mixed Planted and Semi-natural Grassland Complex**Common Species**

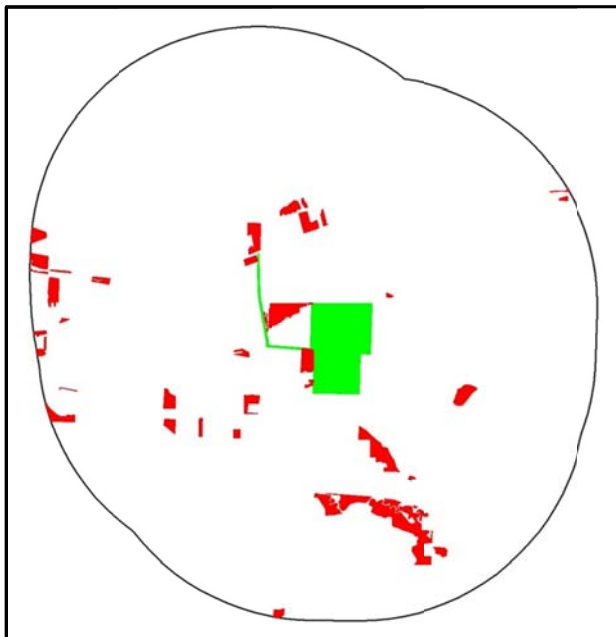
Poa pratensis, *Bromus tectorum*, *Secale
cereal*

NVCS Alliance

- [No Alliance – Park Special]

Representative Ground Photo**Description**

This map unit represents previously planted pastures and cultivated lands in the Living Trust Area and grassland areas in the environs where the dominant grass species could not be documented. This map unit was used to map dry, fallow fields, slopes, benches and other grassy areas that were not actively being cropped when the 2011 NAIP ortho-imagery was acquired. Old agricultural tillage and irrigation lines were also sometimes apparent in polygons of this type. No classification data was collected in these areas and more ground-truthing in the future would greatly aid in distinguishing these areas from the cheatgrass, weedy and reed canarygrass map units.

Range and Distribution**Photo Signature Example**

Map Unit	<i>Phalaris arundinacea</i> Western Herbaceous Vegetation
PHAR	Reed Canarygrass Western Herbaceous Vegetation

Common Species

Phalaris arundinacea, *Rubus armeniacus*,
Dipsacus fullonum, *Urtica dioica*,
Bromus tectorum, *Rumex crispus*,
Thinopyrum ponticum, *Cirsium arvense*

NVCS Association

- *Phalaris arundinacea* Western Herbaceous Vegetation

Representative Ground Photo



Description

Reed canarygrass occurred in nearly monotypic stands on broad floodplains and on mesic terraces throughout WHMI. Three distinct associations were documented and this map unit was used to map the reed canarygrass association that contained little if any cover of associated grass species. Polygons of this type ranged in density from sparse stands on streambanks to very dense on deeper floodplain soils. On the NAIP imagery stands of pure reed canarygrass with high cover (> 50%) had a characteristic smooth, bright green color and sparse stands were lighter in green and contained some white and gray areas representing exposed soil. Due to the close similarity with the other reed canarygrass and the tall wheatgrass map units some overlap in mapping likely exists between all three grass types.

Range and Distribution

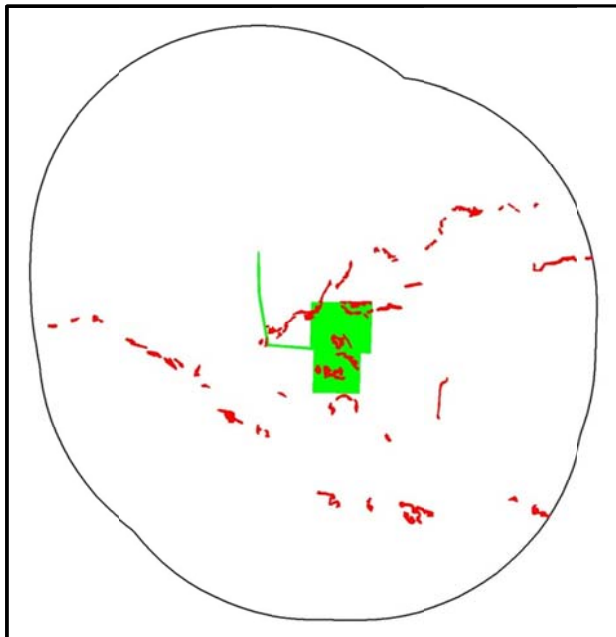


Photo Signature Example



Map Unit	<i>Phalaris arundinacea</i> Seasonally Flooded Herbaceous Alliance
PHAR-GRS	Reed Canarygrass Seasonally Flooded Herbaceous Alliance

Common Species

Phalaris arundinacea, *Thinopyrum ponticum*,
Urtica dioica, *Bromus tectorum*, *Dipsacus*
fullonum, *Rumex crispus*, *Cirsium arvense*

