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Vegetation Classification and Mapping Project Report, Timpanogos Cave National Monument

Natural Resource Technical Report NPS/NCPN/NRTR—2009/210

ON THE COVER
American Fork River riparian vegetation, Timpanogos Cave National Monument (Photograph by Janet Coles)

Vegetation Classification and Mapping Project Report, Timpanogos Cave National Monument

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Acronyms and Abbreviations

AA	Accuracy Assessment
CEGL	Community Element Code
DBH	Diameter At Breast Height (4.5 feet)
DEM	Digital Elevation Model
DOQQ	Digital Orthophotograph Quarter Quadrangle
e^2M	engineering-environmental Management, Inc.
ES	Ecological System
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
ft	Feet
GIS	Geographic Information System(s)
GPS	Global Positioning System
I&M	Inventory and Monitoring Program
in	Inch
ITIS	Integrated Taxonomic Information System
MMU	Minimum Mapping Unit
NAD	North American Datum
NBII	National Biological Information Infrastructure
NCPN	Northern Colorado Plateau Network
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NVC	National Vegetation Classification
NVCS	National Vegetation Classification System
QA/QC	Quality Assurance/Quality Control
SCS	Soil Conservation Service
TICA	Timpanogos Cave National Monument
TNC	The Nature Conservancy
TSN	Taxonomic Serial Number
UNESCO	United Nations Education, Science, and Cultural Organization
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WRCC	Western Region Climate Center

Summary

With the support of the U.S. Geological Survey - National Park Service Vegetation Mapping Program, the Northern Colorado Plateau Inventory and Monitoring Network completed this project to describe and map vegetation at Timpanogos Cave National Monument. This collaborative effort involved project partners engineering-environmental Management, Inc., the Western Region office of NatureServe, and their cooperators.

The mapping area is 100 hectares (248 acres), encompassing only the lands within the Monument boundary. Project partners identified plant associations for Timpanogos Cave National Monument and determined how best to map them using 1:12,000-scale, true color orthophotography. The field team collected vegetation and environmental data from 13 vegetation classification plots and 10 observation points. No supplemental fuels data were collected during the project. Fieldwork and mapping were completed in 2007.

Analysis of the plot data revealed 13 National Vegetation Classification plant associations or park special vegetation types within the Monument. Four other vegetation types were not documented by plot or observation point data, but were included in the map classes.

Vegetation and land use were delineated in the field on base maps of 1:12,000 true-color orthophotography acquired in 2006. On-the-ground delineation was possible because of the small size of the Monument and because every part of the unit is accessible on foot or viewable from relatively close range. Because Timpanogos Cave is a small park, the program standard minimum mapping unit of 0.5 ha was discarded and polygons were delineated to approximately 0.2 ha.

A total of 84 map polygons representing 16 natural and semi-natural vegetation map classes were developed for the Timpanogos Cave mapping project. Three land use and two geologic map classes describe 36 polygons within the mapping area. Average polygon size across all map classes is 0.8 ha (2.0 acres). Ten land use/land cover polygons such as roadways and Monument facilities total 0.8 ha (2.0 acres). The vegetation map class with the greatest cover is White fir - Douglas-fir / Gambel Oak - Bigtooth Maple Forest (Map Class # 7) with 7 polygons covering 29.0 ha or 29% of the mapping area.

Because many polygons were visited or viewed and delineated in the field, a standard thematic accuracy assessment of the 16 vegetated map classes was not employed.

Products resulting from the Timpanogos Cave National Monument vegetation mapping project include:

Available in this report:

- project summary of methods and results
- illustrated dichotomous field key to the vegetation associations
- illustrated guide to the map classes
- detailed descriptions of vegetation associations

- samples of completed field forms
- field manual used to guide plot and observation point data collection

Available elsewhere[1]:

- geodatabase containing map polygon attribute, land use, plot data and Monument and project boundaries
- ground photography of vegetation plots, observation points in hard copy and digital formats
- all field data (plot, and observation point) stored in a Microsoft Access database
- hard copy vegetation maps
- metadata for all digital products

Geospatial products are in Universal Transverse Mercator (UTM) projection, Zone 12, using the North American datum of 1983.

[1] This document and most of the digital products are available on the internet at: http://biology.usgs.gov/npsveg/. Hard copies of the orthophotos and original data forms are retained by NCPN and TICA.

Acknowledgements

This project was completed through the effort and dedication of numerous individuals and organizations. Angela Evenden coordinated the NCPN Vegetation Mapping Program in its early years and guided the development of the methodologies used for this project. Karl Brown and Tammy Hamer (USGS/NPS) and Mike Mulligan (USGS) provided program oversight and coordination. Funding for this project was provided through the USGS-NPS National Vegetation Mapping Program and the Northern Colorado Plateau Inventory and Monitoring Network.

Bruce Condie and Pete Williams collected plot and observation point data, and drew the first draft of the vegetation map in the field. Bruce also helped developed the map unit concepts employed in the final vegetation map. Keith Schulz of the Western Region office of NatureServe prepared the final vegetation classification and the global descriptions. Jim Von Loh, Senior Biologist with engineering-environmental Management, Inc. prepared the local descriptions and helped write the report. Database management and support were skillfully performed by Helen Thomas and Russ DenBleyker of the Northern Colorado I&M Network. Aneth Wight created the geodatabase and made sure everything worked in a GIS environment.

The staff of Timpanogos Cave National Monument made us welcome when we arrived to collect the field data and fed us popsicles on hot afternoons. Camille Pulham in particular assisted with the field work and provided helpful advice as to the best way to access different parts of the Monument. She also provided the descriptive information and photographs used for the meadow community and map class.

For these and other contributors to the success of the project, we are grateful.

Introduction

Vegetation Classification and Mapping Project, Timpanogos Cave National Monument

The Timpanogos Cave National Monument (TICA) Vegetation Mapping Project was organized and coordinated by the Northern Colorado Plateau Network (NCPN) Inventory and Monitoring (I&M) Program during 2007 and 2008, with assistance from several project cooperators. The purpose of this project was to describe and map existing plant associations on 100 hectares (248 acres) within the TICA administrative boundary, and to provide this information in written, tabular, digital, and spatial formats useful to NPS resource managers, the NCPN I&M Program, and others. The basic project components consisted of vegetation classification, description, and spatial database development. No accuracy assessment was conducted for this project.

In 2001, the NCPN I&M Program launched a multi-year project to complete vegetation classifications and maps for 15 network park units. Funding was provided by the USGS-NPS Vegetation Mapping Program and the Northern Colorado Plateau Network. The TICA Vegetation Classification and Mapping Project was completed by the NCPN, engineering-environmental Management, Incorporated (e^2M), and NatureServe. The vegetation plot and observation point data collection occurred in 2007. The draft map was created in 2007 and refined in 2009.

Project methods, results, and products are documented in this report. This introductory section describes the NPS I&M Program and the USGS-NPS Vegetation Mapping Program, as well as the TICA project area. Later sections document the methods and results for each of the major steps in the project: scoping, vegetation classification and description, and vegetation mapping.

The USGS-NPS Vegetation Mapping Program

The National Vegetation Mapping Program is a cooperative project between the U. S. Geological Survey (USGS) and the National Park Service (NPS) to inventory, classify, describe, and map vegetation in more than 270 national park units within the United States. Consistent vegetation classification, mapping, and accuracy assessment protocols and standards are applied across projects supported by this program. The National Vegetation Mapping Program is administered by the USGS Center for Biological Informatics in cooperation with the NPS I&M Program. Through implementation of the NPS Natural Resource Challenge (NPS 1999), significant funding became available for completing important natural resource baseline inventories in park units, including vegetation classification and mapping. This support provided the NPS with the opportunity to move forward with dozens of new park unit vegetation classification and mapping projects, including TICA. Vegetation classification and mapping products produced by this program are incorporated into the USGS National Biological Information Infrastructure Program, which serves as an information-sharing network (http://biology.usgs.gov/npsveg/).

Northern Colorado Plateau Network Inventory and Monitoring Program

The National Park Service developed an inventory and long-term monitoring program for park natural resources over the last two decades of the twentieth century. This effort was enhanced by

the NPS Natural Resource Challenge (NPS 1999); as a part of this initiative, the NCPN was formed in 2000 to develop an integrated inventory and monitoring program for 16 park units in Utah, Colorado, Arizona, and Wyoming.

A goal of the NPS I&M Program is to complete baseline inventories of biological and geophysical resources for each park unit. These inventories cover 12 basic data sets needed by NPS staff to guide resource management. Vegetation classification and mapping constitute one of these data sets. Early in the development of its I&M program, the NCPN made completing vegetation maps for each network park unit a priority. In addition to assisting park management, vegetation maps and classification information were seen as contributing significantly to NCPN long-term monitoring efforts. In 2001, the network began implementation of a strategy to complete vegetation mapping in 15 network park units. The TICA vegetation mapping project is the seventh of the network-coordinated projects to be completed.

Vegetation Mapping Program Standards

The NPS I&M Program established guidance and standards for all vegetation mapping projects in a series of documents:

Protocols

- National Vegetation Classification System (TNC and ESRI 1994a, Natureserve 2003a)
- Field methods and mapping procedures (TNC and ESRI 1994b)
- Statistically rigorous and consistent accuracy assessment procedures (ESRI and TNC 1994)
- Guidelines for using existing vegetation data (TNC 1996)

Standards

- National Vegetation Classification Standard (FGDC 1997)
- Content Standard for Digital Geospatial Metadata (FGDC 1998a)
- Spatial Data Transfer Standard (FGDC 1998b)
- United States National Map Accuracy Standards (USGS 1999)
- Integrated Taxonomic Information System
- Program-defined standards for map attribute accuracy and minimum mapping unit

These documents are available on the USGS-NPS Vegetation Program Web site (http://biology.usgs.gov/npsveg/standards.html).

National Vegetation Classification Standard

The National Vegetation Classification (NVC) is the system used in NCPN vegetation mapping projects (TNC and ESRI 1994a), and is based on the National Vegetation Classification Standard adopted by the Federal Geographic Data Committee (FGDC 1997). The NVC evolved from

work conducted primarily by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network over more than two decades (Grossman et al. 1998). The NVC is based in part on earlier vegetation classification produced by the United Nations Educational, Cultural, and Scientific Organization (UNESCO 1973, Driscoll et al. 1984). Use of a standardized classification system helps ensure data compatibility throughout the National Park Service and other agencies. The FGDC Vegetation Subcommittee works to keep this standard current and relevant. The substantial revisions to the upper levels of the NVC hierarchy accepted by the FGDC Vegetation Subcommittee (2008) are not used in this project.

Classification systems attempt to recognize and describe repeating assemblages of plants in similar habitats. The NVC is a hierarchical system that incorporates physiognomic characters and floristic data to define seven levels of terrestrial vegetation classification. The five upper levels (class, subclass, group, subgroup, and formation) are based on physiognomic features. The two lower levels (alliance and association) are distinguished by variability in floristic composition. The physiognomic units have a broad geographic perspective and the floristic units have utility in local and site-specific applications (Grossman et al. 1998). The physiognomic levels of the NVC are based on physical, structural, and environmental characteristics identifiable from satellite imagery, aerial photography, or ground observations (Table 1). Specific criteria defining these physiognomic units are based on ecologic characteristics that vary among major vegetation groups (FGDC 1997).

The alliance and association levels form the base of the NVC and are determined by the most abundant or diagnostic species comprising the strata of a homogenous vegetation community. An association is here defined as a plant community type with a consistent species composition, uniform physiognomy, and similar habitat conditions (Flahault and Schroter 1910). Species composition differentiates associations (TNC and ERSI 1994a). An alliance is "a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species which, as a rule, are found in the uppermost strata of the vegetation." (Reid and Comer 1998). NatureServe coordinates plant association data for the NCPN vegetation mapping projects. Associations are added to the NVC and older concepts are refined as new data become available.

Table 1. National Vegetation Classification System hierarchy for terrestrial vegetation.

Level	Criteria Delineating Level	Example
Class	Structure (height, cover) of dominant vegetation strata	Forest
Subclass	Growth form characters including leaf type (evergreen, deciduous) for woody plants and persistence (perennial, annual) for herbaceous species	Evergreen forest
Group	Leaf morphology (broad leaf, microphyllous, xeromorphic), leaf phenology, and climatic conditions	Temperate or subpolar needle-leaved evergreen forest
Subgroup	Relative degree of human disturbance	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest

Level	Criteria Delineating Level	Example
Formation	Additional physiognomic characteristics, general environmental conditions, relative landscape position, and hydrologic regimes	Rounded-crowned temperate or subpolar needle-leaved evergreen forest
Alliance	Dominant or diagnostic species of uppermost or dominant stratum	*Abies concolor* Forest Alliance
Association	Other dominant or diagnostic species from any stratum	*Abies concolor / Quercus gambelii* Forest

Other Standards

In addition to vegetation classification, the FGDC sets standards for map spatial accuracy and for metadata employed in NPS vegetation mapping projects. Standards for map products stipulate map scales of 1:24,000 or finer, and minimum polygon size of 0.5 ha (1.24 acres). Positional accuracy for vegetation maps must meet National Map Accuracy Standards, which specify horizontal errors of less than 10.2 m (33.5 ft.) on the ground for 1:12,000-scale maps.

All digital vegetation products resulting from this project are accompanied by FGDC-compliant metadata. Metadata are “data about the data,” and describe the content, quality, condition, and other characteristics of the spatial dataset. Metadata are critical elements that expedite the interpretation and exchange of information among users.

Project Area Description

Location and Setting

The 100-hectare (248-acre) Timpanogos Cave National Monument (TICA) was established in 1922 by proclamation of President Warren G. Harding (NPS 2008). The word "Timpanogos" is derived from the name of the Timpanogots Ute tribe that lived in and hunted the American Fork Canyon area beginning approximately 600 years ago (NPS 2008). The name translates as "rock" (tumpi), and "water mouth" or "canyon" (panogots).

The Monument was created to preserve an unusually diverse, fault-controlled limestone cave system and protect it from mining and casual damage. The Timpanogos cave system represents a man-made joining of three natural caves (Hansen, Middle, and Timpanogos). The caves feature at least 42 types of formations, some of which are known only from TICA and others of which exhibit dramatic and rare colors. Delicate helictites and anthodites occur in quantities and combinations not observed in other NPS-managed cave systems. The Monument provides unique educational opportunities for visitors, students, and professionals; annual visitation ranges from approximately 70,000 to 100,000. Recreational opportunities include viewing scenery, hiking, picnicking, and viewing the cave system and decorations.

TICA is located in Utah County in northeastern Utah, in the American Fork Canyon on the western slope of the Wasatch Mountain Range (Figure 1). The nearest towns include American Fork (11 km / 7 miles to the southwest), Lehi (16 km / 10 miles to the west), and Pleasant Grove (14 km / 9 miles to the south). The nearest cities are Orem (19 km / 12 miles to the south), Provo (30 km / 19 miles to the south), and Salt Lake City (48 km / 30 miles to the north). Because of its proximity to a major urban area, Utah County has a moderate population density of 71 people per km2 (184 people per square mile), most of whom live on the valley floor below the mouth of the American Fork canyon. Provo is the county seat and has a population of 115,135, nearly one-third the population of Utah County. TICA is located on State Highway 92 and is bordered by public lands of the Uinta-Wasatch-Cache National Forest (Figure 2). The north side of the American Fork canyon is within the Lone Peak Wilderness Areas administered by USFS; this wilderness adjoins the northern boundary of the Monument.

Figure 1. Location of TICA in northeastern Utah between Provo and Salt Lake City.

Topography

TICA occupies a canyon descending the western slope of the Wasatch Mountains within the Overthrust Mountains Section of the Middle Rocky Mountain physiographic province (Figure 3; McNab and Avers 1994). This section covers parts of western Wyoming, southeastern Idaho, and north-central Utah. The Wasatch Mountains are a large, north-south trending fault block whose western margin rises sharply from the Bonneville Plain containing the Great Salt Lake and marked by the seismically active Wasatch Fault. Landscapes within the Monument are determined by the canyon of the American Fork River. Although stream flows and cutting power were enhanced during Pleistocene glaciation of the Wasatch Range, the part of the canyon that includes TICA was never directly affected by glaciers. TICA encompasses rugged topography at an average elevation of approximately 2,042 m (6,700 ft). Elevations within the Monument range from 1,670 m (5,477 ft) to 2,450 m (8,045 ft).

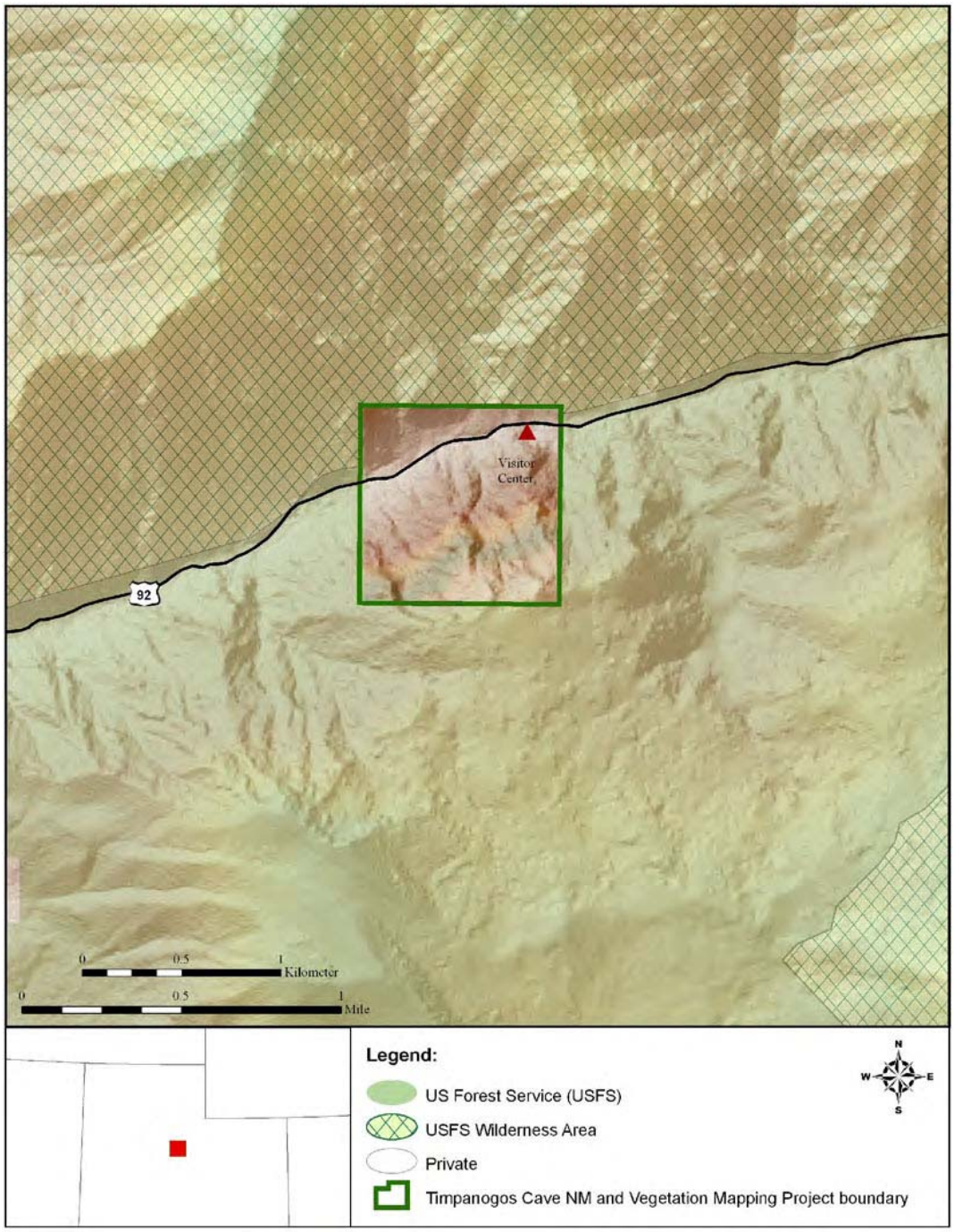


Figure 2. Map of the TICA vegetation mapping project area, showing adjacent land ownership.

Climate

Records of climatic conditions have been maintained continuously at TICA since 1948 (WRCC 2008). TICA is characterized by a montane climate, averaging 24.3 inches (61.7 cm) of precipitation annually (Figure 4). Precipitation is slightly weighted toward the late winter and spring months, and more than half of the Monument's precipitation falls as snow. Total annual

snowfall averages approximately 40 inches (101.6 cm) with January and February being the snowiest months (WRCC 2008). Between May and September, afternoon thundershowers provide moisture for growing vegetation.

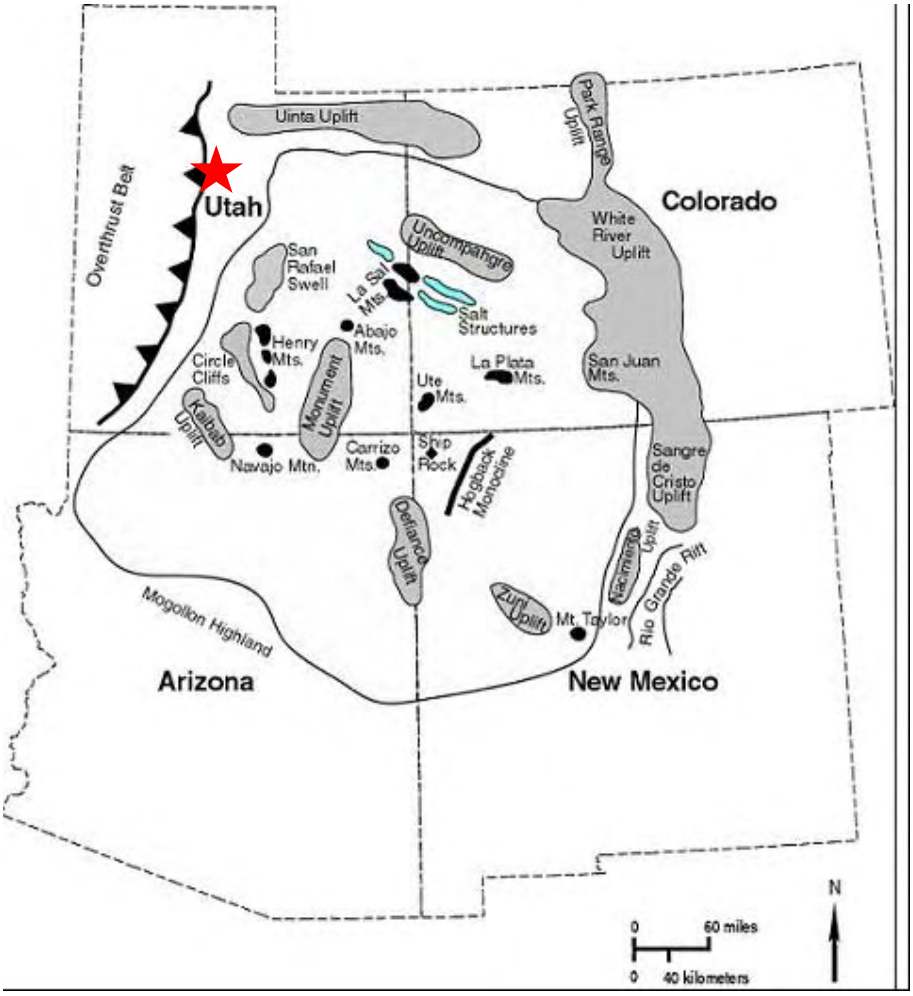


Figure 3. Location of Timpanogos Cave National Monument relative to major Colorado Plateau physiographic features. Light gray signifies the extent of the Colorado Plateau. Gray and black areas represent uplifts and mountains.

Conditions within the Monument change significantly between seasons. Summers are moderately long with hot days averaging 90.2 °F (32.3 °C) and warm nights averaging 57.5 °F (14.2 °C) in July. The hottest days approach or exceed 100 °F (38 °C). Winters are relatively mild to cold with an average maximum temperature of 34.2 °F (1.2 °C) and an average minimum temperature of 20.0 °F (-6.7 °C) occurring in January. The residence time of snow and ice is longer on the cold, north-facing slope that includes TICA; in the winter the trail ascending the canyon wall is closed because of ice and avalanche hazards.

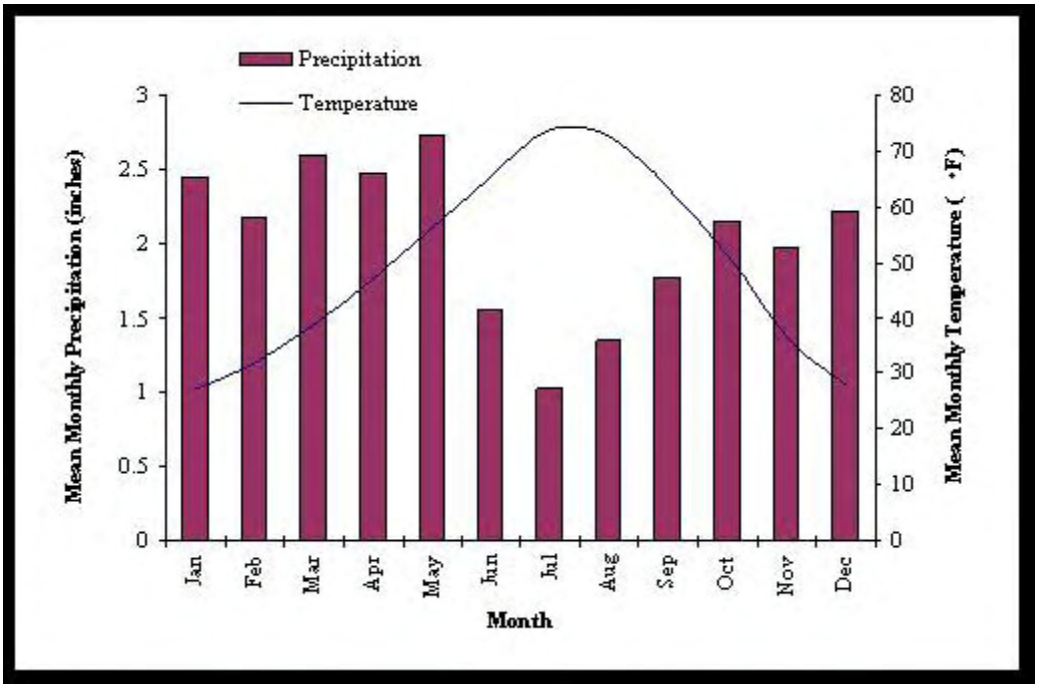


Figure 4. Climate data for TICA (Western Regional Climate Center 2007).

Geology and Vegetation

TICA is located on the steep walls of the American Fork Canyon at the foot of Mount Timpanogos, the second highest mountain in the Wasatch Range at 3,582 m (11,749 ft). The sedimentary rocks exposed in the American Fork Canyon at TICA were deposited in ocean basins beginning around 600 million years ago and ending around 330 MYA (Figure 5). They were deformed and displaced by several episodes of mountain building and crustal movement, including the Late Cretaceous Sevier and Laramide orogenies. They were exposed because of uplift along the Wasatch Fault beginning about 17 million years ago combined with down-cutting of the American Fork River (Mayo et al. 2003). Although the rocks generally appear to form level layers, they are actually tilted between 30 and 45 degrees.

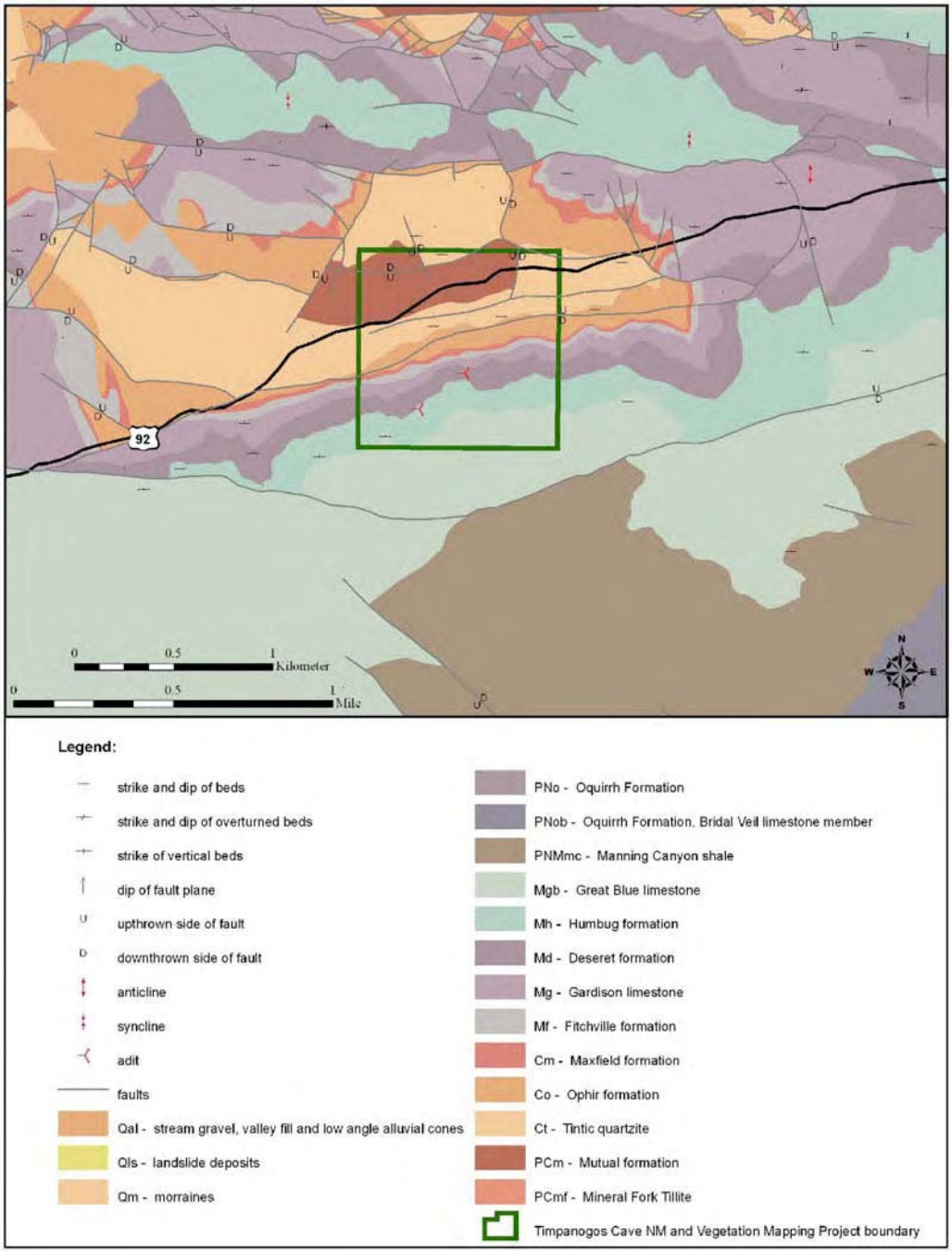


Figure 5. Bedrock geology map of TICA.

TICA lies in the Wasatch Montane Zone within the Wasatch and Uinta Mountains ecoregion (Woods et al. 2001). The vegetation is broadly characterized as montane. Forest, woodland, and tall shrubland communities dominate the landscape. The distribution of vegetation is driven by elevation, aspect, substrate (geology and soils), and disturbance history, including avalanche and rock fall. The remainder of this section is a summary of the general distribution of vegetation in relation to geology within the TICA mapping area, organized from oldest to youngest rocks as described in Mayo et al. (2003).

Mutual Formation (Precambrian). These quartzite and conglomerate strata underlie most of TICA north of the river. The sediments were deposited in a shallow marine environment approximately 620 to 543 million years ago. Although outcrops are visible, most of this formation is covered by talus from outcrops of other formations higher on the canyon walls. The most common community type is a tall shrubland of Gambel oak (*Quercus gambelii*), bigtooth maple (*Acer grandidentatum*), Rocky Mountain maple (*Acer glabrum*), chokecherry (*Prunus virginiana*), and Saskatoon serviceberry (*Amelanchier alnifolia*; Figure 6 foreground).

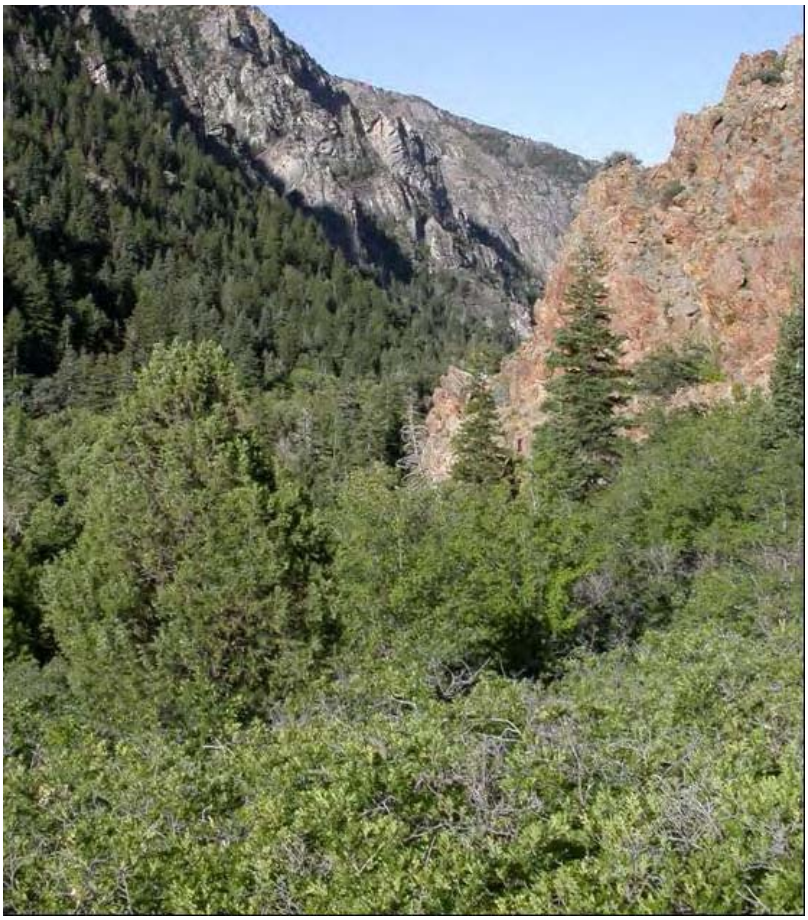


Figure 6. Characteristic oak shrub and open woodland communities of the Precambrian Mutual Formation; the reddish outcrop on the right of the photograph is Mutual Formation conglomerate.

Tintic Quartzite (Cambrian). This formation forms the lower slopes of the canyon south of the river. The nearly pure quartzite was deposited in a shallow marine environment beginning approximately 543 million years ago. Depending on the slope angle and the degree of soil development, this formation supports mixed conifer woodlands with canopies ranging from open to dense. One prominent Tintic bluff standing above the visitor center supports sparse vegetation of Rocky Mountain juniper (*Juniperus scopulorum*), Gambel oak, and native bunchgrasses. (Figure 7).

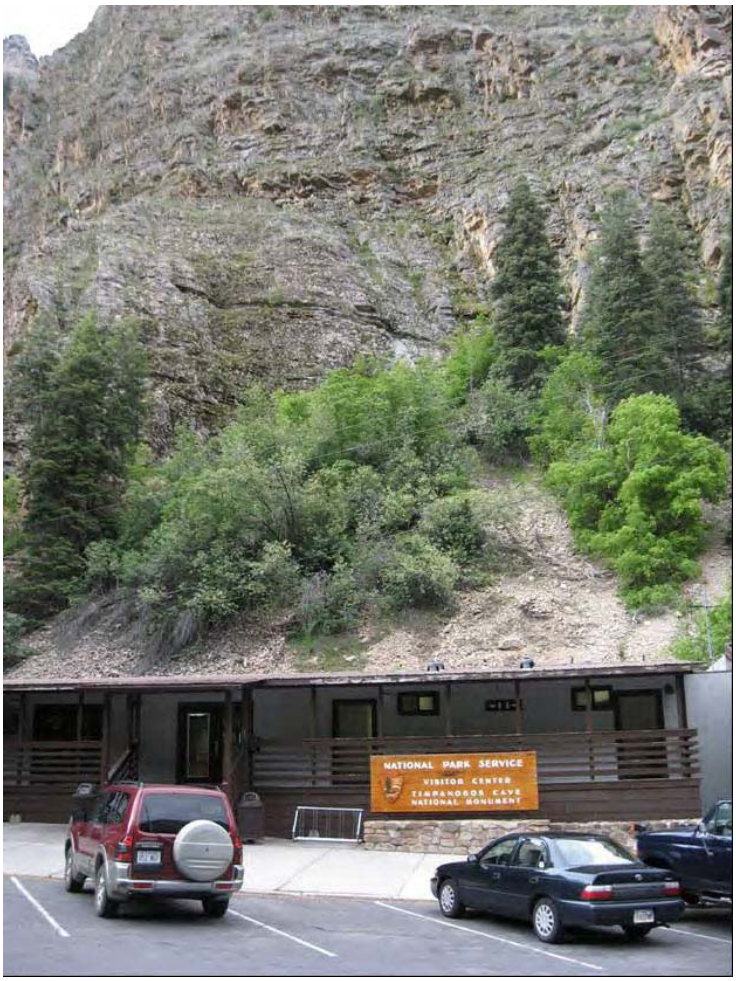


Figure 7. This bluff of Tintic quartzite rising behind the visitor center supports a native bunchgrass community unique within TICA.

Ophir Formation and Maxfield Limestone (Cambrian). These formations consist of 550-million year old marine sandstone, limestone, and shale rocks that are generally obscured by debris fallen from cliffs higher on the slope. The primary vegetation type supported by the Ophir Formation is closed-canopy white fir – Douglas-fir (*Abies concolor – Pseudotsuga menziesii*) forest with a rich understory dominated by bigtooth maple and Gambel oak (Figure 8).

Fitchville Formation and Gardison Limestone (Mississippian). The dolomitic sandstone, dolomite and dolomitic limestone rocks of these formations were deposited in a shallow marine environment beginning approximately 517 million years ago. They are more resistant to erosion than the underlying Cambrian rocks and therefore tend to form steeper slopes with thinner soils and more outcrops. The vegetation is similar to that described above, except that the forest canopy tends to be more open.

Deseret Limestone (Mississippian). This 340 million-year-old limestone contains the caves for which TICA was established as a national monument. It forms the lower band of cliffs that

dominate the upper third of the canyon wall. Common communities include open mixed conifer woodlands and rock outcrops with sparse cover by Rocky Mountain juniper, littleleaf mountain mahogany (*Cercocarpus intricatus*), and Gambel oak.

Figure 8. Characteristic vegetation of Ophir, Maxfield, and Fitchville geologic strata.

Humbug Formation (Mississippian). This formation consists of alternating dolomite and limey sandstone beds deposited about 320 million years ago in a shallow marine environment. They are more than 240 m (800 ft) thick and comprise the cliffs above the level of the caves to the canyon rim. Limber pine (*Pinus flexilis*) is a prominent member of the plant community, and Douglas-fir tends to replace white fir as the principal conifer. The understory is unknown because stands are inaccessible, but Gambel oak and bigtooth maple are visible.

Great Blue Limestone (Mississippian). This formation underlies the rolling bench known as Sagebrush Flat above the canyon rim. It consists of limestone and thin shale beds The bench is generally soil-covered and supports woodlands of quaking aspen (*Populus tremuloides*) and conifers. Thinner soils closer to the canyon rim support shrublands of Gambel oak and mountain snowberry (*Symphoricarpos oreophilus*; Figure 9). The very edge of the canyon is exposed limestone supporting a sparse herbaceous community of grassy rock goldenrod (*Petradoria pumila*) and bluebunch wheatgrass (*Pseudoroegneria spicata*).

Figure 9. Characteristic vegetation of Great Blue Limestone on Sagebrush Flat.

Surficial Deposits (Pleistocene and Holocene). Vegetated surficial deposits at TICA include alluvium, colluvium, avalanche /debris flow deposits, and landslides. Stable surficial deposits tend to support woodland or forest vegetation; less-stable or active deposits tend to support shrublands, dominated by clonal species such as Gambel oak.

Colluvial deposits cover virtually every surface within TICA except the canyon floor and bedrock outcrops. On older, relatively stable sites, the colluvial material may be covered by soil, duff and litter. On more recent or less stable deposits, rocks cover the surface. Stable slopes support forests and woodlands characterized by Douglas-fir and white fir; with a mixed, usually shrub-dominated, understory of bigtooth maple, Rocky Mountain maple, Gambel oak, mallow ninebark (*Physocarpus malvaceus*), mountain snowberry, mountain lover (*Paxistima myrsinites*), common juniper (*Juniperus communis*), and Oregon-grape (*Mahonia repens*). Common herbaceous species may include bluebunch wheatgrass, muttongrass (*Poa fendleriana*), spike fescue (*Leucopoa kingii*), American vetch (*Vicia americana*), and starry false Solomon's-seal (*Maianthemum stellatum*; Figure 10). Rocky sites tend to have few or no trees and instead are dominated by disturbance-adapted shrubs such as Gambel oak, bigtooth maple, and chokecherry.

Figure 10. Typical active colluvial slope within TICA

Avalanche chutes occur in many places across the steep, north-facing slopes of the American Fork River canyon. These chutes are typically narrow, relatively wet, and are lined with large rocks. They provide habitat for disturbance-adapted woodlands and shrublands of boxelder; bigtooth maple, Rocky Mountain maple, red-osier dogwood (*Cornus sericea*), chokecherry, and blue elderberry (*Sambucus caerulea*) shrubs.

A large debris-flow fan occurs at the mouth of Swinging Bridge Creek where it joins the American Fork River. As one of the few places on the south-facing canyon wall where soil-sized particles collect, the fan supports the only significant stand of coniferous trees north of the river. The forest is a relatively young stand of white fir and Douglas-fir with a shrub-dominated understory that includes Gambel oak, bigtooth maple, Saskatoon serviceberry, and creeping Oregon-grape.

The banks of the American Fork River have been heavily modified to protect the highway and other developments in the valley bottom (Figure 11). The narrow, undeveloped corridor that exists between the river and the highway supports a diverse montane riparian forest characterized by narrowleaf cottonwood (*Populus angustifolia*), boxelder (*Acer negund*o), white fir, and Douglas-fir with an understory of water birch (*Betula occidentalis*), chokecherry, red-osier dogwood, orchard grass (*Dactylis glomerata*), and smooth brome (*Bromus inermis*).

Figure 11. The banks of the American Fork River are heavily modified throughout TICA.

Soils

Soils are poorly developed over most of TICA due to extreme slopes and instability of the substrate, whether from mass wasting (canyon walls) or from cycles of flooding and erosion (American Fork River). The deepest and most developed soils occur on toeslopes near the Visitor Center. Layers of litter and duff accumulate under dense stands of coniferous trees in these areas.

Nearly all of TICA is mapped as Rock Land (SCS 1972), a steep to nearly perpendicular cliff and ledge soil unit. Up to 90% of an area of Rock Land soil consists of rock outcrops, rock slides, or areas that have only a few centimeters of soil formed over rocks. Within the Rock Land unit there may be small inclusions of Rake extremely stony loam (a shallow colluvial soil), and Picayune cobbly silt loam (a deep colluvial soil). The canyon bottom includes a narrow strip of Pleasant Grove stony loam (an alluvial soil).

Hydrology and Water Resources

The principal drainage of TICA is the American Fork River, with headwaters in the Wasatch Range above the Monument. The river forms a portion of the Utah Lake Watershed within theJordan River Basin (USGS 2008). Daily discharge of the American Fork River ranges from a low of approximately 10 cubic feet per second (cfs) to a high of approximately 300 cfs (USGS 2008). The American Fork River supports riparian vegetation as well as provides the focus for much of the non-cave-related recreation opportunities within TICA.

Until recently, a hydroelectric project managed by PacifiCorp had the right to divert flows from the American Fork River above TICA into a pipeline routed through the Monument, although theoperator of the project was required to maintain a minimum instream flow of four cfs (NPS 2002). This pipeline had the capacity to dewater the American Fork River in TICA for seven months during an average year and was exposed in some areas, creating erosion and safety concerns. During the years of operation, the pipeline broke several times, washing rocks, soil, and debris into the river. PacifiCorp, resource agencies, and others signed a settlement agreement in 2003 to decommission this hydroelectric project and restore natural flow regimes in the river. This agreement was filed with FERC and the pipeline was removed by helicopter in 2006. The even older Lower American Fork plant was decommissioned before 1970.

Groundwater is an important resource within TICA; the ongoing formation of cave features depends on a steady supply of mineral-enriched groundwater. Groundwater inflows occur as both conduit flow along fault surfaces and diffuse flow along bedding surfaces (Mayo et al. 2003). The rate of inflow is greatest in Hansen Cave, near the cliff face. Both Hansen and Middle caves exhibit considerable conduit flow along fault surfaces, responding rapidly to major precipitation and snowmelt events. Groundwater flow in Timpanogos Cave is largely bedding plane flow, with maximum drip rates occurring two to six months later than in Hansen Cave (Mayo et al. 2003).

Water quality (contaminant testing) and quantity (drip rates) are monitered within the cave system by Monument staff. The Utah Division of Water Quality monitors the American Fork River in cooperation with the Uinta National Forest.

Land Use and Settlement History

Humans have inhabited the region surrounding TICA for at least 10,000 years (Lewis 1994). Peoples associated with the Fremont culture used the area between approximately 1,600 and 1,000 years ago. Beginning about 1200 AD, hunter-gatherer ancestors of the Shoshone and Ute tribes arrived in the vicinity of TICA. Bands of Utes and Shoshone still occupied the area when the Dominguez-Escalante Expedition passed through the area in 1776. Trappers of European descent gathered furs in the canyons beginning in the 1810s. Mormon settlement of the eastern shore of the Great Salt Lake began in 1847 and displacement of aboriginal peoples occurred rapidly thereafter as farming and cattle ranching became the primary land use (Lewis 1994). Today, most of Utah’s population lives within a two-hour drive of TICA in cities along the Wasatch Front.

TICA's Hansen Cave is named for Martin Hansen, who located the cave entrance in 1887 while tracking a mountain lion on the steep slopes of the American Fork Canyon. During the 1890s, Hansen Cave was stripped of its unique onyx and other mineral deposits for commercial use. Following the discovery of Timpanogos Cave in 1915 and Middle Cave in 1921, local groups worked with USDA Forest Service (USFS) to designate the area around the caves as a national monument in order to protected the system from mining and commercial exploitation. The cave system was managed by a group of local businessmen, the Timpanogos Outdoor Committee, under an agreement with the USFS from 1922 through 1934. In 1934, the management of all national monuments, including TICA, was transferred to the NPS (Roper 1994).

Human activities on the TICA landscape over the past century have caused changes in the distribution and abundance of native vegetation. Post-settlement fire suppression has probably increased the density of white fir and Rocky Mountain juniper trees on the south canyon wall and decreased the abundance of native shrubs and grasses. Many of the coniferous trees emerging from the Gambel oak shrublands of the north canyon wall appear to be less than 100 years old. Because of the number of historic structures and the difficulty of access over most of the Monument, the current fire management plan (NPS 2004) states that wildfires will continue to be suppressed and prescribed fire will not be used as a fuels management tool. Mechanical fuels reduction techniques will be used to reduce the risk of wildfire.

Settlers arriving in the area beginning in 1847 brought the first non-native plants to the area. Subsequent development of the cave for mining and exploration and the American Fork Canyon for transportation and irrigation introduced more exotic species. As of 2008, 63 of the 235 plant taxa (26.8%) known to occur within TICA are non-native (Fertig and Atwood 2009).

Previous Vegetation Studies

TICA supports mesic and dry forest, woodland, shrubland, and herbaceous vegetation within a montane canyon and cliff setting. The sedimentary geology and occasionally complex interaction of rock outcrops, colluvium, soils, hydrology, and disturbance history results in a greater diversity of plant communities and species than might be expected for an area of this size. The documented vascular flora of TICA includes 235 taxa; an additional 285 plant taxa are considered likely to occur within the Monument (Fertig and Atwood 2009).

Only occasional specimens were collected in the American Fork Canyon in the vicinity of TICA between 1869 and 1935 (Fertig and Atwood 2009). Beginning in 1963, NPS staff and others began collecting specimens for the Monument. The most significant collections were by Allred (1975) and Atwood (2001). These two studies brought the total number of species known from TICA to more than 200. The final tally of 235 taxa results from minor collections since 2001 and an herbarium review by Fertig and Atwood (2009).

Most of the recent vegetation work at TICA has focused on the inventory and management of non-native species. Most non-native species were imported accidentally to TICA by livestock, wildlife, maintenance and construction activities, and visitors. Other species such as burdock (*Arctium minus*) and chicory (*Cichorium intybus*) may have been intentionally introduced for food. Other non-native species such as smooth brome, orchard grass, crested wheatgrass

(*Agropyron cristatum*), and yellow sweetclover (*Melilotus officinalis*) were commonly used for revegetation or soil stabilization. Dalmatian toadflax (*Linaria dalmatica*), perennial pepperweed (*Lepidium latifolium*), and spotted knapweed (*Centaurea maculosa*) represent the greatest threat to the ecological integrity of TICA communities because of their ability to spread into undisturbed habitats and their tendency to exclude native herbaceous species once established (Jasper and Gosse 2003). These three invasive species have been a focus of eradication and restoration efforts by Monument staff since 2001.

In 2002, TICA staff initiated a native plant propagation program to revegetate disturbed areas where invasive plant species typically become established. Employees of the USFS Shrub Science Laboratory have volunteered resources for growing native plants for large-scale revegetation projects on TICA. The Monument also recently acquired a small greenhouse for small-scale native plant propagation.

Project Overview

Partner Roles and Timeline

The goals of this project were to inventory, describe, and map the existing vegetation of Timpanogos Cave National Monument. The project at TICA is part of a larger effort undertaken by the NCPN to classify and map vegetation in all network parks. As part of the network-wide coordinated effort, the NCPN developed standardized databases, mapping and reporting standards, and naming conventions to ensure that data across parks can be collated or compared.

