United States National Vegetation Classification USNVC

# U.S. National Vegetation Classification: Advancing the Description and Management of the Nation's Ecosystems

NATIONAL PARK SERVICE

Institute for Natural Resources

# A Data-Driven Method for Assembling Map Classes from Vegetation Associations in WA State National Parks

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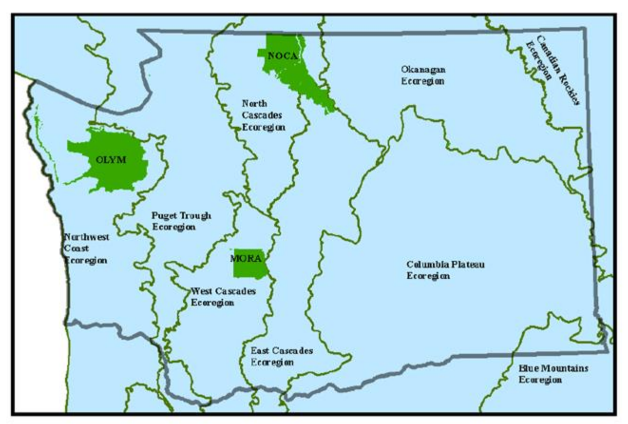
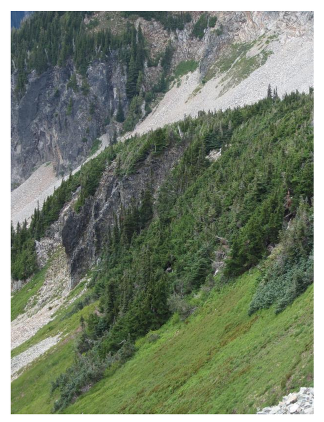
## Background

The large national parks of Washington State are large, rugged, and ecologically complicated; exhaustive field mapping of plant communities would be prohibitively expensive. Therefore, our plant community maps rely on modeling to extend field data across remote areas. We model with predictor layers derived (in-house) from satellite data, air photos, lidar, and climate data.

Figure 1. Location of Mount Rainier (MORA), North Cascades (NOCA), and Olympic (OLYM) National Parks with respect to Washington State ecoregions



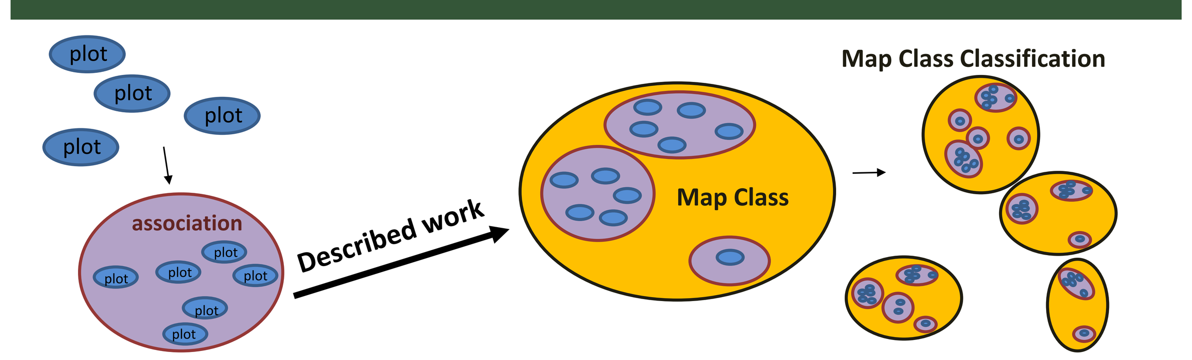


Training data were collected at more than 6000 field plots representing 294 distinct vegetation associations—far too many to map. National Park Service methods suggest mapping at higher levels of the vegetation hierarchy, such as alliances or even groups (Natureserve 2010). Based on this approach, we initially lumped associations into 40 alliance and group level map classes.

Unfortunately, this hierarchical lumping did not produce well distinguished map classes. On average, the map class an association was assigned to received just 0.5% more model votes than its second best fit. Floristics were also not well separated: associations were only 3.6% more similar to their assigned class than to their second best fit.

Accurate modeled maps require map classes to be distinguishable on the ground *and* in predictor data. We worked to group associations in a way that maximized the separability of map classes in mapping while maintain field identification (floristic separation) and structure from the United States National Vegetation Classification (USNVC).