NVCS Associations

-*Phalaris arundinacea* - *Bromus tectorum*
Herbaceous Vegetation

-*Phalaris arundinacea* - *Thinopyrum*
ponticum Herbaceous Vegetation

Description

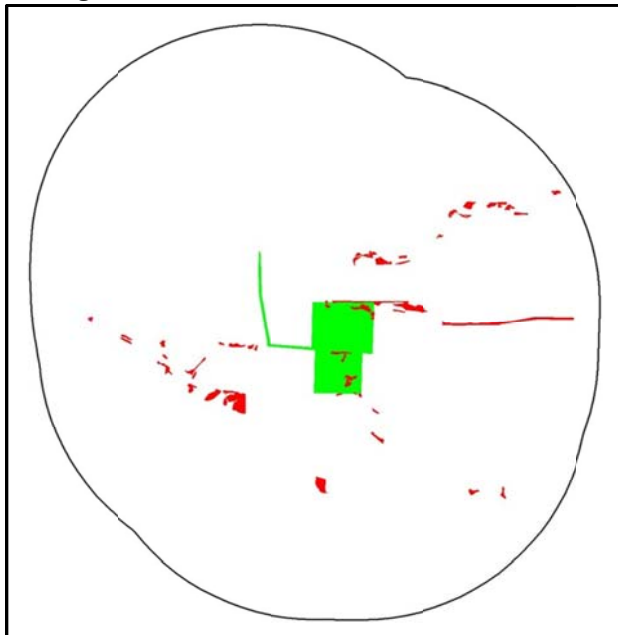
In addition to the nearly pure stands of reed canarygrass, WHMI and its surrounding areas also contained sparser reed canarygrass communities that had multiple associated grass species. Of these associates, cheatgrass and tall wheatgrass were the most common. In addition to the presence of other grass species this map unit also usually contained higher levels of forb and weed cover than the PHAR map unit. It is likely that this type represents a transition from active agricultural fields to early successional grasslands. To map these unique areas, two of the reed canarygrass associations were combined and the alliance was used as the map unit name. On the 2011 imagery this type was mapped based on the mottled green and tan color with old tillage lines sometimes present. This type was similar in appearance to the other reed canarygrass, tall wheatgrass, and the cheatgrass map units and some overlap in mapping likely exists.

Representative Ground Photo



Photo Signature Example

Range and Distribution



Map Unit	<i>Poa pratensis</i> Semi-natural Herbaceous Alliance
POPR	Kentucky Bluegrass Semi-natural Herbaceous Alliance

Common Species

Poa pratensis, *Trifolium repens*

NVCS Alliance

- *Poa pratensis* Semi-natural Herbaceous Alliance

Representative Ground Photo



Description

This perennial rhizomatous graminoid type represents monotypic mowed lawns at WHMI and pastures in the surrounding areas. Kentucky bluegrass was likely seeded at WHMI in the past to maintain the Mission Ground setting and to create picnic and park environments. In the environs this Kentucky bluegrass was also likely seeded for residential lawns and to provide ground cover for livestock. Polygons of this map unit were characterized by a very smooth, light green signature and may include small inclusions of mottled tans, to blotchy greens resulting from dryness and grazing patterns.

Range and Distribution

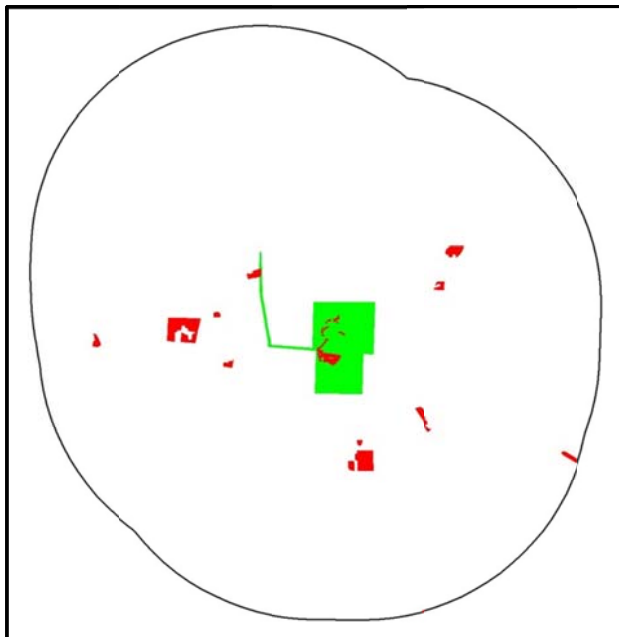


Photo Signature Example



Map Unit	<i>Pseudoroegneria spicata</i> - <i>Festuca ovina</i> Herbaceous Vegetation
PSSP-FEOV	Bluebunch Wheatgrass - Sheep Fescue Herbaceous Vegetation

Common Species

Pseudoroegneria spicata, *Festuca idahoensis*,
Thinopyrum ponticum, *Bromus tectorum*,
Festuca ovina

NVCS Association

- *Pseudoroegneria spicata* - *Festuca ovina*
Herbaceous Vegetation

Representative Ground Photo



Description

Bluebunch wheatgrass with sheep fescue was an upland grassland type found on dry upper slopes and ridges on Memorial Hill. This rare native grassland type was very similar to the Idaho fescue, the rabbitbrush shrubland and the non-native cheatgrass map units in both appearance and composition. This type was separated from the others due its high cover of bluebunch wheatgrass and its unique location on the highest portion of Memorial Hill. In the two polygons mapped as this type, bluebunch wheatgrass was the dominant grass forming moderate to thick stands with little shrub cover. Other native grasslands likely occur in the mapping environs but were not mapped due to lack of verification data. The photo signature for this map unit appeared smooth due to the lack of shrubs and had a deep brown color.