No formal scoping or preparation was conducted for this vegetation classification and mapping project. TICA was contacted in early 2007 and a permit secured to facilitate field work (vegetation sampling and mapping) that was completed in August 2007.

NCPN ecologists created the draft digital vegetation map and completed the preliminary vegetation classification in October 2007. NatureServe submitted a final vegetation classification in February 2008. e2M ecologists prepared local plant association descriptions, while global plant association descriptions were completed by NatureServe ecologists. An illustrated field key to TICA plant associations was developed in 2008 by NCPN.

NCPN staff created a draft map and associated spatial database from the 2007 field data. Map classes were defined for the project such that most map classes represent one NVC association or association subtype. Polygon attribution follows standards developed by NCPN for all network vegetation mapping projects (Evenden 2004). Final revisions were made to the vegetation classification, map, and spatial database in late 2008 and early 2009.

Table 2. Project timeline for TICA vegetation mapping project tasks 2007 – 2009.

TASK DESCRIPTION	2007	2008	2009
Planning			
Field Data Collection			
Photo Interpretation			
Vegetation Classification			
Local & Global Descriptions			
Spatial Database			
Field Key to Plant Associations			
Final Report and Products			

Aerial Photography

NCPN decided to use existing imagery rather than fly new stereo and orthophotography for the TICA vegetation mapping project. NCPN staff and partners worked with 2006 true-color orthophotographs available through the State of Utah to delineate polygons (Figure 12). The acquired photography had relatively low contrast and 1m resolution (i.e., objects smaller than 1m

in diameter, including many shrubs, are usually indistinguishable); however, major vegetation boundaries were generally easy to identify.

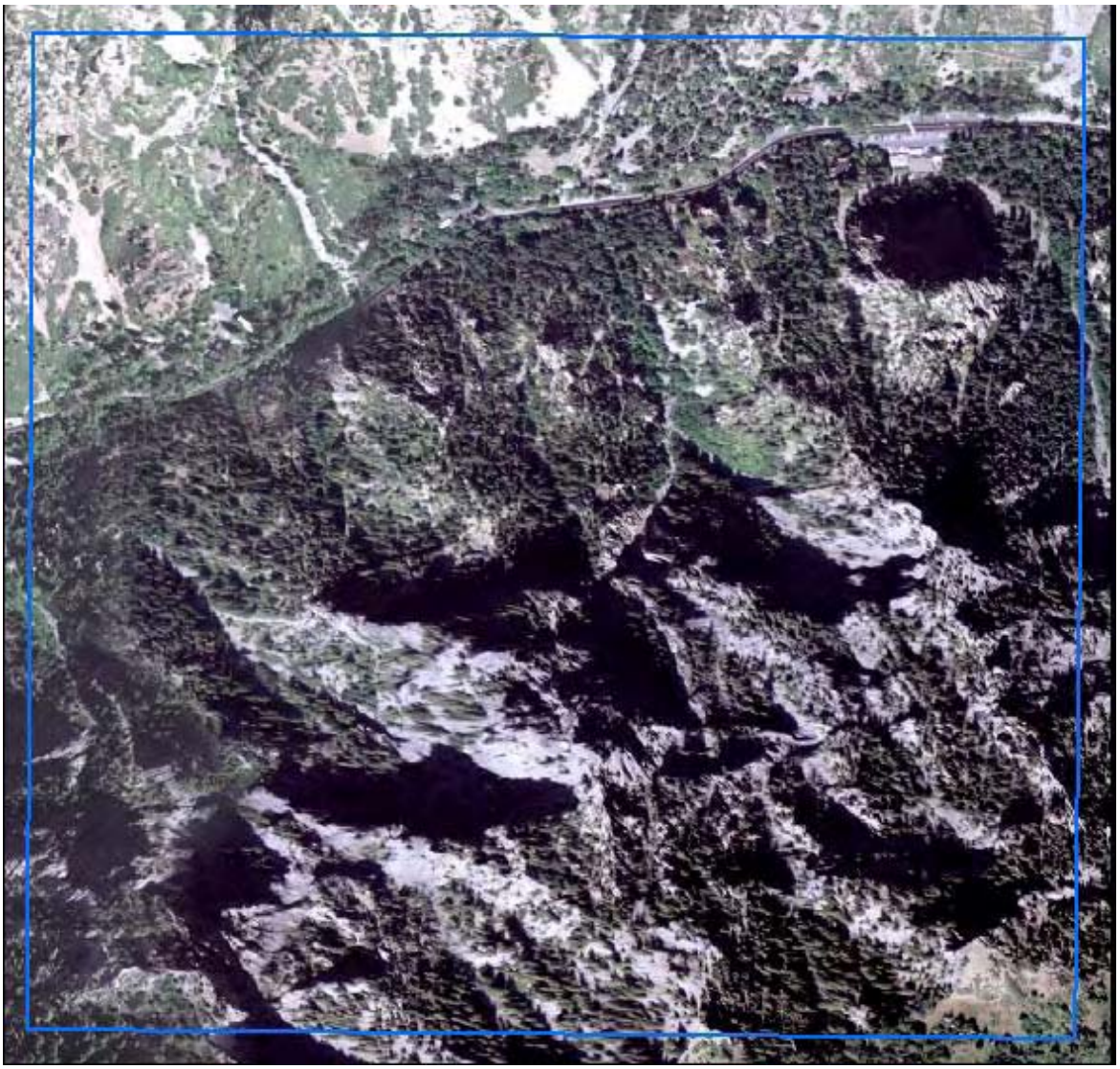


Figure 12. The color orthophotography used as the base image for the TICA vegetation classification and mapping project. The figure is the approximate area mapped; the blue line represents the TICA boundary.

Project Boundary and Map Extent

The project boundary extends only to the Monument boundary. The reason for this is that TICA is located on an extremely steep canyon wall and we did not wish to increase the field crew's exposure to falls or falling rocks by having them sample an environs in addition to the Monument. Surrounding lands are managed by the USDA Forest Service and are indistinguishable from NPS lands. The mapping area is 100 ha (248 acres).
Monument staff requested that NCPN field crews note locations of the invasive weeds Dalmatian toadflax, orchard grass, and field bindweed (Convolvulus arvensis). The UTM coordinates of

Park Features of Special Interest

Monument staff requested that NCPN field crews note locations of the invasive weeds Dalmatian toadflax, orchard grass, and field bindweed (*Convolvulus arvensis*). The UTM coordinates of occurrences of these species were recorded and reported directly to Monument staff. They are not included in the final vegetation map or in this report.

Minimum Mapping Unit

The standard 0.5 ha (1.24 acre) minimum mapping unit (MMU) was discarded in favor of a MMU of 0.2 ha (0.5 acres). Because TICA is a small park, using the program standard MMU would have resulted in a loss of detail and reduced the utility of the vegetation map. With the imagery available to NCPN, it was possible to identify distinct features as small as 0.2 ha.

Ecological System Classification

The NCPN used the ecological system classification structure developed by NatureServe (Comer et al. 2003, NatureServe 2003b) as a framework for organizing and presenting plant community data. An ecological system (ES) is defined as a group of plant associations from two or more alliances that tend to co-exist in a given landscape due to similar ecologic processes, substrates, and/or environmental gradients. The ES classification was developed to provide larger scale classification units for application to resource management, mapping, and conservation. Current estimates are that Utah contains more than 60 ecological systems (NatureServe Explorer 2008). This approach complements the NVC where the finer-scale association units provide a basis for interpreting larger-scale ES patterns and concepts. A description of each ecological system occurring within TICA appears in Appendix A. \

The ecological system classification addresses natural landscapes. Land-use categories used to organize developed areas are described elsewhere in this report. Nine ecological system units were used for the TICA vegetation mapping project (in alphabetical order with their NatureServe identifying codes):

- Inter-Mountain Basins Cliff and Canyon (CES304.779)
- Inter-Mountain Basins Sagebrush Shrub-Steppe (CES304.785)
- Rocky Mountain Aspen Forest and Woodland (CES306.813)
- Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)
- Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)
- Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (CES306.819)
- Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)
- Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)
- Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)

Vegetation Classification and Description

Pre-Field Methods

Preliminary Classification List

A preliminary list of vegetation associations and alliances for TICA was compiled prior to vegetation sampling in 2007. Previous vegetation classification work, floristic information for TICA, and USFS cover type publications for the Uinta Mountains were used to refine the list. This list was used to plan field work and assign provisional association names to vegetation plots and observation points.

Field Methods

The primary purpose of classification plot data was to derive quantitative information documenting the composition and structure of TICA vegetation types and their associated environmental conditions. These data became the basis for classifying the vegetation of the Monument. Field methods followed national program standards (e.g., TNC and ESRI 1994a, 1994b) for vegetation classification sampling and mapping. The method we used to sample classification plots (also known as relevé sampling) is widely used by ecologists. The plot dataset was enhanced by collecting observation point data, whose primary purpose was to support aerial photo interpretation. Data gathered during this project can contribute to understanding vegetation relationships across landscapes beyond the Monument boundary.

In addition to the basic vegetation data collected at each plot, the NCPN defined additional data fields to meet needs of network managers. Plot forms and individual data field descriptions appear in Appendix B. This section is a summary of the vegetation data collection methods used at TICA.

Field Sampling Approach

The sampling area included the entire Monument (Figure 12). Although the project area is relatively small, much of it, including the slopes above the level of the caves, was inaccessible. We visited as much of the Monument as we could on foot, mapping and sampling simultaneously, and inspected the remainder of the Monument from the opposite side of the canyon or from the canyon rim with binoculars. The sampling was completed in June 2007 by NCPN vegetation mapping program staff. Thirteen vegetation plots and ten observation points were sampled and field notes recorded during the 2007 field visit (Figure 13).

Plot Data Collection

Field crews placed classification plots subjectively within stands in order to represent accurately the association being sampled. Ecotones (areas where two or more plant communities mix) were avoided. Excessively dangerous slopes and cliffs were avoided. Plots were generally located in stands exceeding the project minimum mapping unit (MMU) of 0.2 hectares. Plot size and shape requirements were generally consistent with National Vegetation Mapping Program guidelines (TNC and ESRI 1994a). Plot size was determined by the physiognomy of the community being sampled (Table 3) and by the size of the stand that could safely be navigated. Plot shape was

adjusted as needed to sample linear stands of vegetation. Plot size and shape were recorded for all TICA plots.

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

Vegetation Class	Area (m^2)	Circular Plot Radius (m)	Other Shapes Used (m)
Forest, Woodland	400	22.6	40 x 10, 20 x 20
Shrublands	100	11.3	10 x 10

TICA staff requested that the vegetation plot locations not be permanently marked. Locations were recorded on the orthoimagery field map during field data collection to ensure that the Monument was adequately sampled.

Within each plot and observation point, researchers estimated and recorded an array of vegetation and environmental data using the field forms in Appendix B and data definitions in Appendix C. Three categories of data were collected for vegetation plots (Table 4):

- location and plot identifiers
- environmental description
- vegetation description

Table 4. General plot data categories and specific data components collected at each vegetation classification plot.

Plot Data Category	Data Components
Location and Plot Identifiers	Plot code, park name, site name, state, county, quad name, quad code, GPS receiver type, GPS file ID, UTM coordinates, UTM zone, GPS error, 3D differential, survey date, surveyor names, directions to plot, plot dimensions, photograph documentation
Environmental Description	Elevation, slope, aspect, topographic position, landform, geology, Cowardin wetland type, hydrologic regime, ground cover, soil texture, soil drainage, evidence of disturbance and animal use
Vegetation Description	Height and cover of all strata, cover by species, physiognomic type, provisional association name, plot representativeness

Location and Plot Identifiers. The bounds of each plot were marked using measuring tapes. The Universal Transverse Mercator (UTM) XY coordinates at the center of each plot were recorded using Garmin recreational-grade GPS receivers. Other data fields documenting the location of each plot are listed in Table 4 and are described in detail in Appendix C.

Environmental Description. The physical characteristics of each plot were documented in both categorical and narrative fields (Table 4; Appendix B, Appendix C). These included topographic site features (elevation, slope, aspect, topography), hydrology, geology, and soils. The ground surface was divided into categories of rocks, sand, litter, bare soil, biological soil crust, moss,

and lichen, and the cover of each category estimated. A narrative field provided for a general description of the plot setting and the influence of physical factors on the vegetation.

Vegetation Description. Every vascular plant species in each plot was assigned to one of 14 physiognomic strata (Appendix B). Within each stratum, the investigator recorded average height and percent canopy cover for all species using the scales in Table 5. Consistent and repeatable cover estimates were obtained by relating the area occupied by an individual species to the area of the entire plot. When it was not possible to identify a species in the field, plant material was collected and pressed for later identification. All plant material collected for identification was destroyed in analysis. Provisional plant association names were assigned to each plot using the preliminary association list and professional judgment.

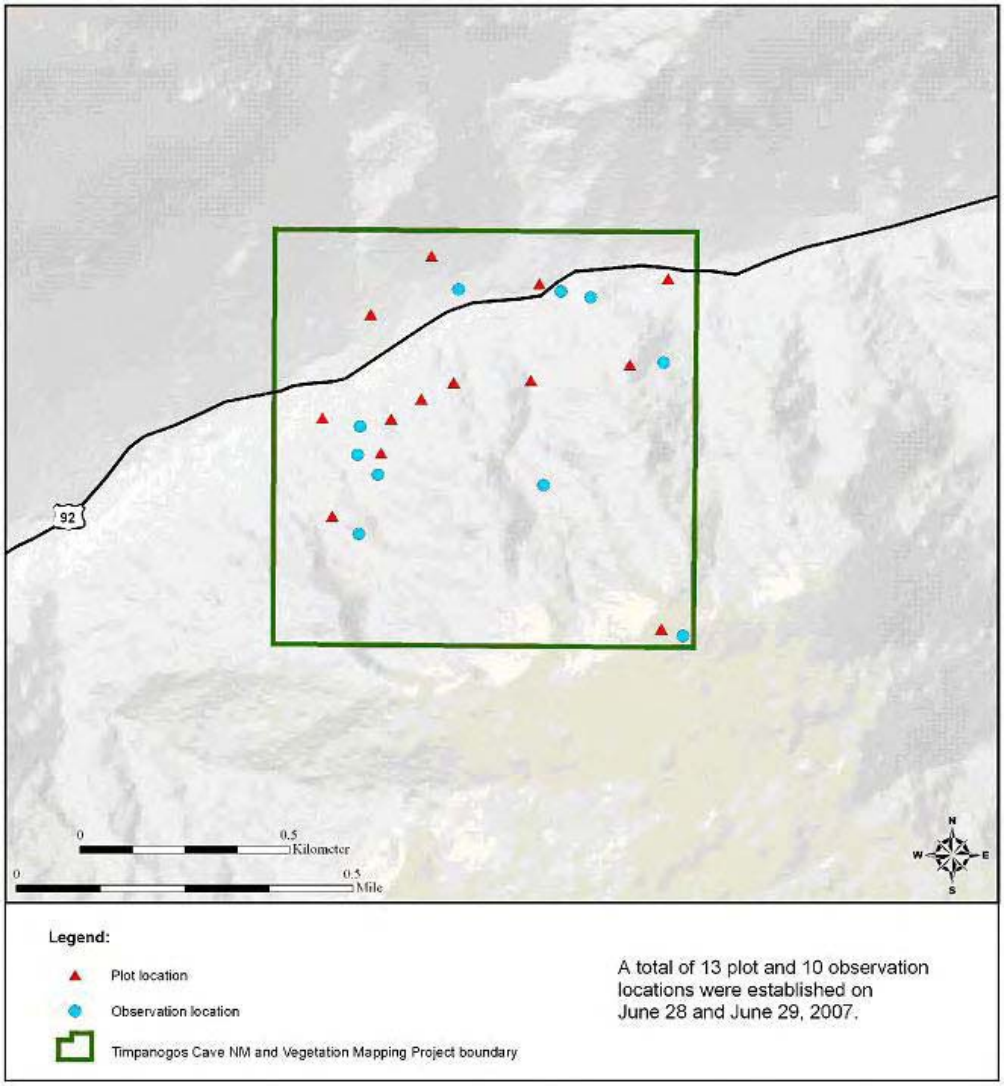


Figure 13. Locations of sample plots (vegetation plots and observation points) in the TICA vegetation classification and mapping project area.

Descriptive Information. Field crews recorded observations describing how well the plot represented the stand, the relationship of site conditions to vegetative patterns, and site disturbance history. The overall character of the vegetation and features of each plot were documented by two or more 35 mm color slide photographs.

Table 5. Vegetation cover and height classes used in the TICA vegetation mapping project.

Species and Strata Canopy Cover Classes				Strata Height Classes			
Code	***Range***	***Code***	***Range***	***Code***	***Range***	***Code***	***Range***
T	0-1%	5	> 45-55%	01	<0.5 m	06	>10-15 m
P	>1-5%	6	>55-65%	02	0.5-1 m	07	>15-20 m
1	>5-15%	7	>65-75%	03	>1-2 m	08	>20-35 m
2	>15-25%	8	>75-85%	04	>2-5 m	09	>35-50 m
3	>25-35%	9	>85-95%	05	>5-10 m	10	> 50 m
4	>35-45%	10	>95%				

Observation Points

In addition to classification plots, the field crew collected vegetation and environmental data at 10 observation points (Figure 13). Data collected at observation points reflected the vegetation of an undefined area around the point rather than a measured plot, and were less detailed (Appendix B). These data were intended primarily to support modeling and interpretation of the aerial imagery, but were also used to help describe plant associations. Field crews could choose to sample an observation point instead of a full classification plot when:

- the vegetation was highly disturbed, ecotonal, or otherwise anomalous
- cartographers requested documentation of a specific photo signature or area
- they wished to document special features or vegetation occurring in stands smaller than 0.5 ha (1.24 acres).

Data Processing and Analysis

Plot and observation point data were manually entered into the TICA Vegetation Mapping Project Database. This database is compatible with the data standards of the PLOTS Database System developed for the USGS-NPS Vegetation Classification and Mapping Program by TNC (1997). The TICA database offers NCPN greater flexibility in overall data management than does the NatureServe PLOTS database. The NCPN database was designed to accommodate all project data including plots and observation points. Data standards were established by NCPN for all network vegetation mapping projects, allowing compatibility of data across network park units. Fields associated with the TICA plots database are described in Appendix C.

A thorough quality assessment and quality check (QA/QC) was performed on all field data following entry to the plots database. Individual data records were reviewed with the field data sheets in hand. Additional QA/QC was performed using a set of queries designed to identify inconsistencies across data fields and check for missing data. NCPN technicians standardized the scientific names in the database and noted name changes on the field forms.

The primary authority used for plant names for the TICA vegetation mapping project and all other NCPN I&M projects is A *Utah Flora* (Welsh et al. 2003). It is important to note that NatureServe, a primary project partner, follows Kartesz (1999) as its primary nomenclatural authority. As a result, nomenclature used in the body of this report follows Kartesz, whereas nomenclature in the project database follows Welsh et al. (2003). Differences between the two nomenclatural authorities are reconciled in a crosswalk table (Appendix D).

A GIS data layer (point data) was developed to document classification plot locations. Each 35 mm slide associated with the project was scanned into digital format. The 16 digital images were stored in a photograph database. A unique identifier allows each photograph to be linked with the plots and spatial databases. Slide labels were printed from the database. An additional 48 digital photographs were taken in June 2008 to help illustrate the report and appendices.

Classification Data Analysis

Because of the small number of plots and observation points sampled at TICA, we did not conduct a quantitative vegetation classification. Instead, NCPN staff compared the plot data with information available from NatureServe's Explorer website (www.natureserve.org/explorer) and with plot data from other NCPN vegetation mapping projects. All vegetation plots and observation points classified easily to existing NVC associations (Table 6). NatureServe ecologists reviewed the assignments of NVC associations and alliances and concurred with most of the NCPN determinations.

Classification Results

The documented vegetation includes five forest, two woodland, and five shrubland associations or park special vegetation types in five alliances and six ecological systems (Table 6, Appendix E). The two woodland associations describe riparian vegetation found along the American Fork River and in snowslide ravines. The park specials describe vegetation that could not be classified into the current NVC structure, are relatively rare, and appear to be limited to the immediately vicinity of the Monument. Two additional ecological systems and three alliances are associated only with map classes and are not included in Table 6.

Table 6. Plant associations identified within the TICA vegetation mapping project area*.

NVC Association	Common Name	CEGL Code†
UPLAND FORESTS		
Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)‡		
Abies concolor / Acer grandidentatum Forest	White Fir / Bigtooth Maple Forest	CEGL000241
Abies concolor / Physocarpus malvaceus Forest	White Fir / Mallow-leaf Ninebark Forest	CEGL000254
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)		
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest	White Fir - Douglas-fir / Rocky Mountain Maple Forest	CEGL000240
Abies concolor / Quercus gambelii Forest	White Fir / Gambel Oak Forest	CEGL000261
Abies concolor / Mixed Grasses Forest	White Fir / Mixed Grasses Forest	CEGL005357
UPLAND SHRUBLANDS		
Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)		
Acer grandidentatum - Prunus virginiana Shrubland [Park Special]	Bigtooth Maple - Chokecherry Shrubland	Park Special
Acer grandidentatum / Quercus gambelii Forest	Bigtooth Maple / Gambel Oak Forest	CEGL000559
Acer negundo / Acer grandidentatum Woodland [Park Special]	Box-elder / Bigtooth Maple Woodland	Park Special
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)		
Quercus gambelii / Symphoricarpos oreophilus Shrubland	Gambel Oak / Mountain Snowberry Shrubland	CEGL001117
Quercus gambelii Shrubland	Gambel Oak Shrubland	CEGL002477
Inter-Mountain Basins Cliff and Canyon (CES304.779)		
Cercocarpus intricatus Montane Shrubland	Littleleaf Mountain-mahogany Montane Shrubland	CEGL002587
RIPARIAN WOODLANDS		
Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821)		
Acer negundo - Populus angustifolia - Abies concolor Woodland [Park Special]	Box-elder - Narrowleaf Cottonwood - White Fir Woodland	Park Special

* Plant associations determined from the vegetation plot and observation point data. Associations are ordered by physiognomy and grouped by ES. Identification codes are provided for plant associations and ecological systems.

† The CEGL code is assigned by NatureServe to track NVC associations within their databases. Park Specials are not part of the NVC and therefore do not have a CEGL code.

‡ The NatureServe codes following each Ecological System unit name provide a means of tracking the evolution of the concept in NatureServe's Biotics Tracking Database.

Plant Community Descriptions

This section provides a summary of TICA vegetation by physiognomic group. Appendix F provides detailed local and global descriptions of the twelve plant associations, alliances, and park special vegetation types sampled within the Monument. Local descriptions are based on plot and observation point data from the Monument. Global descriptions characterize the association across its range, based primarily on published and unpublished literature. Community types such as quaking aspen forest, that were not sampled, are not included in the local or global descriptions of Appendix F.

Forest and Woodland Associations

Forest and woodland communities dominate TICA. They occupy slopes stable enough to allow a degree of soil formation and the growth of long-lived woody plants. Dry sites tend to have more open canopies and higher grass cover in the understory. More mesic sites have denser canopies and more shrubs in the understory. The forest and woodland associations of TICA include:

- *Abies concolor - Pseudotsuga menziesii / Acer glabrum* Forest
- *Abies concolor / Acer grandidentatum* Forest
- *Abies concolor / Physocarpus malvaceus* Forest
- *Abies concolor / Quercus gambelii* Forest
- *Abies concolor* / Mixed Grasses Forest

Shrubland Associations

Shrublands dominate the unstable, south-facing slopes of TICA as well as avalanche chutes on the north-facing slopes. Composition varies depending on the amount of moisture available. The shrubland associations at TICA include:

- *Acer grandidentatum / Quercus gambelii* Forest
- *Quercus gambelii / Symphoricarpos oreophilus* Shrubland
- *Quercus gambelii* Shrubland
- *Cercocarpus intricatus* Shrubland
- *Acer grandidentatum - Prunus virginiana* Shrubland

Herbaceous Associations

Herbaceous communities are rare within TICA and are restricted to rocky substrates with very thin soils. Sites supporting herbaceous-dominated communities include the canyon rim and steep bluffs and cliffs. Because of the small size and dangerous locations of these habitats, they were not sampled. A small (0.5 ha / 1 acre) meadow occurs near the Swinging Bridge Picnic area. The vegetation in the meadow is dominated by exotic grasses and forbs.

Riparian Associations

Riparian plant communities occur on the bars and banks of the American Fork River, as well as in tributary ravines and gullies that carry runoff. Although they are inherently unstable habitats (subject to severe floods and rock fall), riparian communities at TICA consist of forests and woodlands. Riparian plant species common to TICA include narrowleaf cottonwood, boxelder,

Douglas-fir, Rocky Mountain juniper, white fir, water birch, mountain willow (*Salix monticola*), sandbar willow (*Salix exigua*), chokecherry, skunkbush (*Rhus trilobata*), rubber rabbitbrush (*Ericameria nauseosa*), sedges (*Carex* spp.), rushes (*Juncus* spp.), and mesic grasses. The riparian associations of TICA include:

- *Acer negundo - Populus angustifolia - Abies concolor* (Box-elder - Narrowleaf Cottonwood - White Fir) Woodland
- *Acer negundo / Acer grandidentatum* (Box-elder / Bigtooth Maple) Woodland

Field Key Preparation

An illustrated dichotomous field key to plant associations of the TICA mapping area was developed for this project (Appendix G). The key is designed to assist users in identifying vegetation associations in the field. The key has two levels; the first level is defined by the physiognomy of the vegetation, i.e., forest, woodland, shrubland, or herbaceous. The second level focuses on the dominant species in each layer. Brief environmental descriptions are included with the floristic descriptions to assist in identifying plant associations. To increase the utility of the key, individual plant associations are cross-referenced to map classes.

The field key was constructed from data collected specifically for this mapping project. Because the key is based on a sample of the vegetation, it may not include all associations occurring within the Monument, nor does it describe the full range of variation of the associations as they appear in the Monument.

Fuels Data Collection

Fuels data were not analyzed as part of this project and data pertinent only to fuels modeling were not collected. The plot photographs and some of the data collected for vegetation classification may be useful for fuels management. Data collected in the vegetation plots at TICA that are potentially useful for fuels modeling include measures of groundcover elements (e.g., litter, bare ground, rock), tree canopy density, height data for each community stratum, and species composition and cover data.

Vegetation Mapping

Methods

The process of mapping vegetation and land uses of NCPN park units consists of four steps:

- Field reconnaissance
- Map class and attribute development
- Mapping
- Spatial database development

Field reconnaissance is intended to familiarize the photo interpreter with the Monument, patterns of vegetation distribution, and environmental factors. During map class and attribute development, the mapping ecologist uses all available information, professional experience, and an inspection of the aerial imagery to develop map classes and appropriate attributes. Mapping is the process during which the photo interpreter uses field data, field notes, and characteristic photo signatures to draw consistent, homogenous polygons on the base photography. During spatial database development, attributes (e.g., vegetation height, land use category) and ancillary datasets (e.g., photos, map class descriptions) are linked to each point or polygon in the spatial layer. Because TICA is a small park, the first three steps were accomplished simultaneously during the plot data collection visit in June 2007.

Field Reconnaissance

Reconnaissance was conducted concurrently with vegetation plot and observation point data collection during June 2007. The primary project ecologist walked the entire park over two days. The reconnaissance focused on comparing site-based vegetation conditions with signatures on a paper plot of the orthoimage of the Monument, understanding environmental drivers influencing vegetation patterns, and identifying what information could be extracted from the project imagery. Field notes were written directly on the orthoimage and were used to guide digitization of the final map.

Map Class and Polygon Attribute Development

The goal of mapping was to identify meaningful units to represent existing vegetation and land uses for the TICA vegetation mapping project area. Map classes specific to this project were developed to characterize vegetation types within the Monument. Standard land-use map classes (Anderson et al. 2002) were used to map developed parts of the Monument such as buildings, corrals, and roads.

Interpretation and attribution of map classes for vegetation addressed all types observed within TICA regardless of size. Most map classes include polygons smaller than the 0.5-hectare program minimum mapping unit. Because TICA is a small park, it was possible to map much of the Monument in the field to the level of vegetation association and in some cases, to sub-association where rock outcrops contributed to variations in association structure, density, and understory composition.

In order to facilitate use of vegetation maps and mapping data across multiple parks, the NCPN adopted a convention for naming and presenting map classes. For each map class representing an NVC plant association or alliance, a translated common name (e.g., Aspen Forest) was used. To facilitate tracking and management of vegetation map class information, a coding system was developed. The original map class coding system used by the photo interpreter consisted of a unique but arbitrary number for each map class. These numeric codes have been retained within the spatial database and map class key (Appendix J). A complementary, five-letter alphacode system for map classes was created for all park vegetation mapping projects. Each alphacode begins with the first letter of the corresponding NVC Class (F = Forest, W = Woodland, S = Shrubland, H = Herbaceous, and N = nonvascular). The subsequent four letters generally abbreviate the map class name. For example, the Douglas-fir / Mountain Maple Woodland map class is represented by the alphacode "W-DFMM". For map classes representing coarser levels of the NVC, geologic exposures, and other non-vegetated features, generic names incorporating vegetation and landscape features were used. Map classes representing developments such as roads or buildings were given alphacodes with the prefix L = land use. Map classes representing unvegetated geologic features were given alphacodes with the prefix G = geologic.

Photointerpretation and polygon labeling and attribution procedures were standardized for all park vegetation mapping projects (Evenden 2004). After a map class was assigned to each polygon, the polygon was assigned attributes to characterize vegetation structure (density, pattern, height; Table 7), land use, and disturbance. All map polygons were assigned to a land cover / land use type (Anderson et al. 2002; Appendix H). In addition, all polygons were assigned to higher levels of the NVC hierarchy, with the exception of non-vegetated map classes, which were coded as 'unclassified' or 'unvegetated' in the NVC columns.

Table 7. Physiognomic attributes assigned to map polygons. When appropriate, these attributes were assigned to individual polygons. Otherwise they were assigned to an entire map class.

Category	Attribute	Description
Vegetation Canopy Density (Applied to forest, woodland, and shrub-dominated map classes)	A	Closed Tree Canopy/Continuous (> 60% cover)
	B	Open Tree Canopy/Discontinuous (25- 60% cover)
	C	Dispersed – Sparse Tree Canopy (10-25% cover)
	D	Dense Sagebrush Canopy (> 40% cover)
	E	Light Sagebrush Canopy (10 – 40% cover)
Vegetation Pattern (Applied to all vegetation map classes)	1	Clumped/Bunched
	2	Linear
	3	Gradational/Transitional
	4	Regularly Alternating
	5	Homogenous
Vegetation Height (Applied to woody terrestrial vegetation map classes only)	F	Forest and Woodlands > 30 meters tall
	G	Forest and Woodlands 15 – 30 meters
	H	Forest and Woodlands 5 – 15 meters
	I	Forest and Woodlands 1 – 5 meters
	J	Forest and Woodlands < 0.5 meters
	K	Shrublands 1 – 5 meters
	L	Shrublands 0.5 – 1 meters
	M	Shrublands 0 – 0.5 meters

Park Specials

Vegetation types that do not fit within the National Vegetation Classification were documented as "park specials" (Table 6). At TICA, the park specials include two unusual communities adapted to wet but highly disturbed snow slide ravines on the north-facing canyon slopes. A third park special describes the American Fork riparian forest; this type is a transitional mix of foothills and montane riparian elements: box elder, narrowleaf cottonwood, and white fir are the canopy dominants. The fourth park special was created to describe the highly disturbed meadow near the Swinging Bridge picnic area.

Mapping

The mapping component of the TICA project used a combination of methods to interpret and delineate vegetation polygons. The initial set of polygons was drawn and annotated in the field on a 1:3500-scale print of the base orthoimagery. The lines were transferred to a digital environment in an ArcMap personal geodatabase by means of on-screen digitizing.

Spatial Database Development

Each polygon was assigned a map class number, alpha code and name, Anderson land use class, and vegetation density, pattern, and height attributes. In order to improve the utility of the map and related data, the spatial database was moved into a geodatabase format, the general structure of which is illustrated in Figure 14. This format allows text and image information to be incorporated and linked to spatial coordinates. Detailed documentation of the geodatabase is provided in Appendix C. All geospatial products associated with this project are in the UTM projection, NAD83, Zone 12. Table 2 is a timeline for the completion of major project tasks.

Map Classes

Twenty-one classes were developed to describe the TICA vegetation mapping project area (Table 8, Appendix J). Of these, 16 are natural or semi-natural vegetation map classes, two are geologic land cover classes, and three are non-vegetated land-use map classes. All but two of the natural vegetation map classes represent single NVC plant associations or sub-associations. The two map classes that represent multiple NVC associations are complexes of closely related forest associations.

Ecological systems (Comer et al. 2003) are used to organize the vegetation map classes. They were developed by NatureServe to complement the finer-scale NVC by creating a mappable classification unit representing groups of biologic communities in similar environments and shaped by similar ecologic processes. Ecological systems typically occur in patches of tens to thousands of hectares and are expected to persist for 50 or more years. The timeframe allows successional dynamics to be integrated into the concept of each ecological system.

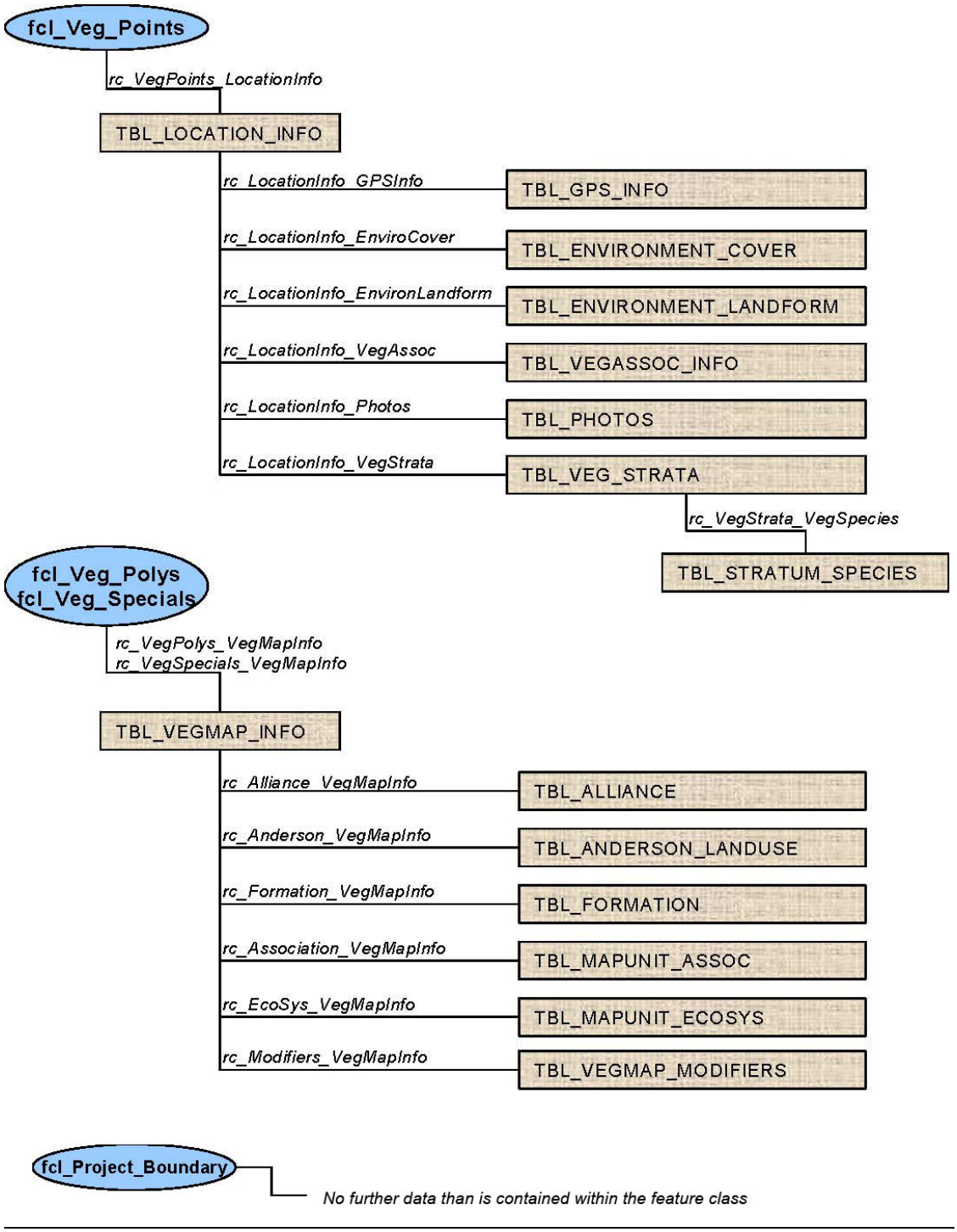


Figure 14. Structure of the TICA geodatabase.

Results

Table 8 shows the relationship of vegetation map classes to ecological systems. Appendix A provides summary descriptions of each ecological system. The geologic and Anderson land use map classes could not be placed within the ecological system classification.

Table 8. Map classes used in the TICA vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. TICA vegetation map classes are arranged using the NatureServe ecological systems classification.

Map Class #	Map Class Code	Map Class Name	Associations Assigned to Map Class	Relation
Rocky Mountain Aspen Forest and Woodland (CES306.813)				
1	F-POTR	Aspen Forest	*Populus tremuloides* Forest Alliance	1 : 1
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)				
3	W-DFMM	Douglas-fir / Mountain Maple Woodland	*Pseudotsuga menziesii* Woodland Alliance	1 : 1
6	F-MCGR	White fir - Douglas-fir / Bunchgrass Forest	*Abies concolor* / Mixed Grasses Forest	1 : 1
9	W-ACQG	White fir / Gambel Oak Woodland	*Abies concolor / Quercus gambelii* Forest	1 : many
31	C-ROJSI	Rock Outcrop Sparse Vegetation (Rocky Mountain Juniper Phase)	*Abies concolor / Quercus gambelii* Forest	1 : many
Mixed Ecological Systems: Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823) Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)				
7	F-MCOM	White fir - Douglas-fir / Gambel Oak - Bigtooth Maple Forest	*Abies concolor - Pseudotsuga menziesii / Acer glabrum* Forest *Abies concolor / Acer grandidentatum* Forest *Abies concolor / Physocarpus malvaceus* Forest *Abies concolor / Quercus gambelii* Forest	1 : many
8	W-MCJS	White fir - Douglas-fir / Rocky Mountain Juniper / Gambel Oak Woodland	*Abies concolor - Pseudotsuga menziesii / Acer glabrum* Forest *Abies concolor / Acer grandidentatum* Forest *Abies concolor / Quercus gambelii* Forest	1 : many
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (CES306.819)				
2	W-DFLP	Douglas-fir - Limber Pine Woodland	*Pseudotsuga menziesii* Woodland Alliance	1 : 1
Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)				
22	S-BMCC	Bigtooth Maple-Chokecherry Ravine Woodland	*Acer grandidentatum - Prunus virginiana* Shrubland	1 : 1
23	W-BEBM	Box-elder-Bigtooth Maple Ravine Woodland	*Acer negundo / Acer grandidentatum* Woodland	1 : 1
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)				
25	S-GOBM	Gambel Oak - Bigtooth Maple Shrubland	*Quercus gambelii* Shrubland	1 : 1
28	W-GOSB	Gambel Oak – Snowberry Shrubland	*Quercus gambelii / Symphoricarpos oreophilus* Shrubland	1 : 1
Inter-Mountain Basins Cliff and Canyon (CES304.779)				

Table 8. Map classes used in the TICA vegetation map, with map class number, code and name, crosswalk to NVC association, and the relationship of map class to plant associations. TICA vegetation map classes are arranged using the NatureServe ecological systems classification.

Map Class #	Map Class Code	Map Class Name	Associations Assigned to Map Class	Relation
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)				
30	C-ROLM	Rock Outcrop Sparse Vegetation (Littleleaf Mtn Mahogany Phase)	*Cercocarpus intricatus* Montane Shrubland	1 : 1
51	H-PPPS	Grassy Rock Goldenrod – Bluebunch Wheatgrass	*Pseudoroegneria spicata - Petradoria pumila* Herbaceous Vegetation	1 : 1
Inter-Mountain Basins Montane Sagebrush Steppe (CES304.785)				
10	H-MEAD	Disturbed Meadow	*Bromus tectorum* – Exotic Forb Herbaceous Vegetation	1 : 1
Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)				
4	W-POAN	Narrowleaf Cottonwood –Conifer Riparian Woodland	*Acer negundo - Populus angustifolia - Abies* Woodland	1 : 1
Unvegetated Anderson Land Cover / Land Use Map Classes				
100	G-CLIF	Cliff Band	Near-vertical to vertical bands of bedrock outcrop forming cliffs	N/A
101	G-TALU	Talus	Areas of unvegetated loose rock covering slopes below cliff bands	N/A
200	L-FACI	Park Facilities	Buildings and other structures associated With TICA	N/A
201	L-ROAD	Road	Utah Highway 92	N/A
202	L-PARK	Parking Areas	Parking areas associated with TICA facilities	N/A

Map Class Descriptions

Appendix J provides detailed descriptions of all map classes used in the final version of the TICA vegetation mapping project. Each map class description includes:

- a summary of the ecological concept of the map class. Reference is made to the abundance and distribution of the map class within the project area
- statistics for polygons of the map class (frequency, area)
- the relevant ecological system, a list of plant associations, and common plant species occurring within the map class
- a qualitative description of the photographic signature along with representative samples from the orthophotography
- ground photographs (if available)

Map Polygons

One hundred twenty polygons were mapped at TICA. Average polygon size is 0.8 ha (2.0 acres).

Eighty-four polygons (69%) represent natural vegetation map classes covering 92% of the mapping project area. Map classes representing non-vegetated geologic features, roads or facilities account for the remaining 36 polygons (31% of polygons, 8% of the mapping area).

The most common vegetation map class is White fir - Douglas-fir / Gambel Oak - Bigtooth Maple Forest (F-MCOM) with seven polygons covering 29% of the mapping area. This map class also had the largest average polygon size at 4.1 ha (10.2 acres) per polygon.

Figure 15 is an example of a map of the vegetation of TICA created from the GIS spatial database. Because we used a geodatabase to store and organize spatial information, there is far more data in the spatial database than can be conveyed in a two-dimensional map. Maps can be produced with vegetation polygons labeled in many different ways at different levels of resolution. Table 9 provides summary statistics for TICA vegetation map polygons.

Table 9. Summary statistics for polygons of each map class developed for the TICA vegetation mapping project.

Map Code	Map Class Name	# of Polygons	Area	
			Hectares	Acres
Rocky Mountain Aspen Forest and Woodland (CES306.813)				
F-POTR	Aspen Forest	1	0.5	1.2
	Subtotal	*1*	*0.5*	*1.2*
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)				
W-DFMM	Douglas-fir / Mountain Maple Woodland	8	6.6	16.2
F-MCGR	White fir - Douglas-fir / Bunchgrass Forest	1	0.5	1.1
W-ACQGI	White fir / Gambel Oak Woodland	3	2.7	6.6
C-ROJS	Rock Outcrop Sparse Vegetation (Rocky Mountain Juniper Phase)	5	12.0	29.7
	Subtotal	*17*	*21.8*	*53.6*
Mixed Ecological Systems: Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823) Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)				
F-MCOM	White fir - Douglas-fir / Gambel Oak - Bigtooth Maple Forest	7	29.0	71.4
W-MCJS	White fir - Douglas-fir / Rocky Mountain Juniper / Gambel Oak Woodland	4	5.4	13.3
	Subtotal	*11*	*34.4*	*84.7*
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (CES306.819)				
W-DFLP	Douglas-fir - Limber Pine Woodland	7	16.5	40.8
	Subtotal	*7*	*16.5*	*40.8*
Rocky Mountain Lower Montane-Riparian Woodland and Shrubland (CES306.821)				

Table 9. Summary statistics for polygons of each map class developed for the TICA vegetation mapping project.

Map Code	Map Class Name	# of Polygons	Area	
			Hectares	Acres
W-POAN	Narrowleaf Cottonwood-Conifer Riparian Woodland	4	5.3	13.0
	Subtotal	*4*	*5.3*	*13.0*
Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)				
S-BMCC	Bigtooth Maple-Chokecherry Ravine Shrubland	5	0.9	2.2
W-BEBM	Box Elder-Bigtooth Maple Ravine Woodland	2	0.8	1.9
	Subtotal	*7*	*1.7*	*4.1*
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)				
S-GOBM	Gambel Oak - Bigtooth Maple Shrubland	19	8.0	19.8
S-GOSB	Gambel Oak - Snowberry Shrubland	6	1.4	3.4
	Subtotal	*25*	*9.4*	*23.2*
Inter-Mountain Basins Cliff and Canyon (CES304.779)				
C-ROLM	Rock Outcrop Sparse Vegetation (Littleleaf Mtn Mahogany Phase)	8	3.1	7.6
H-PPPS	Grassy Rock Goldenrod - Bluebunch Wheatgrass	3	0.2	0.6
	Subtotal	*11*	*3.3*	*8.2*
Inter-Mountain Basins Montane Sagebrush Steppe (CES304.785)				
H-MEAD	Disturbed Meadow	1	0.1	0.3
	Subtotal	*1*	*0.1*	*0.3*
GEOLOGIC LAND COVER MAP CLASSES				
L-CLIF	Cliffs	14	3.3	8.2
L-TALU	Unvegetated Talus	12	2.8	6.9
	Subtotal	*26*	*6.1*	*15.1*
NON-VEGETATED LAND USE MAP CLASSES				
L-ROAD	Highway 92 (paved)	1	0.7	1.7
L-PARK	Parking lots	4	0.3	0.7
L-FACI	Park Facilities (Buildings)	5	0.7	1.8
	Subtotal	*10*	*1.7*	*4.2*
	Total All Map Classes	**120**	**100**	**248**

* Note: Total polygon area may be subject to cumulative rounding error.

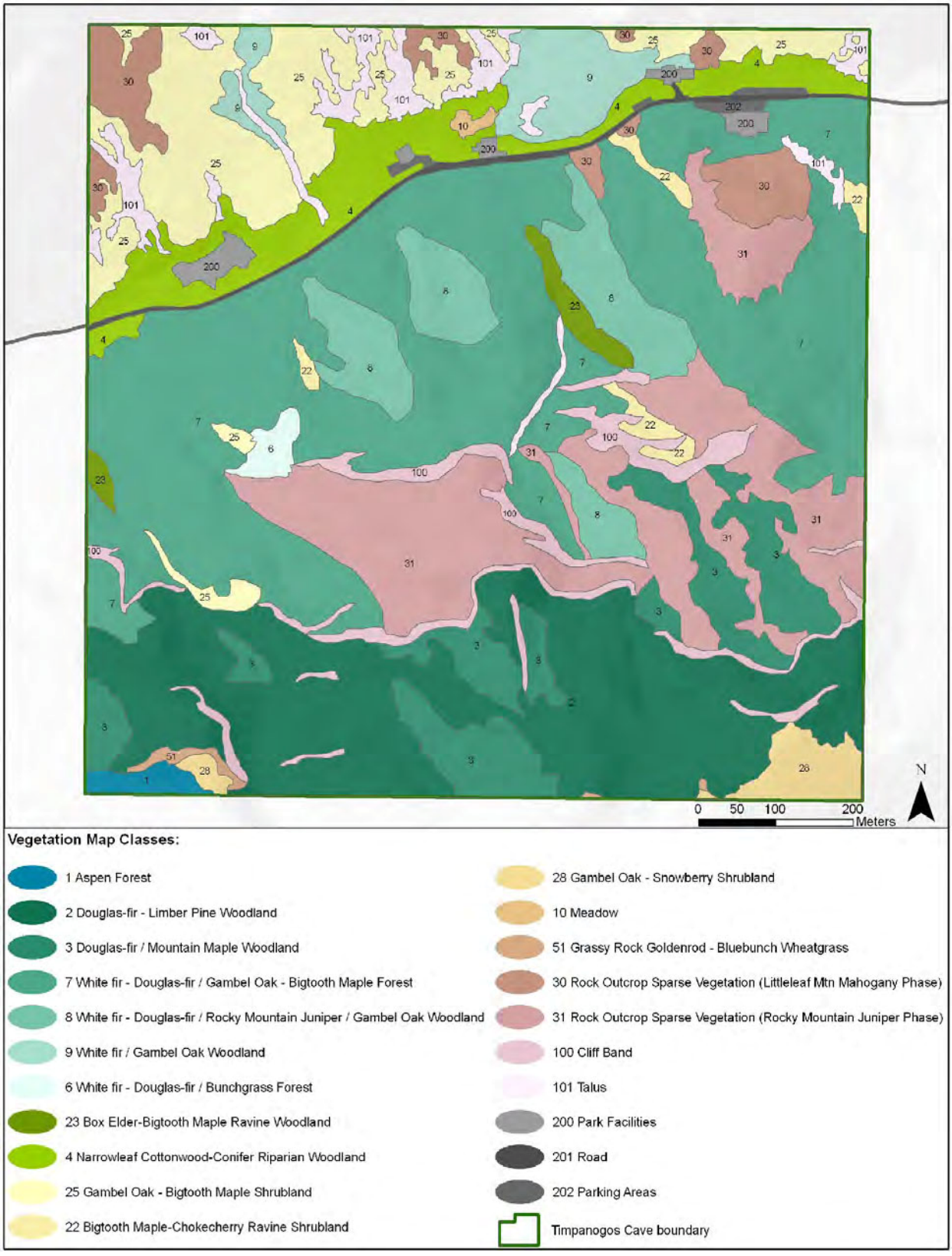


Figure 15. The TICA vegetation map.

Accuracy Assessment

Methods

The TICA vegetation map was not verified by means of the USGS-NPS standard accuracy assessment protocol (ESRI and TNC 1994). The Monument totals only 100 ha (248 acres) and the terrain is very difficult. However, each unit may be visited or viewed with binoculars by a reasonably fit individual in less than a day. The standard procedure for mapping larger parks is to have four types of field visits spread over the duration of the project: (1) reconnaissance, (2) vegetation plot sampling, (3) map verification, and (4) accuracy assessment.