## Methods

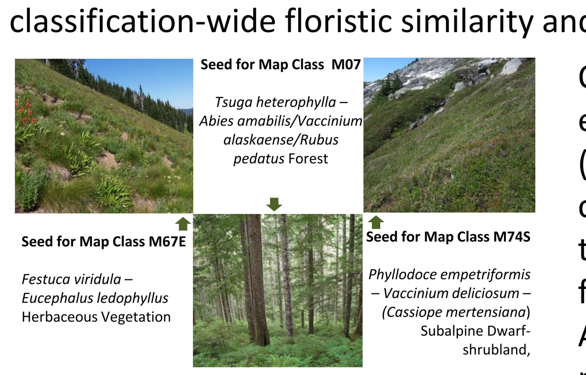



We used a data-driven approach to refine the map classification. Confusion between map classes is realized on the ground, so we based our analysis of confusion on the characteristics of our 6000+ training plots rather than simple association summaries. We optimized the classification to minimize confusion in the field (floristic similarity between map classes) and confusion in the modeling process (which depresses mapability and thus map accuracy).

We define **modeling confusion** as the percent difference in 'model votes' for random forests models between each pair of associations.

We define **floristic similarity** as the Euclidian distance between each plot and the floristic centroid of each association.

For both floristic similarity and modeling confusion, we aimed to **maximize** the plot-level margin of victory (model votes or distance in the assigned class compared to next best fit). Summarized plot-level margin of victory scores were used to assess the consequences of each assignment on classification-wide floristic similarity and model confusion.




Our classification is based on user-expected plant community concepts (often alliances). We seeded map classes with these distinct associations, then grew each class in a stepwise fashion to create the classification. After each assignment, the geometric mean of plot-level margin of victories was re-calculated across all associations and map classes.

Analyses used R (3.3.2, 'vegclust' package), MS Excel, and ArcGIS (10.3)

## Map Classification


**M01**
Deciduous Floodplain and Swamp Forest

***Acer macrophyllum/Oxalis oregana*** **Forest**
***Alnus rubra/Oxalis oregana*** **Forest**
***Alnus rubra/Athyrium filix-femina–Lysichiton americanus*** **Forest**
***Alnus rubra/Elymus glaucus*** **Forest**
***Alnus rubra/Oplopanax horridus–Rubus spectabilis*** **Forest**
***Alnus rubra/Rubus spectabilis/Carex obnupta–Lysichiton americanus*** **Woodland**
***Alnus rubra/Rubus spectabilis*** **Forest**
***Alnus rubra/Stachys chamissonis–Tolmiea menziesii*** **Forest**
***Populus balsamifera/Cornus sericea*** **Forest**
***Populus balsamifera–Alnus rubra/Carex obnupta*** **Forest**
*Populus balsamifera–Alnus rubra/Rubus spectabilis* Forest
***Populus balsamifera–Picea sitchensis–(Acer macrophyllum)/Oxalis oregana*** **Forest**

**M19**
Debris Apron Deciduous Forest

*Acer macrophyllum–(Pseudotsuga menziesii)/Symphoricarpos albus–(Cornus nuttallii)/Pteridium aquilinum* Forest
*Acer macrophyllum/Maianthemum stellatum* Forest
*Acer macrophyllum/Rubus parviflorus–(Cornus sericea)/(Maianthemum racemosa)* Forest

**M20C**
Coastal Bluff Deciduous Forest

***Alnus rubra/Polystichum munitum*** **Forest**
***Picea sitchensis–(Alnus rubra)/Rubus spectabilis/Polystichum munitum*** **Forest**


**M20I**
Upland Deciduous Forest

*Acer macrophyllum–(Pseudotsuga menziesii)/Polystichum munitum* Forest
***Acer macrophyllum/Polystichum munitum–Tolmiea menziesii*** **Forest**
***Acer macrophyllum/Rubus spectabilis*** **Forest**
***Alnus rubra/Acer circinatum/Claytonia sibirica*** **Forest**
*Populus balsamifera–Acer macrophyllum/Acer circinatum/Polystichum munitum* Forest
*Populus tremuloides/Cornus nuttallii* Forest