Range and Distribution

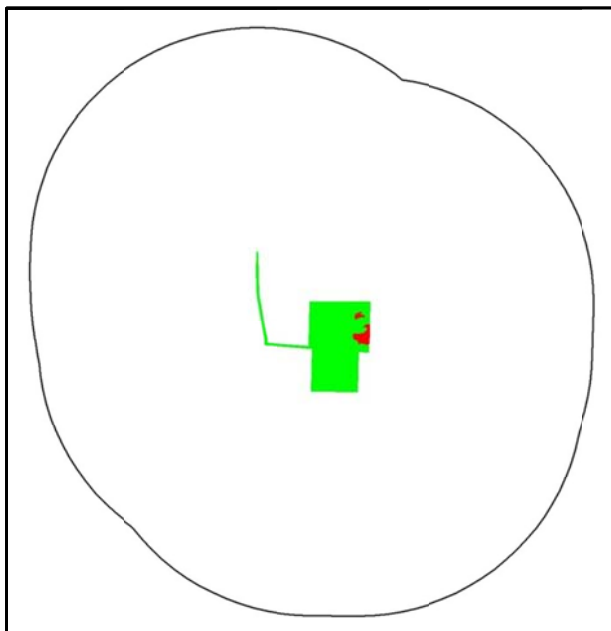
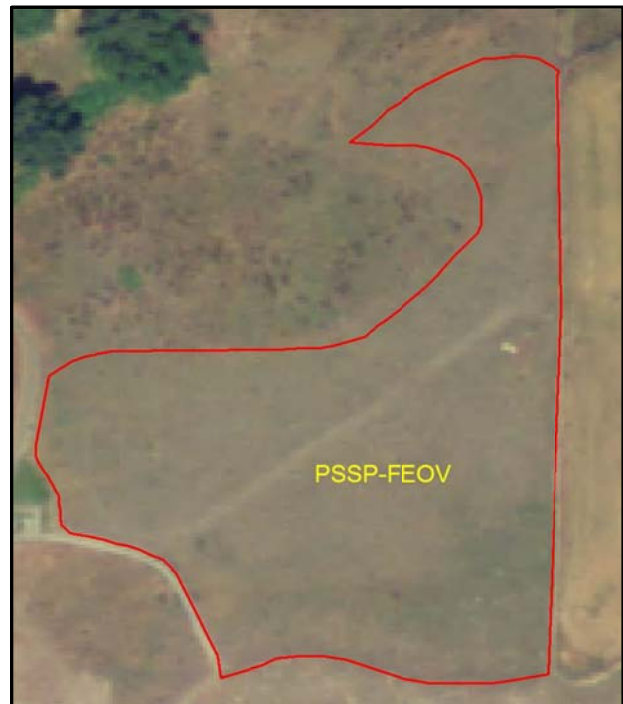


Photo Signature Example



Map Unit	<i>Sisymbrium altissimum</i> Semi-natural Herbaceous Vegetation
SIAL-BRTE	Tall Tumblemustard - Cheatgrass Semi-natural Herbaceous Vegetation

Common Species

Bromus tectorum, *Sisymbrium altissimum*

NVCS Association

- *Bromus tectorum* Semi-natural Herbaceous Vegetation

Representative Ground Photo



Description

This weedy type is closely aligned with the other cheatgrass map unit and the weedy herbaceous type, however the presence of tall tumblemustard warranted the separate mapping of this association. At WHMI, this type was found in the northern half of the Mission Site, primarily along trails and irrigation canals. On the 2011 NAIP imagery stands of tall tumblemustard with cheatgrass had a very mottled tan signature compared to the solid orange-tan color of pure cheatgrass stands. Due to the overlap in species between the three weedy map units at WHMI, more classification data may indicate the combining of all three types into broader mapping unit.

Range and Distribution

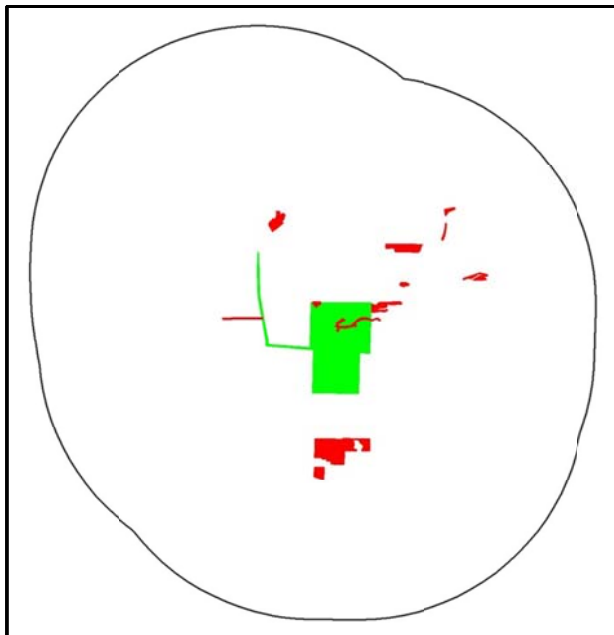


Photo Signature Example



Map Unit	<i>Thinopyrum intermedium</i> Semi-natural Herbaceous Alliance
THIN	Intermediate Wheatgrass Semi-natural Herbaceous Alliance

Common Species

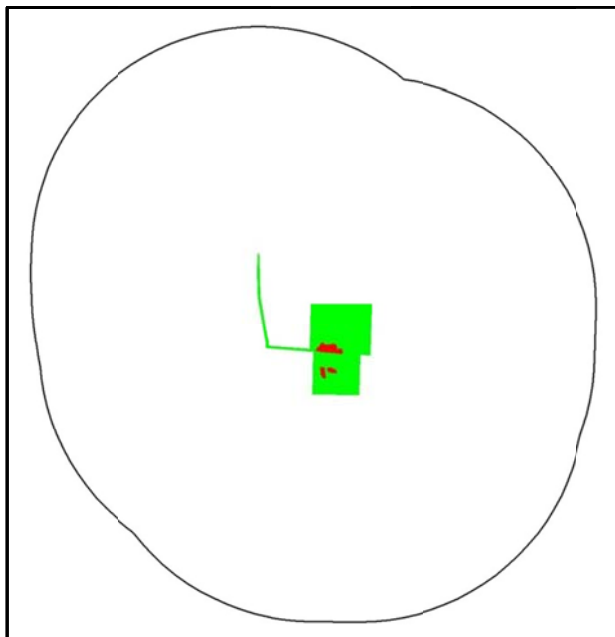
Thinopyrum intermedium, *Conium maculatum*, *Phalaris arundinacea*, *Bromus tectorum*, *Thinopyrum ponticum*

NVCS Alliance

- *Thinopyrum intermedium* Semi-natural Herbaceous Alliance

Representative Ground Photo**Description**

This herbaceous map unit represents a few nearly monotypic grasslands that were likely seeded with intermediate wheatgrass in the past. Stands occurred in the southern half of WHMI on flat floodplain terraces and other polygons of this type likely exist in the environs but were not documented at this time. Polygons of intermediate wheatgrass were often associated with restoration efforts and may contain pockets of reed canarygrass, Great Basin wildrye and tall wheatgrass. On the 2011 NAIP imagery this type exhibited a very faint light green color with some mottling due the presence of other grass species. Due to the dynamic nature of the grassland resoration efforts at WHMI this map unit may need more ground-truthing in the future if areas become cleared or new areas are seeded with intermediate wheatgrass.