Because of the level of risk faced by field crews traversing steep slopes of shattered bedrock, and because of the potential for redundancy in multiple field visits, NCPN ecologists and project partners agreed that it would be more efficient to invest time in the field at the beginning of the project delineating and attributing vegetation polygons in the field as they were observed. The initial map was created in 2007 from detailed field notes recorded on photocopies of the aerial imagery.

The downside of this procedure is that quantification of the degree of confidence users may have in this vegetation map is less rigorous. However, the authors will certify that virtually every acre and management unit was walked or observed from close range, and evaluated, and that (as of April, 2009) this map is accurate.

References

Allred, K.W. 1975. Timpanogos Flora. Master's Thesis, Brigham Young University, Provo, UT. 178 pp.

Anderson, J.R., E. Hardy, J. Roach, and R. Witter. 2002. A land use and land cover classification system for use with Remote Sensor Data. Geological Survey Professional Paper 964. U.S. Government Printing Office, Washington, D.C.

Atwood, N.D. 2001. Timpanogos Cave National Monument plant inventory, 2001. Brigham Young University, Provo, UT.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, VA.

Driscoll, R.S., D.L. Merkel, R.L. Radloff, D.E. Snyder, and J.S. Hagihara. 1984. An ecological land classification framework for the United States. United States Department of Agriculture, Forest Service Miscellaneous Publication Number 1439. Washington, D.C. 56 pp.

Environmental Systems Research Institute, National Center for Geographic Information and Analysis, and The Nature Conservancy [ESRI and TNC]. 1994. Final draft accuracy assessment procedures. NBS/NPS Vegetation Mapping Program. Prepared for the United States Department of Interior, Biological Resources Division and National Park Service.

Evenden, A. 2004. Guidelines for photo interpreters working on vegetation mapping in Northern Colorado Plateau Network Parks, January 21, 2004. Northern Colorado Plateau Network, National Park Service, Moab, UT. 20 p.

Federal Geographic Data Committee [FGDC]. 1997. Vegetation classification standard [online]. Available from http://biology.usgs.gov/fgdc.veg/standards/vegstd.htm [Cited 1 March 2004].

Federal Geographic Data Committee. 1998a. Content standard for digital geospatial metadata, FGDC-STD-001-1998. Web address: http://www.fgdc.gov/metadata/contstan.html.

Federal Geographic Data Committee. 1998b. Spatial data transfer standard, FGDC-STC-002 (modified version ANSI NCITS 20:19998). Web address: http://www.fgdc.gov/standards/status/textstatus.html.

Federal Geographic Data Committee. 2008. National Vegetation Classification Standard (Version 2). Document # FGDC-STD-005. Available online at http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation.

Fertig, W., and N.D. Atwood. 2009. Annotated checklist of vascular flora: Timpanogos Cave National Monument. Natural Resource Technical Report NPS/NCPN/NRTR–2009/167. National Park Service, Fort Collins, Colorado.

Flahault, C., and C. Schroter. 1910. Rapport sur la nomenclature phytogeopraphique. Proceedings of the Third International Botanical Congress, Brussels 1:131-164.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the United States. Volume I. The National Vegetation Classification System: Development, Status, and Applications. The Nature Conservancy, Arlington, VA.

Jasper, J. and M. Gosse. 2003. Controlling Invasive Plants: Timpanogos Cave National Monument. NPS. TICA.

Kartesz, J. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First Edition. In: Kartesz, J.T., and C.A. Meacham. Synthesis of the North American Flora, Version 1.0. North Carolina Botanical Garden, Chapel Hill, NC.

Lewis, D.R. 1994. Native Americans in Utah. In: Powell, A.K., editor. Utah History Encyclopedia. University of Utah Press, Salt Lake City, Utah 84112. Available online at: http://www.media.utah.edu/UHE/

Mayo, A.L., D. Herron, S.T. Nelson, D. Tingey, and M.J. Tranel. 2003. Geology and Hydrogeology of Timpanogos Cave National Monument, Utah. In: D.A. Sprinkel, T.C. Chidsey, Jr., and P.B. Anderson, editors. Geology of Utah's Parks and Monuments. Utah Geological Association Publication 28. Utah Geological Association and Bryce Canyon Natural History Association.

National Park Service [NPS]. 1999. Natural Resource Challenge: The National Park Service's Action Plan for Preserving Natural Resources. In-house publication. U.S. Department of Interior, National Park Service, Washington, D.C. 21p.

National Park Service. 2002. Timpanogos Cave National Monument; Annual Performance Report. U.S. Department of the Interior. TICA.

National Park Service. 2004. Wildland Fire Management Plan – Timpanogos Cave National Monument.

National Park Service. 2008. Timpanogos Cave National Monument – Park Information. Available online at: http://www.nps.gov/tica/.htm.

NatureServe. 2003a. International Ecological Classification Standard: International Vegetation Classification. Natural Heritage Central Databases, NatureServe, Arlington, VA.

NatureServe. 2003b. International Ecological Classification Standard: Terrestrial Ecological Systems of the United States. Natural Heritage Central Databases. NatureServe. Arlington,

VA. Available online: http://www.natureserve.org/explorer.

NatureServe Explorer. 2008. An online encyclopedia of life [Web application]. Version 7.0. Arlington, VA. Available online: http://www.natureserve.org/explorer.

Reid, M. and P. Comer. 1998. Vegetation Alliance Descriptions of the Western U.S. Available online at http://www.gap.uidaho.edu/bulletins/7/VADWUS.htm.

Roper, R. 1994. Timpanogos Cave National Monument. In: Powell, A.K., editor. Utah History Encyclopedia. University of Utah Press, Salt Lake City, Utah 84112. Available online at: http://www.media.utah.edu/UHE/

Soil Conservation Service [SCS]. 1972. Soil Survey of Utah County, Utah – Central Part. Soil Conservation Service with Utah Agricultural Experiment Station. Salt Lake City, UT.

The Nature Conservancy and Environmental Systems Research Institute [TNC and ESRI]. 1994a. NBS/NPS Vegetation Mapping Program: Final Draft, Standardized National Vegetation Classification System. Prepared for USDI – National Biological Survey and National Park Service. Arlington, VA.

The Nature Conservancy and Environmental Systems Research Institute. 1994b. NBS/NPS Vegetation Mapping Program: Final Draft, Field Methods for Vegetation Mapping. Prepared for USDI – National Biological Survey and National Park Service. Arlington, VA.

The Nature Conservancy [TNC]. 1996. Final Draft Methodology for Assessing the Utility of Existing Data for Vegetation Mapping. NBS/NPS Vegetation Mapping Program. Prepared for the USGS-Biological Resources Division and National Park Service.

United Nations Educational, Scientific, and Cultural Organization [UNESCO]. 1973. International classification and mapping of vegetation. UNESCO, Paris, France.

U.S. Geological Survey [USGS]. 1999. Map accuracy standards. Fact sheet FS-171-99 (November 1999). Web address: http://mac.usgs.gov/mac/isb/pubs/factsheets/fs17199.html.

U.S. Geological Survey. 2008. National Water Information System: Web Interface. Accessed Online at: http://waterdata.usgs.gov/nwis...

Welsh, S.L., N.D. Atwood, S. Goodrich, and L.C. Higgins. 2003. A Utah Flora. Third Edition, revised. Brigham Young University Print Services, Provo, UT 912 p.

Western Regional Climate Center [WRCC]. 2007. Reno, NV. Timpanogos Cave, Utah Station (428733). Available online at: http://www.wrcc.dri.edu/weather/nnsc.html.

Woods, A.J., D.A. Lammers, S.A. Bryce, J.M. Omernik, R.L. Denton, M. Domeier, and J.A. Comstock. 2001. Ecoregions of Utah (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,175,000).

Appendix A

Ecological Systems of Timpanogos Cave National Monument

Introduction

This appendix contains summary descriptions of nine terrestrial and riparian/wetland ecological system (ES) units (NatureServe 2003b, Comer et al. 2003) occurring at Timpanogos Cave National Monument. Each ecological system represents one or more National Vegetation Classification (NVC) plant associations (Table 6 within the main report). Map classes were also crosswalked to ES units (Table 8 within the main report). Because the map was created directly from field observations, not every ecological system is represented by a plot or observation point. Three ecological systems have no plot data to support them; they exist primarily to describe map classes:

- Rocky Mountain Aspen Forest and Woodland (CES306.813) describes Map Class F-POTR (#1 / Aspen Forest)
- Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (CES306.819) describes Map Class W-DFLP (#2 / Douglas-fir – Limber Pine Woodland)
- Inter-Mountain Basins Montane Sagebrush Steppe (CES304.785) describes Map Class H-MEAD (#10 / Disturbed Meadow)

The ecological systems classification was developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications. One purpose of ecological systems is to provide a coarse-scale mapping unit that can be applied across management boundaries.

UPLAND ECOLOGICAL SYSTEMS

CES306.813 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND
Division 306 (Rocky Mountain); Forest and Woodland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Montane; Subalpine; Forest and Woodland (Treed); Long Disturbance Interval; F-Patch/Medium Intensity; F-Landscape/Medium Intensity; Broad-leaved Deciduous Tree; *Populus tremuloides*
Concept Summary: This widespread ecological system is more common in the southern and central Rocky Mountains but occurs in montane and subalpine zones throughout much of the western U.S. and into Canada. An eastern extension occurs along the Rocky Mountains front and in mountain "islands" in Montana (Big Snowy and Highwood mountains), and the Black Hills of South Dakota. In California, this system is only found on the east side of the Sierra Nevada. Large stands occur in the Inyo and White mountains, while small stands occur on the Modoc Plateau. Elevations range from 1,525 to 3,050 m (5,000-10,000 feet), but occurrences can be found at lower elevations. Distribution of this ecological system is primarily limited by the soil moisture required to meet its high evapotranspiration rates. Secondary limiters include length of the growing season or low temperatures. These are upland forests and woodlands dominated by *Populus tremuloides* without a significant conifer component (<25% relative tree cover). The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. In California, *Symphyotrichum spathulatum* is a common forb. Associated shrub species include *Symphoricarpos* spp., *Rubus parviflorus*, *Amelanchier alnifolia*, and *Arctostaphylos uva-ursi*. Patches of this system originate and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within a matrix of conifer forests. The similar Northwestern Great Plains Aspen Forest and Parkland (CES303.681) is limited to plains environments.
Range: This system is more common in the central and southern Rocky Mountains extending south to the Sacramento Mountains, however, it occurs in the montane and subalpine zones throughout much of the western U.S. and north into Canada, as well as west into California. Elevations generally range from 1525 to 3050 m (5000-10,000 feet), but occurrences can be found at lower elevations in some regions. Very small occurrences may be found in a few scattered locations of the Trans-Pecos of Texas.
Subnations: AZ, CA, CO, ID, MT, NM, NV, OR, SD, TX, UT, WA, WY

CES306.823 SOUTHERN ROCKY MOUNTAIN MESIC MONTANE MIXED CONIFER FOREST AND WOODLAND

Division 306 (Rocky Mountain); Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Montane, Lower Montane; Forest and Woodland (Treed); Aridic; Intermediate Disturbance Interval; F-Patch/Medium Intensity; F-Landscape/Medium Intensity; Needle-Leaved Tree; Montane Mesic Mixed Conifer; Moderate (100-500 yrs) Persistence
Concept Summary: This is a highly variable ecological system of the montane zone of the Rocky Mountains. It occurs throughout the southern Rockies, north and west into Utah, Nevada, western Wyoming and Idaho. These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Rainfall averages less than 75 cm per year (40-60 cm) with summer "monsoons" during the growing season contributing substantial moisture. The composition and structure of overstory is dependent upon the temperature and moisture relationships of the site, and the successional status of the occurrence. *Pseudotsuga menziesii* and *Abies concolor* are most frequent, but *Pinus ponderosa* may be present to codominant. *Pinus* flexilis is common in Nevada. *Pseudotsuga menziesii* forests occupy drier sites, and *Pinus ponderosa* is a common codominant. *Abies concolor*-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. *Picea pungens* is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including *Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambelii,* and *Festuca arizonica*. This system was undoubtedly characterized by a mixed severity fire regime in its "natural condition," characterized by a high degree of variability in intensity and return interval.
Range: Occurs throughout the southern Rockies, north and west into Utah, Nevada, western Wyoming and Idaho.
Subnations: AZ, CO, ID, NV, OR, UT, WY

CES306.825 SOUTHERN ROCKY MOUNTAIN DRY-MESIC MONTANE MIXED CONIFER FOREST AND WOODLAND

Division 306 (Rocky Mountain); Forest and Woodland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Forest and Woodland (Treed); Ravine; Stream terrace (undifferentiated); Toeslope; Mesotrophic Soil; Ustic; Long Disturbance Interval; F-Patch/Low Intensity; F-Landscape/Low Intensity; Needle-Leaved Tree; Montane Dry-Mesic Mixed Conifer
Concept Summary: These are mixed conifer forests of the Rocky Mountains west into the ranges of the Great Basin, occurring predominantly in cool ravines and on north-facing slopes.

Elevations range from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than ~Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823). Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north- and east-facing slopes which burn somewhat infrequently. *Pseudotsuga menziesii* and *Abies concolor* are most common canopy dominants, but *Picea engelmannii, Picea pungens*, or *Pinus ponderosa* may be present. This system includes mixed conifer/*Populus tremuloides* stands. A number of cold-deciduous shrub species can occur, including *Acer glabrum, Acer grandidentatum, Alnus incana, Betula occidentalis, Cornus sericea, Jamesia americana, Physocarpus malvaceus, Robinia neomexicana, Vaccinium membranaceum*, and *Vaccinium myrtillus*. Herbaceous species include *Bromus ciliatus, Carex geyeri, Carex rossii, Carex siccata, Muhlenbergia virescens, Pseudoroegneria spicata, Erigeron eximius, Fragaria virginiana, Luzula parviflora, Osmorhiza berteroi, Packera cardamine, Thalictrum occidentale*, and *Thalictrum fendleri*. Naturally occurring fires are of variable return intervals and mostly light, erratic, and infrequent due to the cool, moist conditions.
Comments: This system will need to be modeled to separate from similar dry-mesic system.
Range: This system is found in the southern Rocky Mountains of Arizona and New Mexico north and west into the ranges of the Great Basin, Wyoming and southeastern Idaho, occurring predominantly in cool ravines and on north-facing slopes.
Subnations: AZ, CO, ID, NM, NV, OR?, UT, WY

CES306.819 ROCKY MOUNTAIN SUBALPINE-MONTANE LIMBER-BRISTLECONE PINE WOODLAND

Division 306 (Rocky Mountain); Forest and Woodland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Montane; Ridge/Summit/Upper Slope; Calcareous; Very Shallow Soil; Mineral: W/ A-Horizon <10cm; Aridic; W-Patch/High Intensity; W-Landscape/High Intensity; Needle-leaved Tree; *Pinus flexilis, P. aristata*; Upper Treeline
Concept Summary: This ecological system occurs throughout the Rocky Mountains, south of Montana, on dry, rocky ridges and slopes near upper treeline above the matrix spruce-fir forest. It extends down to the lower montane in the northeastern Great Basin mountains where dominated by *Pinus flexilis*. Sites are harsh, exposed to desiccating winds, with rocky substrates and short growing seasons that limit plant growth. Higher-elevation occurrences are found well into the subalpine-alpine transition on wind-blasted, mostly west-facing slopes and exposed ridges. Calcareous substrates are important for *Pinus flexilis*-dominated communities in the northern Rocky Mountains and possibly elsewhere. The open tree canopy is often patchy and is strongly dominated by *Pinus flexilis* or *Pinus aristata* with the latter restricted to southern Colorado, northern New Mexico and the San Francisco Mountains in Arizona. In the Wyoming Rockies and northern Great Basin, Pinus albicaulis is found in some occurrences, but is a minor component. Other trees such as *Juniperus* spp., *Pinus contorta, Pinus ponderosa*, or *Pseudotsuga menziesii* are occasionally present. *Arctostaphylos uva-ursi*, *Cercocarpus ledifolius*, *Juniperus communis, Mahonia repens, Purshia tridentata, Ribes montigenum*, or *Vaccinium* spp. may form an open shrub layer in some stands. The herbaceous layer, if present, is generally sparse and

composed of xeric graminoids, such as *Calamagrostis purpurascens, Festuca arizonica, Festuca idahoensis, Festuca thurberi*, or *Pseudoroegneria spicata*, or more alpine plants.
Range: This system occurs throughout the Rocky Mountains south of Montana on dry, rocky ridges and slopes near upper treeline, including the Uinta and northern Wasatch mountains, and the Jarbidge Mountains in northeastern Nevada. It also occurs farther east, in the Bighorn Range of north-central Wyoming, although it is not common there.
Subnations: CO, ID?, MT?, NM, NV, OR?, UT, WA?, WY

CES306.814 ROCKY MOUNTAIN BIGTOOTH MAPLE RAVINE WOODLAND
Division 306 (Rocky Mountain); Forest and Woodland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Colluvial slope; Ravine; Stream terrace (undifferentiated); Toeslope; Mineral: W/ A-Horizon <10 cm; Unconsolidated; Broad-Leaved Deciduous Tree; *Acer grandidentatum*
Concept Summary: This ecological system occurs in cool ravines, on toeslopes and slump benches associated with riparian areas in the northern and central Wasatch Range and Tavaputs Plateau extending into southern Idaho, as well as in scattered localities in southwestern Utah, central Arizona and New Mexico and the Trans-Pecos of Texas. Substrates are typically rocky colluvial or alluvial soils with favorable soil moisture. These woodlands are dominated by *Acer grandidentatum* but may include mixed stands codominated by *Quercus gambelii* or with scattered conifers. Some stands may include *Acer negundo* or *Populus tremuloides* as minor components. It also occurs on steeper, north-facing slopes at higher elevations, often adjacent to Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818) or Rocky Mountain Aspen Forest and Woodland (CES306.813).
Range: Occurs in the northern and central Wasatch Range and Tavaputs Plateau extending into southern Idaho, as well as in scattered localities in southwestern Utah, central Arizona and New Mexico and the Trans-Pecos of Texas.
Subnations: ID, NM, TX, UT

CES306.818 ROCKY MOUNTAIN GAMBEL OAK-MIXED MONTANE SHRUBLAND
Division 306 (Rocky Mountain); Shrubland

Spatial Scale & Pattern: Large patch
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Shrubland (Shrub-dominated); Shallow Soil; Mineral: W/ A-Horizon <10 cm; Loam Soil Texture; Sand Soil Texture; Ustic; Unconsolidated; Intermediate Disturbance Interval [Periodicity/Polycyclic Disturbance]; Broad-Leaved Deciduous Shrub
Concept Summary: This ecological system occurs in the mountains, plateaus, and foothills in the southern Rocky Mountains and Colorado Plateau including the Uinta and Wasatch ranges and the Mogollon Rim. These shrublands are most commonly found along dry foothills, lower

mountain slopes, and at the edge of the western Great Plains from approximately 2,000 m to 2,900 m in elevation, and are often situated above pinyon-juniper woodlands. Substrates are variable and include soil types ranging from calcareous, heavy, fine-grained loams to sandy loams, gravelly loams, clay loams, deep alluvial sand, or coarse gravel. The vegetation is typically dominated by *Quercus gambelii* alone or codominant with *Amelanchier alnifolia, Amelanchier utahensis, Artemisia tridentata, Cercocarpus montanus, Prunus virginiana, Purshia stansburiana, Purshia tridentata, Robinia neomexicana, Symphoricarpos oreophilus,* or *Symphoricarpos rotundifolius*. There may be inclusions of other mesic montane shrublands with *Quercus gambelii* absent or as a relatively minor component. This ecological system intergrades with the lower montane-foothills shrubland system and shares many site characteristics. Density and cover of *Quercus gambelii* and *Amelanchier* spp. often increase after fire.
Range: Occurs in the mountains, plateaus, and foothills in the southern Rocky Mountains and Colorado Plateau including the Uinta and Wasatch ranges and the Mogollon Rim.
Subnations: AZ, CO, NM, UT, WY

CES304.785 INTER-MOUNTAIN BASINS MONTANE SAGEBRUSH STEPPE
Division 304 (Intermountain Basins); Steppe-Savanna

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Montane; Mountainside; Mountain Valley; Toeslope/Valley Bottom; Temperate Continental; Long-Disturbance Interval; F-Patch/Medium Intensity; Broad-leaved Evergreen Shrub; Graminoid; *Artemisia tridentata* ssp. *vaseyana*
Concept Summary: This ecological system includes sagebrush communities occurring at foothills (in Wyoming) to montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the southern Rockies. In Montana, it occurs on mountain "islands" in the north-central portion of the state and possibly along the Boulder River south of Absarokee and at higher elevations. In British Columbia, it occurs between 450 and 1650 m in the southern Fraser Plateau and the Thompson and Okanagan basins. Climate is cool, semi-arid to subhumid. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. In general, this system shows an affinity for mild topography, fine soils, some source of subsurface moisture or more mesic sites, zones of higher precipitation and areas of snow accumulation. Across its range of distribution, this is a compositionally diverse system. It is composed primarily of *Artemisia tridentata* ssp. *vaseyana*, *Artemisia cana* ssp. *viscidula*, and related taxa such as *Artemisia tridentata* ssp. *spiciformis* (= *Artemisia spiciformis*). *Purshia tridentata* may codominate or even dominate some stands. *Artemisia arbuscula* ssp. *arbuscula*-dominated shrublands commonly occur within this system on rocky or windblown sites. Other common shrubs include *Symphoricarpos* spp., *Amelanchier* spp., *Ericameria nauseosa, Peraphyllum ramosissimum, Ribes cereum,* and *Chrysothamnus viscidiflorus*. *Artemisia tridentata* ssp. *wyomingensis* may be present to codominant if the stand is clearly montane as indicated by montane indicator species such as *Festuca idahoensis, Leucopoa kingii,* or *Danthonia intermedia*. Most stands have an abundant perennial herbaceous layer (over 25% cover, in many cases over 50% cover), but this system also includes *Artemisia tridentata* ssp. *vaseyana* shrublands. Common graminoids include *Danthonia intermedia,*

Festuca arizonica, Festuca idahoensis, Hesperostipa comata, Poa fendleriana, Elymus trachycaulus, Bromus carinatus, Poa secunda, Leucopoa kingii, Deschampsia caespitosa, Calamagrostis rubescens, and *Pseudoroegneria spicata*. Species of *Achnatherum* are common, including *Achnatherum nelsonii* ssp. dorei, *Achnatherum nelsonii* ssp. nelsonii, *Achnatherum hymenoides,* and others. In many areas, wildfires can maintain an open herbaceous-rich steppe condition, although at most sites, shrub cover can be unusually high for a steppe system (>40%), with the moisture providing equally high grass and forb cover.
Range: This system is found at montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the southern Rockies. In British Columbia, it occurs in the southern Fraser Plateau and the Thompson and Okanagan basins.
Subnations: AZ?, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY

CES304.765 COLORADO PLATEAU MIXED BEDROCK CANYON AND TABLELAND
Division 304 (Inter-Mountain Basins); Barren

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.); Upland
Diagnostic Classifiers: Montane [Lower Montane]; Lowland [Foothill]; Shrubland (Shrub-dominated); Ridge/Summit/Upper Slope; Sedimentary Rock; Temperate [Temperate Xeric]; Alkaline Soil; Aridic
Concept Summary: The distribution of this ecological system is centered on the Colorado Plateau where it is comprised of barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and open tablelands of predominantly sedimentary rocks, such as sandstone, shale, and limestone. Some eroding shale layers similar to Inter-Mountain Basins Shale Badland (CES304.789) may be interbedded between the harder rocks. The vegetation is characterized by very open tree canopy or scattered trees and shrubs with a sparse herbaceous layer. Common species include *Pinus edulis, Pinus ponderosa, Juniperus* spp., *Cercocarpus intricatus,* and other short-shrub and herbaceous species, utilizing moisture from cracks and pockets where soil accumulates.
Comments: Geographically restricted and distinct from the related, but broader Inter-Mountain Basins Cliff and Canyon (CES304.779). Bare shale areas are not extensive as in shale badlands.
Range: Colorado Plateau.
Subnations: AZ, CO, NM, UT

RIPARIAN, WETLAND, AND MESIC ECOLOGICAL SYSTEMS

CES306.821 ROCKY MOUNTAIN LOWER MONTANE–RIPARIAN WOODLAND AND SHRUBLAND
Division 306 (Rocky Mountain); Woody Wetland

Spatial Scale & Pattern: Linear

Required Classifiers: Natural/Semi-natural; Vegetated (>10% vasc.)
Diagnostic Classifiers: Lower Montane; Riverine / Alluvial; Mineral: W/ A-Horizon <10 cm; Unconsolidated; Short (<5 yrs) Flooding Interval; Short (50–100 yrs) Persistence
Concept Summary: This system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevation range from approximately 900 m to 2,800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. This system is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate stream banks. They can form large stands on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. Dominant trees may include *Acer negundo, Populus angustifolia, Populus balsamifera, Populus deltoides, Populus fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides,* or *Juniperus scopulorum.* Dominant shrubs include *Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea,* or *Symphoricarpos* spp. *Elaeagnus angustifolia* and *Tamarix* spp. are common in some stands. The upland vegetation surrounding this riparian system ranges from grasslands to forests.
Range: Found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevation range from approximately 900 m to 2,800 m. It is also found in the island mountain ranges of central and eastern Montana.
Subnations: AZ, CO, ID, MT, NM, NV, OR, SD, UT, WY

Appendix B

Plot and Observation Point Instructions and Data Forms

Introduction

This appendix contains the forms and instruction manuals used for collecting field data for the NCPN Vegetation Mapping Project at Timpanogos Cave National Monument. Two types of data were collected: vegetation plot and observation point. Vegetation plots were used primarily in developing the NVC classification for the Monument. They were also used by photointerpreters to help recognize aerial photo signatures. Observation points were used primarily for assisting with photointerpretation, and secondarily for supporting NVC association descriptions and documenting non-standard vegetation types. No map accuracy assessment data were collected in TICA.

Appendix B.1. Plot and Observation Point Field Sampling Manual

Timpanogos Cave National Monument
A Basic Guide for Field Work Modified for the 2007 Field Season

This document is intended to give you general instructions and guidelines for conducting your field work at Timpanogos Cave National Monument. Detailed, field-by-field coding conventions for the primary form you'll be completing in the field (the Plot Survey form) are provided in the 'cheat sheet' at the back of this guide. You will also be taking Observation Points on a form reduced from and similar to the Plot Survey form.

OVERVIEW

The data that you collect this year will be used to create a relatively fine-scale delineation of vegetation pattern in this Northern Colorado Plateau Network (NCPN) park and its environs. The range of habitats and the corresponding diversity of vegetation types, found in this park are complex. The understanding of finer-scale, ecologically distinct vegetation types that you will help create may be used by the park to plan appropriate management activities, monitor the results of these activities, track long-term changes in vegetation, direct searches for rare species, model fire behavior, and portray the wealth of natural diversity on park lands to the public.

Plot location will be guided by aerial photographs, staff advice, and topographic maps, with the goal of adequately sampling the vegetation. A classification based on this sampling will result in interpretation of aerial photos to produce a vegetation map. A combination of manual and electronic digitizing approaches will be used for Timpanogos Cave National Monument to delineate polygons and label the vegetation types. The vegetation "types" the photo interpreters will choose to name their polygons are included within the U.S. National Vegetation Classification System (Grossman et al. 1998).

The field crew will evaluate the field data, assign a preliminary vegetation type based on a list of potential vegetation types developed from the existing literature, and update the tally of vegetation types by number of plots still needed. The goal is to use your time as efficiently as possible: we are trying our best to avoid oversampling of some types and undersampling of others. Deciding where to sample to capture the full range of diversity throughout the Monument is an iterative process.

GETTING THERE

You will have a copy of the 1:6,000-scale orthophotography to guide you. You will navigate towards each selected photo-signature using your Monument road and trail map, USGS 7.5 mm. topographic map, the photo, and/or GPS.

Before you leave on a trip...check that you have all the materials needed to complete your field work (Please see the checklist and 'considerations for mission planning" at the end of this document to help you).

Every single morning... check your GPS receiver to make sure it is set to NAD 83.

Along the way... look around. The goal of this field work is to sample all the different vegetation types that occur in Timpanogos Cave National Monument. If, on the way to one vegetation type, you see an assemblage of plants that seems unique, please sample if time allows.

ONCE THERE

Establishing a Plot

Figure out where to place your plot. This is a subjective process. You'll want to place your plots in areas that seem to be both relatively **homogenous** and **representative** of the vegetation of the signature as a whole. Avoid areas where the vegetation appears to be transitioning from one type to another (ecotones) and areas with anomalous or heterogeneous structure or species composition. Look at all the vegetation strata to determine if the area is structurally and floristically uniform and generally try to place your plots at least 30 m from what you see as the 'boundary' between this vegetation type and any neighboring, distinctly different types. During the training period this step will be emphasized and discussed in detail. However, the rule-of-thumb is to conduct a reconnaissance of the plot area if time and topography allows.

Using your GPS (Global Positioning System) receiver, record the UTM (Universal Transverse Mercator) coordinates in the center of the plot under the Field UTM X and Field UTM Y on the field form. Also mark and label the location of the plot on a USGS 7.5 min. topographic map and/or on an aerial photo. If you cannot obtain a GPS reading, estimate UTMs from the USGS topographic map and note on the form that you had to resort to this method. Plots may be circular, rectangular or square. Note shape and dimensions on the field form. If the plot is rectangular or square, record the azimuth of the long side (any side if square) to help relocate the plot. It may make more sense to establish rectangular plots in linear vegetation types (e.g. riparian or ridgeline types). Standard plot sizes should be as follows:

If you're in a ...	**You should make your plot…**	**Giving you a plot area of…**
Forest (trees have overlapping crowns usually forming 60-100% cover)	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Woodland (open stands of trees with crowns usually not touching. Canopy tree cover is 10-60% OR exceeds shrub, dwarf-shrub, herb, & nonvascular cover).	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Shrubland (shrubs greater than 0.5 m tall are dominant, usually forming more than 10% cover OR exceeding tree, dwarf shrub, herb, & nonvascular cover)	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Dwarf-shrubland (shrubs less than 0.5 m tall are dominant, usually forming more than 10% cover OR exceeding tree, shrub, herb, & nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Herbaceous (herbs dominant, usually forming more than 10 percent cover OR exceeding tree, shrub, dwarf-shrub, & nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Nonvascular (lichen or moss cover dominant, usually more than 10% cover).	2.82 m radius OR 5 m x 5 m	25 m^2 25 m^2

Note: You can deviate from the standard plot shapes where that makes sense, but the total plot area encompassed by the boundaries should be as listed above for each major class of vegetation. For example, forested riparian vegetation may be sampled in a more linear 10 x 40 m (400 m2) plot; herbaceous riparian or ridgeline vegetation in a 2 x 50 m (100m2) plot. You may also increase the size of the plot to the next standard size if necessary to sample the heterogeneity of the vegetation. Forests, woodlands and shrublands can be increased to 1000 m2. Please make a note on plot form..

3) Once the plot is established, it is generally a good time to fill out the **Identifiers/Locators** part of your Plot Survey Form (see the cheat sheet) and take the plot photos.

Taking photographs

Two color photos will be taken of each plot using slide film. The purpose is to obtain a good representation of the vegetation of the plot, not individual species. A piece of paper (or a chalk board or dry erase board) should be placed in the plot, with the plot number recorded on it, so that the photo includes the plot number. Preprinted plot numbers could be printed or copied onto colored paper (white has such strong contrast as to be unreadable in the photo) and attached to the back of a clipboard. This saves having to write plot numbers in the field. Take the photograph looking across the contour if the slope is steep. Record roll #, frame # and azimuth on plot form.

Data Collection

Environmental Description

See the coding instructions at the end of this document for guidance on the specific fields.

Vegetation Description

For guidance on the specific fields on the second page of the form, see the coding instructions.

As you begin to collect the species, DBH (diameter at breast height – 4.5'), and cover information, keep these rules in mind they will speed your data collection considerably:

1) Except in very diverse plots, don't spend more than **20 minutes** looking for new species to record. Remember that these plot data are to be used to classify the overall vegetation of the Monument, not to make a complete species list for it. If you had to spend much more than 20 minutes to find a species, it probably isn't going to be important in characterizing the vegetation type. For diverse plots with over 25 taxa you may take up to 30 minutes on the listing process.

2) If you can't identify a plant to species, record it on your form as "unknown species 1,' "unknown species 2,' "*Carex* unknown sp. I", etc. Record associated cover class and other data for the unknown as you would for any other species. Then do one of two things:

If you need the species identified right away because it appears to be dominant or diagnostic (you're seeing it all over the place or you're seeing much more in this particular vegetation type than in others), take a sample of the species with as much of the plant as possible, especially intact sexual parts (flowers and fruits), if present. Place the sample in a baggie, and label the baggie (or specimen) with the plot code and the name you gave it on the data form.

If you don't need the plant keyed right away, press it. Mark the pressed specimen with the plot code and the name you gave it on the data form.

Store specimens in a cool, dry place. Bagged specimens will keep fresh longer in the refrigerator or ice chest until pressed or identified. You can key some of these out yourself if you want to, but don't let plant keying get in the way of your primary responsibility: field data *collection*. No one expects you to identify every plant but you should make an effort to learn at least the common species that keep recurring in plots. A quick prioritization of what to key and what to press may be made based on the recurrence of the species in samples and on the cover-class estimate of the species in a particular plot. If the species has a high cover value (>1%) it is more of a priority to identify. Field crews should mark the specimen tag with its cover class estimate as well as its unique identifying number for the vegetation sample.

Observation Point Form

When you have sampled one particular vegetation type thoroughly, but want to further define its distribution or when you encounter small but unique vegetation patches that are below the minimum

mapping unit in size (<1.5 ha), record the site on an Observation Point form. This is an abbreviated Plot Survey form and usually takes about 15 minutes to fill in the data. The major difference is that an Observation Point is unbounded and includes an area roughly equal to that of the minimum mapping unit (20 m radius around the observer) or it encompasses the entirety of a small but unique vegetation patch. The data fields are the same as those on the Plot Survey form, so use the above instructions. Minor differences in the Observation Point form from the Plot Survey form include the elimination of some data fields, more general cover classes for ground cover estimates, and only the dominant or diagnostic species are recorded. In addition, only one photo is taken to record the Observation Point plant community.

Accuracy Assessment Point Form

You will navigate to pre-selected coordinates within polygons, scout out the polygon briefly to get a feel for what it is like, and record some general data to characterize it on an Accuracy Assessment Point form. This is also an abbreviated version of the Plot Survey form, much like the Observation Point form, and the same cheat sheet can be used to help with filling it out. A sample completed Accuracy Assessment Point form is provided at the end of this document.

We hope your field season on the northern Colorado Plateau enjoyable and rewarding. Good luck!

LITERATURE CITED

Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K., Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia.

The Nature Conservancy [TNC]. 1998. An environmentally-driven approach to vegetation sampling and mapping at Yosemite National Park. Report prepared for the U.S. Department of the Interior, National Biological Survey and National Park Service. The Nature Conservancy, Arlington, Virginia.

INSTRUCTIONS FOR FILLING OUT PLOT AND OBSERVATION POINT SURVEY FORMS

PLOT DESCRIPTION

Plot Code

Code indicating the specific plot within the vegetation polygon. For the 2007 field season, the codes will be in the following format "PARK ACRONYM.XXX" (i.e., Timpanogos Cave National Monument = "TICA.XXX"). Begin with TICA.00l and go from there. If another team is working, decide which plot numbers each team will use to identify the data they gather. For example, if a second team is working at Timpanogos Cave National Monument and approximately 100 plots have already been collected, they may number their plots TICA.125 through TICA.150.

Provisional Community Name

Using the provisional classification of the parks with which you've been provided, assign the name of the vegetation type that most closely resembles this type. Enter the finest level of the classification possible. In fact, none of the names may be a good fit; you may have found a new type. If that is the case, create a provisional name with the dominant and diagnostic species. The 'provisional community name' that is assigned will be used to update the tally of types x number of plots needed.

State UT.

Park Name TICA

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 or park map.

Quad Name

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

Field UTM X

Use GPS, but if you can't obtain a GPS reading, estimate coordinates from a topographic map and note on the form that this method was used.

Field UTM Y

Use GPS, but if you can't obtain a GPS reading, estimate coordinates from a topographic map and note on the form that this method was used.

GPS Error

Note the error in the GPS reading off the unit.

Survey Date

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

Surveyors

Names of surveyors, with principal surveyor (usually the Lead Ecologist) listed first.

Directions to Plot

Precise directions to the site using a landmark (e.g., a named point on the topographic map, a major highway, using park naming conventions for roads) readily locatable on a 7.5 minute topographic or park map as the starting point. Use clear sentences that will be understandable to someone who is unfamiliar

with the area and has only your directions to follow. Give distances as closely as possible to the 0.1 mile and use compass directions. Give additional directions to the plot within the site. Do not take more than a couple of minutes to fill this out.

Plot Length and Width
Enter diameter for circular plots and 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	11.3 m radius or 20 m x 20 m	400 m^2
Woodland	11.3 m radius or 20 m x 20 m	400 m^2
Shrubland	5.65 m radius or 10 m x 10 m	400 m^2
Dwarf-shrubland	5.65 m radius or 10 m x 10m	100 m^2
Herbaceous	5.65 m radius or 10 m x 10 m	100 m^2
Nonvascular	2.82 m radius or 5 m x *5* m	25 m^2

Plot Photos/ Roll Number/Frame Numbers
Indicate (Y or N) if photos of the plot were taken at the time of sampling, and their roll and frame numbers. Also record azimuth of the photo if not taken in the standard direction.

Plot Permanent (if/when applicable)
Check off that the plot has been permanently marked.

Plot Representativeness
Does this plot represent the full variability of the photo signature? If not, were additional plots taken? Note additional species not seen in the plot in the space provided below. 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.

ENVIRONMENTAL DESCRIPTION
Elevation
Elevation of the plot. Specify whether in feet or meters. We have determined that the reading you obtain from a topographic map, provided you are certain where you are, is more accurate than the average reading from the GPS unit. Thus, please attempt to estimate your elevation with the topographic map.

Slope
Measure the slope in degrees using a clinometer.

Aspect
Measure the slope aspect using a compass (be sure to correct for the magnetic declination). Note: all compasses should be pre-set to an average declination for the park and thus, readings from the compasses carried by the field crews may be directly noted.

Topographic Position
Topographic position of the plot. 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.

High slope (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.
High level (mesa). Level top of a plateau.
Midslope (transportational midslope, middle slope). Intermediate slope position.
Step in slope (ledge, terracette). Level shelf interrupting a steep slope, rock wall, or cliff face.
Lowslope (lower slope, foot slope, colluvial footslope). Gently inclined surface at the base of a slope. Surface profile is usually concave and transitions between midslope 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.
Low level (terrace). Valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.

Landform
Enter the landform that describes the site where the plot was taken. Note on the code sheet the landform choices are listed at different scales. Thus, one can select more than one for plot if appropriate (e.g., mountain could be macro and ridge could be meso scale). Please be consistent so we can analyze by landform. Appendix A provides definitions for most of the landforms you will use.

Surficial Geology
Note the surface substrate influencing the plant community (bedrock, colluvium, talus, alluvium, etc.). We will not be recording the specific geologic unit.

Cowardin System
If the system is a wetland, check off the name of the USFWS system which best describes its hydrology and landform. Indicate "upland" if the system is not a wetland.
Assess the hydrologic regime of the plot using the descriptions below (from Cowardin et al. 1979).

Semipermanently flooded - Surface water persists throughout growing season 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 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 flood-plain 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.
Permanently Flooded - Water covers the land surface at all times of the year in all years. Equivalent to Cowardin's "permanently flooded."
Unknown - The water regime of the area is unclear. The unit is described as a non-tidal wetland.

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.

Unvegetated Surface
Estimate the approximate percentage of the *total* surface area covered by each category. Only include categories with over 5 percent cover.

Soil Texture
Using the key below, assess average soil texture (Brewer and McCann 1982)

A1 Soil does not remain in a ball when squeezed.....sand
A2 Soil remains in a ball when squeezed..... B

B1 Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger.
Soil makes no ribbon.....loamy sand
B2 Soil makes a ribbon; may be very short C

C1 Ribbon extends less than 1 inch before breaking ..... D
C2 Ribbon extends 1 inch or more before breaking .....E

D1 Add excess water to small amount of soil
Soil feels at least slightly gritty ..... loam or sandy loam
D2 Soil feels smooth ..... silt loam

E1 Soil makes a ribbon that breaks when 1 to 2 inches long;
Cracks if bent into a ring .....F
E2 Soil makes a ribbon 2+ inches long; does not crack when bent into a ring .....G

F1 Add excess water to small amount of soil;
Soil feels at least slightly gritty ..... sandy clay loam or clay loam
F2 Soil feels smooth ..... silty clay loam or silt

G1 Add excess water to a small amount of soil;
Soil feels at least slightly gritty ..... sandy clay or clay
G2 Soil feels smooth ..... silty clay

Soil Drainage
The soil drainage classes are defined in terms of (l) 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. We recognize 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 be used as criteria of moisture status. We also know that soil profile morphology, such as mottling, normally but not always reflects soil moisture status; however, 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.

Rapidly drained - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water addition. Soils are free from any evidence of gleying throughout the profile. Rapidly drained soils are commonly coarse textured or soils on steep slopes.
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. Soils are usually free from mottling in the upper 3 feet, but may be mottled below this depth. B horizons, if present, are reddish, brownish, or yellowish.
Moderately well drained - The soil moisture in excess of field capacity remains for a small but significant period of the year. Soils are commonly mottled (chroma <2) in the lower B and C horizons or below a depth of 2 feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils and in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.
Somewhat poorly drained - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are commonly mottled in the B and C horizons; the Ac horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.
Poorly drained - The soil moisture in excess of field capacity remains in all horizons for a large part of the year. The soils are usually very strongly gleyed. Except in high-chroma parent materials the B, if present and upper C horizons usually have matrix colors of low chroma. Faint mottling may occur.
Very poorly drained - Free water remains at or within 12 inches of the surface most of the year. The soils are usually very strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to bluish hues. Mottling may be present but at the depth in the profile. Very poorly drained soils usually have a mucky or peaty surface horizon.

VEGETATION DESCRIPTION

Leaf Phenology

Select the value that 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 admixed.
Perennial - Herbaceous vegetation composed of more than 50% perennial species.
Annual - Herbaceous vegetation composed of more than 50% annual species.

Leaf Type

Select one value that 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).
Microphyllous - Woody cover primarily microphyllous.
Graminoid - Herbaceous vegetation composed of more than 50 percent graminoid 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 fern-like leaves.

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, respectively.
Shrubland - Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 10% cover, trees generally less than 10% cover). Shrub cover may be less than 10% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover. Vegetation dominated by woody vines is generally treated in this class.
Dwarf-Shrubland - Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 10% cover, trees and tall shrubs generally less than 10% cover). Dwarf-shrub cover may be less than 10% where it exceeds tree, shrub, herb, and nonvascular cover, respectively
Herbaceous - Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 10% cover; trees, shrubs, and dwarf-shrubs generally with less than 10% cover). Herb cover may be less than 10% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively. 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, respectively.
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 10% and greater than 0%).

Strata/Lifeform, Height, Cover, 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 5 m in height or greater at maturity and under optimal growing conditions. Shrubs are defined as multiple-stemmed woody plants generally less than 5 m in height at maturity and under optimal growing conditions.

Herbaceous layers are: Ht = total, H1 = Graminoids (grass, sedge, rush), H2 = Forbs (Dicot herbaceous), H3 = Ferns and Fern allies, and H4 = tree seedlings. List the dominant species in each stratum. If a species present is known to be diagnostic of a particular vegetation type, mark them with an asterisk.

Cover Scale for Strata		**Height Scale for Strata**	
T	<1%	01	<0.5 m
P	1-5%	02	0.5-1 m
1	5-15%	03	l-2 m
2	15-25%	04	2-5 m
3	25-35%	05	5-10 m
4	35-45%	06	10-15 m
5	45-55%	07	15-20 m
6	55-65%	08	20-35 m

7	65-75%	09	35-50 m
8	75-85%	10	>50 m
9	85-95%		
10	95+		

Animal Use Evidence
Comment on any evidence of use of the plot/polygon by non-domestic animals (i.e., tracks, scat, gopher 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.

Other Comments
Any other comments.

Species Percent Cover Table
Starting with the uppermost stratum, list all the species present and cover class (using the 12 point scale) and percent cover of each species in that particular stratum. Indicate strata in the left-hand columns. If in the tree layer (single-stemmed woody plants, generally 5 m in height or greater at maturity), note in the "T" column if Tl (emergent tree), T2 (tree canopy), or T3 (tree sub-canopy). If in the shrub layer, note in the "5', column if S1 (tall shrub,> 2m), S2 (short shrub, <2m), or S3 (dwarf-shrub <0.5m). If in the ground layer, note in the "G" column if H1 (herbaceous - graminoid), H2 (herbaceous - forb), H3 (herbaceous - fern), H4 (tree seedlings) N (nonvascular other than ferns), V (vine/liana), or F (epiphyte).

*For plots with trees, estimate cover of seedlings, saplings, mature (all others), and total cover for each tree species. Use a separate line for each and assign the most appropriate strata class (by height). Seedlings are generally less than 1.5 m, but that may vary by species.

TIMPANOGOS CAVE NATIONAL MONUMENT – CHEAT SHEET

LANDFORMS

alluvial fan
alluvial flat
alluvial plain
remanant
alluvial terrace
alluvium
artificial levee
backslope
bajada
ballena
basin
basin floor
bench
blowout
bluff
borrow pit
bottomland
braided stream
break
butte
canyon
channel
cliff
closed depression
colluvium
crest
cuesta
deflation basin
depression
desert pavement
dip
ditch
divide
drainageway
draw
dune
eolian deposit
eolian sands
ephemeral stream
escarpment
finger ridge
flat
flood plain
foothills
gorge
gravel pit
gulch
gully
hill
hillslope
interdune
interfluve
intermittent stream
knob
knoll
ledge
levee
mesa
natural levee
overflow channel
pediment
plain
plateau
playa
pool
quarry
ravine
ridge
rise
rim
rockfall
saddle
sand ramp
sand sheet
scarp
shoulder
slope
slope alluvium
slope wash
stream terrace
summit
swale
taluse slope
tank
terrace
toeslope
valley
valley floor
valley side
wash

TOPOGRAPHIC POSITION

SEE THE ATTACHED DIAGRAM

VEGETATIVE STRATA

T1 = emergent tree
T2 = tree canopy
T3 = tree sub-canopy
S1 = tall shrub > 2m
S2 = short shrub < 2m
S3 = dwarf shrub < 0.5m
H = herbaceous
H4 = Tree seedlings
N = nonvascular other than ferns

PHYSIOGNOMIC CLASS

Forest: Crowns touching
Woodland: Trees>10%, crowns not touching
Shrubland: Shrubs> grass, forbs or trees
Dwarf Shrubland: Shrubland <0.5 m tall
Shrub Herbaceous: Shrubs = Forbs/grasses
Herbaceous: Grass/forbs > trees or shrubs
Wooded Herbaceous: Trees= grass/forbs
Sparsely Vegetated: Total veg<5-7%

ASPECT

Flat
Azimuth (deg.)
Variable

GPS SETTINGS

NAD1983
WAAS on

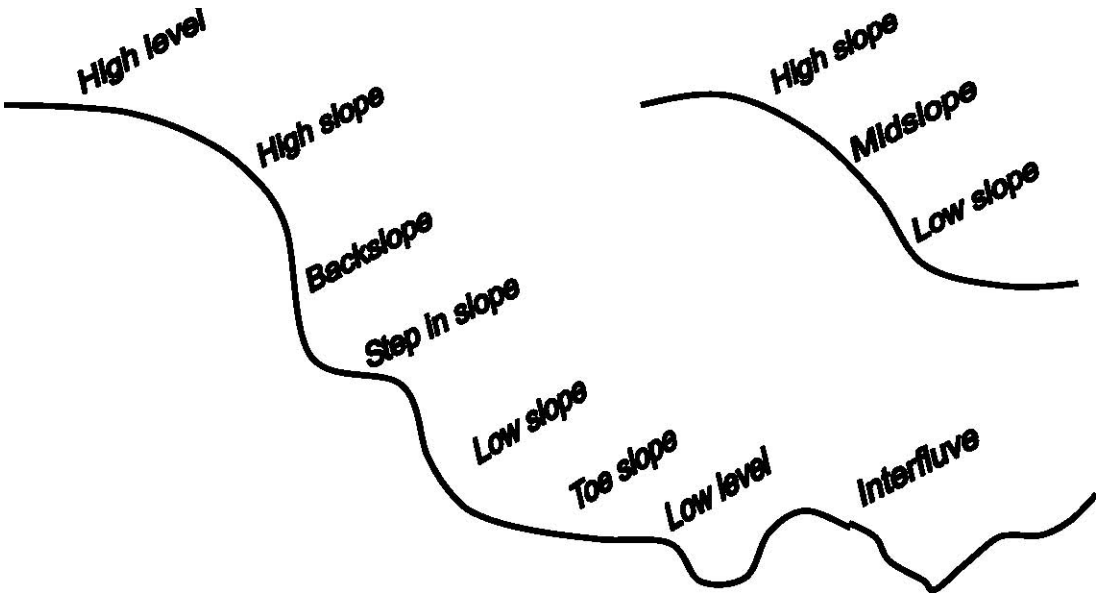
SURFICIAL GEOLOGY

Obscured by soil
Quaternary Alluvium
Do not distinguish the individual bedrock units – just note that bedrock is exposed
Colluvium / Talus / Landslides

DISTURBANCE

Water gullies
Mass wasting
Spruce budworm damage
Flash flooding
Grazing evidence
Development, historic structures
Recreation
Wildlife concentration
Fire

TOPOGRAPHIC POSITION - CHEAT SHEET



CONSIDERATIONS FOR MISSION PLANNING

Planning for the day:

1. Safety and sustenance: Plenty of food, water, first-aid kit, raingear, sunscreen.
2. Field communications:
   a. Develop a plan with other team(s) for radio check-in time.
   b. Do you have a radio and are batteries charged? If you have a walkie talkie, do you have extra batteries for it? Does park staff know the area in which you will be working?
3. Make sure you have the right maps and photos.
4. Check your GPS (Datum set to NAD83? WAAS on? Needs new batteries?).
5. Plan the day's mission before departing using a) USGS quads, b) aerial photo, c) BLM maps.
6. Considerations for mission planning:
   a. Plan travel based on topography, best access routes, density and complexity of vegetation
   b. Communicate with the other team member(s) to make sure you aren't duplicating effort.