**M82**
Ruderal Meadow

*Agrostis (capillaris, stolonifera)* Herbaceous Vegetation

**M27C**
Sitka Spruce–Western Hemlock Hypermaritime Forest

***Picea sitchensis/Gaultheria shallon*** **Forest**
***Picea sitchensis/Maianthemum dilatatum*** **Forest**
***Picea sitchensis/Rubus spectabilis/Carex obnupta–Lysichiton americanus*** **Forest**
***Picea sitchensis–Tsuga heterophylla/Polystichum munitum*** **Forest**
***Tsuga heterophylla–(Abies amabilis)/Gaultheria shallon/Blechnum spicant*** **Forest**
***Tsuga heterophylla/Gaultheria shallon/Polystichum munitum–Blechnum spicant*** **Forest**
***Tsuga heterophylla–Thuja plicata–(Abies amabilis)/Gaultheria shallon/Blechnum spicant*** **Forest**


**M45**
Western Hemlock–Western Red Cedar Hypermaritime Forest

***Picea sitchensis/Vaccinium ovatum*** **Forest**
*Thuja plicata–Tsuga heterophylla/Vaccinium ovatum* Forest
***Tsuga heterophylla–Thuja plicata/Gaultheria shallon/Lysichiton americanus*** **Forest**

**M27I**
Sitka Spruce–Western Hemlock Forest

***Picea sitchensis–Tsuga heterophylla/Polystichum munitum–Oxalis oregana*** **Forest**
***Pseudotsuga menziesii–(Alnus rubra–Tsuga heterophylla)/Rubus spectabilis*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/Polystichum munitum–Oxalis oregana*** **Forest**
***Tsuga heterophylla/Polystichum munitum–Oxalis oregana*** **Forest**
***Tsuga heterophylla/Vaccinium alaskaense/Oxalis oregana*** **Forest**
***Tsuga heterophylla–Pseudotsuga menziesii/Vaccinium alaskaense/Oxalis oregana*** **Forest**

**M44**
Wet Western Hemlock–Douglas-fir Forest

***Abies amabilis/Rubus spectabilis–Vaccinium alaskaense*** **Forest**
*Thuja plicata–Tsuga heterophylla–(Picea engelmannii)/Oplopanax horridus* Forest
***Tsuga heterophylla/Polystichum munitum–Blechnum spicant*** **Forest**
***Tsuga heterophylla–(Pseudotsuga menziesii)/Tiarella trifoliata–Gymnocarpium dryopteris*** **Forest**
***Tsuga heterophylla–(Pseudotsuga menziesii)/Vaccinium alaskaense/Polystichum munitum*** **Forest**
***Tsuga heterophylla–(Pseudotsuga menziesii–Thuja plicata)/Oplopanax horridus/Polystichum munitum*** **Forest**
***Tsuga heterophylla–(Pseudotsuga menziesii–Thuja plicata)/Polystichum munitum–Athyrium filix-femina*** **Forest**
***Tsuga heterophylla–(Thuja plicata–Alnus rubra)/Lysichiton americanus–Athyrium filix-femina*** **Forest**
***Tsuga heterophylla–Abies amabilis/Blechnum spicant–Tiarella trifoliata–Polystichum munitum*** **Forest**
***Tsuga heterophylla–Abies amabilis/Oxalis oregana–Blechnum spicant*** **Forest**


**M42**
Mesic Western Hemlock–Douglas-fir Forest

*Abies lasiocarpa–Pseudotsuga menziesii/Mahonia nervosa* Forest
*Pseudotsuga menziesii–(Thuja plicata–Abies grandis)/Vaccinium membranaceum* Forest
***Pseudotsuga menziesii–Tsuga heterophylla/Achlys triphylla*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/(Acer circinatum)/Polystichum munitum*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/Gaultheria shallon–Vaccinium parvifolium*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/Gaultheria shallon/Polystichum munitum*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/Gaultheria shallon–Mahonia nervosa*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/Mahonia nervosa*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/Mahonia nervosa–Polystichum munitum*** **Forest**
*Pseudotsuga menziesii–Tsuga heterophylla/Paxistima myrsinites/Linnaea borealis* Forest
***Pseudotsuga menziesii–Tsuga heterophylla/Rhododendron macrophyllum*** **Forest**
***Pseudotsuga menziesii–Tsuga heterophylla/Vaccinium alaskaense/Xerophyllum tenax*** **Forest**
***Tsuga heterophylla–(Pseudotsuga menziesii)/Vaccinium alaskaense–Mahonia nervosa–(Gaultheria shallon)*** **Forest**
***Tsuga heterophylla–Pseudotsuga menziesii/Mahonia nervosa–Chimaphila menziesii*** **Forest**