Range and Distribution**Photo Signature Example**

Map Unit	<i>Thinopyrum ponticum</i> Semi-natural Herbaceous Vegetation
THPO	Tall Wheatgrass Semi-natural Herbaceous Vegetation

Common Species

Thinopyrum ponticum, *Bromus tectorum*,
Bromus rigidus, *Phalaris arundinacea*,
Cadaria draba, *Sisymbrium altissimum*,
Dipsacus fullonum

NVCS Association

- *Thinopyrum ponticum* Semi-natural
Herbaceous Vegetation

Representative Ground Photo



Description

Tall wheatgrass was a common grassland type throughout WHMI and surrounding areas and may represent past seeding and planting of this grass species. Other polygons of this type likely exist in the environs but were not documented at this time. Like the other wheatgrass type, polygons of tall wheatgrass at WHMI were often associated with restoration efforts and may contain pockets weedy forbs and other grass species like reed canarygrass, Great Basin wildrye and intermediate wheatgrass. On the 2011 NAIP imagery this type exhibited a light green to tan color with some mottling due the presence of other grass species. Due to the dynamic nature of the grassland resoration efforts at WHMI this map unit may need more ground-truthing in the future if areas become cleared or new areas are seeded..

Range and Distribution

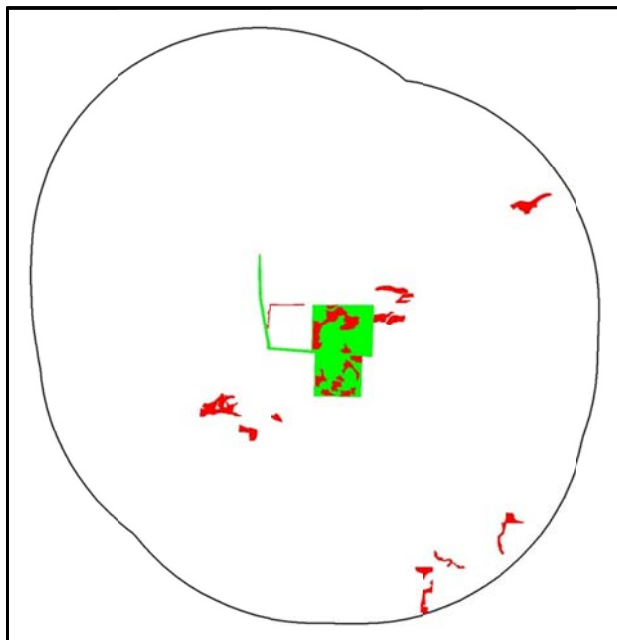
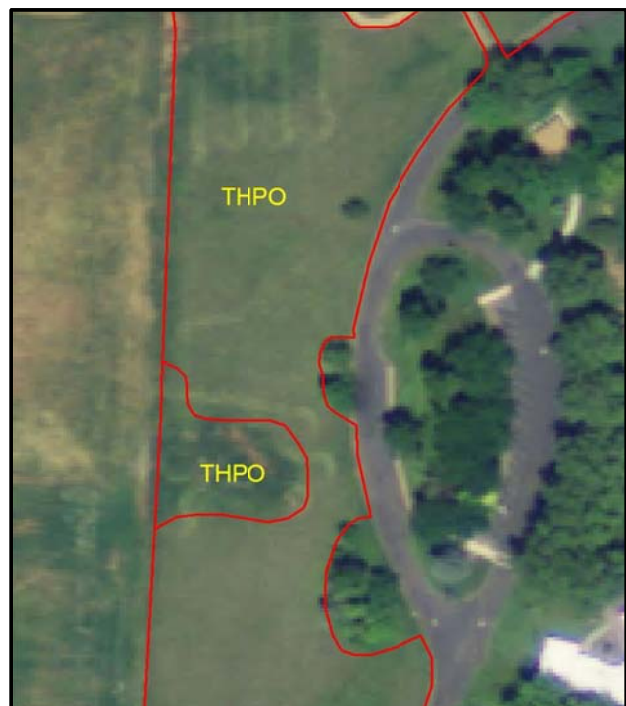


Photo Signature Example



**Map Unit
WEED**

Mixed Weedy Semi-natural Herbaceous Vegetation Complex**Common Species**

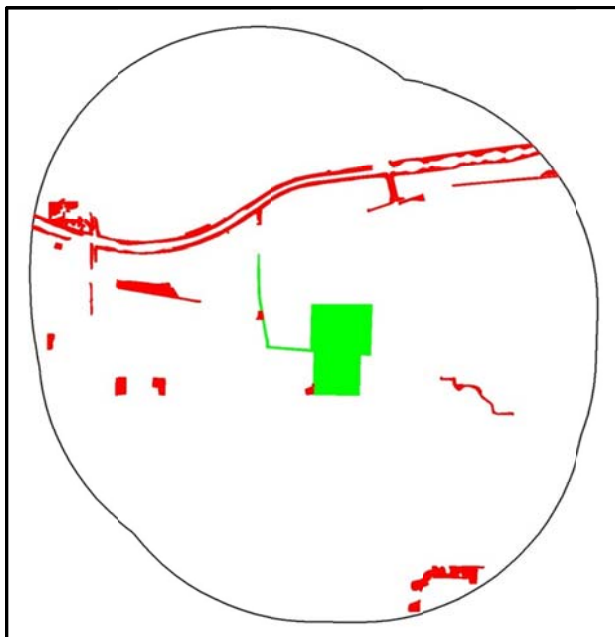
Poa pratensis, *Bromus tectorum*,
Conium maculatum, *Centaurea solstitialis*,
Cirsium arvense, *Onopordum acanthium*