Planning for the week (do this on the first day of the trip)

1. Do you have all appropriate maps, photos?
2. Develop a reasonable estimate of the number of points for each team broken up by day and based on an estimate of individual team's travel logistics for the week.
3. Develop plan of attack for the week to capture all AA points in the work area.
4. Balance points two and three above with the expected work schedule of the teams and ensure adequate time-off and reduce over-time concerns.
5. Do you have all necessary information and backups for the week's planning? E.g., blank field forms, film, plenty of batteries.

Wrapup (Do this on the last day of the trip, after you have returned to base)

1. Clean, recharge and repair equipment.
2. Hold brief meeting to discuss data collection issues, things that came up during the work week, and plan for next work hitch.
3. Edit field forms and file them systematically. File observation points separately.
4. Re-file the aerial photos and maps.
5. Send exposed rolls of film to be developed.
6. Key unknown plants.
7. Enter edited data into database.

Communicate among teams / Topics for wrap-up meetings.

1. What were your questions about the polygons visited during the week?
2. Do you have any questions about the forms or fields?
3. What was accomplished, what was not accomplished?
4. Pass on developments and questions after every trip. Don't let them build up. For example, should we sample the new types we saw? Were there problems with interpreting the aerial photos, or are there personnel issues, problems in consistency in interpreting the forms, or with park-related logistics?

Materials checklist

- Research permit
- Topo maps
- Monument and BLM maps for general navigation
- DOQQ photos of AA point locations
- Geology map
- Compass with adjustable declination
- Clinometer
- GPS reciever
- Extra AA batteries for walkie-talkie
- Radio or walkie-talkie and/or cell phone
- 35 mm camera & slide film (allow at least 2 exposures per point)
- Baggies for temporary storage of unknown plants, and masking tape for labeling
- Plant press & paper
- Plant Keys / Flora(s)
- Pencils / sharpies
- Forms: plot and observation point
- Clipboard/forms holder
- Pens, pencils, pencil lead, slate board, chalk, and chalkboard eraser or supply of clean rags
- Key to the plant associations of the park
- All ancillary information (cheat sheet, species list, floras, sampling priority list for zone, main sampling protocol)
- First aid kit, personal gear (food, water, rain gear, etc.)

APPENDIX A: Landform Glossary

(from http://soils.usda.gov/technical/handbook/contents/part629glossary1.html)

alluvial fan - A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes, shaped like an open fan or a segment of a cone, deposited by a stream (best expressed in semiarid regions) at the place where it issues from a narrow mountain or upland valley; or where a tributary stream is near or at its junction with the main stream. It is steepest near its apex which points upstream and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

alluvial flat (a) (colloquial: western US) A nearly level, graded, alluvial surface in bolsons and semi-bolsons which commonly does not manifest traceable channels, terraces or floodplain levels. (b) (**not preferred**) A general term for a small flood plain bordering a river, on which alluvium is deposited during floods.

alluvial terrace - (not preferred) refer to stream terrace.

alluvium - Unconsolidated, clastic material subaerially deposited by running water, including gravel, sand, silt, clay, and various mixtures of these.

arroyo - (colloquial: southwest A.) The channel of a flat-floored, ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material; sometimes called a wash. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed. Where arroyos intersect zones of ground-water discharge, they are more properly classed as intermittent stream channels.

backslope - The hillslope profile position that forms the steepest and generally linear, middle portion of the slope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below. They may or may not include cliff segments (i.e. free faces). Backslopes are commonly erosional forms produced by mass movement, colluvial action, and running water.

bench - (not preferred) refer to structural bench.

bluff - (a) A high bank or bold headland, with a broad, precipitous, sometimes rounded cliff face overlooking a plain or body of water, especially on the outside of a stream meander; ex. a river bluff. (b) (not preferred) use cliff. Any cliff with a steep, broad face.

bottomland - (not recommended) use flood plain. An obsolete, informal term loosely applied to a flood plain.

break - An abrupt change or inflection in a slope or profile, or a marked variation of topography, or a tract of land distinct from adjacent land, or an irregular or rough piece of ground.

breaks - (colloquial: western US) A landscape or large tract of steep, rough or broken land dissected by ravines and gullies and marks a sudden change in topography as from an elevated plain to lower hilly terrain, or a line of irregular cliffs at the edge of a mesa or a river (e.g., the Missouri River breaks).

channel - (a) The hollow bed where a natural body of surface water flows or may flow. The deepest or central part of the bed of a stream, containing the main current and occupied more or less continuously by water. (b) (colloquial: western US.) The bed of a single or braided watercourse that commonly is barren of vegetation and is formed of modern alluvium. Channels may be enclosed by banks or splayed across and slightly mounded above a fan surface and include bars and mounds of cobbles and stones.

colluvium - Unconsolidated, unsorted material being transported or deposited on sideslopes and/or at the base of slopes by mass movement (e.g. direct gravitational action) and by local, unconcentrated runoff.

debris flow - Mass transport process involving a slurry of sediment (of a variety of different grain sizes from clays to boulders) and water; debris flows can be a common process by which sediments are transported onto alluvial fans in desert regions.

ditch - An open and usually unpaved (unlined), channel or trench excavated to convey water for drainage (removal) or irrigation (addition) to or from a landscape; smaller than a canal; some ditches are modified natural waterways.

drainageway - (a) A general term for a course or channel along which water moves in draining an area. (b) a term restricted to relatively small, roughly linear or arcuate depressions that move concentrated water at some time, and either lack a defined channel (e.g. head slope, swale) or have a small, defined channel (e.g. low order streams).

draw - A small, natural watercourse cut in unconsolidated materials, generally more open with a broader floor and

more gently sloping sides than an arroyo, ravine or gulch, and whose present stream channel may appear inadequate to have cut the drainageway that it occupies.

ephemeral stream - Generally a small stream, or upper reach of a stream, that flows only in direct response to precipitation. It receives no protracted water supply from melting snow or other sources and its channel is above the water table at all times.

escarpment - A continuous, steep slope or cliff produced by erosion or faulting and that topographically interrupts or breaks the general continuity of more gently sloping land surfaces. The term is most commonly applied to cliffs produced by differential erosion. Synonym = scarp.

flat - (a) (adjective) Said of an area characterized by a continuous surface or stretch of land that is smooth, even, or horizontal, or nearly so, and that lacks any significant curvature, slope, elevations, or depressions. (b) (noun) An informal, generic term for a level or nearly level surface or small area of land marked by little or no local relief.

flood plain - The nearly level plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a constructional landform built of sediment deposited during overflow and lateral migration of the streams.

gulch - (colloquial: western US.; not preferred - refer to ravine) A small stream channel, narrow and steep-sided in cross section, and larger than a gully, cut in unconsolidated materials. General synonym - ravine.

gully - A small channel with steep sides caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water usually during and immediately following heavy rains or ice / snow melt. A gully generally is an obstacle to wheeled vehicles and too deep (e.g., > 0.5 m) to be obliterated by ordinary tillage; (a rill is of lesser depth and can be smoothed over by ordinary tillage).

intermittent stream - A stream, or reach of a stream, that does not flow year-round (commonly dry for 3 or more months out of 12) and whose channel is generally below the local water table; it flows only when it receives a) base flow (i.e. solely during wet periods), or b) ground-water discharge or protracted contributions from melting snow or other erratic surface and shallow subsurface sources.

overflow channel - A watercourse that is generally dry but conducts flood waters that have overflowed the banks of a river, commonly from large storms or annual meltwater.

plateau - A comparatively flat area of great extent and elevation; specifically an extensive land region considerably elevated (more than 100 meters) above adjacent lower-lying terrain, and is commonly limited on at least one side by an abrupt descent, has a flat or nearly level surface. A large part of a plateau surface is near summit level.

ravine - A small stream channel; narrow, steep-sided, commonly V-shaped in cross section and larger than a gully, cut in unconsolidated materials. General synonym (not preferred) - gulch.

rim - The border, margin, edge, or face of a landform, such as the curved brim surrounding the top part of a crater or caldera; specifically the rimrock of a plateau or canyon.

rockfall - The process, associated sediments (rockfall deposit) or resultant landform characterized by a very rapid type of *fall* dominated by downslope movement of detached rock bodies which fall freely through the air or by leaps and bounds (lacks an underlying slip face); also spelled rock fall.

saddle - A low point on a ridge or interfluve, generally a divide (pass, col) between the heads of streams flowing in opposite directions.

scarp - An escarpment, cliff, or steep slope of some extent along the margin of a plateau, mesa, terrace, or structural bench. A scarp may be of any height.

shoulder - The hillslope profile position that forms the convex, erosional surface near the top of a hillslope. If present, it comprises the transition zone from summit to backslope.

slope - (also called slope gradient or gradient) The inclination of the land surface from the horizontal. Percent slope is the vertical distance divided by the horizontal distance, then multiplied by 100.

slope alluvium - Sediment transported down mountain or hill slopes primarily by non-channel alluvial processes (i.e., slope wash) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of coarse fragments and may be separated by stone lines. Sorting of pebbles or cobbles distinguish these materials from unsorted colluvium.

slope wash - A collective term for non-fluvial, incipient alluvial *processes* (e.g. overland flow, minor rills) that detach, transport, and deposit sediments down hill and mountain slopes. Related sediments (*slope alluvium*) exhibit nominal sorting or rounding of particles, peds, etc., and lateral sorting downslope on long slopes; stratification is crude and intermittent and readily destroyed by pedoturbation and frost action. Also called *slope wash processes*.

stream terrace - One or a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream, and representing the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition (i.e., currently very rarely or never floods; inactive cut and fill and/or scour and fill processes). Erosional surfaces cut into bedrock and thinly mantled with stream deposits (alluvium) are called “strath terraces.” Remnants of constructional valley floors thickly mantled with alluvium are called alluvial terraces.

swale - (a) A shallow, open depression in unconsolidated materials which lacks a defined channel but can funnel overland or subsurface flow into a drainageway. Soils in swales tend to be more moist and thicker (cummulic) compared to surrounding soils. (b) A small, shallow, typically closed depression in an undulating ground moraine formed by uneven glacial deposition. (c) (not preferred; refer to interdune) A long, narrow, generally shallow, trough-like depression between two beach ridges, and aligned roughly parallel to the coastline.

talus - Rock fragments of any size or shape (usually coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of loose broken rock formed chiefly by falling, rolling, or sliding.

terrace - A step-like surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, or lake or sea shore. The term is usually applied to both the relatively flat summit surface (tread), cut or built by stream or wave action, and the steeper slope (scarp, riser), descending to a lower base level. Practically, terraces

toeslope - The hillslope position that forms the gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear, and are constructional surfaces forming the lower part of a hill-slope continuum that grades to valley or closed-depression floors.

valley - An elongate, relatively large, externally drained depression of the Earth's surface that is primarily developed by stream erosion or glacial activity.

valley floor - A general term for the nearly level to gently sloping, lowest surface of a valley. Landforms include axial stream channels, the flood plain, flood-plain steps, and, in some areas, low terrace surfaces.

valley side - The sloping to very steep surfaces between the valley floor and summits of adjacent uplands. Well-defined, steep valley sides have been termed valley walls (not recommended). Note: Scale, relief, and perspective may require use of closely related terms such as hill slope or mountain slope.

wash (dry wash) - (colloquial: western US.) The broad, flat- floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in alluvium. Note: When channels reach intersect zones of ground-water discharge they are more properly classed as “intermittent stream” channels. Synonym - arroyo.

Appendix B.2. Example of a Vegetation Plot Data Form

NATIONAL PARK VEGETATION MAPPING PROGRAM: PLOT SURVEY FORM
IDENTIFIERS/LOCATORS

Plot Code (Please Circle One): GOSP-PISP-TICA B-5 205

Provisional Community Name JUNIPER WOODLAND

State UT Park Name (Circle One) Golden Spike, Pipe Spring, Timpanogos Park Site Name VISITOR CENTER

Quad Name _____ Quad Code _____ Quad Code _____ Aerial Photo # _____

GPS file name _____ Field UTM X 440170 m E Field UTM Y 4477036 m N
DATUM _____ UTM Zone: 12 Error +/- _____ m 3D Differential? Y / N
Comments/GPS device used:

Survey Date 6 29 07 Surveyors CONDIE

Directions to Plot FROM THE VISITOR CENTER HIKE UP THE TRAIL AROUND THE FIRST SWITCHBACK TO A LARGE TALUS SLOPE. HIKE STRAIGHT UP THE TALUS. THE PLOT IS AT THE VERY TOP OF THE LARGE ROCK OUTCROP ON THE WEST SIDE OF THE TALUS SLOPE.
Plot Permanent: NO

Plot length(m)_____ Azimuth _____ Plot Photos (y/n) __ Roll # BC9 Frame # 17, 18, 19
Plot width(m)_____ Diameter if circle_____ Digital camera frame # _____

Photo Comments: Cryptogamic Soils Photos (y/n) __ Roll # _____ Frame # _____
Digital camera frame # _____

Plot representativeness (discuss plot placement and explain non-representativeness)
a. Representativeness of association compared with occurrences outside park (if known):

b. Representativeness of plot in stand: THIS PLOT IS MEANT TO DESCRIBE THE COMMUNITY FOUND ON THE BARE BEDROCK OUTCROPS THAT JUT OUT OF THE SIDE OF THE MOUNTAIN.

ENVIRONMENTAL DESCRIPTION

Elevation: 1917 ft/m (circle one) Slope: SEE NOTES deg. Aspect: _____ deg.
Topographic Position (see cheat sheet) HIGH SLOPE
Landform (see cheat sheet) PINNACLE
Surficial Geology (see cheat sheet/map)

Cowardin System: X Upland ___ Palustrine ___ Riverine ___ Lacustrine

Hydrology: ___ Unknown ___ Permanently Flooded ___ Seasonally Flooded ___ Temporarily Flooded ___ Semipermanently Flooded ___ Saturated ___ Intermittently Flooded

Environmental Comments (factors controlling community/plant distribution, seral stage, fire history etc): THE PLOT WAS CENTERED ON A PINNACLE OF ROCK STICKING OUT OF THE MOUNTAIN. THE SIDES OF THE ROCK AVERAGE 50°. THE TWO ASPECTS ARE 310° AND 10R°. PLANTS ARE GROWING IN CRACKS IN THE BEDROCK.

Ground Cover: *(please estimate to the nearest percentage. Sum = 100%)*

T Bare soil	5 Large rocks (>10 cm)
92 Bedrock	— Lichen
— Sand (0.1-2 mm) dune /alluvium	1 Wood (>1 cm)
T Moss	T Small rocks (0.2-10 cm)
— Other (describe):	— Water
1 Litter / duff	— Cryptogam

Soil Texture (see cheat sheet):
___ sand ___ loamy sand ___ sandy loam X loam
___ silt loam ___ silt ___ clay loam ___ silty clay
___ sandy clay ___ clay ___ peat ___ muck

Soil Drainage:
X Rapidly drained ___ Well drained
___ Moderately well drained ___ Somewhat poorly drained
___ Poorly drained ___ Very poorly drained

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic Class	Height Scale for Strata	Cover Scale for Strata
Trees and Shrubs X Evergreen __Cold-deciduous __Mixed evergreen-cold-deciduous Herbs __Annual __Perennial	__Broad-leaved X Needle-leaved __Microphyllous __Graminoid __Forb __Pteridophyte __Non-vascular __Mixed (describe)	__Forest X Woodland __Shrubland __Dwarf Shrubland __Shrub Herbaceous __Herbaceous __Nonvascular __Sparsely Vegetated	01 <0.5 m 02 0.5-1m 03 1-2 m 04 2-5 m 05 5-10 m 06 10-15 m 07 15-20 m 08 20-35 m 09 35 – 50 m 10 >50 m	T 0-1% P >1-5% 1 >5-15% 2 >15-25% 3 >25-35% 4 >35-45% 5 >45-55% 6 >55-65% 7 >65-75% 8 >75-85% 9 >85-95% 10 >95%

	Height Class	Cover Class	Dominant Species (mark Diagnostic species with *)
T1 Emergent			
T2 Canopy	05	P	ABI CON*, PSE MEN*
T3 Sub-canopy	04	1	JUN SCO*
S1 Tall shrub	04	2	QUE GAM*
S2 Short Shrub	02	P	CER INT
S3 Dwarf-shrub	01	P	NAPPLOPAPPUS WATSONII
Ht Herbaceous			
H1 Graminoids	01	P	ELY SPI, POA FEN, LEUCOPOA KINGII
H2 Forbs	01	P	ERIOG BREV, ERIGERON ARENARIOIDES
H3 Ferns			
H4 Tree seedlings			
N Non-vascular			
V Vine/liana			
E Epiphyte			

Animal Use Evidence (including scat, browse, burrows, bedding sites, etc) A PILE OF DEER SCAT IS RIGHT AT THE PEAK OF THE PINNACLE.

Natural and Anthropogenic Disturbance Comments (see cheat sheet for examples; describe intensity and effect on the vegetation, also whether disturbance is current, chronic, episodic or historic)

THIS SITE IS UNDISTURBED.

Other Comments/Continuation from previous sections. **Describe surrounding communities and how they relate to the plot.**

THIS COMMUNITY CAN BE SEEN TO REPEAT ON OTHER NEARBY OUTCROPS IN VARYING DENSITIES AND MIXES. THE JUNIPER IS GNARLED AND AT FIRST GLANCE LOOKS LIKE A J. OSTEOSPERMA. TALUS SLOPES DOTTED WITH DOUG AND WHITE FIR SURROUND THIS ROCK. SOME ROCK OUTCROPS IN THE PARK ARE DOMINATED BY CERCOCARPUS INTRICATUS, BUT THAT SHRUB HAS A MINOR ROLE AT THIS SITE.

Plot Code (Please Circle One): GOSP-PISP-(TICA) B5 205

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, and total cover indicating stratum. **List species outside the plot at the end of the table and designate with a 0 in Cover Class column.**

Stratum	Species Name	Cover Class	Stratum	Species Name	Cover Class	Stratum	Species Name	Cover Class	TOTALS
T2	ABICON	3							
	PSEMEN	2							
									T1 =
T3	JUN SCO	7							T2 =
									T3 =
S1	QUE GAM	10							S1 =
									S2 =
S2	CER INT	1							S3 =
									H1 =
S3	HAP WAT	1							H2 =
									H3 =
H1	ELY SPI	T							H4 =
	POA FEN	T							N =
	LEU KIN	T							V =
									E =
H2	ERI BRE	T							
	ERI ARE	T							
	ERIGERON ARENARIOIDES								

Cover Class Scale:	Strata:
T = >0-1%	T1 = Emergent
P = >1-5%	T2 = Canopy
1 = >5-15%	T3 = Subcanopy
2 = >15-25%	S1 = Tall Shrub
3 = >25-35%	S2 = Short Shrub
4 = >35-45%	S3 = Dwarf Shrub
5 = >45-55%	H1 = Graminoid
6 = >55-65%	H2 = Forb
7 = >65-75%	H3 = Fern
8 = >75-85%	H4 = Tree seedling
9 = >85-95%	N = Nonvascular
10 = >95%	V = Vine/liana
	E = Epiphyte

Appendix B.3. Example of an Observation Point Data Form

NATIONAL PARK VEGETATION MAPPING PROGRAM: OBSERVATION POINT FORM

IDENTIFIERS/LOCATORS

Plot Code (Please Circle One): GOSP PISP (TICA) BO-5 1205

Provisional Community Name: CERCOCARPUS INTRICATUS

State: UT ark Name (Pleae Circle One): Golden Spike, Pipe Spring, (Timpanogos) Park Site Name: MAIN TRAIL

Quad Name: Quad Code:

GPS File Name: Field UTM X: 439567 mE Field UTM Y: 4476772 mN

Please do not complete the following information when in the field: +/- m

Corrected UTM X: mE Corrected UTM Y: mN Zone:

Observers: CONDIE Date: 6 28 07 Photos: BC 9 # 12

ENVIRONMENTAL DESCRIPTION

Elevation: 1883 Slope: 42 deg. Aspect: 14 deg.

Topographic Position: MIDSLOPE

Landform: RIDGE Geology:

Cowardin Wetland Classification System

- X Upland
- ___ Estuarine
- ___ Riverine
- ___ Palustrine
- ___ Lacustrine

Hydrologic Regime - Non Tidal

- ___ Permanently Flooded
- ___ Semi-permanently Flooded
- ___ Seasonally/Temporarily Flooded
- ___ Saturated
- ___ Seasonally Flooded/Saturated
- ___ Intermittently Flooded

Environmental Comments: THE ROCKY EXPOSED RIDGE SEEMS TO FAVOR CER INT. OTHER SPECIES SHOW UP IN MORE SHELTERED SPOTS

Unvegetated Surface (*please use cover scale below*)

- 04 Bedrock
- 01 Rocks >10 cm
- 01 Rocks 0.2-10 cm
- — Sand
- ___ Other (describe)
- 01 Bare Soil
- 01 Litter/Duff
- 01 Wood

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic Class	Cover Scale for Strata and Unvegetated Surface
Trees and Shrubs X Evergreen ___ Cold-deciduous ___ Drought-deciduous ___ Mixed evergreen/ cold-deciduous Herbs ___ Annual ___ Perennial	X Broad-leaved ___ Needle-leaved ___ Microphyllous ___ Graminoid ___ Forb ___ Pteridophyte ___ Mixed (describe)	___ Forest ___ Woodland X Shrubland ___ Dwarf shrubland ___ Shrub Herbaceous ___ Herbaceous ___ Nonvascular ___ Sparsely vegetated	01 = 0 - 10% 02 = 10 - 25% 03 = 25 - 60% 04 = 60 - 100%

NATIONAL PARK VEGETATION MAPPING PROGRAM: OBSERVATION POINT FORM

Stratum	Height	Cover Class	Dominant species (mark diagnostic spp with a *)	% cover
T1: Emergent				
T2: Canopy	05	01	PSE MEN	2
T3: Sub-canopy				
S1: Tall shrub	03	01	QUE GAM	3
S2: Short shrub	02	01	CER INT	5
			HOL DUM	2
			CER MON	1
H: Herbaceous	01	01	GALLIUM MULTIFLORUM	T
N: Non-vascular				
V: Vine/liana				
E: Epiphyte				

Height Scale for strata:

01 = <0.5 m	06 = 10-15m
02 = 0.5-1m	07 = 15-20m
03 = 1-2m	08 = 20-35m
04 = 2-5m	09 = 35-50m
05 = 5-10m	10 = >50m

Cover scale for strata and Unvegetated Surface:

01 = 0 - 10%
02 = 10 - 25%
03 = 25 - 60%
04 = 60 - 100%

Appendix C

C.1. Plots Database Documentation

Background

This database, designed for data resulting from fieldwork related to vegetation mapping projects, was developed by the Northern Colorado Plateau Network (NCPN). The Plots Database System, developed by The Nature Conservancy, was the starting point for this database. From this starting point, NCPN normalized the data structure, added fields and lookup tables, and developed an extensive user interface. Similar versions of this database, subsequently referred to as the TICA VegMapDB, have been used for all vegetation mapping projects conducted by NCPN. TICA VegMapDB contains plot and observation point data collected during project field work.

Two database files are required to use TICA VegMapDB:

- *TICA_Plots.mdb*. This "frontend" file contains all queries, forms, reports, associated modules and Visual Basic code.
- *TICA_Plots _be.mdb*. This "backend" file contains the database tables.

The frontend/backend file structure allows multiple users to enter data in a network environment, and allows for easy backup and transfer of the data tables. Users typically launch the frontend file, and a utility will prompt them to establish a link to the backend file. The contents of the backend file, however, can be used independently of the frontend.

Entity Relationship Diagram

The primary tables and relationships from the backend file (TICA_Plots_be.mdb) are illustrated below. The database follows the design structure of the National Park Service Natural Resource Database Template, which is based on a location record, one or more related event records, and observation data elements linked to each event.

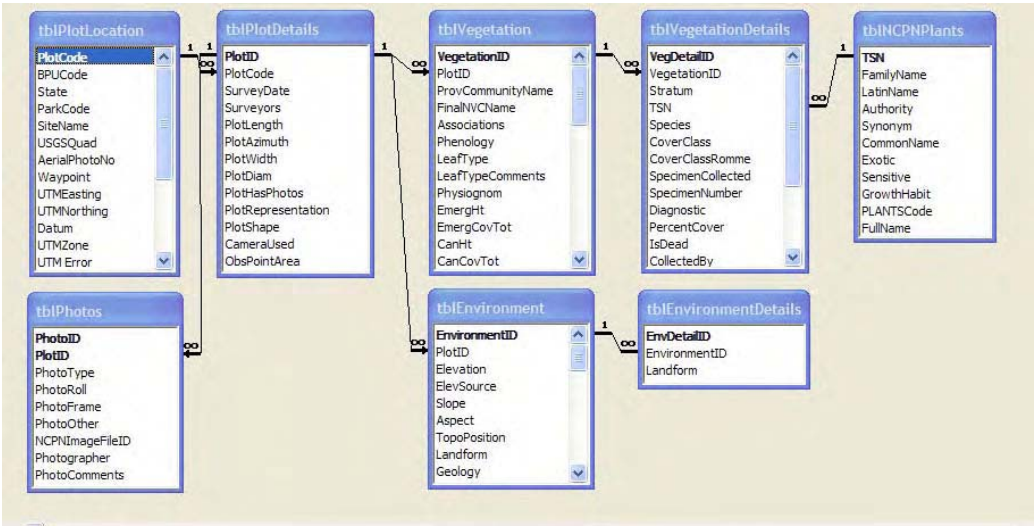


Figure 1. Entity Relationship Diagram for TICA VegMapDB

Data Dictionary

The database consists of two types of tables: plot data and lookup tables (which provide a standardized list of values to be used for certain data fields). Tables appear in alphabetical order within each of these two categories.

Plot-related tables

Table Name: tblDataMgmtLog
Description: Table containing a log of data set manipulations or database object alterations.

Field Name	Field Description	Field Type	Field Width
ActionDate	The date on which the data set was massaged or manipulated.	dbDate	8
ActionMonth	If ActionDate known to month only, use this and the ActionYear field.	dbText	50
ActionYear	If ActionDate known to year only, use this field.	dbText	50
Action	What was done with the data set. How was it altered, massaged, manipulated, etc. Include changes to data and changes to database objects or structures.	dbMemo	0
Who	The name of the person who performed the action with the data set	dbText	50

Table Name: tblEnvironment
Description: Table containing values for environmental features / conditions of plot or observation point.

Field Name	Field Description	Field Type	Field Width
EnvironmentID	Unique record identifier	dbLong	4
PlotID	Foreign key; links record to tblPlotDetails	dbLong	4
Elevation	Elevation of plot in meters as estimated from either map or GPS unit	dbLong	4
ElevSource	How elevation was derived in the field (GPS or Quad Map)	dbText	50
Slope	Slope of plot measured in degrees	dbText	4
Aspect	Aspect of plot	dbText	50
TopoPosition	Topographic position of plot; value selected from tlkpTopography	dbText	50
Landform	Landform on which plot is located; value selected from tlkpLandform	dbText	50
Geology	Geologic substrate influencing the plant community; value selected from tlkpGeology	dbText	75
CowardinSystem	If the plot is in a wetland system, select term that best describes its hydrology; value selected from tlkpCowardin	dbText	12
Hydrology	Select value that best describes hydrology of plot from tlkpHydrology	dbText	50
EnvironmentalComments	Comments on environmental setting and its effect on the vegetation; also comments on any disturbance or reproduction factors	dbMemo	0
BareSoil	Estimate to the nearest percentage of bare soil ground cover	dbText	3
Bedrock	Estimate to the nearest percentage of bedrock ground cover	dbText	3

Field Name	Field Description	Field Type	Field Width
Sand	Estimate to the nearest percentage of sand (particle size 0.1-2mm) ground cover	dbText	3
Moss	Estimate to the nearest percentage of moss ground cover	dbText	3
Other	Estimate to the nearest percentage of other type of ground cover	dbText	3
Litter	Estimate to the nearest percentage of litter ground cover	dbText	3
Rocks	Estimate to the nearest percentage of rocks >10cm wide ground cover	dbText	3
Lichen	Estimate to the nearest percentage of lichen ground cover	dbText	3
Wood	Estimate to the nearest percentage of wood >1cm ground cover	dbText	3
Gravel	Estimate to the nearest percentage of rocks <10cm wide ground cover	dbText	3
Water	Estimate to the nearest percentage of water ground cover	dbText	3
Cryptogam	Estimate to the nearest percentage of cryptogram ground cover	dbText	3
SoilTexture	Assessment of average soil texture from sample taken a few inches below the surface; values selected from tlkpSoilTexture	dbText	50
SoilDrainage	Soil drainage class based on actual moisture content and extent period; values selected from tlkpSoilDrainage	dbText	30
AnimalUseComments	Comments on evidence of use by non-domestic animals in plot area	dbMemo	0
DisturbanceComments	Comments on evidence of natural or anthropogenic disturbance in plot area, severity and effects on vegetation	dbMemo	0
OtherComments	Other general comments	dbMemo	0
LandscapeComments	Description of landscape context of plot, including any important landscape features influencing the community	dbMemo	0
SoilTaxonDesc	Field used for either identifying soils keyed, or to describe if large rocks or outcrops are present on the surface	dbText	255
LiveVegLitter	Estimate to the nearest percentage of live veg litter ground cover	dbText	3
LiveVegWood	Estimate to the nearest percentage of live veg wood ground cover	dbText	3
LiveBasalArea	n/a for TICA	dbText	4
LichenRocks	Estimate to the nearest percentage of lichen covering rocks	dbText	3
LichenGround	Estimate to the nearest percentage of lichen ground cover (on the soil, associated with cryptogams)	dbText	3
MossPct	Estimate to the nearest percentage of moss ground cover	dbText	3

Field Name	Field Description	Field Type	Field Width
DarkCyanobacteria	Estimate to the nearest percentage of dark cyanobacteria ground cover	dbText	3
TotalPct	Calculated total percent of ground cover.	dbInteger	2

Table Name: tblEnvironmentDetails
Description: Table containing values of environmental features and conditions of plot or observation point.

Field Name	Field Description	Field Type	Field Width
EnvDetailID	Unique record identifier	dbLong	4
EnvironmentID	Foreign key; links to tblEnvironment	dbLong	4
Landform	Landform value corresponding to plot location; values chosen from tlkpLandform	dbText	50

Table Name: tblFuels
Description: Table containing details of fuels characteristics of plot.

Field Name	Field Description	Field Type	Field Width
FuelsID	Not used for TICA plots	dbLong	4
PlotID	Not used for TICA plots	dbLong	4
PPDFPhotoGuide	Not used for TICA plots	dbText	3
PJPhotoGuide	Not used for TICA plots	dbText	3
SBPhotoGuide	Not used for TICA plots	dbText	3
PJAgeClass	Not used for TICA plots	dbText	15
LitterOrigin	Not used for TICA plots	dbText	3
LitterNorth	Not used for TICA plots	dbText	3
LitterEast	Not used for TICA plots	dbText	3
LitterSouth	Not used for TICA plots	dbText	3
LitterWest	Not used for TICA plots	dbText	3
DuffOrigin	Not used for TICA plots	dbText	3
DuffNorth	Not used for TICA plots	dbText	3
DuffEast	Not used for TICA plots	dbText	3
DuffSouth	Not used for TICA plots	dbText	3
DuffWest	Not used for TICA plots	dbText	3
IsSubplot	Not used for TICA plots	dbBoolean	1

Table Name: tblFuelsDetails
Description: Not used for TICA plots.

Field Name	Field Description	Field Type	Field Width
FuelsDetailID	Not used for TICA plots	dbLong	4
FuelsID	Not used for TICA plots	dbLong	4
StemCount	Not used for TICA plots	dbInteger	2
StemDiameter	Not used for TICA plots	dbDouble	8
TSN	Not used for TICA plots	dbDouble	8
WoodlandCrownWidth	Not used for TICA plots	dbDouble	8
WoodlandCrownHeight	Not used for TICA plots	dbDouble	8
ForestCrownBaseHeight	Not used for TICA plots	dbDouble	8
ForestCrownHeight	Not used for TICA plots	dbDouble	8
CrownRatio	Not used for TICA plots	dbText	12
StructureStage	Not used for TICA plots	dbText	12
Comments	Not used for TICA plots	dbText	255

Table Name: tblGeneralPhotos

Description: Information pertaining to photos not associated with plots.

Field Name	Field Description	Field Type	Field Width
GenPhotoID	Unique record identifier	dbLong	4
GenPhotoDate	Date photo taken	dbText	50
GenPhotographer	Name of photographer	dbText	75
GenPhotoParkCode	Park Code	dbText	4
GenPhotoDesc	General description of photo contents	dbText	250
GenPhotoAssocName	Association name	dbText	50
GenPhotoUTME	UTME of photo	dbLong	4
GenPhotoUTMN	UTMN of photo	dbLong	4
GenUTMZone	UTMZone of photo UTM coordinates	dbLong	4
GenPhotoRoll10	Roll number of photo	dbText	50
GenPhotoFrame	Frame number of photo	dbText	10
GenPhotoDigFile	Digital file name of photo	dbText	50
ImageFileID	New image file name as indicated in NCPN Photo Database	dbText	50
GenPhotoComments	General comments	dbText	250

Table Name: tblGeneralSpecimens
Description: Table used for data on specimens collected outside of plots or observation points but within the park.

Field Name	Field Description	Field Type	Field Width
GenSpecimenID	Unique record identifier	dbLong	4
GenSpecFamily	Family name of species collected	dbText	50
GenSpecLatinName	Latin name of species collected	dbText	120
GenSpecCollector	Name of person collecting specimen	dbText	50
GenSpecCollectNum	Reference of specimen assigned by collector	dbText	50
GenSpecAccNumber	NPS Accession Number of specimen	dbText	15
GenSpecCatNumber	NPS Catalog Number of specimen	dbText	15
GenSpecDate	Date collection made	dbDate	8
GenSpecUTMN	Northing of collection location	dbLong	4
GenSpecUTME	Easting of collection location	dbLong	4
GenSpecCounty	County of collection location	dbText	50
GenSpecElev	Elevation (ft) of collection location	dbLong	4
GenSpecLocality	Description of locality where specimen was collected	dbText	250
GenSpecHabitat	Description of habitat where specimen was collected	dbText	250
GenSpecAssocSpec	Associated species where specimen was collected	dbText	250
GenSpecComments	General comments	dbText	250

Table Name: tblPhotos
Description: Details of individual photos taken of plot or observation point.

Field Name	Field Description	Field Type	Field Width
PhotoID	Unique record identifier	dbLong	4
PlotID	Foreign key, links to tblPlotDetails	dbLong	4
PhotoType	Type of photo being referenced	dbText	16
PhotoRoll	Reference number for film roll of photo	dbText	12
PhotoFrame	Frame number of photo within roll	dbText	50
PhotoOther	Other unique identifier or reference number for digital photo or name of movie file	dbText	25

Field Name	Field Description	Field Type	Field Width
NCPNImageFileID	NCPN PhotoDatabase digital image file name.	dbText	50
Photographer	Name of photographer	dbText	50
PhotoComments	Brief description of photo	dbText	255

Table Name: tblPlotDetails
Description: Information for a plot that is specific to a visit.

Field Name	Field Description	Field Type	Field Width
PlotID	Unique identifier for record	dbLong	4
PlotCode	Foreign key, links to tblPlotLocation	dbText	10
SurveyDate	Date plot was visited and data collected	dbDate	8
Surveyors	Names of persons collecting data at plot (last names)	dbText	75
PlotLength	Length of plot, in meters	dbText	5
PlotAzimuth	Azimuth of plot; synonymous with aspect. One or the other, or both, can be used	dbText	5
PlotWidth	Width of plot, in meters	dbText	5
PlotDiam	Diameter of plot, in meters, if plot is circular	dbText	5
PlotHasPhotos	Yes if photos are taken of plot	dbBoolean	1
PlotRepresentation	Description or discussion of representativeness of plot in stand, and in comparison to associations outside the park (if known)	dbMemo	0
PlotShape	Shape of plot	dbText	15
CameraUsed	Make and model of camera used to photograph plot	dbText	50
ObsPointArea	Estimated size of observation point	dbText	50

Table Name: tblPlotLocation
Description: Basic and unchanging information for plot or observation point location.

Field Name	Field Description	Field Type	Field Width
PlotCode	Identifier assigned to plot by survey crew	dbText	10
BPUCode	Biophysical unit code where plot is located. Numbers before the slash refer to the BPU number, while numbers after the slash are unique identifiers for the plot. N/a means the plot was not in a BPU.	dbText	25
State	State where plot is located	dbText	2
ParkCode	Park unit where plot is located	dbText	4
SiteName	Short, descriptive name of site where plot is located	dbText	100
USGSQuad	USGS quadrangle (1:24K) where plot is located	dbText	50
AerialPhotoNo	Aerial photo number corresponding to plot location	dbText	10
Waypoint	Garmin plot code	dbText	7
UTMEasting	UTM easting of plot	dbText	50
UTMNorthing	UTM northing of plot	dbText	7
Datum	Datum of UTM coordinates	dbText	10
UTMZone	UTM zone of coordinates	dbText	4
UTMError	error, in meters, of location data (based on reading from Garmin GPS unit)	dbText	5
PDOP	satellite Precision Dilution of Position (based on	dbText	50

Field Name	Field Description	Field Type	Field Width
	reading from Trimble GPS unit)		
DiffCorrected	Indicate if coordinates have been differentially corrected	dbText	3
DirectionsTo Plot	Precise directions to plot	dbMemo	0
County	County where plot is located	dbText	50
GPSUnit	Manufacturer and model of GPS unit (e.g., Trimble GeoExplorer 3)	dbText	25
GPSComments	Any brief comments on GPS data collection at plot	dbText	255
InPark	Select Yes if plot is within park boundaries	dbBoolean	1
IsObservationPt	Yes if observation point.	dbBoolean	1

Table Name: tblVegetation
Description: Overall vegetation characteristics of a plot or observation point.

Field Name	Field Description	Field Type	Field Width
VegetationID	Unique record ID	dbLong	4
PhotoID	Foreign key, links to tblPlotDetails	dbLong	4
ProvCommunityName	Community name (provisional) assigned by field crews by following naming protocols as described in field manual and training 04/04.	dbText	120
FinalNVCName	Final community name, provided by NatureServe	dbText	100
Associations	Association corresponding to provisional community name	dbText	100
Phenology	Leaf phenology of the dominant stratum. Field is blank for non-vascular plots	dbText	35
LeafType	Leaf form of the dominant stratum	dbText	20
LeafTypeComments	If Leaf Type is "mixed," this field describes the multiple leaf types found in the dominant stratum	dbText	255
Physiognom	Physiognomic class of plot (from tllkPhysiogClass)	dbText	20
EmergHt	Height class of emergent stratum (classes are in tlkpHeightClass)	dbText	2
EmergCovTot	Cover class of emergent stratum (classes are in tlkpCover)	dbText	4
CanHt	Height class of canopy stratum	dbText	2
CanCovTot	Cover class of canopy stratum	dbText	50
SubHt	Height class of subcanopy stratum	dbText	2
SubCovTot	Cover class of subcanopy stratum	dbText	4
TallShHt	Height class of tall shrub stratum	dbText	2
TallShCovTot	Cover class of tall shrub stratum	dbText	4
ShrubHt	Height class of short shrub stratum	dbText	2
ShrubCovTot	Cover class of short shrub stratum	dbText	4
DwarfHt	Height class of dwarf shrub stratum	dbText	2
DwarfCovTot	Cover class of dwarf shrub stratum	dbText	4
HerbHt	Height class of herbaceous stratum (all H layers)	dbText	2
HerbCovTot	Cover class of herbaceous stratum (all H layers)	dbText	4
GramHt	Height class of graminoid stratum	dbText	2

Field Name	Field Description	Field Type	Field Width
GramCovTot	Cover class of graminoid stratum	dbText	4
ForbHt	Height class of forb stratum	dbText	2
ForbCovTot	Cover class of forb stratum	dbText	4
FernHt	Height class of fern and fern ally stratum	dbText	2
FernCovTot	Cover class of fern and fern ally stratum	dbText	4
SeedlHt	Height class of seedling stratum	dbText	2
SeedlCovTot	Cover class of seedling stratum	dbText	4
NonvasHt	Height class of nonvascular stratum	dbText	2
NonvasCovTot	Cover class of nonvascular stratum	dbText	4
VineHt	Height class of vine stratum	dbText	2
VineTotCov	Cover class of vine stratum	dbText	4
EpiHt	Height class of epiphyte stratum	dbText	2
EpiTotCov	Cover class of epiphyte stratum	dbText	4
OutsidePlotHt	Height class of species occurring outside plot	dbText	50
OutsidePlotTotCov	Cover class of species occurring outside plot	dbText	50
Alliance	Alliance name	dbText	100

Table Name: tblVegetationDetails
Description: Species and strata-specific data related to a plot or observation point.

Field Name	Field Description	Field Type	Field Width
VegDetailID	Unique record ID	dbLong	4
VegetationID	Foreign key; links to tblVegetation	dbLong	4
Stratum	Strata class from tlkpStrata	dbText	2
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
Species	Latin name of species, from tblNCPNPlants	dbText	100
CoverClass	Cover class to describe species and strata (from tlkpCover)	dbText	4
CoverClassRomme	n/a for TICA	dbText	50
SpecimenCollected	Check yes if a specimen of the species was collected	dbBoolean	1
SpecimenNumber	Enter the collector's reference number for the specimen collected	dbText	50
Diagnostic	Check yes if the species is known to be diagnostic of the vegetation type	dbBoolean	1
PercentCover	Percent (0-100) cover of each species	dbLong	4
IsDead	Check yes if the species being documented was dead	dbBoolean	1
CollectedBy	Name of person making collection	dbText	50
NPSAccessionNumber	Accession number of specimen	dbText	50
NPSCatalogNumber	Unique reference number for individual specimen assigned by park curator	dbText	50
SpecimenLocality	Brief description of where collection was made	dbText	250
SpecimenHabitat	Description of habitat where collection was made	dbText	250
SpecimenAssocSpecies	Description of associated species where collection was made	dbText	250

Table Name: tblFinalAssociationNames
Description: Table containing final Association Names assigned by NatureServe.

Field Name	Field Description	Field Type	Field Width
PlotCode	Identifier assigned to plot by survey crew	dbText	255
Assocation_Name	Association Name assigned by NatureServe	dbText	255
Elcode	Unique ID assigned by NatureServe	dbText	255
Translated_Name	Translated Association Name assigned by NatureServe	dbText	255

Lookup tables

Table Name: tblNCPNPlants
Description: Master look-up table for plant species names and taxonomic information. Derived from ITIS (USDA - Integrated Taxonomic Information System)

Field Name	Field Description	Field Type	Field Width
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
FamilyName	Family name of taxon	dbText	255
LatinName	Latin name of taxon	dbText	255
Authority	Authority of Latin name	dbText	255
Synonym	Accepted synonyms of taxon	dbText	255
CommonName	Locally accepted common name for taxon	dbText	255
Exotic	Check yes if species is exotic	dbBoolean	1
Sensitive	Check yes if species is threatened, endangered, or sensitive	dbBoolean	1
GrowthHabit	Select GrowthHabit for species -- habit can vary based on region; edit as needed to reflect habit in park	dbText	255
PLANTSCode	Code for taxonomic unit assigned by USDA PLANTS	dbText	255
FullName	temporary field; concatenation of Latin name and authority	dbText	255

Table Name: tlkpAlliances
Description: Look-up of provisional community names.

Field Name	Field Description	Field Type	Field Width
Alliance	Alliance name from NatureServe classification	dbText	100

Table Name: tlkpAssociations
Description: Look-up of association names.

Field Name	Field Description	Field Type	Field Width
Associations	Association names from NatureServe classification	dbText	100

Table Name: tlkpCamera
Description: Lookup of Camera make/models used for plot photos.

Field Name	Field Description	Field Type	Field Width
CameraType	Model and make of camera used for photographs of plot	dbText	50
CameraComments	Additional comments on camera, including default focal length	dbText	50

Table Name: tlkpCover
Description: Look-up of cover classes assigned to species and strata in VegetationDetails.

Field Name	Field Description	Field Type	Field Width
CoverClass	Cover class code: T, P, 01a, 01b, 02, 03, ... 10	dbText	50
CoverClassDef	Cover class definition: T >0-1% P >1-5% 1a >5-10% 1b >10-15% 2 >15-25% 3 >25-35% 4>35-45% 5 >45-55% 6>55-65% 7>65-75% 8>75-85% 9>85-95% 10>95%	dbText	50

Table Name: tlkpCowardin
Description: Look-up of Cowardin system categories for Environment descriptions.

Field Name	Field Description	Field Type	Field Width
CowardinSystem	Cowardin system descriptors for environmental description of plot	dbText	50

Table Name: tlkpElevSource
Description: Lookup table of options for source of elevation data.

Field Name	Field Description	Field Type	Field Width
ElevSource	Source of elevation data entered on field forms	dbText	50

Table Name: tlkpGeology
Description: Look-up of geology types to describe substrate of plot.

Field Name	Field Description	Field Type	Field Width
Geology	Geology types used to describe substrate of plot or observation point	dbText	75

Table Name: tlkpHeightClass
Description: Look-up of height classes assigned to strata in VegetationDetails.

Field Name	Field Description	Field Type	Field Width
HeightClass	Height class code: 01, 02, ... 10	dbText	2
HeightClassDef	Height class definition: 01<.5m 02=.5-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m	dbText	50

Table Name: tlkpHydrology
Description: Look-up of hydrology types from Cowardin et al. 1979.

Field Name	Field Description	Field Type	Field Width
Hydrology	Hydrology descriptors for plots that are in a wetland or upland with intermittent flooding (dry wash)	dbText	50

Table Name: tlkpLandform
Description: Look-up of landforms in Veg Mapping Manual (from http://soils.usda.gov/technical/handbook/contents/part629glossary1.html).

Field Name	Field Description	Field Type	Field Width
Landform	Landforms from appendix 1 of field manual	dbText	50

Table Name: tlkpLeafPhen
Description: Look-up of phenology types to describe dominant stratum (from Veg Mapping Manual 04/04).

Field Name	Field Description	Field Type	Field Width
Phenology	Leaf phenology descriptors to describe dominant stratum	dbText	40

Table Name: tlkpLeafType
Description: Look-up of leaf form of dominant stratum (from Veg Mapping Manual 04/04).

Field Name	Field Description	Field Type	Field Width
LeafType	Leaf form description of the dominant stratum	dbText	35

Table Name: tlkpParks
Description: Look-up of parks in the Northern Colorado Plateau Network

Field Name	Field Description	Field Type	Field Width
ParkCode	Four-letter abbreviation for park name	dbText	4
ParkName	Full name of park where data were collected	dbText	50

Table Name: tlkpPhotoComments
Description: Lookup table of photo comments.

Field Name	Field Description	Field Type	Field Width
PhotoComments	Photograph comments	dbText	50

Table Name: tlkpPhotographer
Description: Lookup table of photographer names.

Field Name	Field Description	Field Type	Field Width
Photographer	Photographer name	dbText	50

Table Name: tlkpPhotoTypes
Description: Look-up of types of photos taken during data collection.

Field Name	Field Description	Field Type	Field Width
PhotoType	Type of photo taken, associated with plot	dbText	50

Table Name: tlkpPhysiogClass
Description: Look-up of physiognomic types to describe each plot or observation point.

Field Name	Field Description	Field Type	Field Width
Physiognom	Physiognomic class used to describe plot	dbText	50

Table Name: tlkpPJAge
Description: Look-up of Pinyon-Juniper age classes.

Field Name	Field Description	Field Type	Field Width
PJAgeClass	Pinyon- Juniper age class, if plot contains either of these two species	dbText	15

Table Name: tlkpPlotShapes
Description: Look-up of shapes of plots.

Field Name	Field Description	Field Type	Field Width
PlotShape	Shapes of plots	dbText	15

Table Name: tlkpSoilDrainage
Description: Look-up of soil drainage classes to describe plot or observation point.

Field Name	Field Description	Field Type	Field Width
SoilDrainage	Soil drainage classes used to describe soil where plot is located	dbText	30

Table Name: tlkpSoilTexture
Description: Look-up of soil textures based on Bowker 2003 field key for CANY, ARCH, and NABR.

Field Name	Field Description	Field Type	Field Width
SoilTexture	Look-up of soil textures based on Bowker 2003 field	dbText	15

Field Name	Field Description	Field Type	Field Width
	key for CANY, ARCH, and NABR	dbText	

Table Name: tlkpStates
Description: Look-up of all states in the USA.

Field Name	Field Description	Field Type	Field Width
StateCode	Two-letter abbreviation for each state	dbText	2
StateName	Full name of each state in the USA	dbText	50

Table Name: tlkpStrata
Description: Look-up of strata classes in VegetationDetails (from Veg Mapping Manual 04/04).

Field Name	Field Description	Field Type	Field Width
Stratum	T1=Emergent T2=Canopy T3=Subcanopy S1=Tall Shrub S2=Short Shrub S3=Dwarf Shrub H1=Graminoid H2=Forb H3=Fern H4=Tree Seedl N=Nonvasc V=Vine E=Epiphyte	dbText	3

Table Name: tlkpStructureStages
Description: Look-up of standard fuel model classes for forest and woodland trees.

Field Name	Field Description	Field Type	Field Width
StructureStage	Standard fuel model classes for forest and woodland trees indicating their canopy position	dbText	12

Table Name: tlkpSurveyors
Description: Look-up of data collection teams for 2007 TICA field season.

Field Name	Field Description	Field Type	Field Width
SurveyorName	Last names of crew members on 2007 TICA data collection team.	dbText	75

Table Name: tlkpTopography
Description: Look-up of topographic positions to describe where plot or observation point is located on its related landform.