**M66**
Herbaceous Bald Vegetation

*Arctostaphylos (nevadensis, uva–ursi)–Pseudoroegneria spicata* Dwarf-Shrubland
*Arctostaphylos (nevadensis, uva–ursi)–Paxistima myrsinites* Dwarf-Shrubland
*Arctostaphylos columbiana* Shrubland
*Arctostaphylos uva–ursi–Fragaria virginiana–(Festuca roemeri)* Dwarf-Shrubland
*Danthonia intermedia–Racomitrium canescens* Herbaceous Vegetation
***Festuca roemeri–Cerastium arvense–Koeleria macrantha*** **Herbaceous Vegetation**
*Koeleria macrantha–(Agrostis pallens)* Herbaceous Vegetation
*Lewisia columbiana–(Juncus parryi)* Lithomorphic Vegetation
*Luina hypoleuca* Lithomorphic Vegetation
*Polygonum minimum–Racomitrium elongatum* Lithomorphic Vegetation
*Pseudoroegneria spicata/Selaginella wallacei* Herbaceous Vegetation
*Racomitrium canescens–(Penstemon davidsonii)* Herbaceous Vegetation

**M43W**
Pacific Madrone–Douglas-Fir Forest

***Pseudotsuga menziesii/Gaultheria shallon–Holodiscus discolor*** **Forest**
***Pseudotsuga menziesii/Gaultheria shallon–Mahonia nervosa/Polystichum munitum*** **Forest**
*Pseudotsuga menziesii/Gaultheria shallon–Vaccinium parvifolium* Forest
***Pseudotsuga menziesii/Holodiscus discolor–Rosa gymnocarpa/Festuca occidentalis*** **Forest**
*Pseudotsuga menziesii/Mahonia nervosa/Achlys triphylla* Forest
*Pseudotsuga menziesii–Tsuga heterophylla/Gaultheria shallon–Holodiscus discolor* Forest

**M43E**
Dry Western Hemlock–Douglas-fir Forest

*Betula papyrifera–(Thuja plicata)/Acer circinatum/Mahonia nervosa* Forest
*Pseudotsuga menziesii–(Abies grandis)/Acer circinatum/Paxistima myrsinites* Forest
*Pseudotsuga menziesii–(Tsuga heterophylla)/Acer circinatum–Paxistima myrsinites* Forest
***Pseudotsuga menziesii/Acer circinatum/Mahonia nervosa*** **Forest**
*Pseudotsuga menziesii/Holodiscus discolor/Calamagrostis rubescens* Forest


**M33**
Douglas Fir–Subalpine Fir Woodland

***Abies lasiocarpa–(Pseudotsuga menziesii)/Vaccinium membranaceum/Calamagrostis rubescens*** **Forest**
*Pseudotsuga menziesii/Paxistima myrsinites–Spiraea betulifolia* Woodland
***Pseudotsuga menziesii/Vaccinium membranaceum*** **Forest**

**M35**
Lodgepole Pine–Douglas-Fir Forest

*Pinus contorta/Paxistima myrsinites/Calamagrostis rubescens* Forest
***Pinus contorta/Vaccinium membranaceum*** **Woodland**
***Pinus contorta–Pseudotsuga menziesii/Gaultheria shallon*** **Forest**
***Pseudotsuga menziesii–(Pinus contorta)/Arctostaphylos uva–ursi/Racomitrium canescens*** **Woodland**
*Pseudotsuga menziesii–Pinus contorta/Arctostaphylos nevadensis* Woodland

**M36**
Ponderosa Pine–Douglas-Fir Forest

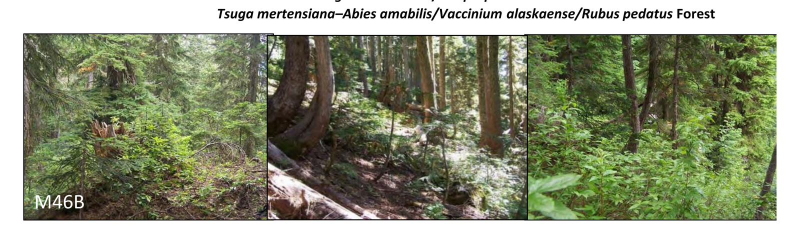
*Pseudotsuga menziesii–(Pinus ponderosa)/Symphoricarpos albus* Forest
*Pseudotsuga menziesii–Pinus ponderosa/Arctostaphylos nevadensis* Woodland
*Pseudotsuga menziesii–Pinus ponderosa/Calamagrostis rubescens* Forest