NVCS Association

- [No Association – Park Special]

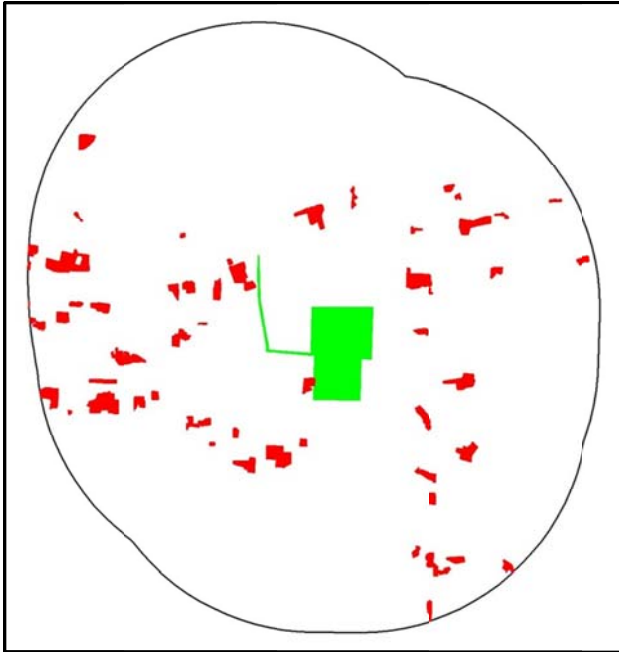
Representative Ground Photo**Description**

The weedy complex map unit was used exclusively at WHMI to map recently disturbed areas in the environs that likely contain early successional annual vegetation or scabby patches of non-native grasslands. Since no classification plot data was collected in these areas the exact species composition is unknown at this time. More ground-truthing (with permission from the landowners) would allow for better classification and description of this type. On the 2011 NAIP imagery, stands of weedy vegetation with sufficient cover (>20%) varied in color from light green to dark brown and varied in texture depending on the size of the vegetation with taller vegetation appearing coarser and more mottled.

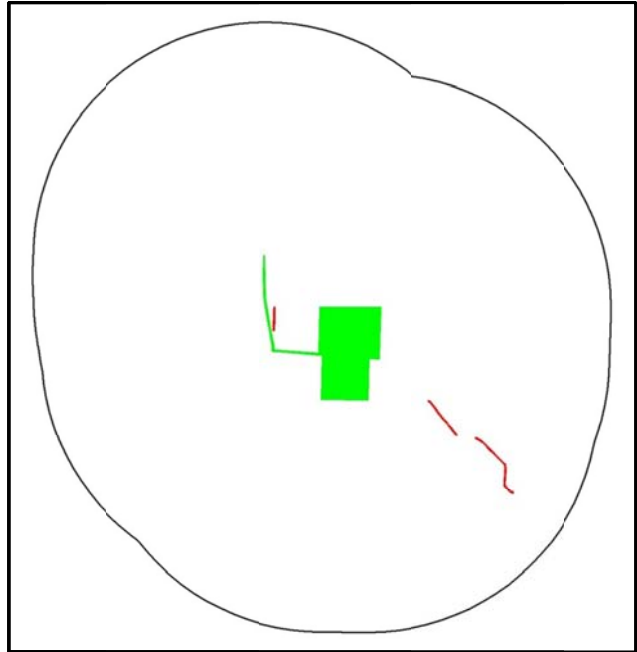
Range and Distribution**Photo Signature Example**