Field Name	Field Description	Field Type	Field Width
TopoPosition	Topographic positions used to describe where plot or observation point is located on its related landform	dbText	50

Table Name: tlkpUSGS_Quad
Description: Look-up of all 7.5 minute USGS quads for TICA.

Field Name	Field Description	Field Type	Field Width
USGSQuad	Names of all 7.5 minute USGS quads for TICA	dbText	50
USGSQuadCode	n/a for TICA	dbText	7

Table Name: tlkpUTMZone
Description: Look-up for UTM zones of TICA

Field Name	Field Description	Field Type	Field Width
UTMZone	UTM zone where TICA plots were collected	dbText	5

C.2. Geodatabase Documentation

Background

The geodatabase was designed to consolidate all spatial and non-spatial (i.e., tabular) data from the TICA vegetation mapping project. In the geodatabase, feature classes were created for the spatial datasets, including plots, observation points, and polygons. These feature classes were then linked to the tables in the Plots database via relationship classes.

Entity Relationship Diagram

The primary tables and relationships for the geodatabase are illustrated below.

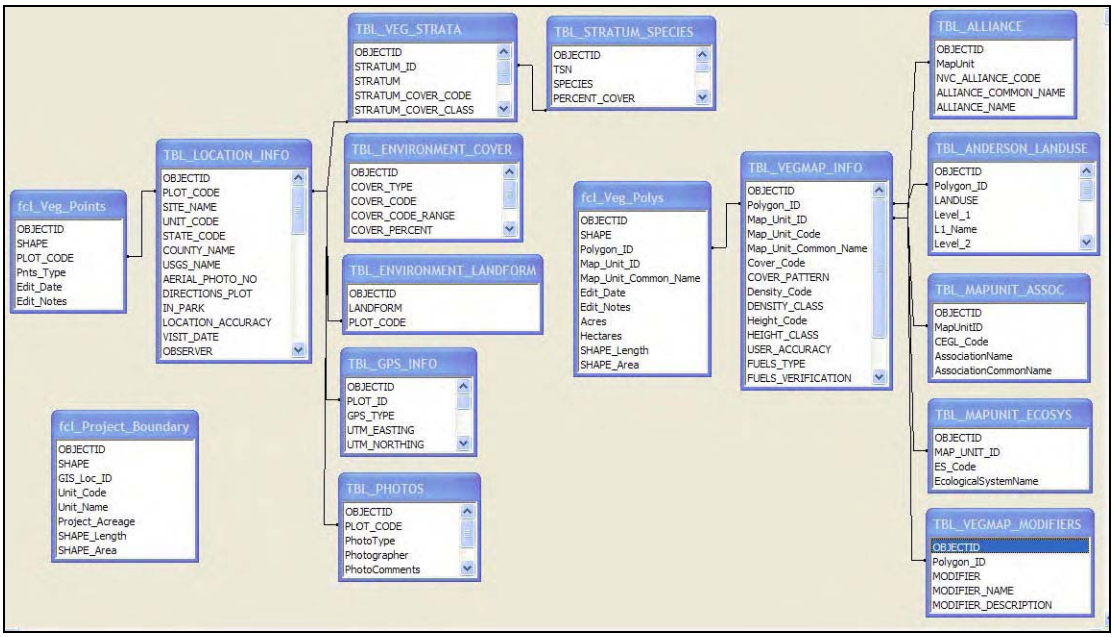


Figure 2. Entity Relationship Diagram for TICA Geodatabase

Data Dictionary

The geodatabase consists of two types of tables: spatial (i.e., feature classes), and non-spatial tables. Tables appear in alphabetical order within these two categories.

Spatial tables

Table Name: fcl_Project_Boundary
Description: The feature class of the boundary of the vegetation mapping project area.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
SHAPE	ESRI generated	dbLongBinary	0
GIS_Loc_ID	unique ID	dbText	128
Unit_Code	Four-letter park code (TICA)	dbText	10
Unit_Name	Full name of national park (Timpanogos Cave National Monument)	dbText	255
Project_Acreage	Acreage of project area	dbLong	4
SHAPE_Length	ESRI generated	dbDouble	8
SHAPE_Area	ESRI generated	dbDouble	8

Table Name: fcl_Veg_Points
Description: The feature class containing all point data associated with the vegetation project (Plots, Observations).

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
SHAPE	ESRI generated	dbLongBinary	0
PLOT_CODE	Unique Plot code, used for relating tables and feature class (TBL_LOCATION_INFO)	dbText	20
Pnts_Type	Type of point (plot, observation)	dbLong	4
Edit_Date	Date of any edits to the point or data	dbText	10
Edit_Notes	Notes regarding any edits.	dbText	255

Table Name: fcl_Veg_Polys
Description: The feature class displaying the vegetation mapping units for the park.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
SHAPE	ESRI generated	dbLongBinary	0
Polygon_ID	Unique polygon code, used for relating tables (TBL_VEGMAP_INFO)	dbText	128
Map_Unit_ID	The map unit identifier used by the mapper (e.g., gridcode or map code)	dbText	10
Map_Unit_Common_Name	The name of the map unit (or map class)	dbText	250
Edit_Date	Date of any edits to the polygon or its attributes	dbDate	8
Edit_Notes	Notes regarding any edits to the polygon or its attributes	dbText	250
Acres	Acres per polygon, generated using ArcMap	dbDouble	8
Hectares	Hectares per polygon, generated using ArcMap	dbDouble	8
SHAPE_Length	ESRI generated	dbDouble	8
SHAPE_Area	ESRI generated	dbDouble	8

Non-spatial tables

Table Name: TBL_ALLIANCE
Description: Contains the alliances for the vegetation polygons by map unit ID.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MapUnit	The map unit identifier, used by the mappers (aka: grid_code or map class code, usually a number)	dbText	12
NVC_ALLIANCE_CODE	The NVC alliance code	dbText	20
ALLIANCE_COMMON_NAME	NVC alliance common name	dbText	250
ALLIANCE_NAME	NVC alliance latin name	dbText	250

Table Name: TBL_ANDERSON_LANDUSE
Description: Contains the Anderson Landuse classes for the vegetation polygons.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4

Field Name	Field Description	Field Type	Field Width
Polygon_ID	Unique polygon code, used for relating tables (TBL_VEGMAP_INFO)	dbText	20
LANDUSE	The Anderson landuse classes of the polygon (version 1.5, January 2002)	dbDouble	8
Level_1	Anderson landuse code for level one	dbText	255
L1_Name	Anderson landuse name for level one	dbText	255
Level_2	Anderson landuse code for level two	dbText	50
L2_Name	Anderson landuse name for level two	dbText	255
Level_3	Anderson landuse code for level three	dbText	255
L3_Name	Anderson landuse name for level three	dbText	255
Level_4	Anderson landuse code for level four	dbText	255
L4_Name	Anderson landuse name for level four	dbText	255
Level_5	Anderson landuse code for level five	dbText	255
L5_Name	Anderson landuse name for level five	dbText	255
Level_6	Anderson landuse code for level six	dbText	255
L6_Name	Anderson landuse name for level six	dbText	255

Table Name: TBL_ENVIRONMENT_COVER
Description: Contains ground cover data for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
COVER_TYPE	Ground cover type	dbText	30
COVER_CODE	Cover code from field sheet (obs pts)	dbText	5
COVER_PERCENT	Field estimate to the nearest %, of ground cover type (plots only).	dbDouble	8
COVER_CODE_RANGE	Cover code range - for plots with non-integer percentages.	dbText	50
COVER_PERCENT_DESC	Description of cover	dbText	255
PLOT_CODE	Unique Plot code, used for relating tables	dbText	20

Table Name: TBL_ENVIRONMENT_LANDFORM
Description: Contains landform data for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
LANDFORM	Landform on which plot is located, any landform could be entered by crew.	dbText	100
PLOT_CODE	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	20

Table Name: TBL_FORMATION
Description: Contains NVC formation level data for the vegetation polygons.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MAP_UNIT_ID	The map unit identifier, used by the mappers (aka: grid_code or map class code)	dbText	10
Formation_Code	NVC formation level code	dbText	30
Formation_Name	NVC formation level name	dbText	255

Table Name: TBL_GPS_INFO

Description: Contains information about the GPS unit and accuracies of data collected for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_ID	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	20
GPS_TYPE	Manufacturer and model of GPS unit (e.g., Garmin Etrex or Trimble XM)	dbText	30
UTM_EASTING	UTM easting of plot	dbDouble	8
UTM_NORTHING	UTM northing of plot	dbDouble	8
UTM_ZONE	UTM zone of coordinates	dbText	3
DATUM	Datum of UTM coordinates (NAD83)	dbText	10
GPS_ERROR	Error, in meters, of location data (based on reading from Garmin GPS unit)	dbText	5
DIFF_CORRECTED	Indicates if coordinates have been differentially corrected (from Garmin screen)	dbText	3
GPS_COMMENTS	Brief comments on GPS data collection at plot.	dbText	255
GPS_QUALITY	Indicates the quality of the GPS unit used (recreational, mapping grade)	dbText	35
PDOP	Positional Dilution Of Precision reading (from Garmin screen)	dbText	30
ERROR_RANGE	General error range, in meters, of the type of GPS unit used.	dbText	20

Table Name: TBL_LOCATION_INFO
Description: Contains data about the location of the point and general observations about the area for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_CODE	Unique Plot code, used for relating tables and feature class (fcl_Veg_Points)	dbText	20
VISIT_DATE	Date the location was visited	dbText	10
SITE_NAME	General Site name given by field crew	dbText	180
PLOT_SHAPE	The shape of the area observed as a point	dbText	20
PLOT_WIDTH	The width of the point (plot and obs only)	dbText	3
PLOT_LENGTH	The length of the point (plot and obs only)	dbText	3
PLOT_DIAMETER	The diameter of the point (plot and obs only)	dbText	5
PLOT_AZIMUTH	The azimuth of the point (plot and obs only)	dbText	5
ASPECT	Aspect of plot	dbText	10
ELEVATION	Elevation of plot in meters, generated by GPS unit	dbDouble	8
SLOPE	Slope of plot measured in degrees	dbText	15
TOPO_POSITION	Topographic position of plot	dbText	50
DIRECTIONS_PLOT	Directions to the location of the plot (plot and obs only)	dbText	255
REPRESENTATIVENESS	The representativeness of the	dbText	255

Field Name	Field Description	Field Type	Field Width
	vegetation (at plots and obs only)		
OBSERVER	The names of the field crew member(s) observing the site.	dbText	50
IN_PARK	Indicates if the point was inside or outside the park boundary (only applicable to Plots and Observation points)	dbBoolean	1
UNIT_CODE	4 letter park code (TICA)	dbText	10
AERIAL_PHOTO_NO	9X9 photo name on which the point most directly falls (2001 flight, plots & obs only)	dbText	30
STATE_CODE	State (UT)	dbText	2
USGS_NAME	USGS 1:24k Topo Name	dbText	75
COUNTY_NAME	County where plot is located	dbText	80
PHENOLOGY	Leaf phenology of the dominant stratum. Field is blank for non-vascular plots	dbText	50
PHYSIOGNOMIC_NAME	Physiognomic class of plot	dbText	80
LEAF_TYPE	Leaf form of the dominant stratum.	dbText	80
LEAF_TYPE_COMMENTS	If Leaf Type is "mixed," this field describes the multiple leaf types found in the dominant stratum.	dbText	250
PROVISIONAL_COMM_NAME	Community name (provisional) assigned by field crews by following naming protocols as described in field manual and training (plot and obs only).	dbText	220
ALLIANCE	Alliance corresponding to provisional community name (plots and obs only)	dbText	150
PLANT_SPECIES_COMMENTS	Comments about the plant species observed.	dbText	200
COWARDIN_SYSTEM	If the plot is in a wetland system, select term that best describes its hydrology (Upland, Palustrine, Riverine, Lacustrine)	dbText	40
HYDROLOGY	Describes hydrology of plot (plots and obs only)	dbText	40
GEOLOGY	Geologic substrate influencing the plant community (plots and obs only)	dbText	60
ENV_COMMENTS	Comments on environmental setting and its effect on the vegetation; also comments on disturbance or reproduction factors	dbText	255
LANDSCAPE_COMMENTS	Description of landscape context of plot, including any important landscape features influencing the community (plots and obs only)	dbText	255
ANIMAL_USE_COMMENTS	Comments on evidence of use by non-domestic animals in plot area (plots and obs only)	dbText	255

Field Name	Field Description	Field Type	Field Width
DISTURBANCE_COMMENTS	Comments on evidence of natural or anthropogenic disturbance in plot area, severity and effects on vegetation (plot and obs only)	dbText	255
OTHER_COMMENTS	Other general comments (plot and obs only)	dbText	255
SOIL_TEXTURE	Assessment of average soil texture from sample taken a few inches below the surface (plot and obs only)	dbText	50
SOIL_DRAINAGE	Soil drainage class based on actual moisture content and extent period (plot and obs only)	dbText	30
SOIL_TAXON_DESC	Field used for either identifying soils keyed, or to describe if large rocks or outcrops are present on the surface (plot and obs only)	dbText	255

Table Name: TBL_MAPUNIT_ASSOC
Description: Contains association data for the vegetation polygons by map unit ID.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MapUnitID	The map unit identifier, used by the mappers (aka: grid_code or map code)	dbText	20
CEGL_Code	NVC association code	dbText	18
AssociationName	The NVC Association name	dbText	250
AssociationCommonName	The NVC Association Common name	dbText	250

Table Name: TBL_MAPUNIT_ECOSYS
Description: Contains ecological system data for the vegetation polygons by map unit ID.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
MAP_UNIT_ID	The map unit identifier, used by the mappers (aka: grid_code or map code)	dbText	10
ES_Code	Ecological System code	dbText	30
EcologicalSystemName	Ecological system name (mid-scale classification, larger than associations or alliances, smaller than ecoregions).	dbText	255

Table Name: TBL_PHOTOS
Description: Details on individual photos taken of a point.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_CODE	Unique Plot code, used for relating tables (TBL_LOCATION_INFO)	dbText	50
PhotoType	Type of photo being referenced.	dbText	16
Photographer	Name of photographer.	dbText	50
PhotoComments	Brief description of photo.	dbText	255
IMAGE_ID	NCPN Photo Database (unique) file name.	dbText	50
PHOTO_PATH	Hard-coded path name to photos	dbText	200

Table Name: TBL_STRATUM_SPECIES

Description: Contains species level data by stratum.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
TSN	Taxonomic Serial Number - unique taxon identifier assigned by ITIS	dbDouble	8
SPECIES	Latin names of species	dbText	255
PERCENT_COVER	Applicable to AA data only, percent cover by species (Not applicable to TICA)	dbText	4
COVER_CODE	Cover class code to describe species and strata	dbText	5
COVER_CLASS	Cover class to describe species and strata	dbText	50
DIAGNOSTIC	Check yes if the species is known to be diagnostic of the vegetation type.	dbInteger	2
SPECIMEN_COLLECTED	"yes" (-1) if a specimen of the species was collected.	dbInteger	2
SPECIMEN_NO	The collector's reference number for the specimen collected.	dbText	10
DEAD	Percent coverof dead species seen at plot. Not completed of every species, but always done if diagnostic species.	dbInteger	2
STRATUM_ID	Unique ID, relates to TBL_VEG_STRATA	dbLong	4

Table Name: TBL_VEG_STRATA
Description: Contains stratum data for the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
STRATUM ID	Links to strata	dbLong	4
STRATUM	Stratum name/type	dbText	20
STRATUM_COVER_CODE	Stratum cover code	dbText	5
STRATUM_COVER_CLASS	Stratum percentage cover class	dbText	50
STRATUM_HEIGHT_CODE	Stratum height code	dbText	5
STRATUM_HEIGHT_CLASS	Stratum height class in meters	dbText	50
PLOT_CODE	Unique Plot code, used for relating tables (TBL_STRATUM_SPECIES)	dbText	12

Table Name: TBL_VEGASSOC_INFO
Description: Contains association data for all points (plots and obs points) in the veg points feature class.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
PLOT_CODE	Unique Plot code, used for relating tables	dbText	35
CEGL_CODE	CEGL (association) code	dbText	10
ASSOCIATION	Association corresponding to provisional community name	dbText	180
FIELD_KEY_NAME	Yes if association name was chosen from field key	dbText	10
CREATED _NAME	Yes if no name really fits from the field key, the surveyor will create a new name.	dbText	10
POST_AA_FIELD_NAME	n/a for TICA	dbText	10
ASSOC_RANK	n/a for TICA	dbText	50
OTHER_ASSOC_50M	n/a for TICA	dbText	200

Table Name: TBL_VEGMAP_INFO
Description: Contains map unit level data for each vegetation map unit polygon.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
Polygon_ID	Unique polygon code, used for relating tables and feature classes (fcl_Veg_polys)	dbText	30
Map_Unit_ID	The map unit identifier, used by the mappers (aka: grid_code or map code)	dbText	10
Map_Unit_Code	NCPN code (X-XXXX)	dbText	10
Map_Unit_Common_Name	The name of the map unit (or map class)	dbText	250
Cover_Code	Cover pattern value class code	dbText	1
COVER_PATTERN	Characterizes the pattern of vegetation in the polygon (Clumped/Bunched, Linear, Gradational/Transitional, Regularly alternating, Homogenous (default)).	dbText	100
Density_Code	Density value code	dbText	1
DENSITY_CLASS	Density of Forest/Woodland vegetation, and density for sagebrush communities per polygon.	dbText	100
Height_Code	Height class value code	dbText	1
HEIGHT_CLASS	Vegetation height classes assigned to each polygon of forest/woodland and/or shrubland types	dbText	100
USER_ACCURACY	User accuracy of the map unit (determined during AA meetings). N/A means the class was not accuracy assessed (Not applicable to TICA).	dbText	3
FUELS_TYPE	Fuels vegetation types (Not used at TICA)	dbText	50
FUELS_VERIFICATION	Fuels verification (Not used at TICA)	dbText	255
VEGMAP_COMMENTS	Any comments about the particular polygon or map class.	dbText	255
MAP_UNIT_PDF	File name of pdf describing map class	dbText	50
MAP_UNIT_PDF_PATH	Hard-coded link to Map Unit description PDF document - path name (e.g. C:/TICA/Vegetation/MapClassDescriptions/ c_rojs_mu31.pdf.pdf)	dbText	250

Table Name: TBL_VEGMAP_MODIFIERS
Description: Contains modifiers for the vegetation map unit polygons.

Field Name	Field Description	Field Type	Field Width
OBJECTID	ESRI generated autonumber	dbLong	4
Polygon_ID	Unique polygon code, used for relating tables (TBL_VEGMAP_INFO)	dbText	20
MODIFIER	Modifier code (one lower case letter)	dbText	12
MODIFIER_NAME	Name/type of modifier	dbText	50
MODIFIER_DESCRIPTION	Description of modifier	dbText	255

Appendix D

Plant Species List and Crosswalk

Introduction

Seventy-eight vascular plant species representing 31 families were noted during plot and observation point collection at Timpanogos Cave National Monument (TICA). Because the data collection occurred in July, the list is depauperate compared with the true diversity of plant species within the Monument.

The Northern Colorado Plateau Network uses three taxonomic authorities for vascular plants: Welsh et al. 2003 as the nomenclatural authority for Utah parks, Weber and Wittmann (2001) for Colorado parks, and Dorn and Lichvar (1984) for the single park in Wyoming; the TICA vegetation mapping project database reflects scientific names as assigned by Welsh. These names are crosswalked to Kartesz (1999), which is the nomenclatural authority used by NatureServe for the National Vegetation Classification. Scientific and common names used by NatureServe are presented in this crosswalk; these names are used throughout the TICA vegetation mapping report and in the individual association descriptions in Appendix F. The taxonomic serial number (TSN) assigned by the Integrated Taxonomic Information System (ITIS) to the Welsh name is provided for each species.

Family	Scientific Name (Welch et al. 1993)	Scientific Name (Kartez 1999)	Common Name (NatureServe)	TSN
Aceraceae	*Acer glabrum* Torr.	*Acer glabrum*	Rocky Mountain Maple	28742
	Acer grandidentatum Nutt.	*Acer grandidentatum*	bigtooth maple	28760
	Acer negundo L.	*Acer negundo*	boxelder	28749
Apocynaceae	*Apocynum androsaemifolium* L..	*Apocynum androsaemifolium*	spreading dogbane	30156
Asteraceae	*Ambrosia psilostachya* DC.	*Ambrosia psilostachya*	western ragweed	3616
Asteraceae	*Artemisia ludoviciana* Nutt.	*Artemisia ludoviciana*	white sagebrush	35474
	Artemisia nova A. Nels.	*Artemisia nova*	black sagebrush	500971
	Artemisia tridentata ssp. *vaseyana* (Rydb.) Beetle	*Artemisiat tridentata* ssp. *vaseyana*	mountain big sagebrush	183740
	Brickellia oblongifolia Nutt.	*Brickellia oblongifolia*	Mojave brickellbush	36727
	Chrysothamus nauseosus var. *graveolens* (Nutt.) Piper ex Hall	*Ericamerira nauseosa*	rubber rabbitbrush	533554
	Chrysothamnus viscidiflorus (Hook.) Nutt.	*Chrysothamnus viscidiflorus*	yellow rabbitbrush	37090
	Haplopappus macronema (Nutt.) Gray	*Ericameria discoidea*	whitestem goldenbush	502361
	Erigeron arenarioides (DC. Eat. ex Gray) Gray ex Rydb.	*Erigeron arenarioides*	sand fleabane	35818
	Helianthella uniflora (Nutt.) Torr. & Gray	*Helianthella uniflora*	oneflower helianthella	37598
	Petradoria pumila (Nutt.) Greene	*Petradoria pumila*	grassy rockgoldenrod	38233
	Solidago velutina DC.	*Solidago velutina*	threenerve goldenrod	505290
	Tragopogon dubius Scop.	*Tragopogon dubius*	western salsify	38564
Berberidaceae	*Mahonia repens* (Lindl.) G. Don	*Mahonia repens*	creeping barberry	195045
Betulaceae	*Betula occidentalis* Hook.	*Betula occidentalis*	water birch	19488
Boraginaceae	*Cynoglossum officinale* L.	*Cynoglossm officinale*	houndstongue	31890
	Lappula occidentalis (S. Wats.) Greene	*Lappula occidentalis*	western stickweed	528678
Brassicaceae	*Alyssum alyssoides* (L.) L.	*Alyssum alyssoides*	yellow alyssum	23030
Caprifoliaceae	*Sambucus caerulea* Raf.	*Sambucus nigra* ssp. *caerulea*	blue elderberry	502892
	Symphoricarpos oreophilus Gray	*Symphoricarpos oreophilus*	mountain snowberry	35338
Caryophyllaceae	*Saponaria officinalis* L.	*Saponaria officinalis*	bouncing bet	20039
Celastraceae	*Paxistima myrsinites* (Pursh) Raf.	*Paxistima myrsinites*	Oregon boxleaf	504149
Chenopodiaceae	*Kochia americana* S. Wats.	*Kochia americana*	kochia, green molly	20694
Convolvulaceae	*Convolvulus arvensis* L.	*Convolvulus arvensis*	field bindweed	30705

Family	Scientific Name (Welch et al. 1993)	Scientific Name (Kartez 1999)	Common Name (NatureServe)	TSN
Cornaceae	*Cornus sericea* L.	*Cornus sericea*	redosier dogwood	501637
Crassulaceae	*Sedum debile* S. Wats.	*Sedum debile*	orpine stonecrop	24111
Cupressaceae	*Juniperus communis* L.	*Juniperus communis*	common juniper	194820
	Juniperus scopulorum Sarg.	*Juniperus scopulorum*	Rocky Mountain juniper	194872
Fabaceae	*Lupinus argenteus* Pursh	*Lupinus argenteus*	silver lupine	503575
	Vicia americana Muhl. ex Willd.	*Vicia americana*	American vetch	26331
Fagaceae	*Quercus gambelii* Nutt.	*Quercus gambelii*	Gambel oak	19337
Grossulariaceae	*Ribes cereum* Dougl.	*Ribes cereum*	wax currant	24457
Hydrangeaceae	*Jamesia americana* Torr. & Gray	*Jamesia americana*	fivepetal cliffbush	24379
Lamiaceae	*Monardella odoratissima* Benth.	*Monardella odoratissima*	mountain monardella	32580
Liliaceae	*Allium acuminatum* Hook.	*Allium acuminatum*	tapertip onion	42707
	Calochortus nuttallii Torr. & Gray	*Calochortus nuttallii*	sego lily	42863
	Smilacina racemosa (L.) Desv.	*Maianthemum racemosa*	feathery false of the vally	503655
Pinaceae	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.	*Abies concolor*	white fir	181826
	Pseudotsuga menziesii (Mirbel) Franco	*Pseudotsuga menziesii*	Douglas-fir	183424
Poaceae	*Bromus tectorum* L.	*Bromus tectorum*	cheatgrass	40524
	Stipa hymenoides Roemer & J.A. Schultes	*Achnatherum hymenoides*	Indian ricegrass	507943
	Stipa lettermanii Vasey	*Achnatherum lettermanii*	Letterman's needlegrass	507946
	Stipa nelsonii Scribn.	*Achnatherum nelsonii*	Columbia needlegrass	507948
	Bromus inermis Leyss.	*Bromus inermis*	smooth brome	40502
	Bromus tectorum L.	*Bromus tectorum*	cheatgrass	40524
	Dactylis glomerata L.	*Dactylis glomerata*	orchard grass	193446
	Elymus L.	*Elymus* sp.	wildrye	40677
	Leucopoa kingii (S. Wats.) W.A. Weber	*Leucopoa kingii*	spike fescue	41832
	Panicum capillare L.	*Panicum capillare*	witchgrass	40914
	Poa fendleriana (Steud.) Vasey	*Poa fendleriana*	muttongrass	504467
	Elymus spicatus (Pursh) Gould	*Pseudoroegneria spicata*	bluebunch wheatgrass	504637
Polygonaceae	*Eriogonum brevicaule* Nutt.	*Eriogonum brevicaule*	shortstem buckwheat	21084
	Eriogonum racemosum Nutt.	*Eriogonum racemosum*	redroot buckwheat	21230

Family	Scientific Name (Welch et al. 1993)	Scientific Name (Kartez 1999)	Common Name (NatureServe)	TSN
Ranunculaceae	*Clematis hirsutissima* Pursh	*Clematis hirsutissima*	hairy cleamtis	18699
Rosaceae	*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roemer	*Amelanchier alnifolia*	Saskatoon serviceberry	25109
	Cercocarpus intricatus S. Wats.	*Cercocarpus intricatus*	littleleaf mountain mahogany	25133
	Cercocarpus montanus Raf.	*Cercocarpus montanus*	alderleaf mountain mahogany	25136
	Holodiscus dumosus (Nutt. ex Hook.) Heller	*Holodiscus dumosus*	rockspirea	25178
	Petrophyton caespitosum (Nutt.) Rydb.	*Petrophyton caespitosum*	mat rockspirea	25272
	Physocarpus alternans (M.E. Jones) J.T. Howell	*Physocarpus alternans*	dwarf ninebark	25278
	Physocarpus malvaceus (Greene) Kuntze	*Physocarpus malvaceus*	mallow ninebark	25280
	Prunus virginiana L.	*Prunus virginiana*	chokecherry	24806
	Rosa woodsii Lindl.	*Rosa woodsii*	Woods' rose	24847
Rubiaceae	*Galium aparine* L.	*Galium aparine*	stickwilly, catchweed	34797
	Galium multiflorum Kellogg	*Galium multiflorum*	shrubby bedstraw	34892
Salicaceae	*Populus angustifolia* James	*Populus angustifolia*	narrowleaf cottonwood	22452
Saxifragaceae	*Heuchera parvifolia* Bartl.	*Heuchera parvifolia*	littleleaf alumroot	24365
Scrophulariaceae	*Castilleja chromosa* A. Nels.	*Castilleja applegatei* spp. *martinii*	wavyleaf Indian paintbrush	525154
	Linaria dalmatica (L.) P. Mill.	*Linaria dalmatica*	Dalmatian toadflax	503474
	Penstemon eatonii Gray	*Penstemon eatonii*	Eaton’s penstemon	33686
	Penstemon pachyphyllus Gray ex Rydb.	*Penstemon pachyphyllus*	thickleaf beardtongue	33963
	Penstemon platyphyllus Rydb.	*Penstemon platyphyllus*	broadleaf beardtongue	33981
	Veronica biloba L.	*Veronica biloba*	bilobed speedwell	33400
Solanaceae	*Solanum sarrachoides* Sendt. ex Martius	*Solanum physalifolium*	hairy nightshade	30455

Appendix E

Field Plot Crosswalk to NVC Associations

Introduction

Plots and observation points from TICA are assigned to National Vegetation Classification (NVC) associations based on their composition and structure as recorded in the field. Element codes are used by NatureServe and state Natural Heritage Programs to track nomenclature and status of rare plants, rare animals, and communities ("elements"). Vegetation types that appear to be unique to TICA and which are otherwise not included in the NVC are denoted as "Park Specials" instead of being assigned an element code. Nomenclature used by the NVC follows Kartesz (1999). Vegetation types documented by map classes but for which there are no plot data are not included in this table.

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plots and Observation Points
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest	CEGL000240	2	TICA.9203, TICA.9208
Abies concolor / Acer grandidentatum Forest	CEGL000241	2	TICA.0104, TICA.0201
Abies concolor / Mixed Grasses Forest	CEGL005357	1	TICA.0202
Abies concolor / Physocarpus malvaceus Forest	CEGL000254	1	TICA.0204
Abies concolor / Quercus gambelii Forest	CEGL000261	4	TICA.0003, TICA.0103, TICA.0205, TICA.9206
Acer grandidentatum – Prunus virginiana Shrubland	Park Special	1	TICA.0105
Acer grandidentatum – Quercus gambelii Forest	CEGL000559	3	TICA.9201, TICA.9204, TICA.9207
Acer negundo / Acer grandidentatum Woodland	Park Special	1	TICA.0203
Acer negundo - Populus angustifolia - Abies concolor Woodland	Park Special	1	TICA.9001
Pseudotsuga menziesii / Quercus gambelii Forest	CEGL000452	1	TICA.0102
Quercus gambelii / Symphoricarpos oreophilus Shrubland	CEGL001117	2	TICA.0101, TICA.9101,
Quercus gambelii Shrubland	CEGL002477	3	TICA.0001, TICA.0002, TICA.9202
Cercocarpus intricatus Montane Shrubland	CEGL002587	1	TICA.9205

Appendix F

Plant Association Descriptions for Timpanogos Cave National Monument

Introduction

The Timpanogos Cave National Monument (TICA) vegetation mapping project sampled ten National Vegetation Classification (NVC) plant associations. Detailed vegetation descriptions are essential for recognizing floristic vegetation types (association and alliance levels of the NVC) in the field. Local and global descriptions "*provide specific information on the geographical distribution, level of acceptable physiognomic and compositional variation, and the key ecological process and environmental / abiotic factors that are associated with a type*" (Grossman et al. 1998). The two levels of vegetation descriptions are valuable for comparing each association as it appears in the Monument with the global range of variation for that association.

The following report was prepared by NatureServe to provide local and global descriptions for each plant association sampled at TICA. These descriptions reflect NatureServe's accumulated data and analysis. Global descriptions of NVC associations are available on the NatureServe Explorer Web site (http://www.natureserve.org/explorer); local descriptions are not.

In this appendix, NVC plant associations are arranged by physiognomic class (i.e., Forest, Woodland, Shrubland, Herbaceous). Within each physiognomic class, associations are sorted by alliance (e.g., *Abies concolor* Forest Alliance).

TABLE OF CONTENTS

Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest
White Fir - Douglas-fir / Rocky Mountain Maple Forest

CODE	CEGL000240
PHYSIOGNOMIC CLASS	Forest (I)
PHYSIOGNOMIC SUBCLASS	Evergreen forest (I.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen forest (I.A.8.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest (I.A.8.N.)
FORMATION	Conical-crowned temperate or subpolar needle-leaved evergreen forest (I.A.8.N.c.)
ALLIANCE	*ABIES CONCOLOR* FOREST ALLIANCE (A.152) White Fir Forest Alliance
ECOLOGICAL SYSTEM(S):	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825) Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)
USFWS WETLAND SYSTEM:	Not applicable

CONCEPT SUMMARY

Globally

This white fir forest association ranges from southern and central Utah and southern Colorado to northern New Mexico and central Arizona and is found between 2073 and 3140 m (6800-10,300 feet) elevation. This forest shows great variety with respect to topographic characteristics. In southern Colorado and northern New Mexico, it is one of the most widespread mixed conifer forests. Though it frequently occurs on moderate to steep north- and northwest-facing slopes, other slope aspects are represented. When found on southern aspects, this forest is at higher elevations or streamside settings. Predominantly found on lower slopes, it has also been located on mid- and upper slopes. Sites can have high amounts of exposed rock (up to 50% or more cover), with abundant leaf litter and coarse woody debris. The overstory is highly complex and has high variability. *Abies concolor* dominates or codominates, if not in the overstory, then as regeneration. *Pseudotsuga menziesii* is a successional dominant and remains a codominant in late-successional stands, becoming minor in very old stands. *Picea pungens* and *Pinus flexilis* may be important, as well as *Pinus strobiformis* at lower latitudes. *Abies lasiocarpa* and *Picea engelmannii* may occur in frost pockets as regeneration or occasional mature trees, but they are minor and almost always are under severe competition from dense regeneration and canopy dominance of *Abies concolor* and *Pseudotsuga menziesii*. The open to dense tall-shrub layer dominates the undergrowth with *Acer glabrum* and often *Amelanchier alnifolia*. If present, *Quercus gambelii* has low cover (<5%). Common low-growing shrubs are *Holodiscus dumosus*, and *Jamesia americana*, which occur on cobbly substrates, along with *Mahonia repens*, *Paxistima myrsinites*, *Physocarpus monogynus*, and *Symphoricarpos oreophilus*; however, some stands have an open shrub of layer of *Acer glabrum* and little else in the understory. The herb layer species are typically low in cover value.

DISTRIBUTION

Timpanogos Cave National Monument

This association is known from the Visitor Center and Cave Exit areas of the monument.

Globally

This montane forest is common in the southern portion of the southern Rocky Mountains and ranges from central and southern Utah and southern Colorado to northern New Mexico and central Arizona.

ENVIRONMENTAL DESCRIPTION

Timpanogos Cave National Monument

This forest association occupies steep (32° to 36°), exposed, north-facing ravine and canyon slopes between 1856 and 2038 m elevation. Bedrock, bare soil and litter cover most of the ground surface; wood and colluvium cover the rest. Soils are rapidly drained and poorly developed.

Globally

This montane forest shows great variety with respect to topographic characteristics where it occurs in the southern portion of the southern Rocky Mountains and high plateaus and mountains of the Colorado Plateau, extending north into the Wasatch Range. In southern Colorado and northern New Mexico, it is one of the most widespread mixed

conifer forests. It ranges between 2400 and 3140 m (7900-10,300 feet) in elevation in upland canyon and mountain slopes, down to 2100 m (6800 feet) along stream terraces and valley bottoms. In the Wasatch Range in Utah stands were sampled in canyons between 1850 and 2040 m (6065-6690 feet) elevation. Though it frequently occurs on cool northeast- to northwest-facing slopes, other slope aspects are represented. When found on southern aspects, this forest occurs at higher elevations or in streamside settings (Fitzhugh et al. 1987). Predominantly found on lower slopes, it has also been located on mid- and upper slopes of mountain, ridges and canyons (DeVelice et al. 1986). Where it lies at lower elevations, sites will be locally wet and cool. Therefore, it is located along canyonsides and cool drainages, and its presence is most striking in cool drainages where the adjacent communities may be much drier. At upper elevations, this forest occurs along the tops of ridges and knolls (Alexander et al. 1984a). This association occurs on shallow, even skeletal soils as it is frequently found on steep slopes. Sites can have high amounts of exposed rock (up to 50% or more cover), with abundant leaf litter and coarse woody debris (Alexander et al. 1984a, Youngblood and Mauk 1985). Soils are moderately well-drained sandy loams, loams and clay loams derived from alluvial deposits or sideslope colluvium derived from a variety of parent materials, including Bandelier tuff, rhyolite, sandstone or andesite rocks. Common soil types are Borolls, Boralfs, and Ochrepts.

VEGETATION DESCRIPTION

Timpanogos Cave National Monument

The open canopy in this forest association is codominated by 10- to 25-m tall *Abies concolor* and *Pseudotsuga menziesii* trees. Total tree cover is around 15-20%. *Acer glabrum* dominates a patchy shrub layer with about 5% cover; *Juniperus scopulorum* may also be present in this layer. Other shrubs may include *Acer grandidentatum, Quercus gambelii, Holodiscus dumosus, Jamesia americana, Juniperus communis, Rosa woodsii,* and *Mahonia repens,* all with very low cover. Because of the open canopy and rocky substrate, the herbaceous layer is diverse and contributes sparse cover. Common grasses include *Achnatherum nelsonii, Leucopoa kingii,* and *Pseudoroegneria spicata.* Characteristic forbs include *Castilleja applegatei* ssp. *martinii, Erigeron arenarioides, Penstemon eatonii, Penstemon platyphyllus, Petrophyton caespitosum, Sedum debile, Maianthemum racemosum,* and *Solidago velutina.*

Globally

The moderately open to closed overstory is highly complex and has high variability. *Abies concolor* dominates or codominates, if not in the overstory, then as regeneration. *Pseudotsuga menziesii* is a successional dominant and remains a codominant in late-successional stands, becoming minor in very old stands. *Picea pungens, Pinus longaeva, Pinus flexilis,* and *Juniperus scopulorum* may be important, as well as *Pinus strobiformis* at lower latitudes. *Abies lasiocarpa* and *Picea engelmannii* may occur in frost pockets as regeneration or occasional mature trees, but they are minor and almost always are under severe competition from dense regeneration and canopy dominance of *Abies concolor* and *Pseudotsuga menziesii* (Moir and Ludwig 1979). *Pinus ponderosa* is an accidental or minor species, since neither regeneration nor mature trees are important in late-successional stands (Moir and Ludwig 1979). Seral stands are often codominated by *Populus tremuloides* (Stuever and Hayden 1997b). The tall-shrub layer dominates the undergrowth typically dominated or codominated by *Acer glabrum* or less frequently *Amelanchier alnifolia*. *Quercus gambelii*, if present, has relatively low cover (<5%). Other short and dwarf-shrubs may be present with low cover, such as *Holodiscus dumosus* and *Jamesia americana,* which occur on cobbly substrates, along with *Acer grandidentatum, Juniperus communis, Mahonia repens, Paxistima myrsinites, Physocarpus monogynus, Rosa woodsii, Shepherdia canadensis,* and *Symphoricarpos oreophilus*; however, some stands have an open shrub of layer of *Acer glabrum* and little else. Herb layer species are typically low in cover. Common species are *Artemisia franserioides, Bromus anomalus, Bromus ciliatus, Carex* spp., *Erigeron* spp., *Lathyrus* spp., *Maianthemum racemosum, Penstemon* spp., *Pyrola chlorantha, Solidago velutina, Stellaria longifolia, Thalictrum fendleri,* and *Viola canadensis.*

MOST ABUNDANT SPECIES

Timpanogos Cave National Monument

Stratum	**Species**
Tree canopy	*Abies concolor, Pseudotsuga menziesii*
Tall shrub/sapling	*Acer glabrum*

Globally

Stratum	**Species**
Tree canopy	*Abies concolor, Pseudotsuga menziesii*
Shrub/sapling (tall & short)	*Acer glabrum*

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Penstemon platyphyllus

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G4 (1-Feb-1996).

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
On steep rocky slopes *Jamesia americana* and *Holodiscus dumosus* become more abundant and this type transitions to scree associations such as *Abies concolor* - (*Pseudotsuga menziesii*) / *Jamesia americana - Holodiscus dumosus* Scree Woodland (CEGL000890). According to Alexander et al. (1987), this type represents a transition from the *Abies concolor / Quercus gambelii* type to types representative of spruce-fir forests. This type appears to be related to the *Pseudotsuga menziesii / Paxistima myrsinites* habitat type of central and northern Colorado of Hoffman and Alexander (1980). The foothill ravine forest community of Rocky Mountain National Park, Colorado (Peet 1981), is weakly related to this association, as is the *Abies grandis / Acer glabrum* habitat type of central Idaho (Steele et al. 1981). The *Abies concolor / Acer glabrum / Berberis nervosa* Plant Association (Atzet and McCrimmon 1990) found in southern Oregon Cascades is not part of this association.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: This association occurs on steep ravine and canyon slopes consisting of bedrock, talus, and scree with little soil development. One site had recent avalanche disturbance.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (2 observation points: TICA.9203, TICA.9208).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: L.D. Engelking, mod. K.A. Schulz

REFERENCES: Alexander et al. 1984a, Alexander et al. 1987, Atzet and McCrimmon 1990, Atzet and Wheeler 1984, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Crane 1982, DeVelice 1983, DeVelice and Ludwig 1983a, DeVelice et al. 1986, Dieterich 1980, Driscoll et al. 1984, Fitzhugh et al. 1987, Hoffman and Alexander 1980, Larson and Moir 1987, Moir and Ludwig 1979, Muldavin et al. 1996, Muldavin et al. 2006, Peet 1981, Steele et al. 1981, Stuever and Hayden 1997b, Youngblood and Mauk 1985

Abies concolor / Acer grandidentatum Forest
White Fir / Bigtooth Maple Forest

CODE	CEGL000241
PHYSIOGNOMIC CLASS	Forest (I)
PHYSIOGNOMIC SUBCLASS	Evergreen forest (I.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen forest (I.A.8.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest (I.A.8.N.)
FORMATION	Conical-crowned temperate or subpolar needle-leaved evergreen forest (I.A.8.N.c.)
ALLIANCE	*ABIES CONCOLOR* FOREST ALLIANCE (A.152) White Fir Forest Alliance
ECOLOGICAL SYSTEM(S):	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825) Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)
USFWS WETLAND SYSTEM:	Not applicable

CONCEPT SUMMARY

Globally

This forest association has been reported from mountains in Utah, New Mexico and Arizona along the Mogollon Rim north into the high plateaus and Wasatch Range of Utah. Elevation ranges from 1525-2590 m (5000-8500 feet). This mesic community generally occurs on steep, lower slopes and benches with northern aspects and in narrow canyons and ravines. Soils are generally deep, well-drained, coarse and fine-textured alluvium. *Abies concolor* and *Pseudotsuga menziesii* codominate the upper tree canopy with the subcanopy or tall-shrub layer dominated by *Acer grandidentatum, Quercus gambelii,* and *Acer negundo. Pinus strobiformis, Pinus ponderosa, Populus tremuloides,* and *Juglans major* may also be present. The short-shrub layer is variable. The herbaceous layer is moderately dense and may include *Carex siccata, Bromus ciliatus* var. *ciliatus, Bromus ciliatus* var. *richardsonii, Koeleria macrantha, Thalictrum fendleri,* and *Aquilegia chrysantha*. This association transitions to *Abies concolor / Quercus gambelii* Forest (CEGL000261) in drier uplands and to riparian types adjacent to streams.

DISTRIBUTION

Timpanogos Cave National Monument

This association was sampled along the abandoned trail to the caves and at Kodachrome Point.

Globally

This forest association has been reported from mountains in New Mexico, Arizona and Utah along the Mogollon Rim north into the high plateaus and Wasatch Range of Utah.

ENVIRONMENTAL DESCRIPTION

Timpanogos Cave National Monument

This forest association occurs on mesic, steep (33° to 40°), north-facing canyon slopes around 1710 m elevation. Litter and rocks cover most of the ground surface. Soils are rapidly drained loams.

Globally

This forest association has been reported from mountains in New Mexico and Arizona along the Mogollon Rim, and in Utah north into high plateaus and the Wasatch Range. Elevation ranges from 1525-2590 m (5000-8500 feet). This mesic community generally occurs on gentle to steep (4° to 40°) lower slopes and benches with northern aspects and in narrow canyons and ravines. Soils are generally deep, rapidly drained, coarse-textured loams, but range from loamy sands to silty clay loams. Parent materials are derived from quaternary alluvium, and bedrock and colluvium derived from local geologic layers.

VEGETATION DESCRIPTION

Timpanogos Cave National Monument

This diverse forest association is characterized by 10- to 15-m tall *Abies concolor* trees with between 2 and 40% cover. The understory is dominated by the tall shrub *Acer grandidentatum* with 2-25% cover. A sparse subcanopy containing *Pseudotsuga menziesii* and *Juniperus scopulorum* may be present. Other shrubs present may include *Prunus virginiana, Quercus gambelii, Mahonia repens,* and *Ribes cereum*. In stands with high canopy cover, the lack of light limits the development of the herbaceous layer. Grasses commonly observed include *Achnatherum hymenoides, Bromus tectorum, Poa fendleriana,* and *Pseudoroegneria spicata*. Scattered forbs include *Galium multiflorum, Heuchera parviflora, Penstemon platyphyllus, Sedum debile,* and *Maianthemum racemosum*. Seedling trees of *Abies concolor* and *Pseudotsuga menziesii* occur throughout the plot.

Globally

his mesic forest is characterized by a mixed-species tree canopy with *Abies concolor* and *Pseudotsuga menziesii* codominating the upper tree canopy and with the subcanopy or tall-shrub layer dominated by *Acer grandidentatum, Quercus gambelii,* and *Acer negundo. Pinus strobiformis, Pinus ponderosa, Populus tremuloides,* and *Juglans major* may also be present. The short-shrub layer is variable. Short shrub species include *Arctostaphylos patula, Juniperus communis, Mahonia repens, Paxistima myrsinites, Prunus virginiana, Quercus gambelii* (<5% cover), *Ribes cereum,* and *Symphoricarpos oreophilus*. The herbaceous layer is an open to moderately dense mixture of graminoids and forbs. Grasses commonly present include *Achnatherum hymenoides, Bromus ciliatus, Carex siccata, Koeleria macrantha, Poa fendleriana,* and *Pseudoroegneria spicata*. Scattered forbs include *Aquilegia chrysantha, Clematis ligusticifolia, Galium multiflorum, Heuchera parviflora, Maianthemum racemosum, Osmorhiza occidentalis, Penstemon platyphyllus, Sedum debile,* and *Thalictrum fendleri.* Seedling trees of *Abies concolor* and *Pseudotsuga menziesii* may occur throughout. The exotic annual grass *Bromus tectorum* is present in some stands.

MOST ABUNDANT SPECIES

Timpanogos Cave National Monument

Stratum	Species
Tree canopy	*Abies concolor, Juniperus scopulorum, Pseudotsuga menziesii*
Tall shrub/sapling	*Acer grandidentatum, Prunus virginiana, Quercus gambelii*
Herb (field)	*Abies concolor*

Globally

Stratum	Species
Tree canopy	*Abies concolor*
Tall shrub/sapling	*Acer grandidentatum, Quercus gambelii*

OTHER NOTEWORTHY SPECIES

Timpanogos Cave National Monument
Bromus tectorum, Penstemon platyphyllus

Globally
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (23-Feb-1994).

CLASSIFICATION COMMENTS

Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Timpanogos Cave National Monument Inventory Notes: This association occupies steep colluvial slopes. There are large quantities of downed old wood probably from a beetle kill or budworm infestation several decades ago. Douglas-fir seedlings are being consumed by small white larvae in one stand. No signs of fire were observed in the sampled plots.
Timpanogos Cave National Monument Data Sources: This description is based on 2007 field data (2 plots: TICA.0104, TICA.0201).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. G. Kittel

REFERENCES: Alexander et al. 1984a, Alexander et al. 1987, Bourgeron and Engelking 1994, Cogan et al. 2004, Driscoll et al. 1984, Fitzhugh et al. 1987, Moir and Ludwig 1979, Muldavin et al. 1996, Stuever and Hayden 1997b

Abies concolor / Mixed Grasses Forest
White Fir / Mixed Grasses Forest

CODE	CEGL005357
PHYSIOGNOMIC CLASS	Forest (I)
PHYSIOGNOMIC SUBCLASS	Evergreen forest (I.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen forest (I.A.8.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest (I.A.8.N.)
FORMATION	Conical-crowned temperate or subpolar needle-leaved evergreen forest (I.A.8.N.c.)
ALLIANCE	*ABIES CONCOLOR* FOREST ALLIANCE (A.152) White Fir Forest Alliance

ECOLOGICAL SYSTEM(S): Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This white fir forest occurs in southern and central Utah and likely occurs elsewhere in the southern Rocky Mountains. Elevations range from 1848-2718 m (6060-8910 feet). Stands occur on high slopes of hills, mesas, plateaus, canyons, and benches. The ground surface generally has high cover of litter and sometimes rocks with sparse to moderate exposure of bedrock, bare soil, and wood. Soils are rapidly drained with variable textures ranging from gravelly loams to silty clay loams. Vegetation is characterized by an open to moderate (10-40% cover) tree canopy with an understory dominated by mixed grasses. The tree canopy is dominated or codominated by *Abies concolor* with *Psuedotsuga menziesii, Pinus ponderosa, Populus tremuloides,* or *Juniperus scopulorum* often present in the canopy and subcanopy. The understory consists primarily of bunch grasses with low to moderately dense cover (10-55%), among which *Achnatherum lettermanii, Koeleria macrantha, Leucopoa kingii, Poa fendleriana, Poa secunda,* and *Psuedoroegneria spicata* are the most common. The non-native grasses *Bromus inermis* and *Poa pratensis* are common in some stands. Forb cover is sparse and often diverse. Scattered shrubs and dwarf-shrubs may be present but do not form a layer. The mixed perennial grass herbaceous layer and lack of a distinct shrub layer are diagnostic of this white fir forest.

DISTRIBUTION

Timpanogos Cave National Monument

This association was sampled adjacent to the route of the cave trail that is no longer in use.

Globally

This forest association occurs in southern and central Utah and likely occurs elsewhere in the southern Rocky Mountains.

ENVIRONMENTAL DESCRIPTION

Timpanogos Cave National Monument

This association was sampled once on a mesic, steep (36^{o}), northwest-facing canyon slope at an elevation of 1848 m. Litter and rocks cover most of the ground surface, with low cover by bedrock, bare soil, and wood. The soil is rapidly drained and shows little development, probably because of downslope soil movement on the steep slope.

Globally

This forest association occurs in southern and central Utah and likely occurs elsewhere in the southern Rocky Mountains. Elevations range from 1848-2718 m (6060-8910 feet). Stands occur on high slopes of hills, mesas, plateaus, canyon and benches. The ground surface generally has high cover of litter and sometimes rocks with sparse to moderate exposure of bedrock, bare soil, and wood. Soils are rapidly drained with variable textures ranging from gravelly loams to silty clay loams.

VEGETATION DESCRIPTION

Timpanogos Cave National Monument

This diverse forest association is characterized by 10- to 15-m tall *Abies concolor* and *Pseudotsuga menziesii* trees with 15 and 25% cover, respectively. The understory consists primarily of bunch grasses with approximately 15% cover. among which *Leucopoa kingii, Poa fendleriana,* and *Pseudoroegneria spicata* are conspicuous. Scattered Juniperus scopulorum are present in the subcanopy. Other shrubs in the understory include *Quercus gambelii, Cercocarpus intricatus, Physocarpus alternans,* and *Mahonia repens*. Forbs are a minor component of the herbaceous layer; *Penstemon eatonii, Penstemon platyphyllus,* and *Sedum debile* are the most conspicuous species. Seedling *Abies concolor* trees are present, and Bromus inermis has invaded the stand from plantings associated with the trail to the cave entrance.

Globally

This associations is characterized by an open to moderate (10-40% cover) tree canopy with an understory dominated by mixed grasses. The tree canopy is dominated or codominated by *Abies concolor* with *Pseudotsuga menziesii, Pinus ponderosa, Populus tremuloides,* or *Juniperus scopulorum* often present in the canopy and subcanopy. The understory consists primarily of bunch grasses with low to moderately dense cover (10-55%), among which *Achnatherum lettermanii, Koeleria macrantha, Leucopoa kingii, Poa fendleriana, Poa secunda,* and *Pseudoroegneria spicata* are the most common. The non-native grasses *Bromus inermis* and *Poa pratensis* are

common in some stands. Forb cover is sparse and often diverse. Frequent species include *Artemisia ludoviciana, Balsamorhiza sagittata, Lupinus argenteus, Penstemon eatonii, Penstemon platyphyllus,* and *Sedum debile*. Scattered shrubs and dwarf-shrubs may be present but do not form a distinct layer. Shrub species include *Cercocarpus intricatus, Chrysothamnus depressus, Ericameria nauseosa, Mahonia repens, Quercus gambelii* (<5% cover), *Physocarpus alternans*, or *Symphoricarpos oreophilus. Pseudotsuga menziesii* and *Abies concolor* saplings up to 2 m tall may also be present.

MOST ABUNDANT SPECIES

Timpanogos Cave National Monument

Stratum	Species
Tree canopy	*Abies concolor, Pseudotsuga menziesii*
Tree subcanopy	*Juniperus scopulorum*
Herb (field)	*Leucopoa kingii, Poa fendleriana, Pseudoroegneria spicata*

Globally

Stratum	Species
Tree canopy	*Abies concolor, Pseudotsuga menziesii*
Tree subcanopy	*Juniperus scopulorum*
Herb (field)	*Achnatherum lettermanii, Leucopoa kingii, Poa fendleriana, Poa secunda, Pseudoroegneria spicata*

OTHER NOTEWORTHY SPECIES

Timpanogos Cave National Monument
Bromus inermis, Penstemon platyphyllus

Globally
Bromus inermis, Poa pratensis, Taraxacum officinale, Tragopogon dubius

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (6-Mar-2008).

CLASSIFICATION COMMENTS

Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Timpanogos Cave National Monument Inventory Notes: This association occurs on a steep slope consisting of bedrock and talus, with little soil development; however, there is also no evidence of major slides.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (1 plot: TICA.0202).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Abies concolor / Physocarpus malvaceus Forest
White Fir / Mallow Ninebark Forest

CODE	CEGL000254
PHYSIOGNOMIC CLASS	Forest (I)
PHYSIOGNOMIC SUBCLASS	Evergreen forest (I.A.)
PHYSIOGNOMIC GROUP	Temperate or subpolar needle-leaved evergreen forest (I.A.8.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest (I.A.8.N.)
FORMATION	Conical-crowned temperate or subpolar needle-leaved evergreen forest (I.A.8.N.c.)

ALLIANCE — *ABIES CONCOLOR* FOREST ALLIANCE (A.152)
White Fir Forest Alliance

ECOLOGICAL SYSTEM(S): Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This forest association is limited to central to northern Utah. It is found from 1720-2290 m (5640-7500 feet) in elevation on moderately steep northern slopes. The soils of this association are derived primarily from shaly quartzite. Soils are gravelly with loam to silt loam surface texture. Litter depth averages 6.8 cm. Surface rock exposed is low at 4%. Bare soil exposed averages 1%. *Abies concolor* is the indicated climax. *Pseudotsuga menziesii* is a major seral associate, and stands are fairly closed. Occasionally, *Acer grandidentatum* and *Quercus gambelii* are represented as seral associates, but they are persistent in the largest canopy openings only. The shrub stratum is dominated by typically dense *Physocarpus malvaceus*. Other species which commonly occur are *Amelanchier alnifolia, Paxistima myrsinites,* and *Prunus virginiana*. The herbaceous layer varies; *Carex geyeri* is locally abundant.

DISTRIBUTION

Timpanogos Cave National Monument

This association was sampled from the vicinity of the Visitor Center.

Globally

This association is limited in its range from central to northern Utah.

ENVIRONMENTAL DESCRIPTION

Timpanogos Cave National Monument

The sampled plot of this forest association occupies a mesic, moderately steep (16°), northeast-facing canyon slope at 1720 m elevation. Litter covers most of the ground surface with low cover of wood. Soils are rapidly drained and beginning to develop under the duff layer.

Globally

This forest is found from 1720-2290 m (5640-7500 feet) in elevation on moderately steep northern slopes. The soils are derived primarily from shaly quartzite and are rapidly drained and gravelly with loam to silt loam surface texture. Litter depth averages 6.8 cm. Cover of exposed surface rock and bare soil is low (4% and 1%, respectively).

VEGETATION DESCRIPTION

Timpanogos Cave National Monument

This diverse montane forest association is characterized by a closed canopy of *Pseudotsuga menziesii* and *Abies concolor* trees. Total canopy closure is around 70%. *Physocarpus malvaceus* dominates a patchy tall-shrub layer which may also contain *Paxistima myrsinites, Sambucus caerulea, Symphoricarpos oreophilus, Acer grandidentatum,* and *Prunus virginiana. Mahonia repens* may be abundant, with up to 50% cover. Because of the closed tree canopy, the herbaceous layer tends to be sparse and depauperate, consisting primarily of *Abies concolor* and *Juniperus scopulorum* seedlings, as well as scattered *Maianthemum racemosum, Elymus* sp., and *Clematis hirsutissima*.

Globally

This diverse montane forest is characterized by a moderately dense to closed tree canopy. *Abies concolor* is the indicated climax species, and *Pseudotsuga menziesii* is a major seral associate. Occasionally, *Acer grandidentatum* and *Quercus gambelii* (<5% cover) are represented as seral associates, but they are persistent in the largest canopy openings only. The shrub stratum is dominated by typically dense *Physocarpus malvaceus*. Other species which commonly occur include *Acer grandidentatum, Amelanchier alnifolia, Paxistima myrsinites, Prunus virginiana, Sambucus caerulea,* and *Symphoricarpos oreophilus* with low cover. However, *Mahonia repens* may be abundant with up to 50% cover. *Abies concolor* and *Juniperus scopulorum* seedlings may also be abundant. The herbaceous

layer varies. Mauk and Henderson (1984) report that *Carex geyeri* is locally abundant. Other species include *Maianthemun racemosum, Elymus* sp., and *Clematis hirsutissima*.

MOST ABUNDANT SPECIES

Timpanogos Cave National Monument

Stratum	Species
Tree canopy	*Abies concolor, Pseudotsuga menziesii*
Tall shrub/sapling	*Acer grandidentatum, Prinus virginiana*
Short shrub/sapling	*Physocarpus malvaceus*
Herb (field)	*Mahonia repens*
Herb (field)	*Abies concolor, Juniperus scopulorum*

Globally

Stratum	Species
Tree canopy	*Abies concolor, Pseudotsuga menziesii*
Short shrub/sapling	*Physocarpus malvaceus*
Herb (field)	*Abies concolor*

OTHER NOTEWORTHY SPECIES

Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons: G4G5 (23-Feb-1994).

CLASSIFICATION COMMENTS

Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Timpanogos Cave National Monument Inventory Notes: This association is similar to medium-density forests found on the steeper slopes.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (1 plot: TICA.0204).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: L.D. Engelking, mod. K.A. Schulz

REFERENCES: Bourgeron and Engelking 1994, Driscoll et al. 1984, Mauk and Henderson 1984, Western Ecology Working Group n.d., Youngblood and Mauk 1985

Abies concolor / Quercus gambelii Forest
White Fir / Gambel Oak Forest

CODE	CEGL000261
PHYSIOGNOMIC CLASS	Forest (I)
PHYSIOGNOMIC SUBCLASS	Deciduous forest (I.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous forest (I.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
FORMATION	Montane or boreal cold-deciduous forest (I.B.2.N.b.)
ALLIANCE	*ABIES CONCOLOR* FOREST ALLIANCE (A.152) White Fir Forest Alliance

ECOLOGICAL SYSTEM(S): Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This forest a ssociation has b een reported from mountai ns in New Mexico, Colorado, Utah, and in Arizona. Stands occur along t he Mogollon R im north to the Wasatch Range and east t o the southern Rocky Mountains. Elevations range from 1680-2930 m (55 00-9600 feet). This community is widespread and often occurs on middle and lower slopes and all aspects except south and southwestern. *Abies concolor* and *Pseudotsuga menziesii* typically codominate the upper tree canopy. *Pinus ponderosa, Pinus strobiformis*, and *Juniperus* spp. may also be present. *Quercus gambelii* dominates the subcanopy and undergrowth. Other s hrub species may include *Amelanchier alnifolia, Symphoricarpos oreophilus, Robinia neomexicana*, and *Mahonia repens*. The sparse to moderately dense herbaceous layer is typically composed of *Carex rossi i, Poa fendleriana, Lathyrus lanszwertii* var. *leucanthus, Thalictrum fendleri*, and *Achillea millefolium* . Stands transition to *Pinus ponderosa / Quercus gambelii* Woodland (CEGL000870) in drier sites.

DISTRIBUTION

Timpanogos Cave National Monument

This association was sampled near the Visitor Center, on the Canyon Nature Trail, near Soda Pop Point, and adjacent to Kodachrome Point.

Globally

This forest association has been reported from mountains and plateaus in New Mexico, Colorado, Utah, and Arizona. Stands occur along the Mogollon Rim north into the Wasatch Range and west into the southern Rocky Mountains.

ENVIRONMENTAL DESCRIPTION

Timpanogos Cave National Monument

This fores t association occupies gentle to steep (3° to 50°) cliffs, canyons, scree slopes, and toeslopes with variableexposure between 1717 and 1914 m elevation. Litter, bedrock, rocks and bare soils cover most of the ground surface, with lesser cover by gravel and wood. Soils are rapidly drained loams.

Globally

This forest association has been reported from mountains in New Mexico, Colorado, Utah, and in Arizona along the Mogollon Rim. Elevat ions range from 1717-2930 m (5630-9600 feet). This community is widespread and often occurs on middle and lower slopes of canyons and mountains and on all aspects except southern and southwestern. Slopes range from gentle to steep. Substrates are variable but are frequently rapidly drained loams. Litter cover is generally high except on steep slopes where rock cover is high. Stands transition to *Pinus ponderosa / Quercus gambelii* Woodland (CEGL000870) in drier sites.

VEGETATION DESCRIPTION

Timpanogos Cave National Monument

The canopy of this forest is characterized by *Abies concolor* with 2-25% cover. *Quercus gambelii* dominates the understory with 10-30% cover. Scattered *Pseudotsug a menziesii* and *Juniperus scopulorum* are present in the emergent canopy and subcanopy layers. Other shrubs in this association may include *Acer grandidentatum, Amelanchier alnifolia, Prunus virginiana , Cercocarpus intricatus, Ericameria discoidea, Mahonia repens*, and *Paxistima myrsinites*. The herbaceous layer is limited in cover because of the dense shade cast by the tree and shrub layers, although diversity is relatively high. Common grasses include *Bromus inermis, Bromus tectorum, Dactylis glomerata, Leucopoa kingii, Poa fendleriana*, and *Pseudoroegneria spicata*. Characteristic forbs i nclude *Apocynum androsaemifolium, Artemisia ludo iciana, Erigeron arenarioides, Eriogonum brevicaule, Eriogonum racemosum , Galium multiflorum, Linaria dalmatica, Penstemon pachyphyllus, Penstemon platyphyllus, Petradoria pumila, Sedum debile, Maianthemum racemosum*, and *Solidago velutina*. Seedlings of *Abie s concolor* and *Juniperus scopulorum* may be present.

Globally
This forest association is characterized by a moderately dense to dense tree canopy typically codominated by *Abies concolor* and *Pseudotsuga menziesii*. *Abies concolor* may not dominate all stands but is present in the tree canopy with at least 5% cover. *Pinus ponderosa, Pinus strobiformis*, and *Juniperus* spp. may also be present to codominant. *Quercus gambelii* dominates the subcanopy and undergrowth with 5-30% cover. Other shrub species may include *Acer grandidentatum, Amelanchier alnifolia, Amelanchier utahensis, Cercocarpus intricatus, Paxistima myrsinites, Prunus virginiana, Robinia neomexicana, Mahonia repens*, and *Symphoricarpos oreophilus*. The sparse to moderately dense herbaceous layer may be diverse. Characteristic species include *Achillea millefolium, Apocynum androsaemifolium, Artemisia ludoviciana, Carex rossii, Erigeron arenarioides, Erigeron brevicaule, Erigeron racemosum, Galium multiflorum, Lathyrus lanszwertii, Leucopoa kingii, Linaria dalmatica, Maianthemum racemosum, Penstemon pachyphyllus, Penstemon platyphyllus, Petradoria pumila, Poa fendleriana, Pseudoroegneria spicata, Sedum debile, Solidago velutina*, and *Thalictrum fendleri*. Seedlings of *Abies concolor* and *Juniperus scopulorum* may also be present. *Pseudotsuga menziesii* and *Abies concolor* saplings up to 2 m tall contribute sparse cover.

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	**Species**
Tree canopy	*Abies concolor, Juniperus scopulorum, Pseudotsuga menziesii*
Tree subcanopy	*Juniperus scopulorum*
Tall shrub/sapling	*Acer grandidentatum, Prunus virginiana, Quercus gambelii*
Herb (field)	*Leucopoa kingii*

Globally

Tree canopy	*Abies concolor, Juniperus scopulorum, Pseudotsuga menziesii*
Tall shrub/sapling	*Quercus gambelii*

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Bromus inermis, Bromus tectorum, Dactylis glomerata, Linaria dalmatica, Penstemon platyphyllus

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (1-Feb-1996).

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
Note that this association typically does not include *Acer grandidentatum*.

CLASSIFICATION CONFIDENCE: 1 - Strong

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: This association is characteristic of rock outcrops throughout the lower two-thirds of the monument. Steep gullies in one stand are unvegetated. One sample includes a paved nature trail and has several dead white fir and Douglas-fir trees. This association is the most common forest community within the monument.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (4 plots: TICA.0003, TICA.0102, TICA.0103, TICA.0205 and one observation point: TICA.9206).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Alexander et al. 1984a, Alexander et al. 1987, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Cogan et al. 2004, DeVelice 1983, DeVelice and Ludwig 1983a, DeVelice et al. 1986, Driscoll et al.

1984, Fitz hugh et al. 1987, Johnston 1984, Johnston 1987, Larson and Moir 1987, Madany and West 1984, Moir and Ludwig 1979, Muldavin et al. 1996, Western Ecology Working Group n.d., Youngblood and Mauk 1985

Acer grandidentatum / Quercus gambelii Forest
Bigtooth Maple / Gambel Oak Forest

CODE	CEGL000599
PHYSIOGNOMIC CLASS	Forest (I)
PHYSIOGNOMIC SUBCLASS	Deciduous forest (I.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous forest (I.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
FORMATION	Montane or boreal cold-deciduous forest (I.B.2.N.b.)
ALLIANCE	*ACER GRANDIDENTATUM* MONTANE FOREST ALLIANCE (A.265) Bigtooth Maple Montane Forest Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY

Globally

This forest associat ion has been reported from mountains and plateaus of Utah. Elevations range from 1220-2620 m. Sites include moderate to steep, middle and lower sl opes with cool northern or eastern aspects, intermittently flooded canyon bottoms, alluvial benches, and shaded colluvial slopes. *Acer grandidentatum* and *Quercus gambelii* codomina te the tree canopy. The understory is variable and may be dominated by tall or short shrubs. Species include *Prunus virginiana, Rosa woodsii, Symphoricarpos oreophilus, Physocarpus malvaceus, Mahonia repens,* and seedling trees. The herb aceous layer is generally sparse because of heavy shading. Stands transition to *Quercus gambelii* woodland in the drier uplands.

DISTRIBUTION

Timpanogos Cave National Monument

This association was sampled on the abandoned cave access train, near Dead Dog Point, and just up slope from the Visitor Center.

Globally

This forest association is documented f rom the Wasatch and Uinta ranges in northeastern Utah and the Markagunt Plateau in southwestern Utah.

ENVIRONMENTAL DESCRIPTION

Timpanogos Cave National Monument

This association occupies steep (22° to 36°), north-facing canyon and ravine slopes between 1711 and 1958 m elevation. Litter and rocks cover most of the ground surface, with lower cover by gravel, wood, bare soil and bedrock. The soil is usually rapidly drained.

Globally

This forest association occurs in the mountains and plateaus of Utah. Elevations range from 1220-2620 m. Sites include moderate to steep , middle and lower slopes with cool northern or eastern aspects, intermittently flooded canyon bottoms, alluvial benches, and shaded colluvial slopes. These forests typically occur on relatively mesic sites, especially at lower latitudes and elevations. However, stands have been reported on dry, open slopes in the northern part of its range in the Wasatch Mountains where fire suppression may be allowing Gambel oak-dominated stands to succeed to mixed maple-oak. Substrates are generally calcareous and rocky with soil textures ranging from sand to clay loam.

VEGETATION DESCRIPTION

Timpanogos Cave National Monument

This mesic tall shrubland is characterized by codominance by *Acer grandidentatum* and *Quercus gambelii*, each with 10-50% cover. The community may have some individual plants that approach 10 m in height. *Pseudotsuga menziesii* and *Abies concolor* trees may be scattered throughout the stand, but do not have enough cover to constitute

a canopy layer. Other shrubs may include *Juniperus scopulorum, Prunus virginiana, Acer glabrum, Holodiscus dumosus, Jamesia americana, Mahonia repens,* and *Physocarpus malvaceus*. Because of the high cover by shrubs, the herbaceous layer tends to be sparse and lacking in diversity. *Achnatherum hymenoides, Poa fendleriana, Pseudoroegneria spicata, Galium multiflorum*, and *Heuchera parviflora* are the only herbaceous species reported, and none occur with more than trace cover.

Globally
This association is characterized by a moderately dense to dense tree canopy o f *Acer grandidentatum* that is typically codominated by *Quercus gambelii* with 10-50% c over. *Celtis laevigata* var. *reticulata, Juniperus scopulorum*, or *Juniperus osteosperma* may also be present to abundant. *Pseudotsuga menziesii* and *Abies concolor* trees may be scattered througho ut the stand. The shrub layer is variable, depending on the stand age, elevation and habitat. It ranges from dense *Quercus gambelii*-dominated tall-shrub stratum to a mixed short-shrub layer that includes *Symphoricarpos oreophilus, Prunus virginiana, Amelanchier utahensis, Mahonia repens, Physocarpus malvaceus, Paxistima myrsinites, Acer glabrum, Holodiscus dumosus, Jamesia americana*, and *Rosa woodsii*. The herbaceous layer is generally sparse because of shading. Associates include graminoids such as *Achnatherum hymenoides, Carex hoodii, Elymus glaucus, Poa fendleriana*, and *Pseudoroegneria spicata*, and forbs *Galium multiflorum, Heterotheca villosa, Heuchera parviflora, Thalictrum fendleri, Vicia americana,* and species of *Lathyrus, Osmorhiza, Eriogonum,* and *Polygonum.*

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	**Species**
Tall shrub/sapling	*Acer glabrum, Acer grandidentatum, Prunus virginiana, Quercus gambelii*

Globally

Stratum	**Species**
Tree canopy	*Juniperus scopulorum*
Tall shrub/sapling	*Acer grandidentatum, Quercus gambelii*
Short shrub/sapling	*Symphoricarpos oreophilus*
Herb (field)	*Poa fendleriana*

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Data are not available.

Globally
Bromus diandrus, Bromus tectorum, Poa pratensis

CONSERVATION STATUS RANK
Global Rank & Reasons: G4G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
Acer grandidentatum and *Quercus gambelii* both are widespread western species and occur in the understory of several conifer-dominated associations. There are several similar forest associations that are dominated by *Acer grandidentatum* with one of several oak species codominant or in the understory. Both *Acer grandidentatum* and *Quercus gambelii* have shrub and tree forms which complicate the vegetation classification of this mixed type. This association is typically late seral with some large single- or few-stemmed maples and oaks that are over 5 m tall.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: In one stand the Gambel oak is treelike with large trunks. Rockfall may prevent tree growth at one site. Vertical strips of scree support this type at one site
Timpanogos Cave National Monument Data: This description is based on 2007 field data (3 observation points:

TICA.9201, TICA.9204, TICA.9207).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Allman 1952, Bourgeron and Engelking 1994, Christensen 1955, Cogan et al. 2004, Driscoll et al. 1984, FEIS 2001, Harper et al. 1985, Kun zler et al. 1981, Ream 1960, Ream 1964

Cercocarpus intricatus Montane Shrubland
Littleleaf Mountain-mahogany Montane Shrubland

CODE	CEGL002587
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Evergreen shrubland (III.A.)
PHYSIOGNOMIC GROUP	Temperate broad-leaved evergreen shrubland (III.A.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural temperate broad-leaved evergreen shrubland (III.A.2.N.)
FORMATION	Sclerophyllous temperate broad-leaved evergreen shrubland (III.A.2.N.c.)
ALLIANCE	*CERCOCARPUS INTRICATUS* SHRUBLAND ALLIANCE (A.2659) Littleleaf Mountain-mahogany Shrubland Alliance
ECOLOGICAL SYSTEM(S):	Inter-Mountain Basins Cliff and Canyon (CES304.779) Colo rado Plateau Mixed Bedrock Canyon and Tableland (CES304.765)
USFWS WETLAND SYSTEM:	Not applicable

CONCEPT SUMMARY
Globally
This montane association occurs on ex posed peaks, ridges and plateaus in the Colorado Plateau of western Colorado and eastern Utah and the Wasatch Range in northern Utah. Elevations range from 1850 to 2650 m (6070-8700 feet).Sites are on level to gentle slopes that may be oriented to any aspect. Plants are rooted in cracks and potholes in the limestone or sandsto ne bedrock. Exposed bedrock, gravel a nd large rock cover much of the surface area. Soil collects only in depressions and crevices of the rocky surface and is generally a poorly developed sandy loam. The vegetation is dominated by low-statured *Cercocarpus intricatus* with more than 10% cover. Other shrubs with lesser cover commonly associated include *Amelanchier utahensis, Cercocarpus montanus, Ephedra viridis, Eriogonum corymbosum*, and *Symphoricarpos oreophilus*. The herbaceous layer is diverse but sparse in cover and may include the graminoids *Leymus salinus, Poa fendleriana, Pseudoroegneria spicata, Poa fendleriana, Achnatherum hymenoides, Koeleria macrantha*, and the cushion forbs *Arenaria fendleri, Petrophyton caespitosum*, and *Phlox* spp. Scattered individuals of *Pinus edulis* or *Juniperus osteosperma* may occur in stunted, shrublike form rarely exceeding 2 m in height and not exceeding 5% cover.

DISTRIBUTION
Timpanogos Cave National Monument
This association was sampled adjacent to the main cave access trail.

Globally
This association is documented from Blue Mountain within Dinosaur National Monument in northwestern Colorado as well as from slickrock sites in Canyonlands National Park in eastern Utah and the Wasatch Range in northern Utah. It probably also occurs on other high limestone ridges in northwestern Colorado, such as Douglas Mountai n and Cold Springs Mountain. It may also occur in analogous habitats in southwestern Wyoming and elsewhere in t he Colorado Plateau.

ENVIRONMENTAL DESCRIPTION
Timpanogos Cave National Monument
This shrubland is restricted to rocky ridges with high exposure of bedrock. The sampled stand is located on a steep (42°), northeast-facing ridge at 1881 m elevation. Most of the ground surface is exposed bedrock, with little bare soil, litter, wood, or rocks ev ident. The soil is generally shallow and rapidly drained.

Globally
This montane association occurs on exposed peaks, ridges and plateaus in the Colorado Plateau of western Colorado

and eastern Utah. Elevations range from 1850 to 2650 m (6070-8700 feet). Slopes are gentle, and sites may be oriented to any aspect. Plants are rooted in cracks and po tholes in the limestone or sandstone bedrock. Exposed bedrock, gravel and large rock cover much of the surface area. Soil collects only in depressions and crevices of the rocky surface and is generally a poorly developed sandy loam.

VEGETATION DESCRIPTION

Timpanogos Cave National Monument

This sparse shrub association is characterized by scattered *Cercocarpus intricatus* growing in bedrock cracks and providing 5% cover. Other shrubs present may include *Cercocarpus montanus, Holodiscus dumosus,* and *Quercus gambelii,* as well as occasional stunted *Pseudotsuga menziesii*. The forb *Galium multiflorum* provides sparse cover in the herbaceous layer.

Globally

This montane shrubland is dom inated by *Cercocarpus intricatus,* usually with more than 10% cover, growing in bedrock cracks. Other commonly a ssociated shrubs with less cover include *Amelanchier utahensis, Cercocarpus montanus, Ephedra viridis, Eriogonum corymbosum, Holodiscus dumosus, Quercus gambelii* (<5% cover), and *Symphoricarpos oreophilus*. Although *Cercocarpus intricatus* is overwhelmingly dominant, scattered individuals of *Pinus edulis, Juniperus osteosperma,* or *Pseudotsuga menziesii* may occur in stunted, shrub-like form, rarely exceeding 2 m in height and not exceeding 5% cover. The herbaceous layer is diverse but sparse in cover and may include the graminoids *Leymus salinus, Poa fendleriana, Pseudoroegneria spicata, Poa fendleriana, Achnatherum hymenoides,* and *Koeleria macrantha,* and the cushion forbs *Arenaria fendleri, Galium multiflorum, Petrophyton caespitosum,* and *Phlox* spp.

MOST ABUNDANT SPECIES

Timpanogos Cave National Monument

Stratum	**Species**
Tree canopy	*Pseudotsuga menziesii*
Tall shrub/sapling	*Quercus gambelii*
Short shrub/sapling	*Cercocarpus intricatus, Holodiscus dumosus*

Globally

Stratum	**Species**
Short shrub/sapling	*Cercocarpus intricatus*

OTHER NOTEWORTHY SPECIES

Timpanogos Cave National Monument

Data are not available.

Globally

Bromus tectorum

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (7-Apr-2005).

CLASSIFICATION COMMENTS

Timpanogos Cave National Monument

Data are not available.

Globally

This type represents *Cercocarpus intricatus* shrublands at a much higher density than usually occurs on slickrock. The only difference between this association and *Cercocarpus intricatus* Slickrock Sparse Vegetation (CEGL002977) is the density of *Cercocarpus intricatus* (>10%). Otherwise the setting is similar and the associated species are very similar.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES

Timpanogos Cave National Monument Inventory Notes: This association occurs on a rocky exposed ridge; other shrub species occupy more sheltered sites with deeper soils.

Timpanogos Cave National Monument Data: This description is based on 2007 field data (1 observation point: TICA.9205).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: J. Coles, mod. K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Quercus gambelii / Symphoricarpos oreophilus Shrubland
Gambel Oak / Mountain Snowberry Shrubland

CODE	CEGL001117
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Temperate cold-deciduous shrubland (III.B.2.N.a.)
ALLIANCE	*QUERCUS GAMBELII* SHRUBLAND ALLIANCE (A.920) Gambel Oak Shrubland Alliance

ECOLOGICAL SYSTEM(S): Madrean Lower Montane Pine-Oak Forest and Woodland (CES305.796)
Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)
Southwestern Great Plains Canyon (CES303.664)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This shrublan d association i s found in foothills, plateaus and mountains from western Texas to southern and western Colorado and throughout sou thern Utah north in to the Wasatch Range, and likely occurs in northern Arizona. It is a mesic upland and non-obligate riparian community. Some stands appear to be transitional between riparian areas and drier upland communities such as *Artemisia* spp. It occurs on cool, moist sites, such as along drainages in canyons and steep draws in more xeric areas, and as a mesic upland shrubland forming extensive stands on cooler northern slopes. Substrates are typical ly deep, well-drained sandy loam to clay loam derived from alluvium or colluvium. The vegetation is characterized by an open to closed, typically tall-shrub layer (2-5 m tall) that is dominated by *Quercus gambelii*. The understory is composed of a short-shrub layer that is dominated by *Symphoricarpos oreophilus* or a closely related local *Symphoricarpos* species such as *Symphoricarpos rotundifolius* or *Symphoricarpos palmeri* . Other mesic shrubs may be present, including *Amelanchier* spp., *Prunus virginiana, Robinia neomexicana,* and *Brickellia* sp. In some stands, the *Quercus gambelii* develop into small trees that form a tree canopy. These "woodlands" are included in this association because their floristic composition is identical to the tall shrublands. In other stands the oak is mostly under 2 m tall, forming a short-shrub layer. The herbaceous layer is sparse to moderately dense, depending on density of woody canopy, and is often dominated by graminoids, such as species of *Achnatherum, Bromus, Elym us, Poa,* and *Koeleria*. Common forbs include *Vicia americana, Thalictrum fendleri,* and *Achillea millefolium*. Occasionally, tree species are present in the overstory.

DISTRIBUTION
Timpanogos Cave National Monument
This association was sam pled in the southeast corner of the monument on the canyon rim.

Globally
This shrubland is reported from foothills, plateaus and mountains of western Texas to southern and western Colorado, southern Utah north into the Wasatch Range, and likely occurs in Arizona.

ENVIRONMENTAL DESCRIPTION
Timpanogos Cave National Monument
This tall shrubland occurs on moderate (15° to 20°), sou theast-facing slopes and knolls (slopes). Litter and bare soil cover most of the ground surface, with lower cover by rocks. The soil in the sampled stand is a rapidly drained sandy loam.

Globally
This shrubland is found in foothills, plateaus and mountains from western Texas to southern and western Colorado, throughout southern Utah north into the Wasatch Range , and likely occurs in northern Arizona. Elevation ranges from 1750-2745 m (6000-8600 feet). It is a mesic upland a nd non-obligate riparian community. Some stands appear to be transitional between riparian areas and drier upland c ommunities such as *Artemisia* shrublands. It occurs on hills, high slopes, ridges, mesas, canyon rims, knolls and valley flo ors typically on cooler, moist sites at lower elevations, such as along drainages in canyons and steep draws in more xeric areas, and as a mesic upland shrubland forming extensive stands on cooler northern slopes. Higher-elevation stan ds occur on all aspects. Substrates are typically deep, well-drained sandy loam to silty clay loam derived from al luvium or colluvium. Parent materials include sandstone, shale, and granite conglomerate.

VEGETATION DESCRIPTION
Timpanogos Cave National Monument
This shrub association has a canopy up to 2 m tall dominated by *Quercu s gambelii* shrubs with between 15 and 20% cover. The understory shrub layer is dominated by *Symphoricarpos oreophilus* with between 6 and 20% cover. Other shrubs present with low cover may include *Artemisia tridentata* ssp. *vaseyana* and *Chrysothamnus viscidiflorus*. The herbaceous layer is best developed in the openings between *Quercus gambelii* shrubs and tends to be dominated by forbs such as *Allium acuminatum, Brickellia oblongifolia, Calochortus nuttallii, Helianthella uniflora, Lupinus argenteus*, and *Monardella odoratissima*. Grasses such as *Achnatherum lettermanii, Bromus tectorum*, and *Pseudoroegneria spicata* contribute low cover.

Globally
The vegetation is characterized by an open to closed, tall-shrub layer (2-5 m tall) that is dominated by *Quercus gambelii*. The understory is composed of a short-shrub layer that is dominated by *Symphoricarpos oreophilus* or a closely related local *Symphoricarpos* species such as *Symphoricarpos rotundifolius* or *Symphoricarpos palmeri*. Other shrubs may be present, including *Amelanchier* spp., *Artemisia nova, Artemisia tridentata, Chrysothamnus viscidiflorus, Ericameria nauseosa, Mahonia repens, Peraphyllum ramosissimum Prunus virginiana, Purshia tridentata, Robinia neomexicana, Rosa woodsii*, and *Tetradymia canescens*. In some stands, *Quercus gambelii* develop into small trees that form a tree canopy. These "woodlands" are included in this association because their floristic composition is identical to the tall shrublands. In other stands, the Gambel oak is mostly less than 2 m tall, forming a short-shrub layer. The herbaceous layer is sparse to moderately dense, depending on density of woody canopy, and is often dominated by graminoids, such as species of *Achnatherum, Bromus, Elymus, Poa, Pseudoroegneria spicata*, and *Koeleria macrantha*. Common forbs include *Achillea millefolium, Balsamorhiza sagittata, Chenopodium leptophyllum, Clematis ligusticifolia, Ligusticum porteri, Lupinus argenteus, Thalictrum fendleri*, and *Vicia americana*. Occasionally, tree species are present in the overstory, including *Pinus ponderosa, Juniperus scopulorum*, and *Pseudotsuga menziesii*. Introduced graminoids such as *Bromus inermis* and *Poa pratensis* are often common in stands that have been disturbed by heavy livestock grazing.

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	**Species**
Tall shrub/sapling	*Quercus gambelii*
Short shrub/sapling	*Symphoricarpos oreophilus*
Herb (field)	*Helianthella uniflora, Lupinus argenteus*

Globally

Tall shrub/sapling	*Quercus gambelii*
Short shrub/sapling	*Symphoricarpos oreophilus*

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
This plant association is similar to other montane Gambel oak shrublands except for the codominance of *Symphoricarpos oreophilus* with minor amounts (<10% cover) of *Amelanchier utahensis, Artemisia tridentata*, or *Cercocarpus montanus*.

CLASSIFICATION CONFIDENCE: 2 - Moderate

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: This association is limited to the rim of the canyon, far above the level of the caves. Some stands have taller Gambel oak shrubs with denser vegetation in the understory.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (1 plot: TICA.0101and 1 observation point: TICA.9101).
Local Description Authors: J. Thompson, mod. J. Coles
Global Description Authors: K.A. Schulz, mod. J. Coles

REFERENCES: Baker 1982b, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Clary 1992, Cogan et al. 2004, Crane 1982, Driscoll et al. 1984, Erdman 1962, Hess and Wasser 1982, Hoffman and Alexander 1980, Hoffman and Alexander 1983, Johnston 1987, Kittel et al. 1994, Kittel et al. 1999a, Kittel et al. 1999b, Komarkovaet al. 1988a, Muldavin 1994, Muldavin and Mehlhop 1992, Muldavin et al. 1994a, Muldavin et al. 1998b, Muldavin et al. 2000b, Soil Conservation Service 1978, Western Ecology Working Group n.d., Wright et al. 1979

Quercus gambelii Shrubland
Gambel Oak Shrubland

CODE	CEGL002477
PHYSIOGNOMIC CLASS	Shrubland (III)
PHYSIOGNOMIC SUBCLASS	Deciduous shrubland (III.B.)
PHYSIOGNOMIC GROUP	Cold-deciduous shrubland (III.B.2.)
PHYSIOGNOMIC SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N.)
FORMATION	Temperate cold-deciduous shrubland (III.B.2.N.a.)
ALLIANCE	*QUERCUS GAMBELII* SHRUBLAND ALLIANCE (A.920) Gambel Oak Shrubland Alliance

ECOLOGICAL SYSTEM(S): Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
This tall shrubland is known from northeastern Arizona, southwestern Colorado and southeastern Utah on the Colorado Plateau north into the Wasatch Range. Stands occur on southeastern to western aspects at 1884 to 2379 m (6181-7805 feet) elevation on gentle to moderately steep slopes (0-30%). Sites include canyons, mesas, stream terraces and a toeslope at the base of a cliff. The frequently sandy soils have low cover of rock and moderate to high cover of littler on the ground surface. There is frequently evidence of past fires. The vegetation is characterized by an open to dense (25-75% cover), tall-shrub (>10 m) canopy dominated by *Quercus gambelii*. Scattered *Pinus edulis* and *Juniperus osteosperma* trees may be present. Other shrubs (all with <1% cover) are *Ericameria nauseosa, Gutierrezia sarothrae, Mahonia repens, Opuntia phaeacantha*, and *Purshia tridentata*. The herbaceous stratum is variable. *Artemisia ludoviciana* and *Elymus elymoides* are important species as is the exotic annual grass and forb species. *Bromus tectorum* and *Erodium cicutarium*, respectively. The herbaceous stratum has a diversity of other species with low cover (<1%).

DISTRIBUTION

Timpanogos Cave National Monument
This association is known from near the Rock House, the Swinging Bridge, and the abandoned cave trail areas.

Globally
This association has been reported from Mesa Verde National Park in southwestern Colorado and Canyon de Chelly National Monument in northeastern Arizona on the Colorado Plateau. It likely occurs elsewhere in the region, especially in areas relatively recently disturbed.

ENVIRONMENTAL DESCRIPTION
Timpanogos Cave National Monument
This tall-shrub association occupies moderately steep to steep (18° to 36°) canyon and ravine slopes with varying exposures. Litter and rocks cover most of the ground surface, with lower cover by bare soil and bedrock. The soil is generally a rapidly drained sandy loam.

Globally
This tall shrubland is known from northeastern Arizona, southwestern Colorado and southern Utah in the Colorado Plateau and extends north into the Wasatch Range. Stands occur on southeastern to western aspects at 1884-2379 m (6181-7805 feet) elevation on gentle to moderately steep slopes (0-30%). Sites include canyons, ravines, mesas, stream terraces and toeslopes. The soils are often sandy loams but may include silty clay loams with low cover of rock and moderate to high cover of litter on the ground surface. There is frequently evidence of past fires.

VEGETATION DESCRIPTION
Timpanogos Cave National Monument
This shrubland association is characterized by a closed canopy of *Quercus gambelii* (60-80% cover). Minor shrub canopy components include *Acer grandidentatum, Holodiscus dumosus, Mahonia repens, Juniperus communis, Prunus virginiana,* and *Ribes cereum*. The herbaceous layer is limited in diversity and cover due to the density of the shrub layer. Grasses include *Bromus tectorum, Poa fendleriana,* and *Pseudoroegneria spicata*. Forbs may include scattered individuals of *Apocynum androsaemifolium, Eriogonum racemosum, Galium aparine,* and *Vicia americana*. Seedling *Abies concolor* rees are present in the herbaceous layer of one stand.

Globally
This tall shrubland is characterized by an open to dense (25-75% cover) tall-shrub (>10 m) dominated by *Quercus gambelii*. Scattered *Pinus edulis* and *Juniperus osteosperma* trees may be present. Other shrubs (all with <1% cover) are *Amelanchier utahensis, Ericameria nauseosa, Gutierrezia sarothrae, Mahonia repens, Opuntia phaeacantha, Rhus trilobata,* and *Purshia tridentata.* The herbaceous stratum is variable and often has a high diversity of species with low cover (<1%), such as *Achillea millefolium* var. *occidentalis, Achnatherum hymenoides, Artemisia ludoviciana, Balsamorhiza sagittata, Eriogonum racemosum, Elymus elymoides, Elymus trachycaulus* ssp. *trachycaulus, Galium aparine, Maianthemum stellatum, Poa fendleriana, Pseudoroegneria spicata, Solidago velutina,* and *Vicia americana*. Exotic annual grass and forb species *Bromus tectorum* and *Erodium cicutarium* are frequently present to abundant.

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	**Species**
Tall shrub/sapling	*Acer grandidentatum, Quercus gambelii*
Herb (field)	*Apocynum androsaemifolium*
Herb (field)	*Abies concolor*

Globally

Stratum	**Species**
Shrub/sapling (tall & short)	*Quercus gambelii*

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Data are not available.

Globally

Bromus tectorum, Erodium cicutarium

CONSERVATION STATUS RANK
Global Rank & Reasons: GNR (29-Mar-2005).

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
This association is intended for shrublands of oak with no other shrubs associated with mixed mountain shrublands (e.g., *Amelanchier* spp., *Symphoricarpos oreophilus, Prunus virginiana, Cercocarpus montanus,* etc.) or a distinctive herbaceous layer. Many stands are in unusual settings, such as recent burns (e.g., Mesa Verde National Park). It is likely to be a transitional phase that will eventually return to a more mixed shrub canopy understory or in some cases become dominated by exotic herbaceous species.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: One stand supports taller Gambel oak stems killed by a fast burn. One stand is in the midst of active rockfall and sliding talus.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (2 plots: TICA.0001, TICA.0002 and 1 observation point: TICA.9202).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: K.A. Schulz

REFERENCES: Western Ecology Working Group n.d.

Acer grandidentatum – Prunus virginiana Shrubland [Park Special]
Bigtooth Maple – Chokecherry Shrubland [Park Special]

CODE	Park Special
PHYSIOGNOMIC CLASS	Not Applicable
PHYSIOGNOMIC SUBCLASS	Not Applicable
PHYSIOGNOMIC GROUP	Not Applicable
PHYSIOGNOMIC SUBGROUP	Not Applicable
FORMATION	Not Applicable
ALLIANCE	Not Applicable

ECOLOGICAL SYSTEM(S): Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
Data are not available.

DISTRIBUTION
Timpanogos Cave National Monument
This association was sampled near the Rock House.

Globally
Data are not available.

ENVIRONMENTAL DESCRIPTION
Timpanogos Cave National Monument
This association occupies steep (40^{o}), northwest-facing mesic gullies. Litter and moss cover most of the ground surface. The soil is rapidly drained.

Globally
Data are not available.

VEGETATION DESCRIPTION
Timpanogos Cave National Monument
The canopy of this disturbance-adapted tall shrubland is dominated by *Acer grandidentatum* and *Prunus virginiana* totaling more than 90% cover. *Mahonia repens* provided sparse cover in the ground layer. Herbaceous species are sparse, but may include *Leucopoa kingii* and *Galium multiflorum*.

Globally
Data are not available.

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	Species
Tall shrub/sapling	*Acer grandidentatum, Prunus virginiana*

Globally
Data are not available.

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: Not applicable.

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: This association occurs in a steep gully system; trunks of shrubs showed rock damage.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (1 plot: TICA.0105).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: Data are not available

REFERENCES: Western Ecology Working Group n.d.

Acer negundo / Acer grandidentatum Woodland [Park Special]
Box-elder / Bigtooth Maple Woodland [Park Special]

CODE	Park Special
PHYSIOGNOMIC CLASS	Not Applicable
PHYSIOGNOMIC SUBCLASS	Not Applicable
PHYSIOGNOMIC GROUP	Not Applicable
PHYSIOGNOMIC SUBGROUP	Not Applicable
FORMATION	Not Applicable
ALLIANCE	Not Applicable

ECOLOGICAL SYSTEM(S): Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
Data are not available.

DISTRIBUTION
Timpanogos Cave National Monument
This association is known from the Second Tunnel area of the cave access trail.

Globally
Data are not available.

ENVIRONMENTAL DESCRIPTION
Timpanogos Cave National Monument
This woodland association occupies a steep (32o), northeast-facing ravine containing an avalanche chute at 1795 m elevation. Rocks and litter cover most of the ground surface. The soil is a rapidly drained loam.

Globally
Data are not available.

VEGETATION DESCRIPTION
Timpanogos Cave National Monument
This disturbance-maintained woodland is characterized by an open canopy of *Acer negundo* and a mixed shrub layer in which *Acer grandidentatum* is dominant. *Acer glabrum, Cornus sericea, Juniperus scopulorum*, and *Sambucus caerulea* may also occur. The herbaceous layer consists of sparse *Achnatherum hymenoides*.

Globally
Data are not available.

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	**Species**
Tree canopy	*Acer negundo*
Herb (field)	*Acer grandidentatum, Acer glabrum*

Globally
Data are not available.

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: Not applicable.

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: This association occupies a ravine that acts as an avalanche chute; snow movement results in bent but not broken shrubs. There is no Gambel oak establishment here as would occur on drier sites.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (1 plot: TICA.0203).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: Data are not available

REFERENCES: Western Ecology Working Group n.d.

Acer negundo – Populus angustifolia – Abies concolor Woodland [Park Special]
Box-elder – Narrowleaf Cottonwood – White Fir Woodland [Park Special]

CODE	Park Special
PHYSIOGNOMIC CLASS	Not Applicable
PHYSIOGNOMIC SUBCLASS	Not Applicable
PHYSIOGNOMIC GROUP	Not Applicable
PHYSIOGNOMIC SUBGROUP	Not Applicable
FORMATION	Not Applicable
ALLIANCE	Not Applicable

ECOLOGICAL SYSTEM(S): Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
Data are not available.

DISTRIBUTION
Timpanogos Cave National Monument
This association was sampled in the Swinging Bridge Picnic Area of the Monument.

Globally
Data are not available.

ENVIRONMENTAL DESCRIPTION
Timpanogos Cave National Monument
This woodland occupies mesic toe slope and terraces at the bottom of the canyon. Slopes do not exceed 5o; the elevation of the sampled stand is 1705 m. Litter and bare soil comprise most of the ground surface, with lower cover by large rocks. Soils are rapidly drained and derived from alluvium.

Globally
Data are not available.

VEGETATION DESCRIPTION
Timpanogos Cave National Monument
This woodland is characterized by a mixed canopy of *Acer negundo, Abies concolor*, and *Populus angustifolia* trees with a total cover of around 45%. The subcanopy layer includes 2-5 m tall *Acer negundo, Abies concolor*, and *Pseudotsuga menziesii*. The sampled stand is clearly used as a developed picnic area and the understory is disturbed. Shrubs are concentrated along the banks of the American Fork River and include *Acer grandidentatum, Betula occidentalis, Cornus sericea, Mahonia repens,* and *Prunus virginiana*. Exotic species dominate the patchy herbaceous layer, including *Bromus inermis, Bromus tectorum,* and *Dactylis glomerata*. Seedling *Abies concolor* trees are present.

Globally
Data are not available.

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	Species
Tree canopy	*Acer negundo, Abies concolor, Populus angustifolia*

Globally
Data are not available.

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Bromus inermis, Bromus tectorum, Dactylis glomerata

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: Not Applicable.

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes: This association occurs within a picnic area where much of the understory was removed to harden the ground surface with gravel and asphalt.
Timpanogos Cave National Monument Data: This description is based on 2007 field data (1 observation point: TICA.9001).
Local Description Authors: J. Von Loh, mod. J. Coles
Global Description Authors: Data are not available

REFERENCES: Western Ecology Working Group n.d.

Bromus tectorum – Exotic Forbs Herbaceous Vegetation [Park Special]
Cheatgrass – Exotic Forbs Herbaceous Vegetation [Park Special]

CODE	Park Special
PHYSIOGNOMIC CLASS	Not Applicable
PHYSIOGNOMIC SUBCLASS	Not Applicable
PHYSIOGNOMIC GROUP	Not Applicable
PHYSIOGNOMIC SUBGROUP	Not Applicable
FORMATION	Not Applicable
ALLIANCE	Not Applicable

ECOLOGICAL SYSTEM(S): Inter-Mountain Basins Montane Sagebrush Steppe (CES304.785)

USFWS WETLAND SYSTEM: Not applicable

CONCEPT SUMMARY
Globally
Data are not available.

DISTRIBUTION
Timpanogos Cave National Monument
This association occurs near the Swinging Bridge Picnic Area.

Globally
Data are not available.

ENVIRONMENTAL DESCRIPTION
Timpanogos Cave National Monument
This association occupies a rocky toeslope that is part of a debris flow fan for Swinging Bridge Creek. Bare ground and litter cover most of the ground surface. The soil is rapidly drained.

Globally
Data are not available.

VEGETATION DESCRIPTION
Timpanogos Cave National Monument
This community is dominated by *Bromus tectorum* with a mix of weedy exotic and native forbs. The exact composition varies by year and season. Scattered shrubs of *Artemisia tridentata* ssp. *vaseyana* and *Ericameria nauseosa* occur throughout this meadow, and young sagebrush suggest that eventually this community will become a shrubland.

Globally
Data are not available.

MOST ABUNDANT SPECIES
Timpanogos Cave National Monument

Stratum	**Species**
Short shrub/sapling	*Artemisia tridentata* ssp. *vaseyana*, *Ericameria nauseosa* var. *graveolens*
Herb (field)	*Bromus tectorum*, *Panicum capillare*
Herb (field)	*Berteroa incana*, *Convolvulus arvense*, *Kochia americana*, *Tragopogon dubius*

Globally
Data are not available.

OTHER NOTEWORTHY SPECIES
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons: Not applicable.

CLASSIFICATION COMMENTS
Timpanogos Cave National Monument
Data are not available.

Globally
Data are not available.

CLASSIFICATION CONFIDENCE: 3 - Weak

ELEMENT SOURCES
Timpanogos Cave National Monument Inventory Notes:
Timpanogos Cave National Monument Data: This description is based on information provided by Natural Resources Program Manager Camille Pulham. It was not sampled.
Local Description Authors: J. Coles
Global Description Authors:

REFERENCES:

Bibliography for Timpanogos Cave National Monument

Alexander, B. G., Jr., E. L. Fitzhugh, F. Ronco, Jr., and J. A. Ludwig. 1987. A classification of forest habitat types of the northern portion of the Cibola National Forest, NM. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General technical Report RM-143. Fort Collins, CO. 35 pp.