LAND COVER – LAND USE

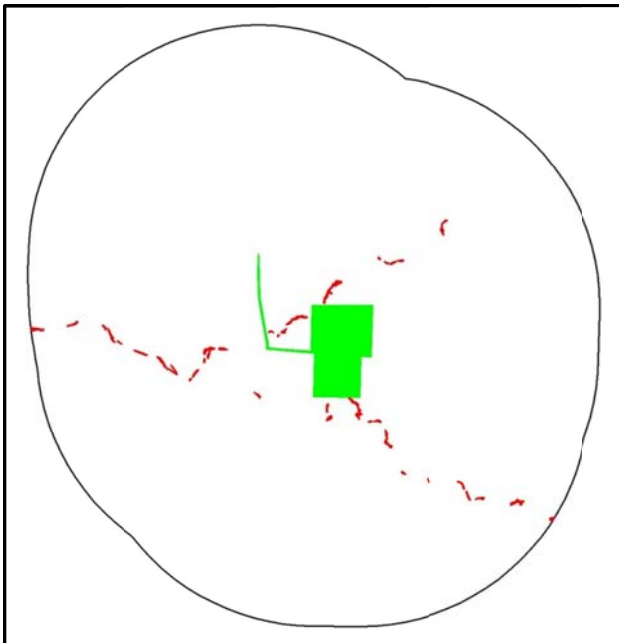
Agricultural Business



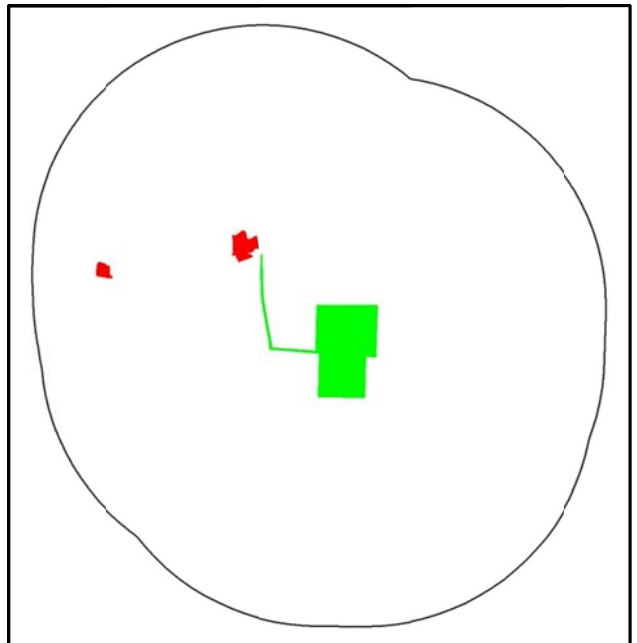
Canal / Ditch



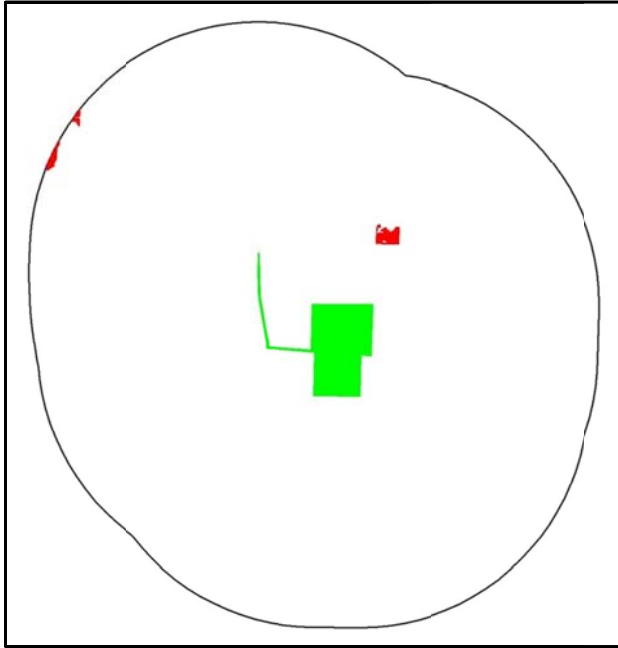
Bare Rock / Sand / Other Bare Ground



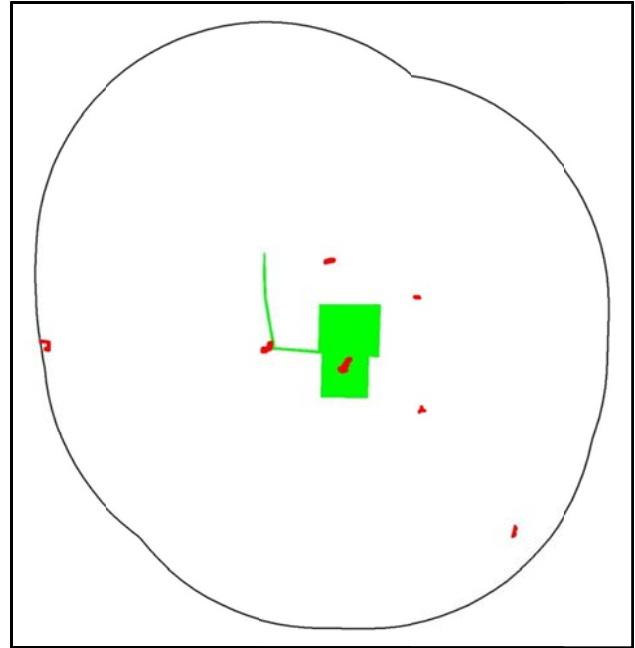
Commercial / Light Industry



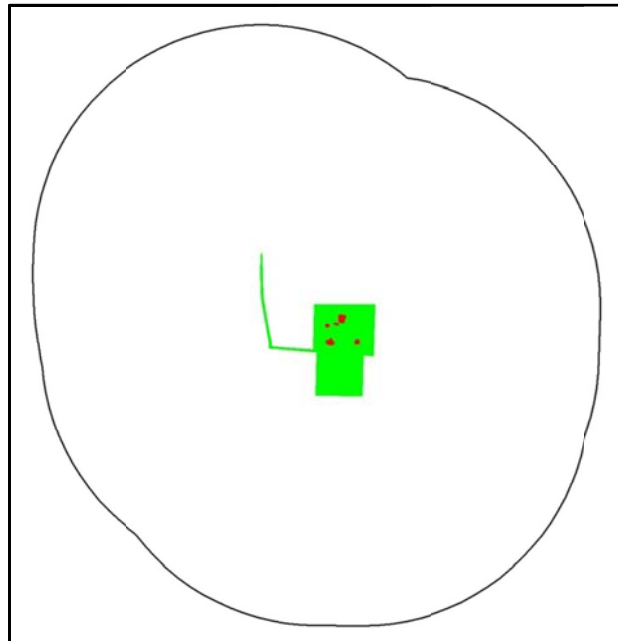
Entertainment / Recreation



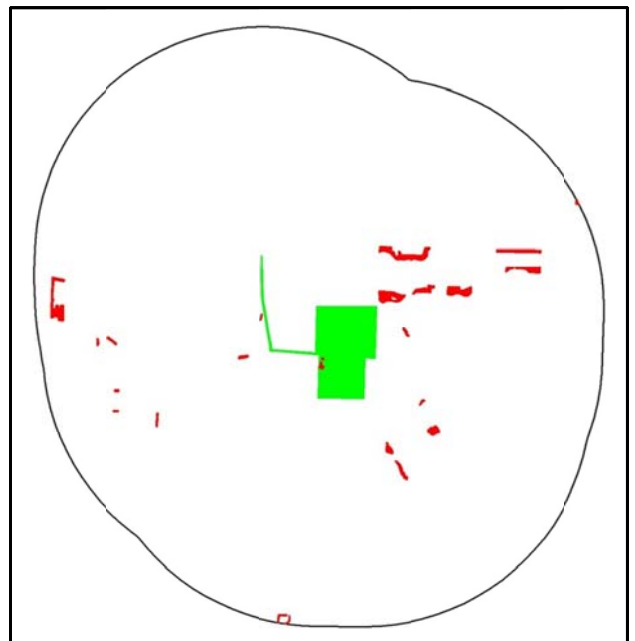
Lake / Pond



Facilities



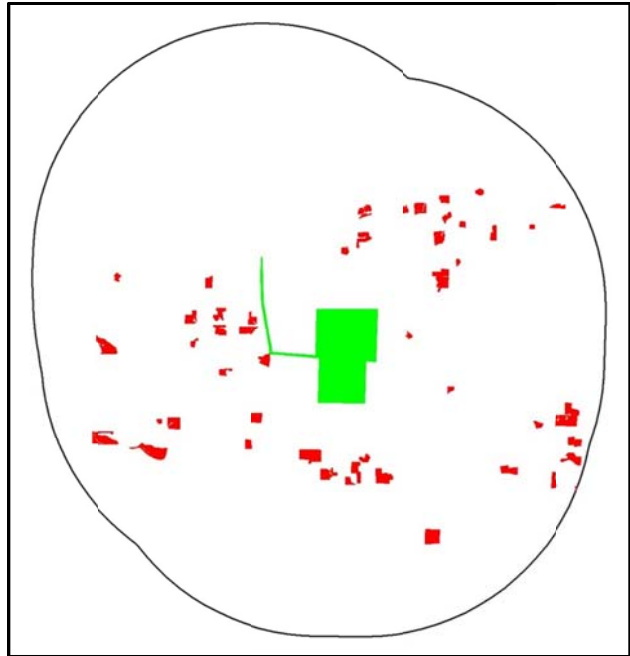
**Orchards, Groves, Vineyards, Nurseries,
and Horticultural Areas**