Alexander, B. G., Jr., F. Ronco, Jr., E. L. Fitzhugh, and J. A. Ludwig. 1984a. A classification of forest habitat types of the Lincoln National Forest, New Mexico. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-104. Fort Collins, CO. 29 pp.

Allman, V.P. 1952. A preliminary study of the vegetation in an exclosure in the chaparral of the Wasatch Mountains, Utah. Unpublished thesis, Brigham Young University, Provo, UT.

Atzet, T. and D. L. Wheeler. 1984. Preliminary plant associations of the Siskiyou Mountains Province, Siskiyou National Forest. USDA Forest Service, Pacific Northwest Region, Portland, OR.

Atzet, T. and L. A. McCrimmon. 1990. Preliminary plant associations of the southern Oregon Cascade Mountain Province. USDA Forest Service, Pacific Northwest Region, Siskiyou National Forest, Grants Pass, OR. 330 pp.

Baker, W. L. 1982b. Natural vegetation of the Piceance Basin, Colorado. Appendix D, pages 1-113 in: J. S. Peterson and W. L. Baker, editors. Inventory of the Piceance Basin, Colorado. Unpublished report for the Bureau Land Management, Craig, CO.

Bourgeron, P. S., and L. D. Engelking, editors. 1994. A preliminary vegetation classification of the western United States. Unpublished report. The Nature Conservancy, Boulder, CO. 175 pp. plus appendix.

CONHP [Colorado Natural Heritage Program]. 2003. Unpublished data. Elements and Elcodes entered into Biotics Tracker 4.0. Colorado Natural Heritage Program, Colorado State University, Ft Collins, CO.

Christensen, E. M. 1955. Ecological notes on the mountain brush in Utah. Proceedings of the Utah Academy of Science, Arts, and Letters 32:107-111.

Clary, W. P. 1992. Ecology and values of Gambel oak woodlands. Pages 87-95 in: USDA Forest Service General Technical Report RM-218. Ecology and management of oak and associated woodlands. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 224 pp.

Cogan, D., M. Reid, K. Schulz, and M. Pucherelli. 2004. Zion National Park, Utah 1999-2003. Vegetation Mapping Project. Technical Memorandum 8260-03-01. Remote Sensing and GIS Group Technical Service Center, Bureau of Reclamation, Denver, CO. Appendix F: Vegetation Association Descriptions for Zion.

Crane, M. F. 1982. Fire ecology of Rocky Mountain forest habitat types. USDA Forest Service report. 272 pp.

DeVelice, R. L. 1983. Forest vegetation of northern New Mexico and southern Colorado. Unpublished dissertation, New Mexico State University, Las Cruces. 191 pp.

DeVelice, R. L., J. A. Ludwig, W. H. Moir, and F. Ronco, Jr. 1986. A classification of forest habitat types of northern New Mexico and southern Colorado. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-131. Fort Collins, CO. 59 pp.

DeVelice, R. L., J. A. Ludwig. 1983a. Climax forest series of northern New Mexico and southern Colorado. Pages 45-53 in: Proceedings of the Workshops on Southwestern Habitat Types, 6-8 April 1983, Albuquerque, NM. USDA Forest Service, Southwest Region, Albuquerque, NM.

Dieterich, J. H. 1980. Chimney Spring forest fire history. USDA Forest Service Research Paper RM-220. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 8 pp.

Driscoll, R. S., D. L. Merkel, D. L. Radloff, D. E. Snyder, and J. S. Hagihara. 1984. An ecological land classification framework for the United States. USDA Forest Service. Miscellaneous Publication No. 1439. Washington, DC. 56 pp.

Erdman, J. A. 1962. Ecology of the pinyon-juniper woodland of Wetherill Mesa, Mesa Verde National Park, Colorado. Unpublished thesis, University of Colorado, Boulder. 109 pp.

FEIS [Fire Effects Information System]. 2001. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2001, May). http://www. fs.fed.us/database/feis/. Accessed [07-20-01].

Fitzhugh, E. L., W. H. Moir, J. A. Ludwig, and F. Ronco, Jr. 1987. Forest habitat types in the Apache, Gila, and part of the Cibola national forests. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-145. Fort Collins, CO. 116 pp.

Harper, K. T., F. J. Wagstaff, and L. M. Kunzler. 1985. Biology and management of the Gambel oak vegetative type: a literature review. USDA Forest Service General Technical Report INT-179 Intermountain Forest and Range Experiment Station, Ogden, UT. 31 pp.

Hess, K., and C. H. Wasser. 1982. Grassland, shrubland, and forest habitat types of the White River-Arapaho National Forest. Unpublished final report 53-82 FT-1-19. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 335 pp.

Hoffman, G. R. and R. R. Alexander. 1980. Forest vegetation of the Routt National Forest in northwestern Colorado: A habitat type classification. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-221. Fort Collins, CO. 41 pp.

Hoffman, G. R. and R. R. Alexander. 1983. Forest vegetation of the White River National Forest in western Colorado: A habitat type classification. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Research Paper RM-249. Fort Collins, CO. 36 pp.

Johnston, B. C. 1984. Plant associations of Region Two. Edition 3.5. USDA Forest Service, Rocky Mountain Region. Lakewood, CO.

Johnston, B. C. 1987. Plant associations of Region Two: Potential plant communities of Wyoming, South Dakota, Nebraska, Colorado, and Kansas. R2-ECOL-87-2. USDA Forest Service, RM Region. Lakewood, CO. 429 pp.

Kittel, G., E. Van Wie, M. Damm, R. Rondeau, S. Kettler, A. McMullen, and J. Sanderson. 1999b. A classification of riparian and wetland plant associations of Colorado: A user's guide to the classification project. Colorado Natural Heritage Program, Colorado State University, Fort Collins CO. 70 pp. plus appendices.

Kittel, G., E. Van Wie, M. Damm, R. Rondeau, S. Kettler, and J. Sanderson. 1999a. A classification of the riparian plant associations of the Rio Grande and Closed Basin watersheds, Colorado. Unpublished report prepared by the Colorado Natural Heritage Program, Colorado State University, Fort Collins.

Kittel, G., R. Rondeau, N. Lederer, and D. Randolph. 1994. A classification of the riparian vegetation of the White and Colorado River basins, Colorado. Final report submitted to Colorado Department of Natural Resources and the Environmental Protection Agency. Colorado Natural Heritage Program, Boulder. 166 pp.

Komarkova, V., A. Peters, G. Kamani, W. Jones, V. Howard, H. Gordon, and K. Southwick. 1988a. Natural recovery of plant communities on disturbance plots and history of land use in the Niwot Ridge/Green Lakes Valley, Front Range, Colorado. University of Colorado Longterm Ecological Research Working Paper 88/1. Boulder, CO. 46 pp.

Kunzler, L. M., K. T. Harper, and D. B. Kunzler. 1981. Compositional similarity within the oakbrush type in central and northern Utah. Great Basin Naturalist 41(1):147-153.

Larson, M. and W. H. Moir. 1987. Forest and woodland habitat types of northern New Mexico and northern Arizona. Edition 2. USDA Forest Service, Southwestern Region, Albuquerque, NM.

Madany, M. H., and N. E. West. 1984. Vegetation of two relict mesas in Zion National Park. Journal of Range Management 37(5):456-461.

Mauk, R. L., and J. A. Henderson. 1984. Coniferous forest habitat types of northern Utah. USDA Forest Service
General Technical Report INT-170. Intermountain Forest and Range Experiment Station, Ogden, UT. 89 pp.

Moir, W. H., and J. A. Ludwig. 1979. A classification of spruce-fir and mixed conifer habitat types of Arizona and New Mexico. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Research Paper RM-207. Fort Collins, CO. 47 pp.

Muldavin, E. 1994. Organ Mountains sensitive species and plant community inventory. Unpublished report prepared by the New Mexico Natural Heritage Program, Albuquerque.

Muldavin, E. H., R. L. DeVelice, and F. Ronco, Jr. 1996. A classification of forest habitat types of southern Arizona and portions of the Colorado Plateau. USDA Forest Service General Technical Report RM-GTR-287. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 130 pp.

Muldavin, E. G. Harper, P. Neville, and Y. Chauvin. 1998b. The vegetation of White Sands Missile Range, New Mexico. Final report for Cooperative Agreement No. 14-16-00-91-233 White Sands Missile Range, U.S. Fish & Wildlife Service. The Nature Conservancy and the University of New Mexico.

Muldavin, E., P. Mehlhop, and E. DeBruin. 1994a. A survey of sensitive species and vegetation communities in the Organ Mountains of Fort Bliss. Volume III: Vegetation communities. Report prepared for Fort Bliss, Texas, by New Mexico Natural Heritage Program, Albuquerque.

Muldavin, E., P. Neville, C. Jackson, and T. Neville. 2006. A vegetation map of Valles Caldera National Preserve, New Mexico. Natural Heritage New Mexico Publication No. 06-GTR-302. Natural Heritage New Mexico, University of New Mexico, Albuquerque. 59 pp.

Muldavin, E., Y. Chauvin, and G. Harper. 2000b. Vegetation of White Sands Missile Range, New Mexico: Volume I. Handbook of vegetation communities. Final Report to White Sands Missile Range by New Mexico Natural Heritage Program, University of New Mexico, New Mexico. 192 pp.

Muldavin, E., and P. Mehlhop. 1992. A preliminary classification and test vegetation map for White Sands Missle Range and San Andreas National Wildlife Refuge, New Mexico. University of New Mexico, New Mexico Natural Heritage Program.

Peet, R. K. 1981. Forest vegetation of the Colorado Front Range. Vegetatio 45:3-75.

Ream, R. D. 1960. An ordination of the oak communities of the Wasatch Mountains. M.S. thesis, University of Utah, Salt Lake City. 52 pp.

Ream, R. R. 1964. The vegetation of the Wasatch Mountains, Utah and Idaho. Unpublished Ph.D. dissertation, University of Wisconsin, Madison. 190 pp.

Soil Conservation Service. 1978. Range site descriptions for Colorado. Technical Guide, Section II-E. USDA Soil Conservation Service, Colorado State Office, Denver.

Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kittams. 1981. Forest habitat types of central Idaho. USDA Forest Service General Technical Report INT-114. IM Forest and Range Experiment Station, Ogden, UT. 138 pp.

Stuever, M. C., and J. S. Hayden. 1997b. Plant associations of Arizona and New Mexico. Edition 3. Volume 1: Forests. USDA Forest Service, Southwestern Region. Habitat Typing Guides. 291 pp.

Western Ecology Working Group of NatureServe. No date. International Ecological Classification Standard: International Vegetation Classification. Terrestrial Vegetation. NatureServe, Boulder, CO.

Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state of the art review. USDA Forest Service General Technical Report INT-58. Intermountain Forest and Range Experiment Station. Ogden, UT.

Youngblood, A. P., and R. L. Mauk. 1985. Coniferous forest habitat types of central and southern Utah. USDA Forest Service, Intermountain Research Station. General Technical Report INT-187. Ogden, UT. 89 pp.

Appendix G

Illustrated Keys to the Plant Associations of Timpanogos Cave National Monument

Introduction

The vegetation of Timpanogos Cave National Monument was sampled during the summer of 2007 under the USGS-NPS Vegetation Mapping Program. This dichotomous key, illustrated with field photographs, has been prepared to assist in the identification of native vegetation present at the Monument. The key is designed to be effective using one or more dominant species with environmental characteristics. In ecotones (areas where plant associations mix) or in areas where small patches of several distinct associations mix, it may be difficult to determine a definitive association name.

This key also allows the user to crosswalk plant associations to the Timpanogos Cave National Monument vegetation map. In general, each map class represents one association, with several exceptions. The *Abies concolor / Quercus gambelii* Forest, *Abies concolor - Pseudotsuga menziesii / Acer glabrum* Forest, and *Abies concolor / Acer grandidentatum* Forest associations are divided between two map classes based on their environmental setting (colluvial slopes versus rock outcrops) and slight variations in cover and understory composition. These differences, although recognizable in the field at TICA, are too subtle to be recognized at the association level by the NVC.

Four map classes (Appendix J) are based on vegetation types that were not sampled for safety or logistical reasons. These vegetation types were not classified or otherwise included in this key or the report because of the lack of plot data and descriptive information:

Quaking Aspen Forest. This type occurs in the extreme southwestern corner of the Monument on the canyon rim, and was not sampled because of logistical constraints.
Douglas-fir - Limber Pine Woodland. This type occupies dry convex slopes on the upper canyon wall within the Monument. White fir is absent from the canopy. Access to stands was limited by vertical cliffs and extreme exposure.
Douglas-fir / Mountain Maple Woodland. This type occupies mesic concave slopes on the upper canyon wall within the Monument. White fir is absent from the canopy, but some stands contain quaking aspen as a canopy co-dominant. Access to stands was limited by vertical cliffs and extreme exposure.
Grassy Rock Goldenrod - Bluebunch Wheatgrass. This sparse herbaceous type occurs consistently on thin soils on the canyon rim. It was not sampled because no stand was large enough for a sample plot.

HOW TO USE THE KEY

The key approaches plant association identification at two levels. The first level is physiognomic (forest, woodland, tall shrubland, shrubland, dwarf-shrubland, graminoid, or forb). The second level allows identification to plant association based on the dominant species, and to a lesser

extent, habitat characteristics. Photographs illustrating some of the variation within associations appear below association names.

NVC conventions dictate that in mixed conifer stands, the tree species with the highest diagnostic value are those for which the association is named. Because of this convention, most of the coniferous vegetation at TICA is assigned to associations within the *Abies concolor* Forest Alliance, although many stands are clearly dominated by *Pseudotsuga menziesii.* Because *Abies concolor* has greater shade tolerance and is more restricted in its habitat tolerances and distribution, it is the primary diagnostic species no matter how low its cover in the canopy or seedling layers.

A Key to the Vegetation of Timpanogos Cave National Monument

1a) Woodland or forest vegetation dominated by trees, either the coniferous species *Abies concolor* and *Pseudotsuga menziesii*, or the deciduous species *Acer negundo* and *Populus angustifolia*. Some stands may have mixed canopies, and understories may be dominated by grasses or by shrubs - **2**

1b) Vegetation dominated by shrubs, or in one case, by herbaceous species with scattered shrubs; total vegetation cover may be sparse to dense. Characteristic species dominating the shrub canopy may include *Quercus gambelii, Cercocarpus montanus, Acer grandidentatum, Mahonia repens, Artemisia tridentata* ssp. *vaseyana, Ericameria nauseosa,* and *Prunus virginiana* - **9**

2a) (from couplet 1) Woodland or forest vegetation in which the canopy is dominated by the coniferous species *Abies concolor* or *Pseudotsuga menziesii* - **3**

2b) Woodland or forest vegetation dominated or co-dominated by the deciduous species *Acer negundo* or *Populus angustifolia*. Coniferous species may be present, especially in the seedling and subcanopy layers, but do not dominate the upper levels of the canopy - **7**

3a) (2) Coniferous stands with canopies ranging from sparse (10% cover) to closed (>60%). The tree canopy may be dominated by either *Abies concolor* or *Pseudotsuga menziesii*; in most cases, both species are present in the canopy and in the seedling layers. *Juniperus scopulorum* may form a significant subcanopy in dry stands. The sparse to dense understory is dominated by shrub species, including *Acer* spp., *Quercus gambelii*, *Physocarpus* spp., and *Mahonia repens* - **4**

3b) Open mixed conifer woodlands with an understory dominated by native bunchgrasses, including *Leucopoa kingii, Pseudoroegneria spicata*, and *Poa fendleriana*. Shrubs in the understory include *Mahonia repens, Physocarpus alternans, Cercocarpus intricatus,* and *Quercus gambelii*; however, total shrub cover is much less than that of the grasses - ***Abies concolor* / Mixed Grasses Forest (White Fir / Mixed Grasses Forest) [Map Class 6]**

4a) (3) Mixed conifer woodland and forest stands with an understory dominated by species of *Acer* - **5**

4b) Mixed conifer woodland and forest stands with an understory dominated by shrub species other than *Acer*, although *Acer grandidentatum* may be present with low cover - **6**

5a) (4) Open mixed conifer woodlands on relatively dry talus deposits with a shrub understory dominated by *Acer* spp. *Acer glabrum* has at least twice as much cover as *Acer grandidentatum*. Other shrubs present (with lower cover than *Acer* spp.) may include *Quercus gambelii* and *Mahonia repens*, and grasses may have at least a few percent cover - ***Abies concolor - Pseudotsuga menziesii / Acer glabrum*** **Forest (White Fir – Douglas-fir / Mountain Maple Forest) [Closed stands on colluvial slopes = Map Class 7; Sparse stands in areas dominated by rock outcrops = Map Class 8]**

5b) Sparse to dense mixed conifer woodlands with a shrub understory dominated by *Acer grandidentatum. Acer glabrum* is absent or has very low cover relative to *A. grandidentatum*. Shrub cover may exceed that of the tree canopy, but total tree cover is at least 10% - ***Abies concolor / Acer grandidentatum*** **Forest (White Fir / Bigtooth Maple Forest) [Closed stands on colluvial slopes = Map Class 7; Sparse stands in areas dominated by rock outcrops = Map Class 8]**

6a) (4) Closed mixed conifer forests with a multi-layered shrub understory. The tall shrub layer is co-dominated by *Prunus virginiana, Acer grandidentatum* and Physocarpus malvaceus; the short shrub layer is clearly dominated by ***Mahonia repens - Abies concolor / Physocarpus malvaceus*** **Forest (White Fir / Mallow Ninebark Forest) [Map Class 7]**

6b) Sparse to open mixed conifer woodlands on relatively dry sites with a subcanopy commonly containing *Juniperus scopulorum*. The well-developed mixed shrub layer has *Quercus gambelii*

as a dominant to co-dominant species. Other shrubs present to co-dominant include *Acer grandidentatum, Amelanchier alnifolia, Cercocarpus intricatus,* and *Mahonia repens* - ***Abies concolor / Quercus gambelii*** **Forest (White Fir / Gambel Oak Forest) [Closed stands on colluvial slopes = Map Class 7; Open stands on debris flow fans = Map Class 9; Sparse stands in areas dominated by rock outcrops = Map Class 8 or Map Class 31]**

7a) (2) Riparian woodlands on the banks of the American Fork River with a mixed tall canopy of *Populus angustifolia, Abies concolor,* and *Acer negundo*. The subcanopy and seedling layers are similarly mixed. The sampled stand contains the picnic area, so the understory is interrupted by areas hardened for use and contains many exotic species such as *Bromus inermis, Bromus tectorum,* and *Dactylis glomerata* - ***Acer negundo - Populus angustifolia - Abies concolor*** **Woodland (Box-elder – Narrowleaf Cottonwood – White Fir Woodland) [Map Class 4]**

7b) Mesic woodlands occupying wet avalanche chutes on the north-facing canyon wall. The canopy

includes clumps of box elder trees with many stems because of the frequent damage caused by snowslides and rock fall. The understory is dominated by the tall deciduous shrub *Acer grandidentatum*; other common shrubs include *Sambucus caerulea, Cornus sericea,* and *Acer glabrum* - ***Acer negundo / Acer grandidentatum*** **Woodland (Box-elder / Bigtooth Maple Woodland) [Map Class 23]**

8a) Shrubland vegetation, generally occupying rocky slopes or rock outcrops - **9**

8b) Herbaceous community near the Swinging Bridge Picnic area, dominated by cheatgrass and a variety of forb species; the stand contains scattered rubber rabbitbrush and mountain sagebrush - ***Bromus tectorum*** **– Exotic Forbs Herbaceous Vegetation (Cheatgrass – Exotic Forbs Herbaceous Vegetation) [Map Class 10]**

9a) (1) Shrubland vegetation on cool, generally mesic, north-facing slopes, in which *Acer grandidentatum* is dominant to co-dominant; other conspicuous shrubs may include *Prunus virginiana* and *Quercus gambelii* - **10**

9b) Shrubland vegetation on drier, generally south-facing slopes, or occupying crevices in outcrops of exposed bedrock. The dominant species include *Quercus gambelii, Symphoricarpos oreophilus, Cercocarpus intricatus,* and *Holodiscus dumosus* - **11**

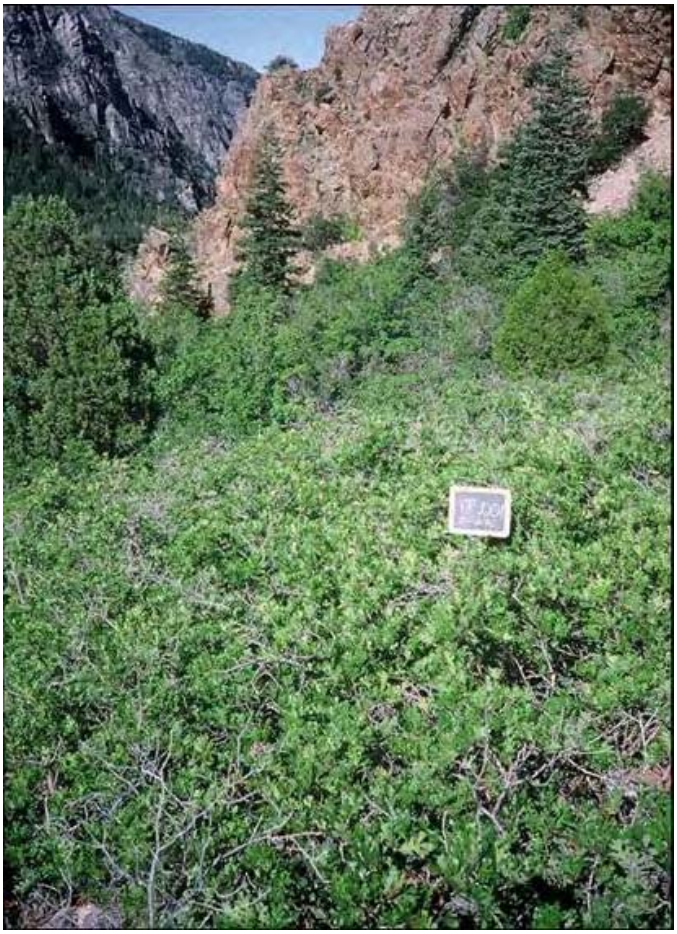
10a) (9) Tall shrublands occupying mesic talus slopes in ravines; the shrub canopy may be tall enough to appear as a woodland. The dominant species are *Acer grandidentatum* and *Prunus virginiana* - ***Acer grandidentatum - Prunus virginiana*** **Shrubland (Bigtooth Maple – Chokecherry Shrubland) [Map Class 22]**

10b) Tall shrubland occupying colluvial slopes in slightly drier situations on convex talus slopes or at the heads of ravines; the shrub canopy may be tall or short. The dominant species are *Acer grandidentatum* and *Quercus gambelii* - ***Acer grandidentatum – Quercus gambelii*** **Shrubland (Bigtooth Maple – Gambel Oak Shrubland) [Map Class 25]**

11a) (9) Sparse shrub communities growing out of cracks in exposed bedrock. Characteristic species include *Cercocarpus intricatus* and *Holodiscus dumosus* - ***Cercocarpus intricatus* Montane Shrubland (Littleleaf Mountain Mahogany Montane Shrubland) [Map Class 30]**

11b) Open to dense shrub communities dominated by *Quercus gambelii*, generally on south-facing slopes; a few stands are on xeric colluvial slopes on the north-facing canyon wall. Other shrub species are often present with low cover - **12**

12a) (11) Open to dense shrub communities dominated by *Quercus gambelii*. If *Symphoricarpos oreophilus* or *Acer grandidentatum* are present, it is with very low relative cover; xeric species such as *Juniperus communis* and *Mahonia repens* are generally present in the understory - ***Quercus gambelii* Shrubland (Gambel Oak Shrubland) [Map Class 25]**



12b) Open *Quercus gambelii*-dominated shrublands in which *Symphoricarpos oreophilus* is dominant in the understory or in the openings among oak clones. Other species present include *Artemisia tridentata* ssp. *vaseyana* and *Helianthella uniflora* - ***Quercus gambelii / Symphoricarpos oreophilus*** **Shrubland (Gambel Oak / Snowberry Shrubland) [Map Class 28]**

INDEX TO THE SAMPLED PLANT ASSOCIATIONS OF TIMPANOGOS CAVE NATIONAL MONUMENT

Appendix H

Modified Anderson Land Use-Land Cover Classification

This classification was applied to all polygons in the Timpanogos Cave National Monument vegetation mapping area. It includes many categories that do not occur within the Monument.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
1.0 Water	1.1 Open Water	1.11 Stream/river			
		1.12 Canal/ditch	1.121 Lined canal/ditch		
			1.122 Unlined canal/ditch		
		1.13 Lake/pond			
		1.14 Reservoir			
		1.15 Bay/estuary			
		1.16 Sea/ocean			
	1.2 Perennial Ice/Snow	1.21 Snowfield			
		1.22 Glacier			
2.0 Developed	2.1 Residential	2.11 Single-family residential			
		2.12 Multi-family residential			
	2.2 Non-residential Developed	2.21 Commercial/Light Industry	2.211 Major Retail		
			2.212 Mixed/Minor Retail and Services		
			2.213 Office		
			2.214 Light industry		
		2.22 Heavy Industry	2.221 Petro-chemical Refinery		
		2.23 Communications and Utilities			
		2.24 Institutional	2.241 Schools		
			2.242 Cemeteries		
		2.25 Agricultural Business	2.251 Aquiculture		
			2.252 Confined feeding		
		2.26 Transportation	2.261 Airport		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
		2.27 Entertainment/ Recreation	2.271 Golf Course		
			2.272 Urban Parks		
	2.3 Mixed Urban				
3.0 Bare	3.1 Transitional				
	3.2 Quarries/Strip mines/Gravel pits				
	3.3 Bare Rock/Sand				
	3.4 Flats				
	3.5 Disposal				
4.0 Vegetated	4.1 Woody	4.11 Forested	4.111 Deciduous		
			4.112 Evergreen		
			4.113 Mixed		
		4.12 Shrub land	4.121 Deciduous		
			4.122 Evergreen		
			4.123 Mixed		
			4.124 Desert scrub		
		4.13 Orchards/vineyards /groves	4.131 Irrigated Orchard/ vineyards/groves		
			4.132 Citrus		
			4.133 Non-managed Citrus		
		4.14 Mixed Forest/Shrub			
	4.2 Herbaceous	4.21 Natural Herbaceous	4.211 Natural Grassland		
		4.22 Planted/cultivated	4.221 Fallow/Bare Fields		
			4.222 Small Grains	4.2221 Irrigated small grains	4.2211 Rice Fields
			4.223 Row Crops	4.2231 Irrigated row crops	

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
				4.2232 Sugar Cane	
			4.224 Planted grasses	4.2241 Pasture/ hay	4.22411 Irrigated Pasture/hay
				4.2242 Other grass	4.22421 Irrigated Other grass
			4.225 Irrigated Planted/ cultivated		
	4.3 Wetlands	4.31 Woody wetlands			
		4.32 Emergent wetlands			

Classification Definitions

1.0 WATER - area covered by water, snow, or ice with less than 25% vegetated or developed cover, unless specifically included in another category

1.1 Open Water - all areas of open water with less than 25% vegetative or developed cover

1.11 Stream/river - a natural body of flowing water. Includes streams and rivers that have been channelized in order to control flooding or erosion or to maintain navigation.

1.12 Canal/ditch - a man-made open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for water craft. Includes right of ways and associated dikes and levees.

1.121 Lined canal/ditch - a canal or ditch lined with concrete or other impervious material preventing passage of water into underlying strata

1.122 Unlined canal/ditch - a canal or ditch constructed with dirt or other porous material allowing water to drain

1.13 Lake/pond - a non-flowing body of water. Includes water impounded by natural occurrences and artificially regulated natural lakes. The delineation of a lake is based on the areal extent of water at the time the imagery was acquired.

1.14 Reservoir - any artificial body of water, unless specifically included in another category. It can lie in a natural basin or a man-constructed basin. The delineation of a reservoir is based on the areal extent of water at the time the imagery was acquired.

1.15 Bay/estuary - the inlets or arms of the sea that extend inland

1.16 Sea/ocean - an area of the great body of salt water that covers much of the earth

1.2 Perennial Ice/Snow - areas covered year-round with snow and ice

1.21 Snowfield - permanent snow not underlain by a glacier

1.22 Glacier - a body of ice and snow, showing evidence of past or present flow

2.0 DEVELOPED - Areas of the earth which have been improved by man. Includes all "built-up" and urban areas of the landscape. Does NOT include mining lands, crop lands,

or waste-disposal areas (dumps). This land use category takes precedence over a land cover category when the criteria for more than one category are met.

2.1 Residential - lands containing structures used for human habitation

2.11 Single-family Residential - Lands used for housing residents in single-family dwelling units. Includes trailer parks, mobile home parks, and entire "farmsteads" when there is a home in the complex. Single-family residential buildings located within another category, such as military family housing, should be identified in this category.

2.12 Multi-family Residential - All lands devoted to housing more than one family on a permanent or semi-permanent basis, group living situations, and their associated grounds. Includes apartments, apartment complexes, duplexes, triplexes, attached row houses, condominiums, retirement homes, nursing homes, and residential hotels. Residential buildings located within another category, such as barracks and dormitories, should be identified in this category when possible.

2.2 Non-residential Developed - Any "developed" area or feature which is used for a purpose other than habitation.

2.21 Commercial/Light Industry - tructures and associated grounds used for the sale of products and services, for business, or for light industrial activities. Includes all retail and wholesale operations. Include "industrial parks" and other features which cannot be clearly classified as either a retail service or light industry, such as heavy equipment yards, machinery repair, and junkyards.

2.211 Major Retail - This category includes shopping malls, retail "outlet centers", and "superstores" which draw clientele from a regional area. Major retail centers consist of extremely large single buildings or a complex of large buildings and their parking lots. Malls usually house one or two major department stores and numerous small retail stores. Includes outlet centers, "superstores", multi-plex movie theaters, and huge warehouse-type stores. The structures themselves are often several acres in size and have extensive parking lots.

2.212 Mixed/Minor Retail and Services - Includes individual stores and services of various sizes and associated grounds and parking. Includes neighborhood strip malls and shopping centers, small movie theaters, gas stations and auto repair shops, garden centers, motels, small auto dealerships, public parking lots, lumber yards, art galleries, farm supply stores, flea-markets, bars and restaurants, grocery stores, and commercial "truck stops". Many small office buildings will have no features to distinguish them from retail stores and will fall in this category.

2.213 Office - structures and their associated grounds and parking, that provide financial, professional, administrative, and informational type services. Includes administrative government offices, trade schools, professional medical office complexes, research facilities/centers, and banks. Usually only office buildings in office complexes or in downtown areas will be distinguishable as offices. Small, single-story office buildings may blend in with minor retail.

2.214 Light industry - structures and their associated grounds and facilities which are used primarily to produce or process some finished product; or as a wholesale distribution center. Activities include design, assembly, finishing, packaging, warehousing or shipping of products rather than processing raw materials. The materials used in light industry have generally been processed at least once. Use this category as a default for those facilities with semi-truck and trailer activity

around loading docks, but that cannot be classified as either retail services or heavy industry. Includes electronic firms, clothing and furniture manufacture, grain elevators, printing plants, commercial bakeries, shipping and distribution centers, sand/gravel sorting facilities, secondary buildings associated with a mining or quarrying site, and generic warehouses.

2.22 Heavy Industry - structures and their associated grounds used for fabrication, manufacturing and assembling parts which are, in themselves, large and heavy; or for processing raw materials such as iron ore, timber, and animal products. Heavy industries generally require large amounts of energy and raw materials and produce a significant amount of waste products. Indicators of heavy industry may be stockpiles of raw materials, energy producing sources and fuels, waste disposal areas and ponds, transportation facilities capable of handling heavy materials, smokestacks, furnaces, tanks, and extremely large buildings which are complex in outline and roof structure. Include associated waste piles and waste ponds. Heavy industry is usually located away from residential areas. Includes steel mills, paper mills, lumber mills, cotton gins, chemical plants, cement and brick plants, smelters, rock crushing machinery, and ore-processing facilities associated with mining.

2.221 Petro-chemical Refinery - tructures and all associated equipment and grounds used for processing petro-chemicals. Include associated waste ponds.

2.23 Communications and Utilities - structures, facilities, and associated grounds used for the generation of power and communications, the treatment or storage of drinking water, waste management, flood control, or the distribution and storage of gas and oil not associated with a unique feature. Includes pumping stations (oil, gas, or water), tank farms, power plants, electric substations, sewage treatment facilities and ponds, garbage collection facilities, dams, levees, and spillways of appropriate dimensions, filtration plants, and heavy concentrations of antennas or satellite dishes; along with the related operational buildings.

2.24 Institutional - specialized government or private features which meet the educational, religious, medical, governmental, protective, and correctional needs of the public. Parking lots and associated grounds are included with these features. Includes public and private schools, government buildings, courthouses, libraries, churches, convents, monasteries, hospitals and training hospitals, post offices, police and fire departments, prisons, and military bases.

2.241 Schools/Universities - public and private schools, seminaries, university campuses, and associated lands. Include the entire “core campus” area, along with athletic fields and vegetated areas.

2.242 Cemeteries - structures and lands devoted to burial of the dead. Includes mausoleums, service areas, and parking lots.

2.25 Agricultural Business - structures and all associated grounds used for raising plants or animals for food or fiber. Includes fish farms and hatcheries, feedlots, poultry farms, dairy farms, temporary shipping and holding pens, animal breeding or training facilities, and greenhouses.

2.251 Aquiculture site - a set of pools of water and related structures used for producing fish, shellfish, or aquatic plants

2.252 Confined feeding operation - structures and associated pens, storage facilities, waste areas, and ponds which are used for raising meat and dairy cattle,

hogs, poultry, or other animals. These features must have a relatively permanent and high animal population density. Temporary holding pens and thoroughbred horse farms usually do not qualify.

2.26 Transportation - Roads, railroads, airports, port facilities, and their associated lands. Roads and railroads include the right-of-way, interchanges, and median strips. Category includes railroad stations, railroad yards, bus stations, highway maintenance yards, school bus parking and service yards, and park-and-ride lots. Port facilities include loading and unloading facilities, docks, locks and, temporary storage areas. Associated warehousing and transfer stations for truck or rail are included only if they appear to be an integral part of the airport or port facility. Nearby but separate warehouses will be classified as light industry.

2.261 Airport - Includes the maintained active and overrun areas of the runways, landing strips, and taxiways, with the intervening land; along with the plane tie-down areas, terminals, hangers, related fuel storage facilities, service buildings, parking lots, navigation aids, and airport offices.

2.27 Entertainment and Recreational - areas and structures used predominantly for athletic or artistic events, or for leisure activities, and all associated lands and developed parking areas. Includes outdoor amphitheaters, drive-in theaters, campgrounds, zoos, sports arenas, developed parks and playgrounds, community recreation centers, museums, amusement parks, public swimming pools, fairgrounds, and ski complexes. Marinas with over 25% of water surface covered by docks and boats are included here.

2.271 Golf Course - structures, associated grounds, driving ranges, and interspersed natural areas used for the game of golf.

2.272 Urban Parks - designated open space in urban settings used for outdoor recreation. Include grass fields and associated structures, parking lots, and facilities. Includes city parks, “green-belt” urban parks, and athletic fields not associated with a school. Does not include undeveloped “open space” on the periphery of urban areas or undeveloped regional, state, or national park areas.

2.3 Mixed Urban - developed areas which have such a mixture of residential and non-residential features where no single feature meets the minimum mapping unit specification. This category is used when more than one-third of the features in an area do not fit into a single category. Often applicable in the central, urban-core area of cities.

3.0 BARE - undeveloped areas of the earth not covered by water which exhibit less than 25% vegetative cover or less than 5% vegetative cover if in an arid area. The earth’s surface may be composed of bare soil, rock, sand, gravel, salt deposits, or mud.

3.1 Transitional Bare - areas dynamically changing from one category to another, often because of land use activities. Includes all construction areas, areas transitioning between forest and agricultural land, and urban renewal areas which are in a state of transition.

3.2 Quarries/Strip Mines/Gravel Pits - areas of extractive mining activities with significant surface disturbance. Vegetative cover and overburden are removed for the extraction of deposits such as coal, iron ore, limestone, copper, sand and gravel, or building and decorative stone. Current mining activity does not need to be identifiable. Inactive or unreclaimed mines and pits are included in this category until another land cover or land use has been established. Includes strip mines, open-pit mines, quarries, borrow pits, oil and gas drilling sites, and gravel pits with their associated structures, waste dumps, and stockpiles.

3.3 Bare Rock/Sand - includes bare bedrock, natural sand beaches, sand bars, deserts, desert pavement, scarps, talus, slides, lava, and glacial debris.
3.4 Flats - A level landform composed of unconsolidated sediments of mud, sand, gravel, or salt deposits. Includes coastal tidal flats and interior desert basin flats and playas.
3.5 Disposal - designated areas where refuse is dumped or exists, such as landfills, trash dumps, or hazardous-waste disposal sites. Reclaimed, revegetated areas do not qualify.

4.0 VEGETATED - areas having generally 25% or more of the land or water with vegetation. Arid or semi-arid areas may have as little as 5% vegetation cover.

4.1 Woody Vegetation - land with at least 25% tree and (or) shrub canopy cover

4.11 Forested - land where trees form at least 25% of the canopy cover

4.111 Deciduous Forest - area dominated by trees where 75% or more of the canopy cover can be determined to be trees which loose all their leaves for a specific season of the year.

4.112 Evergreen Forest - area dominated by trees where 75% or more of the canopy cover can be determined to be trees which maintain their leaves all year.

4.113 Mixed Forest - areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the canopy cover.

4.12 Shrub land - areas where trees have less than 25% canopy cover and the existing vegetation is dominated by plants that have persistent woody stems, a relatively low growth habit, and which generally produce several basal shoots instead of a single shoot. Includes true shrubs, trees that are small or stunted because of environmental conditions, desert scrub, and chaparral. Clear-cut areas will exhibit a stage of shrub cover during the regrowth cycle. Some common species which would be classified as shrub land are mountain mahogany, sagebrush, and scrub oaks.

4.121 Deciduous Shrub land - areas where 75% or more of the land cover can be determined to be shrubs which loose all their leaves for a part of the year

4.122 Evergreen Shrub land - areas where 75% or more of the land cover can be determined to be shrubs which keep their leaves year round.

4.123 Mixed Shrub land - areas dominated by shrubs where neither deciduous nor evergreen species represent more than 75% of the land cover

4.124 Desert Scrub - land areas predominantly in arid and semi-arid portions of the southwestern U.S. Existing vegetation is sparse and often covers only 5-25% of the land. Example species include sagebrush, creosote, saltbush, greasewood.

4.13 Planted/Cultivated Woody (Orchards/Vineyards/Groves) - areas containing plantings of evenly spaced trees, shrubs, bushes, or other cultivated climbing plants usually supported and arranged evenly in rows. Includes orchards, groves, vineyards, cranberry bogs, berry vines, and hops. Includes tree plantations planted for the production of fruit, nuts, Christmas trees, and commercial tree nurseries.

4.131 Irrigated Planted/Cultivated Woody - orchards, groves, or vineyards where a visible irrigation system is in place to supply water

4.132 Citrus - trees or shrubs cultivated in orchards or groves that bear edible fruit such as orange, lemon, lime, grapefruit, and pineapple.

4.133 Non-managed Citrus - orchards or groves containing fruit bearing trees or shrubs which are no longer maintained or harvested by humans. Evidence includes the presence of non citrus vegetation within an orchard or grove.

4.14 Mixed Forest/Shrub – areas dominated by forest and shrub where neither species represent more than 75 % of the canopy cover.

4.2 Herbaceous Vegetation - areas dominated by non-woody plants such as grasses, forbs, ferns and weeds, either native, naturalized, or planted. Trees must account for less than 25% canopy cover while herbaceous plants dominate all existing vegetation.

4.21 Natural Herbaceous - areas dominated by native or naturalized grasses, forbs, ferns and weeds. Lands can be managed, maintained, or improved for ecological purposes such as weed/brush control or soil erosion. Includes vegetated vacant lots and areas where it cannot be determined whether the vegetation was planted or cultivated such as in areas of dispersed grazing by feral or domesticated animals. Includes landscapes dominated by grass-like plants such as bunch grasses, palouse grass, and tundra vegetation, as well as true prairie grasses.

4.211 Natural Grasslands - natural areas dominated by true grasses. Includes undisturbed tall-grass and short-grass prairie in the Great Plains of the U.S.

4.22 Planted/Cultivated Herbaceous - areas of herbaceous vegetation planted and/or cultivated by humans for agronomic purposes in developed settings. The majority of vegetation in these areas is planted and/or maintained for the production of food, feed, fiber, pasture, or seed.

4.221 Fallow/Bare Fields - areas within planted or cultivated regions that have been tilled or plowed and do not exhibit any visible vegetation cover

4.222 Small Grains - areas used for the production of grain crops such as wheat, oats, barley, graham, and rice. Category is difficult to distinguish from cultivated grasses grown for hay and pasture. Indicators of small grains may be a less than 10% slope, annual plowing and seeding, distinctive field patterns and sizes, variable timing of green-up and harvest, and a very “even” texture and tone.

4.2221 Irrigated Small Grains - areas used for the production of small grain crops where a visible irrigation system is in place to supply water including the flooding of entire fields.

4.22211 Rice Fields - a cereal grass cultivated extensively and used as a staple food. Rice is grown on submerged land in coastal plains, tidal deltas, and river basins of tropical, semi-tropical, semi-tropical, and temperate regions of the U.S. Fields are characterized by a slope of less than 0.5% and have many dikes that meander parallel to the contours of the land surface. At times, the fields may be covered in water.

4.223 Row Crops - areas used for the production of crops or plants such as corn, soybeans, vegetables, tobacco, flowers and cotton. Fields which exhibit characteristics similar to row crops, but that do not have any other distinguishing features for a more specific category may be included.

4.2231 Irrigated Row Crops - areas used for the production of row crops where a visible irrigation system is in place to supply water

4.2232 Sugar Cane - a tropical grass up to 15 feet high with thick, tough stems that is cultivated as the main source of sugar. It grows in tropical and sub-tropical areas of the US such as Louisiana, Florida, Hawaii, and Texas.

4.224 Cultivated grasses - areas of herbaceous vegetation, including perennial grasses, legumes, or grass-legume mixtures that are planted by humans and used for erosion control, for seed or hay crops, for grazing animals, or for landscaping.

4.2241 Pasture/Hay - areas of cultivated perennial grasses and/or legumes (e.g., alfalfa) used for grazing livestock or for seed or hay crops.

4.22411 Irrigated Pasture/Hay - areas used as pasture or hay fields where a visible irrigation system is in place to supply water

4.2242 Other planted grasses - areas of other cultivated grass such as turf and sod farms.

4.22421 Irrigated other grasses - areas of other cultivated grasses where a visible irrigation system is in place to supply water

4.225 Irrigated Planted Herbaceous - land which is growing some indistinguishable crop or grass, but is obviously irrigated

4.3 Vegetated Wetland - areas where the natural water table is at, near, or above the land surface for a significant part of most years and vegetation indicative of this covers more than 25% of the land surface. Wetlands can include marshes, swamps situated on the shallow margins of bays, lakes, ponds, streams, or reservoirs; wet meadows or perched bogs in high mountain valleys, or seasonally wet or flooded low spots or basins.

4.31 Woody Wetland - areas dominated by woody vegetation. Includes seasonally flooded bottomland, mangrove swamps, shrub swamps, and wooded swamps. Floodplains of the Southwest may be dominated by mesquite, saltcedar, seepwillow.

4.32 Emergent Herbaceous Wetlands - areas dominated by wetland herbaceous vegetation that is present for most of the growing season. Includes freshwater, brackish, and saltwater marshes, tidal marshes, mountain meadows, wet prairies, and open bogs.

Appendix J

Map Class Descriptions for Timpanogos Cave National Monument

Introduction

This document provides a visual guide and description of the map classes created for the Timpanogos Cave National Monument Vegetation Mapping Project. Sixteen natural vegetation, two geological, and three developed land use map classes were delineated and are described in this guide. Each of the map classes associated with this project is documented by

- ground photographs (if available)
- a list of component NVC associations and ecological systems
- common or characteristic plant species
- a description of the ecology and distribution of the map class within the Monument, as well as a description and example of the corresponding aerial photo signature
- polygon statistics report (polygon number, size, area and proportion)

This guide does not attempt to show all variations within each vegetation map class; only the most common or significant representations are included. These examples should be sufficient to give the user an understanding of the imagery and the relationships between the TICA vegetation classification and mapping.

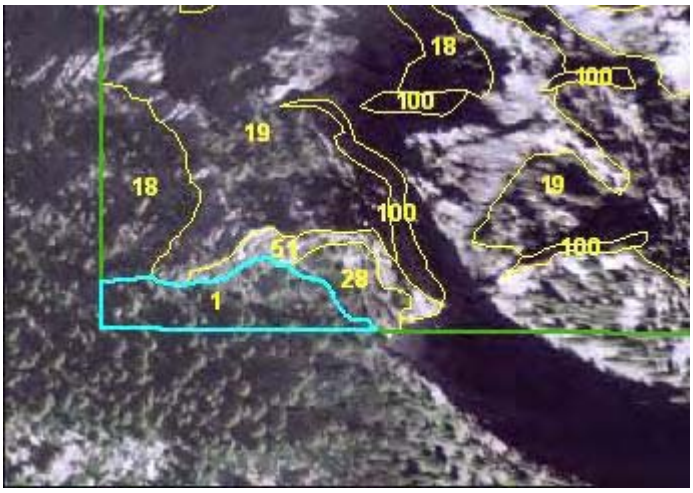
Forests and Woodlands

1 Aspen Forest (F-POTR)

Associations:
Populus tremuloides Alliance
Described from field notes only

Common species:
Populus tremuloides

Project Specifics:
Frequency = 1 polygon
Area = 0.5 ha / 1.2 acres (<1%)
Average polygon size = 0.5 ha / 1.2 acres



Ecological System
Rocky Mountain Aspen Forest and Woodland (CES306.813)

Distribution/Ecology/Composition
This map class is restricted to the extreme southwestern corner of the Monument, where an extensive quaking aspen stand on the canyon rim enters the boundary. The stand was not sampled or visited, and nothing is known of the understory composition or ecological condition of the stand.

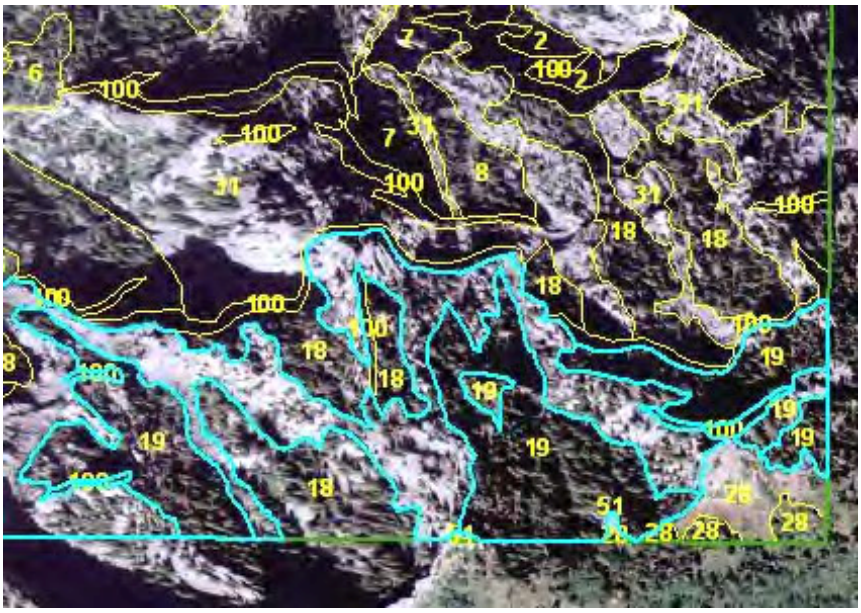
NO GROUND PHOTO AVAILABLE

2 Douglas-fir - Limber Pine Woodland (W-DFLP)

Associations:
Unknown. Only the canopy species, *Pseudotsuga menziesii* and *Pinus flexilis*, were visible to ecologists viewing stands from the canyon rim. The type may be similar to the *Pseudotsuga menziesii - Pinus flexilis / Leucopoa kingii* Woodland association described from Montana.

Common species:
Pinus flexilis
Pseudotsuga menziesii

Project Specifics:
Frequency = 7 polygons
Area = 16.5 ha / 40.8 acres (17%)
Average polygon size = 2.4 ha / 5.8 acres



Ecological System

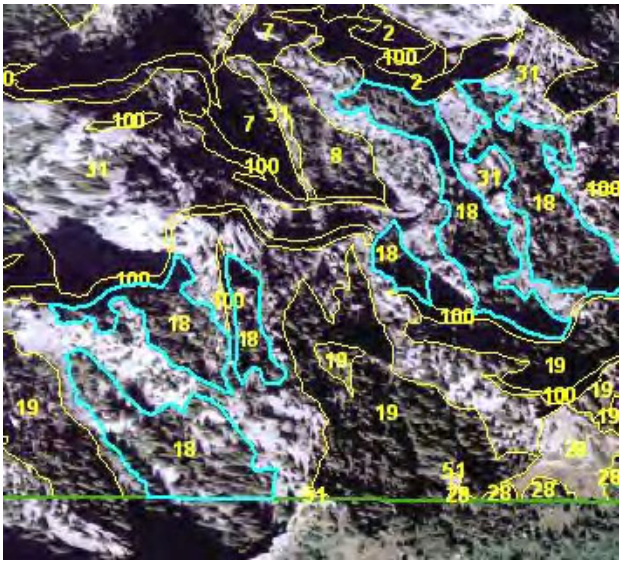
Not assigned. Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (CES306.819) is probably the best ecological system assignment.

Distribution/Ecology/Composition

This map class is restricted to dry, convex slopes on the upper one-third of the north-facing American Fork River canyon. The type was only viewed from the canyon rim. It was not sampled or visited due to inaccesibility, and nothing is known of the understory composition or ecological condition of the stands.