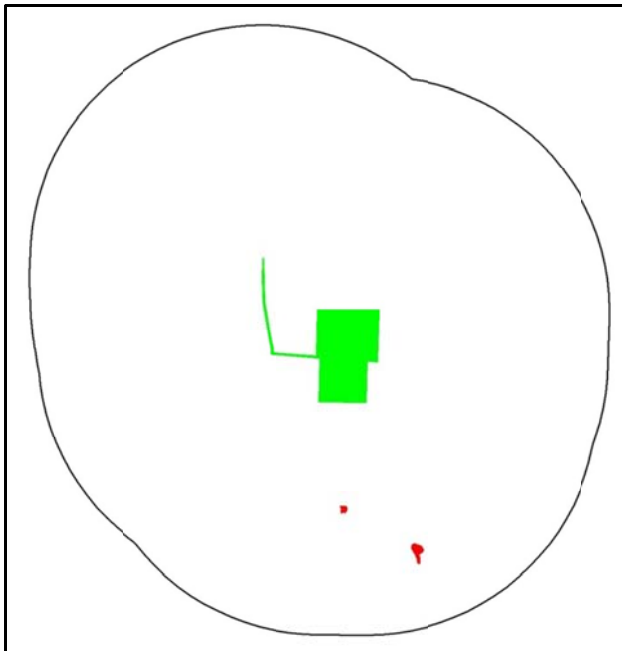
Planted / Cultivated



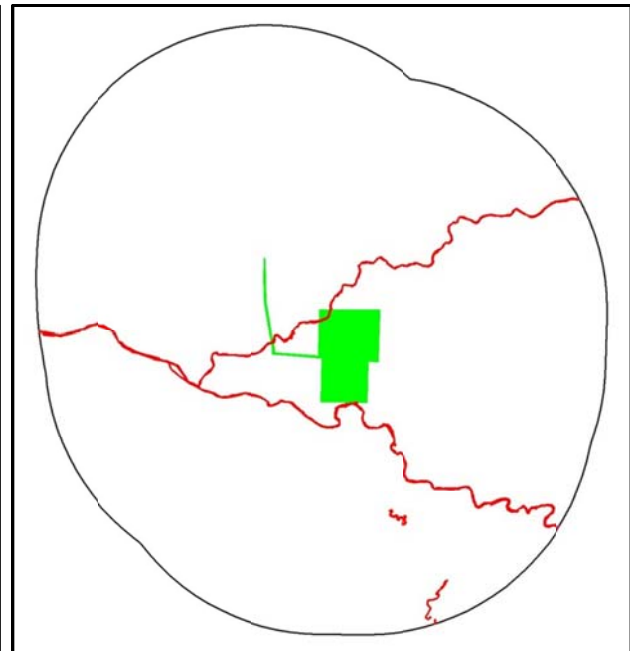
Residential



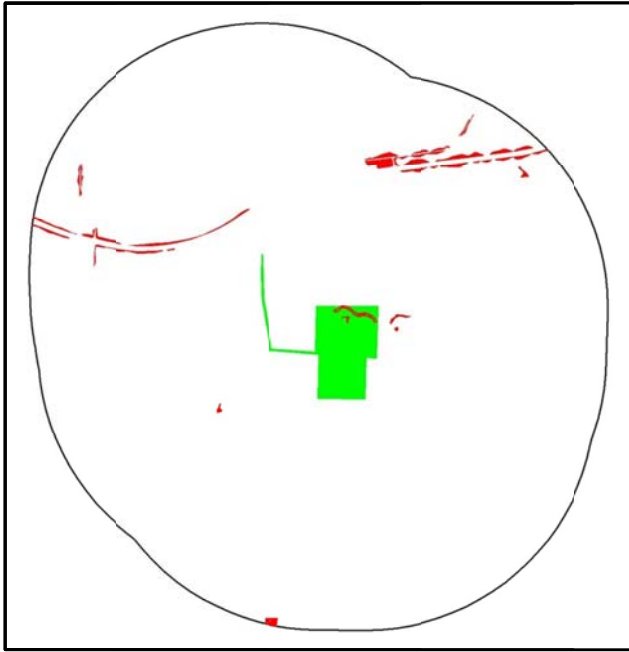
Quarries / Strip Mines / Gravel Pits



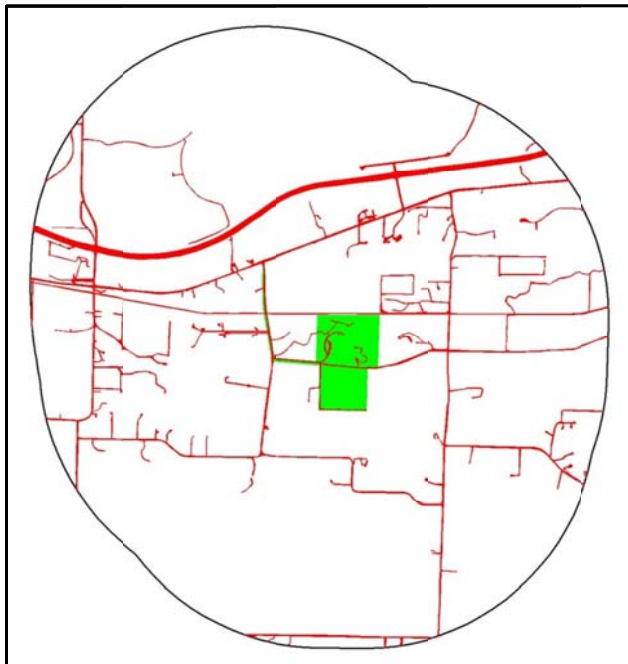
Stream / River

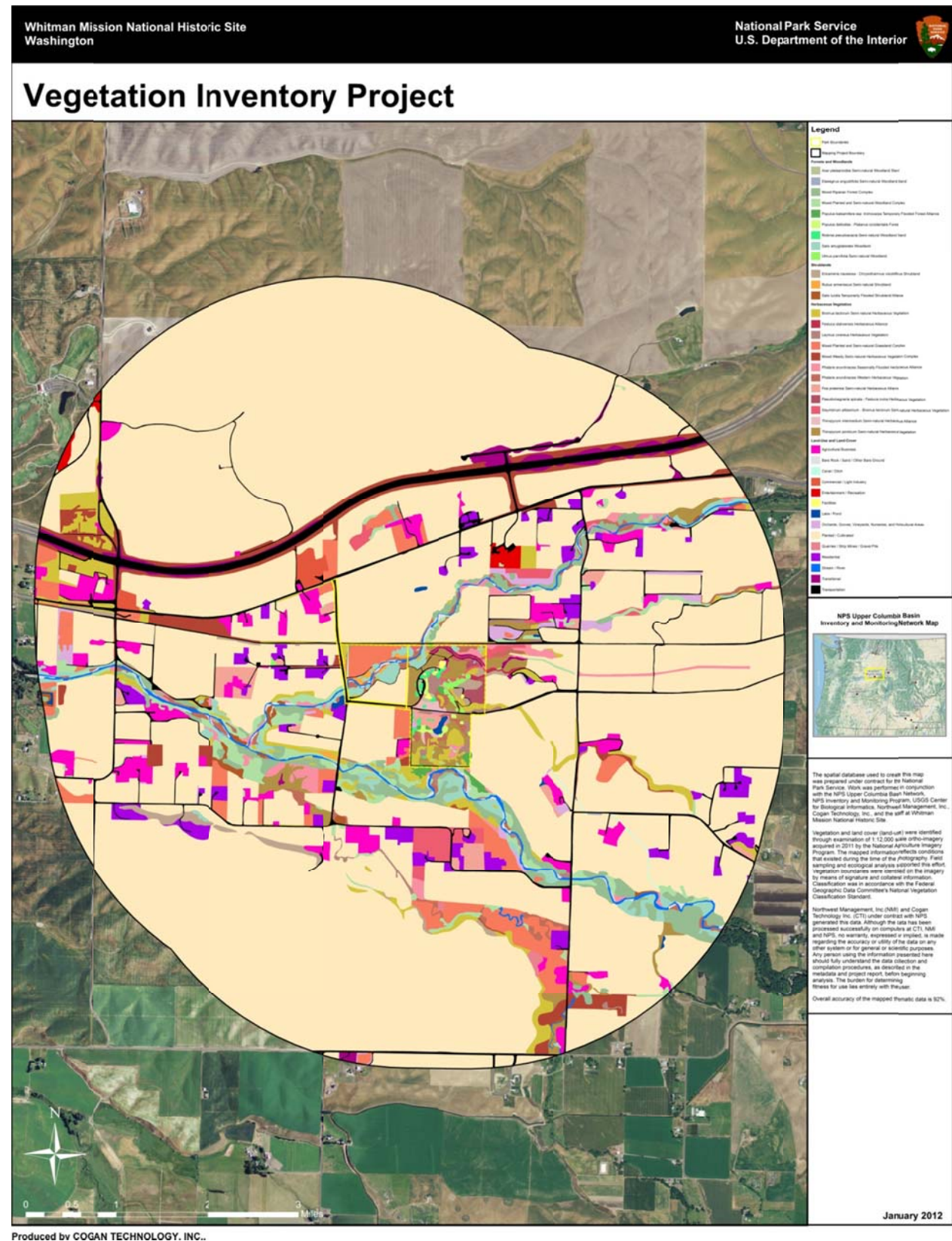


Transitional



Transportation





The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 371/113956, April 2012

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

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