NO GROUND PHOTO AVAILABLE

3 Douglas-fir / Mountain Maple Woodland (W-DFMM)



Associations:
Unknown. The most likely association is the *Pseudotsuga menziesii / Acer glabrum* Forest described from Utah. *Pseudotsuga menziesii / Quercus gambelii* Forest may also occur.

Common species:
Pseudotsuga menziesii
Acer glabrum
Quercus gambelii

Project Specifics:
Frequency = 8 polygons
Area = 6.6 ha / 16.2 acres (7%)
Average polygon size =0.8 ha / 2.0 acres

Ecological System

Not assigned. Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823) is the probably the best placement for this map class.

Distribution/Ecology/Composition

This map class is restricted to mesic, concave slopes on the upper one-third of the north-facing American Fork River canyon. The type was viewed from the canyon rim. It was not sampled or visited due to unacceptable hazards to field crews, and little is known of the understory composition or ecological condition of the stands.

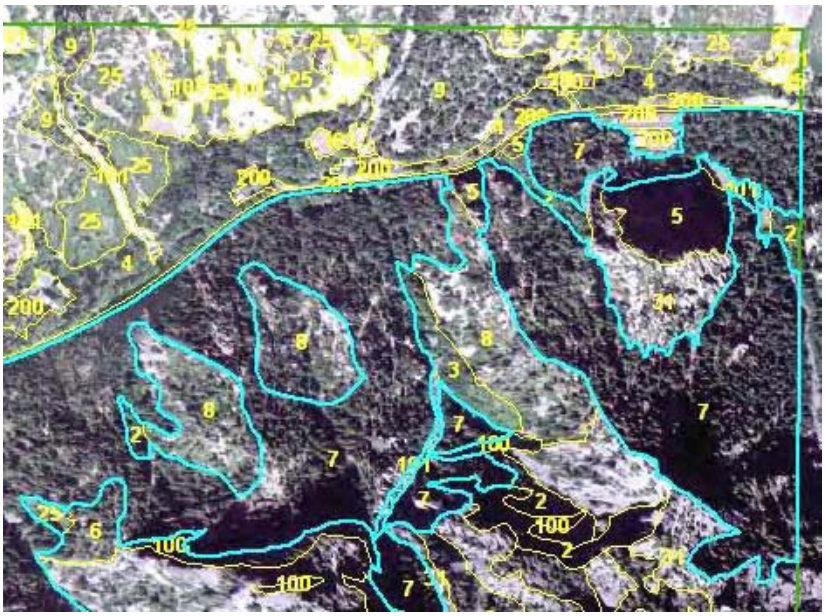
NO GROUND PHOTO AVAILABLE

7 White fir - Douglas-fir / Gambel Oak - Bigtooth Maple Forest (F-MCOM)

Associations:
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest
Abies concolor / Acer grandidentatum Forest
Abies concolor / Physocarpus malvaceus Forest
Abies concolor / Quercus gambelii Forest

Common species:
Abies concolor
Juniperus scopulorum
Pseudotsuga menziesii
Acer glabrum
Acer grandidentatum
Mahonia repens
Physocarpus malvaceus
Quercus gambelii
Leucopoa kingii
Poa fendleriana

Project Specifics:
Frequency = 7 polygons
Area = 28.9 ha / 71.4 acres (29%)
Average polygon size = 4.1 ha / 10.2 acres



Ecological System

Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)
Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)

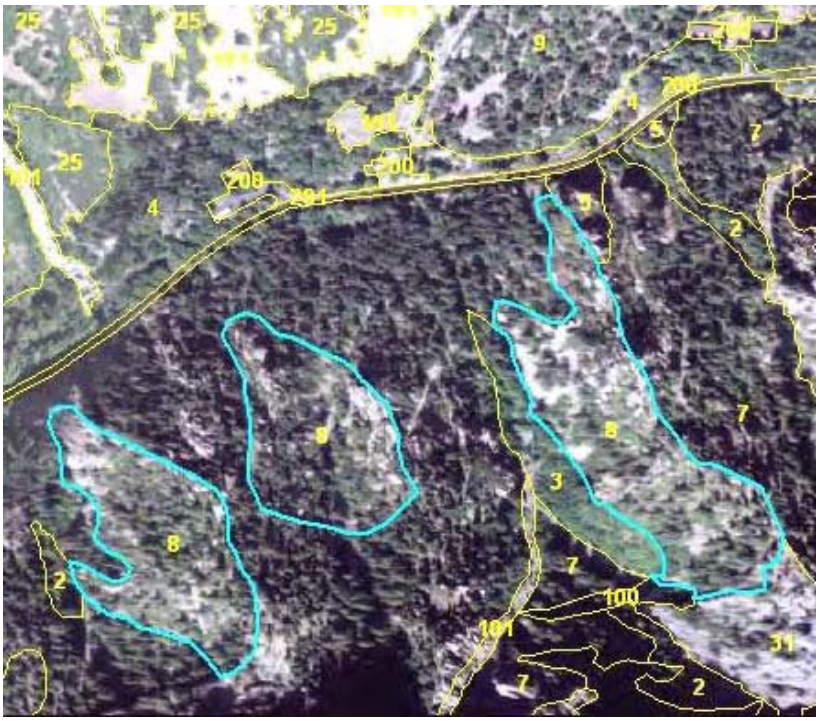
Distribution/Ecology/Composition

This is the most common and widely distributed forest type within the Monument. It is the dominant community type on the lower one-third of the north-facing canyon slope. The canopy is moderately closed to closed and co-dominated by white fir and Douglas-fir. These tree species also comprise the scattered subcanopy, although Rocky Mountain juniper may be present with low cover. The understory is dominated by shrubs, including Gambel oak, bigtooth maple, chokecherry, mallowleaf ninebark, mountain maple, and creeping Oregon-grape. The herbaceous layer is generally diverse, but often has very low cover because the tree canopy allows little sunlight to reach the forest floor.

Photo credit: NPS

Photo credit: NPS

8 White fir - Douglas-fir / Rocky Mountain Juniper / Gambel Oak Woodland (W-MCJS)



Associations:
Abies concolor / Quercus gambelii Forest
Abies concolor / Acer grandidentatum Forest
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest

Common species:
Abies concolor
Juniperus scopulorum
Pseudostuga menziesii
Acer grandidentatum
Mahonia repens
Quercus gambelii
Elymus spicatus

Project Specifics:
Frequency = 4 polygons
Area = 5.4 ha / 13.3 acres (5%)
Average polygon size = 1.3 ha / 3.2 acres

Ecological System

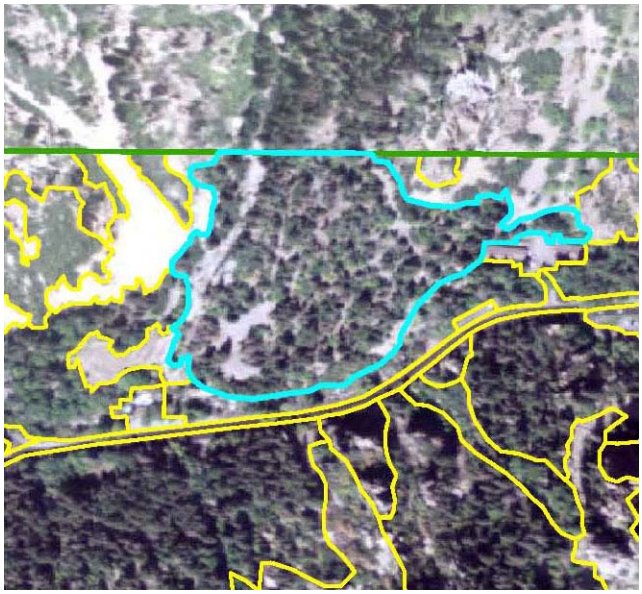
Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland Southern (CES306.823)

Distribution/Ecology/Composition

This is the xeric version of the White fir - Douglas-fir / Gambel Oak - Bigtooth Maple Forest (F-MCOM) Map Class. It occupies convex ribs and ridges of rock extending from the lower slopes of the south wall of the American Fork Canyon. Vegetation composition is very similar to that of Map Class 7; it differs in the relative openness of the canopy and the increased importance of Rocky Mountain juniper. The tree canopy of white fir and Douglas-fir rarely exceeds 10% cover; the juniper often has as much or more cover than the taller trees. The shrub layer is diverse and may have greater cover than the tree layer; bigtooth maple, mountain maple, Gambel oak, and creeping Oregon-grape are the most consistent species. The herbaceous layer is diverse and may also have significant cover. Species common to cool closed forests, such as false Solomon's-seal, are generally less important than those of open, dry woodlands such as bluebunch wheatgrass, flatleaf beardtongue, and stonecrop.

Photo credit: NCPN

9 White fir / Gambel Oak Woodland (W-ACQG)



Associations:
Abies concolor / Quercus gambelii Forest

Common species:
Abies concolor
Juniperus scopulorum
Pseudotsuga menziesii
Acer grandidentatum
Quercus gambelii

Project Specifics:
Frequency = 3 polygons
Area = 2.7 ha / 6.6 acres (3%)
Average polygon size = 0.9 ha / 2.2 acres

Ecological System

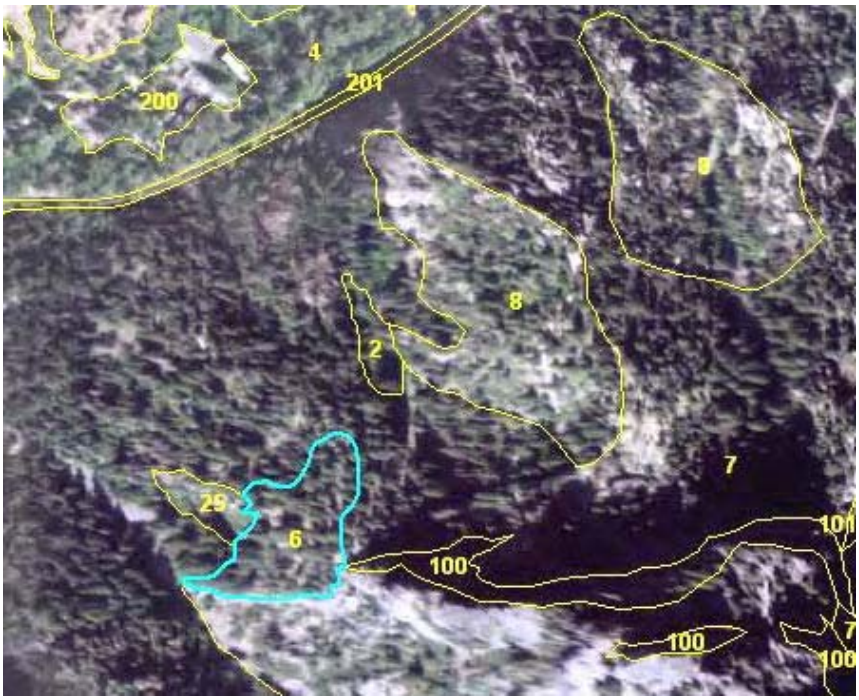
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)

Distribution/Ecology/Composition

This association is known only from debris flow fans on the lower slopes of the north canyon wall, in the northern part of the Monument. Sites are well drained but there is some soil development and in general the slopes are not as steep as in most of the Monument. The tree canopy is generally open and the shrub layer generally has higher cover than grasses or forbs. The warm exposure favors the growth of white fir over Douglas-fir, although both are present in the canopy and seedling layers. Gambel oak is the overwhelming dominant in the shrub layer, with up to 30% cover. Other shrubs present may include bigtooth maple, Saskatoon serviceberry, mountainlover, and Oregon-grape. The herbaceous layer is diverse but has relatively low cover. Common forbs include beardtongue and goldenrod and muttongrass is the common graminoid. Proximity to the nature trail has resulted in opportunities for exotic species to become established; this map class commonly includes cheatgrass, Dalmatian toadflax, and smooth brome in the forest understory.

Photo credit: NPS

6 White fir - Douglas-fir / Bunchgrass Forest (F-MCGR)



Associations:
Abies concolor - Pseudotsuga menziesii / Mixed Grasses Forest

Common species:
Abies concolor
Juniperus scopulorum
Pseudotsuga menziesii
Quercus gambelii
Leocopoa kingii
Poa fendleriana
Pseudoroegneria spicata

Project Specifics:
Frequency = 1 polygon
Area = 0.5 ha / 1.1 acres (<1%)
Average polygon size = 0.5 ha / 1.1 acres

Ecological System

Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)

Distribution/Ecology/Composition

This unusual forest community is known from a single locality on the lower canyon slopes. The site is dry and rocky and the canopy is open, allowing bunchgrasses to dominate the understory. The canopy is a mix of white fir and Douglas-fir, which also occur in the seedling layer. Rocky Mountain juniper and younger white fir trees form an open subcanopy. Scattered shrubs include Gambel oak, ninebark, and littleleaf mountain mahogany. Grasses are more abundant than shrubs in terms of cover; the most conspicuous grass species include spike fescue, muttongrass, and bluebunch wheatgrass.

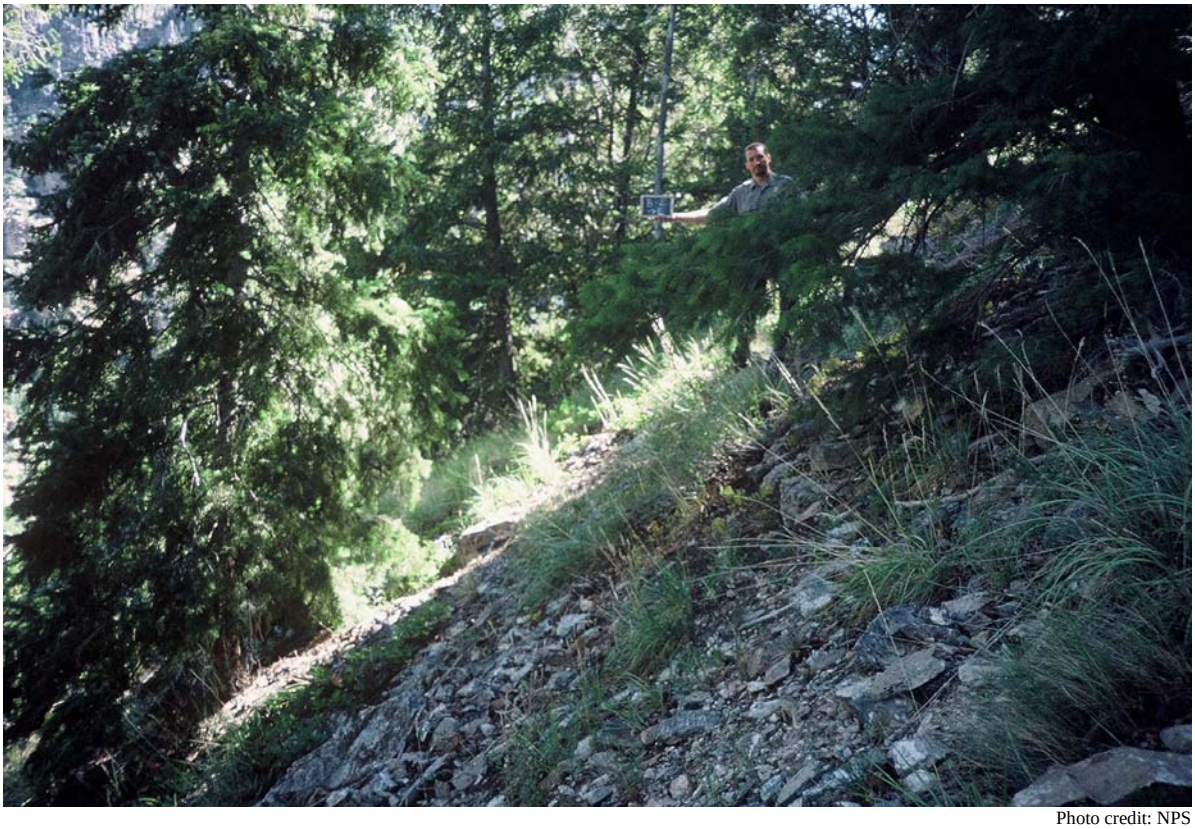


Photo credit: NPS

23 Box-elder-Bigtooth Maple Ravine Woodland (W-BEBM)

Associations:
Acer negundo / Acer grandidentatum Woodland

Common species:
Acer negundo
Acer grandidentatum
Acer glabrum
Cornus sericea
Sambucus caerulea

Project Specifics:
Frequency = 2 polygons
Area = 0.8 ha / 1.9 acres (1%)
Average polygon size = 54.2 acres / 21.9 ha
User's accuracy = 0.4 ha / 1.0 acres

Ecological System
Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)

Distribution/Ecology/Composition
This type is restricted to wet ravines on the middle and lower canyon walls. Sites are mesic and the vegetation is dense. Older plants exhibit broken stems and trunk scars suggesting that rockfall and snow avalanches are relatively common in this habitat. Box-elder and bigtooth maple form a patchy but dense canopy. The other shrub species and the few herbaceous species present have much lower cover and occupy the few openings among the taller shrubs.

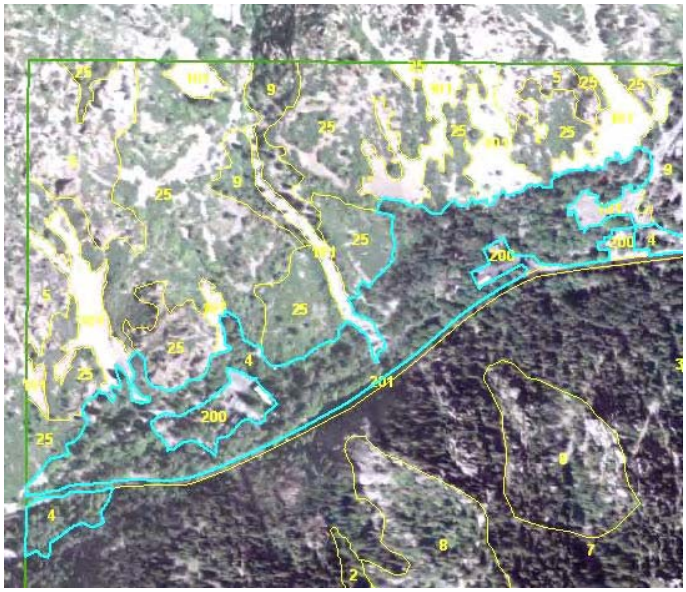
Photo credit: NPS

4 Narrowleaf Cottonwood-Conifer Riparian Woodland (W-POAN)

Associations:
Acer negundo - Populus angustifolia - Abies concolor Woodland

Common species:
Abies concolor
Acer negundo
Populus angustifolia
Acer grandidentatum
Betula occidentalis
Cornus sericea

Project Specifics:
Frequency = 4 polygons
Area = 5.3 ha / 13.0 acres (5%)
Average polygon size = 1.3 ha / 3.3 acres



Ecological System

Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)

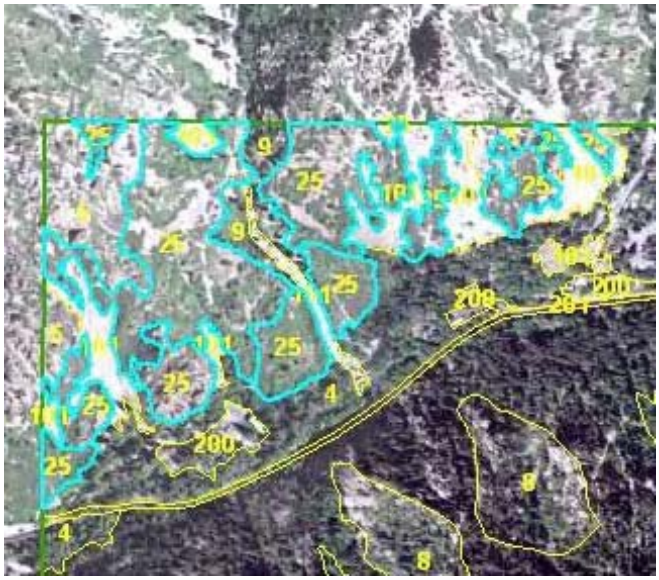
Distribution/Ecology/Composition

This mixed riparian forest community occupies the floodplain of the American Fork River. Most stands have been affected by development for recreation or administration, including park buildings, picnic areas, restrooms, and hiking trails.

The canopy is mixed, and includes white fir, narrowleaf cottonwood, and boxelder. Douglas-fir is a minor component or is absent. Reproduction of canopy species is sparse; altered hydrology of the American Fork River and artificial armoring of the banks limit opportunities for seedling trees to become established. The understory has been altered by development and by the introduction of non-native species. Common shrub species include bigtooth maple, river birch, red-osier dogwood, chokecherry, and Oregon-grape. Most herbaceous species are exotic, including smooth brome, orchard grass, Dalmatian toadflax, and cheatgrass.

Shrublands

25 Gambel Oak - Bigtooth Maple Shrubland (S-GOBM)



Associations:
Acer grandidentatum / Quercus gambelii Forest
Quercus gambelii Shrubland

Common species:
Acer grandidentatum
Holodiscus dumosus
Mahonia repens
Quercus gambelii
Pseudoroegneria spicata

Project Specifics:
Frequency = 19 polygons
Area = 8.0 ha / 19.8 acres (8%)
Average polygon size = 0.4 ha / 1.0 acres

Ecological System

Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)

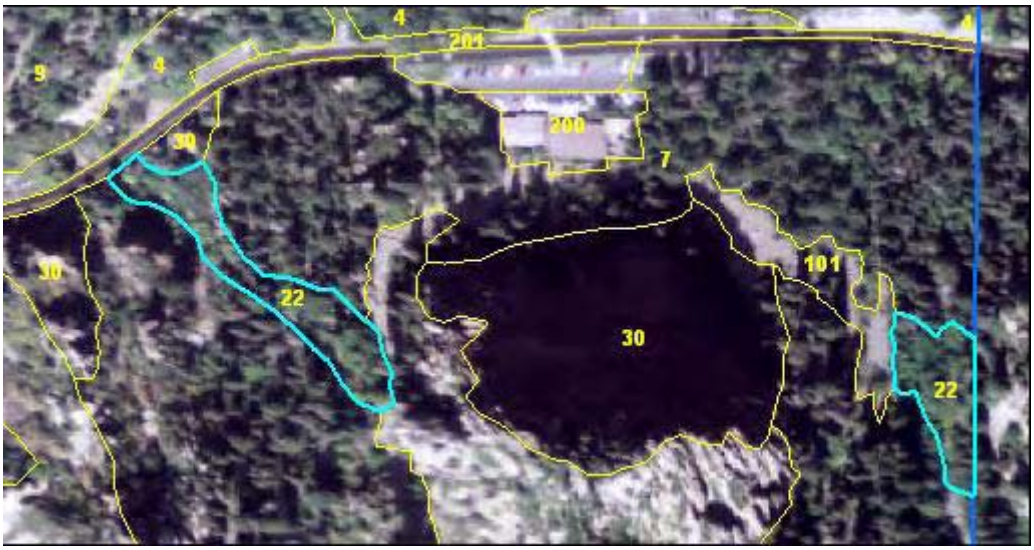
Distribution/Ecology/Composition

This shrubland is the primary community on dry, rocky, south-facing lower slopes of the American Fork Canyon. It also occurs on the north-facing canyon slopes, but is less prevalent.

Gambel oak is the overwhelming dominant; bigtooth maple is always present and on mesic, stable slopes it may codominate with Gambel oak. Chokecherry is absent or has very low cover. Depending on soil depth, the Gambel oak may grow from 0.5 to more than 2 m tall. Herbaceous and low shrub species are limited by the rockiness of the substrate, but creeping Oregon-grape, bluebunch wheatgrass, muttongrass, and dogbane have been reported from these stands.

Photo credit: NPS

22 Bigtooth Maple-Chokecherry Ravine Shrubland (S-BMCC)



Associations:
Acer grandidentatum - Prunus virginiana Shrubland

Common species:
Acer grandidentatum
Physocarpus malvaceus
Prunus virginiana
Quercus gambelii

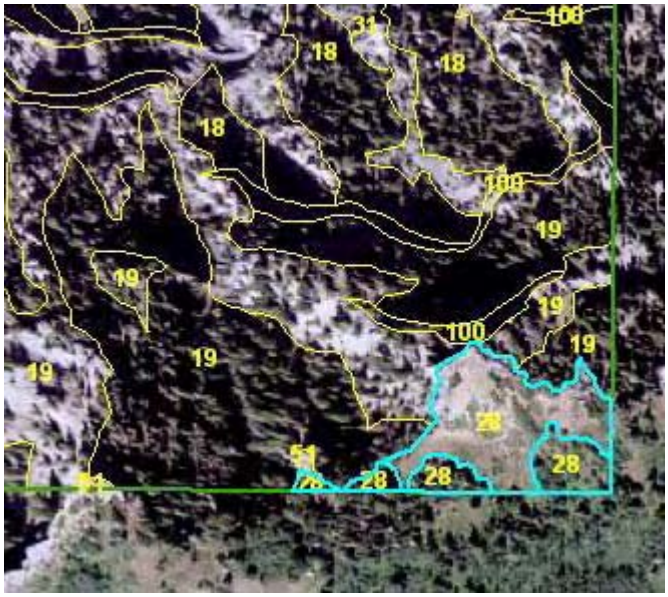
Project Specifics:
Frequency = 5 polygons
Area = 0.9 ha / 2.2 acres (1%)
Average polygon size = 0.2 ha / 0.4 acres

Ecological System
Rocky Mountain Bigtooth Maple Ravine Woodland (CES306.814)

Distribution/Ecology/Composition
This rare shrubland community is restricted to mesic ravines on the north-facing canyon wall that drain rock outcrops. The ravines are subject to frequent disturbance from rock fall and snow slides; the community is therefore composed of species that tolerate damage or partial burial and can root sprout. Bigtooth maple and chokecherry are the most consistent species and often form a dense tangle; Gambel oak may occupy dry patches within these ravines and the occasional white fir or Douglas-fir tree may be present. Low shrubs and herbaceous species provide little cover in this community.

Photo credit: NPS

28 Gambel Oak - Snowberry Shrubland (S-GOSB)



Associations:
Quercus gambelii / Symphoricarpos oreophilus Shrubland

Common species:
Artemisia tridentata ssp. *vaseyana*
Quercus gambelii
Symphoricarpos oreophilus
Helianthella uniflora
Lupinus argenteus
Pseudoroegneria spicata

Project Specifics:
Frequency = 6 polygons
Area = 1.4 ha / 3.4 acres (1%)
Average polygon size = 0.2 ha / 0.6 acres

Ecological System

Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818)

Distribution/Ecology/Composition

This community occurs on Sagebrush Flat, a structural bench that forms the rim of the American Fork Canyon. It occurs as openings on rolling to sloping terrain among patches of quaking aspen and quaking aspen-conifer forest. On deeper soils the Gambel oak may be more than 2m in height; on shallow soils close to the rim, the oak is shorter and mountain snowberry has higher cover. Mountain big sagebrush and a diversity of native forbs and grasses are common.

Photo credit: NPS

Photo credit: NPS

Herbaceous Communities

10 Disturbed Meadow (H-MEAD)

Associations:
Bromus tectorum – Mixed forb Herbaceous Vegetation [Park Special]
Described from field notes only

Common species:
Artemisia tridentata ssp. *vaseyana*
Ericameria nauseosa
Bromus tectorum
Berteroa incana
Convolvulus arvense
Kochia americana
Panicum capillare
Tragopogon dubius

Project Specifics:
Frequency = 1 polygon
Area = 0.13 ha / 0.33 acres (<<1%)
Average polygon size = 0.13 ha / 0.33 acres

Ecological System
Inter-Mountain Basins Montane Sagebrush Steppe (CES304.785)

Distribution/Ecology/Composition
This map class is restricted to a single polygon near the Swinging Bridge Picnic Area. A major debris flow came down Swinging Bridge Creek in 1965 to create the opening now occupied by this community. The vegetation is primarily herbaceous and exotic, with scattered mountain sagebrush and rubber rabbitbrush. This meadow is the focus of intensive exotic species management by Monument staff. A popular interpretive trail crosses the meadow.

Photo credit: Camille Pulham/TICA

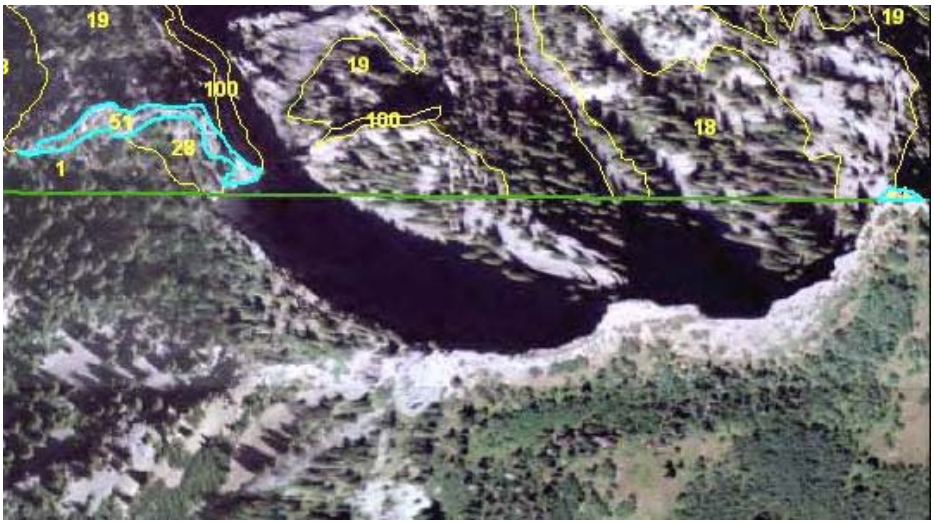
Sparse Vegetation

51 Grassy Rock Goldenrod - Bluebunch Wheatgrass (H-PPPS)

Associations:
Unknown

Common species:
Petradoria pumila
Pseudoroegneria spicata

Project Specifics:
Frequency = 3 polygons
Area = 0.2 ha / 0.6 acres (<1%)
Average polygon size = 0.1 ha / 0.2 acres

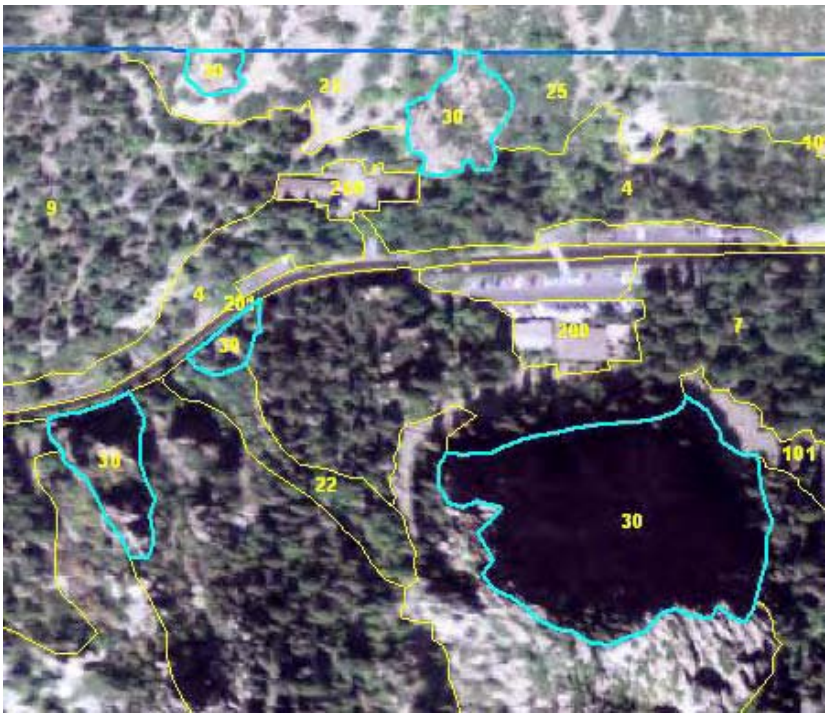


Ecological System
Unassigned

Distribution/Ecology/Composition
This type is restricted to the south canyon rim. Occurrences within the Monument consist of a few small patches near the southern boundary, none were sampled. Soils are thin and rocky, and nothing is known of the composition or ecological condition of the stand other than the total vegetation cover is sparse.

NO GROUND PHOTO AVAILABLE

30 Rock Outcrop Sparse Vegetation (Littleleaf Mtn Mahogany Phase) (C-ROLM)



Associations:
Cercocarpus intricatus Montane Shrubland

Common species:
Cercocarpus intricatus
Cercocarpus montanus
Holodiscus dumosus
Quercus gambelii

Project Specifics:
Frequency = 8 polygons
Area = 3.1 ha / 7.6 acres (3%)
Average polygon size = 0.4 ha / 1.0 acres

Ecological System

Not Assigned. Rocky Mountain Cliff, Canyon and Massive Bedrock (CES306.815) is probably the best assignment.

Distribution/Ecology/Composition

This sparse community is restricted to rock outcrops on the lower canyon slopes. Vegetation roots in cracks in the exposed rock; because of the limited rooting sites, trees are generally limited to a few percent cover. The shrubs rock spiraea, littleleaf mountain mahogany, true mountain mahogany, and Gambel oak are scattered throughout the type. Perennial grasses and forbs are conspicuous, including alumroot, muttongrass, bluebunch wheatgrass, spike fescue, shortstem buckwheat, and sand fleabane.

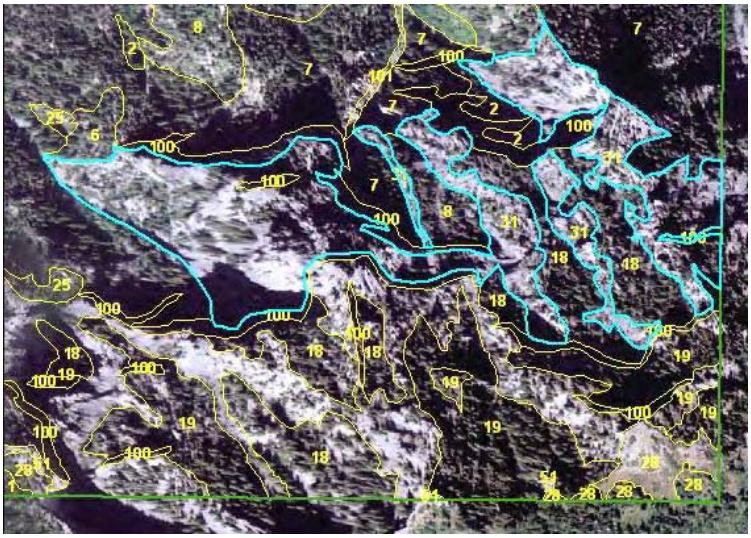
Photo credit: NPS

31 Rock Outcrop Sparse Vegetation (Rocky Mountain Juniper Phase) (C-ROJS)

Associations:
Abies concolor / Quercus gambelii Forest

Common species:
Abies concolor
Juniperus scopulorum
Pseudotsuga menziesii
Cercocarpus intricatus
Quercus gambelii
Elymus spicatus
Leucopoa kingii
Erigeron arenarioides
Haplopappus macronema
Eriogonum brevicaule

Project Specifics:
Frequency = 5 polygons
Area = 12.0 ha / 29.7 acres (12%)
Average polygon size = 2.4 ha / 5.9 acres



Ecological System
Not Assigned. Rocky Mountain Cliff, Canyon and Massive Bedrock (CES306.815) is probably the best assignment.

Distribution/Ecology/Composition
This map class represents a sparse woodland community growing on convex outcrops or on the ledges of cliffs. Floristically, the community is similar to the woodlands on adjacent canyon slopes (Map Class 7 / F-MCOM), but this community is sparser, grows in areas with greater bedrock exposure, and has higher cover of shrubs, forbs, and grass relative to tree cover.

Although white fir and Douglas-fir are usually present with a few percent cover, the most conspicuous and common tree species is Rocky Mountain juniper. Total vegetation cover generally does not exceed 20%. Shrubs such as Gambel oak, littleleaf mountain mahogany, and whitestem goldenbush are scattered throughout the community. Herbaceous species such as muttongrass, spike fescue, and shortstem buckwheat are present but contribute little cover.

Photo credit: NCPN

Geological Map Classes

100 Cliff Band (G-CLIF)

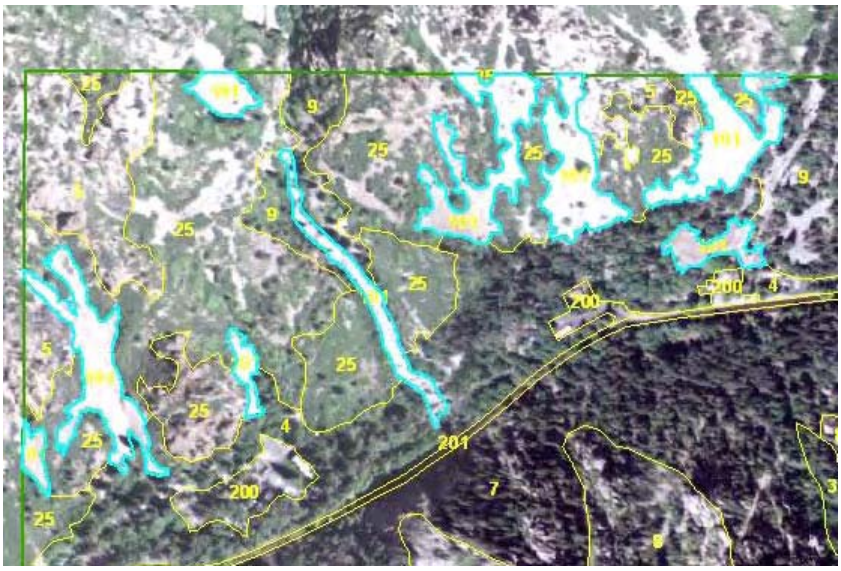
Project Specifics:
Frequency = 14 polygons
Area = 3.3 ha / 8.2 acres (3%)
Average polygon size = 0.2 ha / 0.6 acres

Description

This map class describes unvegetated vertical cliffs in the upper walls of the American Fork River canyon. Most are limestone, and include the cliffs containing the entrance to Timpanogos Cave. These cliffs are the source of much of the talus and colluvium that coats the lower canyon slopes. Because they are vertical features, most cliffs are not apparent on the aerial photos and were generally mapped in the field and from topographic maps.

Photo credit: NCPN

101 Talus (G-TALU)



Project Specifics:
Frequency = 12 polygons
Area = 2.8 ha / 7.0 acres (3%)
Average polygon size = 0.2 ha / 0.6 acres

Description

This map class represents areas of unvegetated or sparsely vegetated loose rock fallen from the many cliffs and outcrops forming the walls of the American Fork Canyon. Most occurrences are on the south-facing canyon wall.

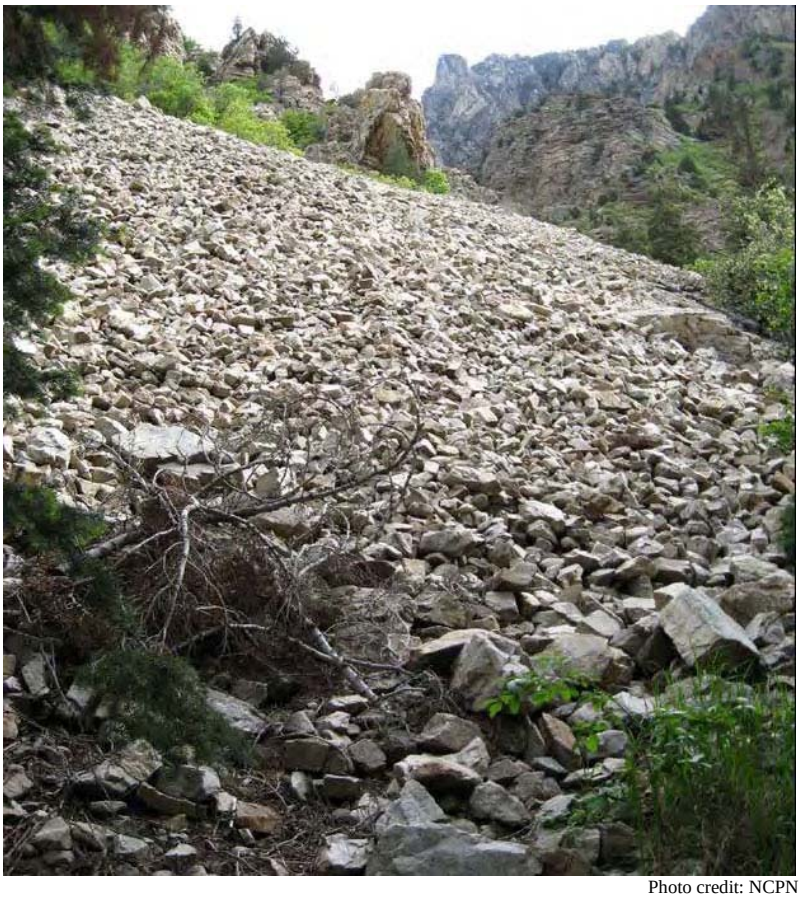
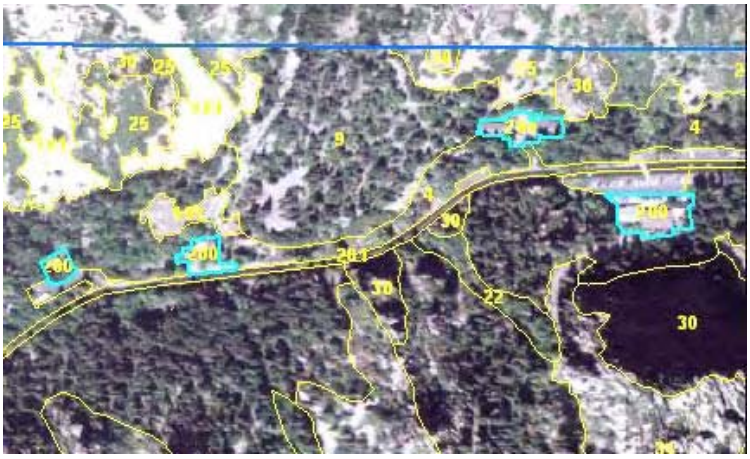


Photo credit: NCPN

Land use Map Classes

200 Park Facilities (L-FACI)



Project Specifics:
Frequency = 5 polygons
Area = 0.7 ha / 1.8 acres (1%)
Average polygon size = 0.15 ha / 0.36 acres

Description

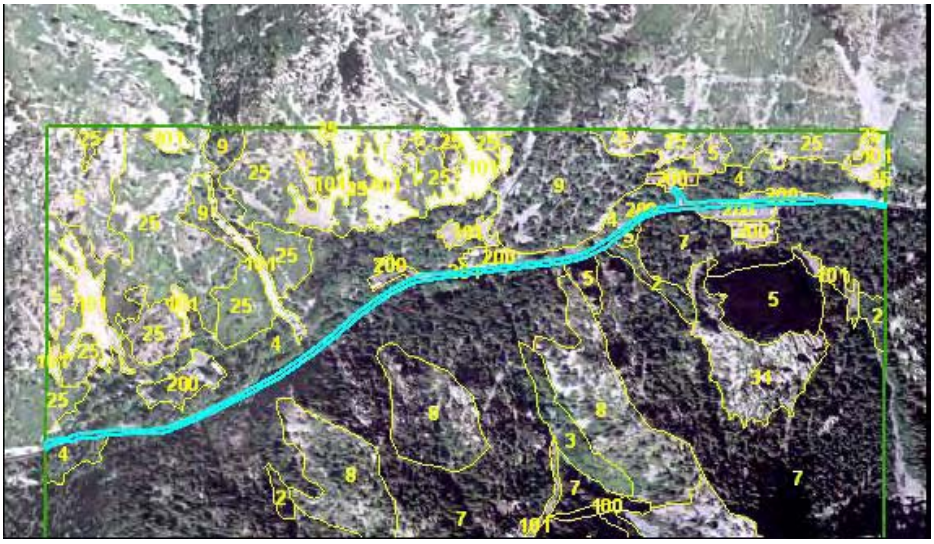
This map class describes administrative buildings and facilities of the Monument. The visitor center, picnic area, maintenance buildings and employee housing are included in this category.

Photo credit: NCPN

Photo credit: NCPN

Photo credit: NCPN

201 Road (L-ROAD)



Project Specifics:
Frequency = 1 polygon
Area = 0.7 ha / 1.7 acres (1%)
Average polygon size = 0.7 ha / 1.7 acres

Description

This map class describes State Highway 92. This paved, 2-lane road divides the northern third of the Monument from east to west. All park developments are accessed directly from this highway.

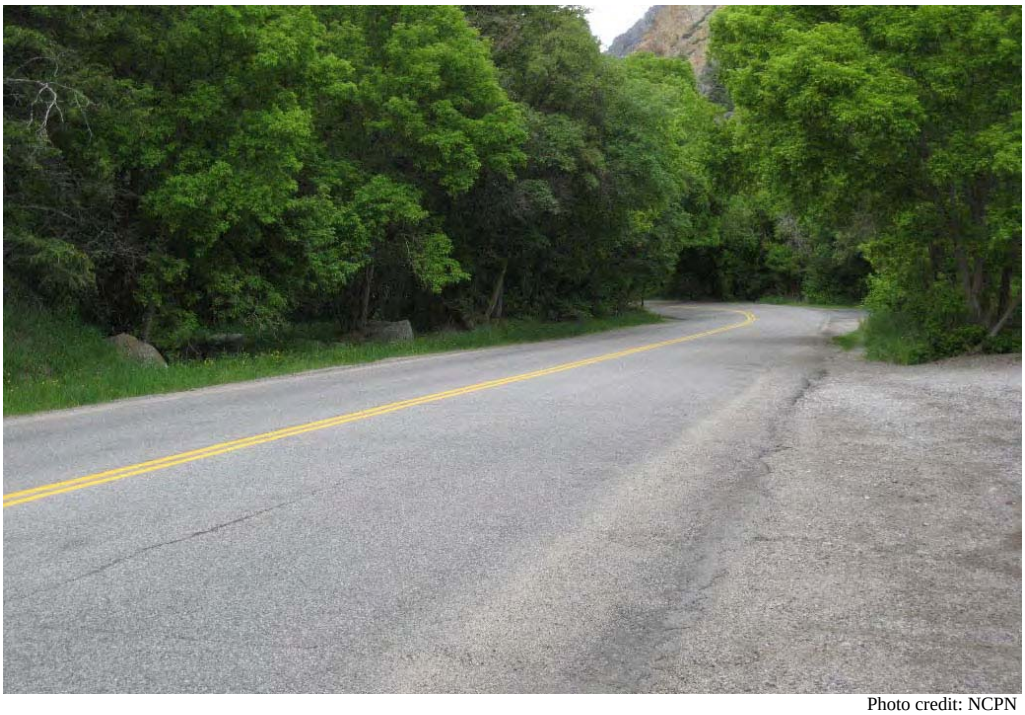


Photo credit: NCPN

202 Parking Areas (L-PARK)

Project Specifics:
Frequency = 4 polygons
Area = 0.3 ha / 0.7 acres (<1%)
Average polygon size = 0.1 ha / 0.2 acres

Description

This map class represents parking areas associated with TICA facilities, including the visitor center, trailheads, and the picnic area. All facilities are adjacent to State Highway 92.

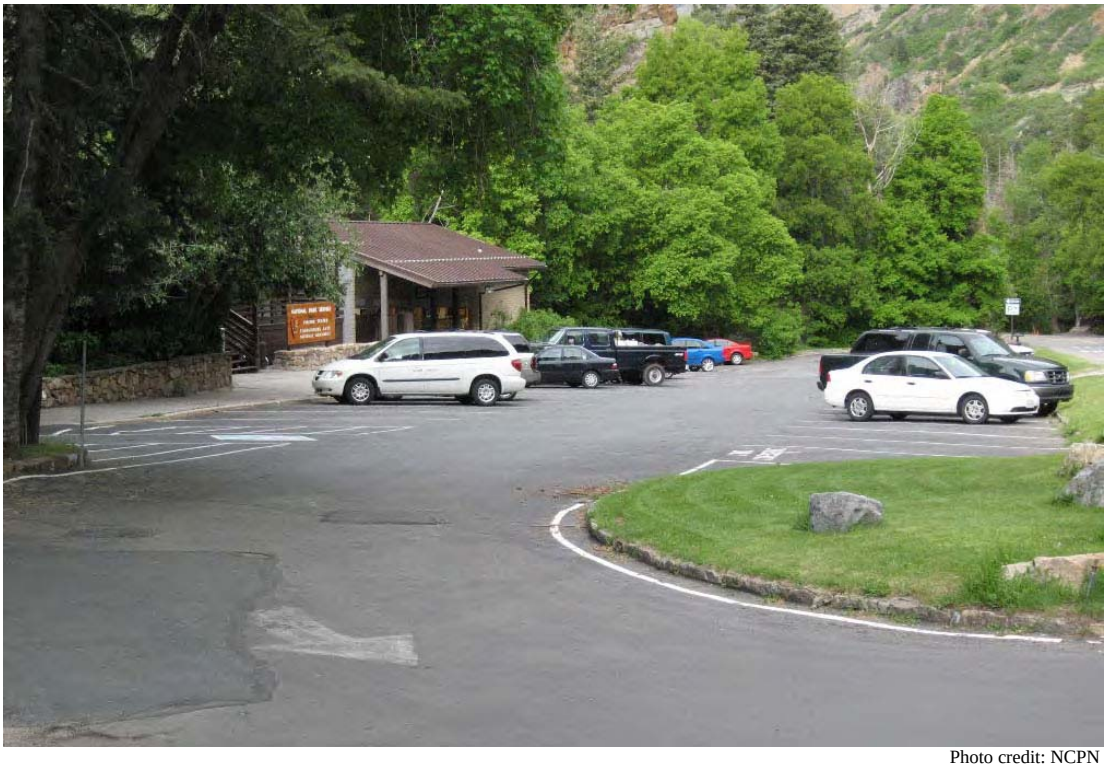


Photo credit: NCPN

Index to the Map Classes of Timpanogos Cave National Monument

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 D-40, April 2009

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
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Fort Collins, CO 80525

www.nature.nps.gov