**M07**
Warm Silver Fir–Western Hemlock Forest

*Abies amabilis–(Pseudotsuga menziesii)/Achlys triphylla–Tiarella trifoliata* Forest
***Abies amabilis–Pseudotsuga menziesii/Achlys triphylla*** **Forest**
***Abies amabilis–Tsuga heterophylla/Oplopanax horridus*** **Forest**
*Abies amabilis–Tsuga heterophylla/*Depauperate Forest
*Abies amabilis–Tsuga heterophylla/Rubus pedatus–Tiarella trifoliata* Forest
***Tsuga heterophylla–(Pseudotsuga menziesii)/Vaccinium alaskaense/Cornus unalaschkensis*** **Forest**
*Tsuga heterophylla–Abies amabilis–(Pseudotsuga menziesii)/Vaccinium alaskaense* Forest
***Tsuga heterophylla–Abies amabilis–(Thuja plicata)/Vaccinium alaskaense/Blechnum spicant*** **Forest**
***Tsuga heterophylla–Abies amabilis/Vaccinium alaskaense/Rubus pedatus*** **Forest**
***Tsuga heterophylla–Abies amabilis/Vaccinium alaskaense/Tiarella trifoliata*** **Forest**
***Tsuga heterophylla–Abies amabilis–Pseudotsuga menziesii/Gaultheria shallon*** **Forest**
***Tsuga heterophylla–Abies amabilis–Pseudotsuga menziesii/Mahonia nervosa*** **Forest**

**M46A**
Mountain Hemlock–Silver Fir Forest

***Abies amabilis–(Pseudotsuga menziesii–Abies procera)/Vaccinium membranaceum/Xerophyllum tenax*** **Forest**
***Abies amabilis–(Tsuga heterophylla)/Vaccinium membranaceum–Vaccinium alaskaense*** **Forest**
***Abies amabilis/Menziesia ferruginea*** **Forest**
***Abies amabilis–Tsuga mertensiana/Menziesia ferruginea*** **Forest**
***Abies amabilis–Tsuga mertensiana/Streptopus lanceolatus*** **Forest**
***Tsuga mertensiana–Abies amabilis/Vaccinium alaskaense/Rubus pedatus*** **Forest**




**M46B**
Silver Fir–Mountain Hemlock Forest

***Abies amabilis–(Tsuga heterophylla)/Vaccinium membranaceum*** **Forest**
***Abies amabilis/Rhododendron albiflorum*** **Forest**
***Abies amabilis/Vaccinium membranaceum/Rubus lasiococcus*** **Forest**
***Abies amabilis–Tsuga mertensiana/Vaccinium membranaceum/Rubus lasiococcus*** **Forest**
***Tsuga mertensiana–Abies amabilis/Rhododendron albiflorum*** **Forest**

**M06**
Mesic Subalpine Forest and Woodland

***Abies lasiocarpa–(Abies amabilis)/Vaccinium membranaceum/Valeriana sitchensis*** **Forest**
*Abies lasiocarpa–(Abies amabilis)/Vaccinium membranaceum/Xerophyllum tenax* Forest
***Abies lasiocarpa–(Picea engelmannii)/Rhododendron albiflorum*** **Forest**
***Abies lasiocarpa/Rhododendron albiflorum/Rubus lasiococcus*** **Forest**
***Abies lasiocarpa/Vaccinium membranaceum/Lupinus arcticus*** **Woodland**
***Abies lasiocarpa/Valeriana sitchensis*** **Forest**
*Abies lasiocarpa/Veratrum viride* Woodland
*Cupressus nootkatensis/Valeriana sitchensis* Forest

**M47**
Subalpine Mixed Woodland and Shrubland

***Abies lasiocarpa/Vaccinium deliciosum*** **Woodland**
***Tsuga mertensiana/Phyllodoce empetriformis–Vaccinium deliciosum*** **Woodland**
***Tsuga mertensiana–Abies amabilis/Vaccinium membranaceum/Xerophyllum tenax*** **Forest**
***Tsuga mertensiana–Abies lasiocarpa/Vaccinium deliciosum–Phyllodoce empetriformis*** **Woodland**


**M17E**
Whitebark Pine-Subalpine Fir Woodland

***Abies lasiocarpa–(Tsuga mertensiana)/Festuca viridula*** **Woodland**
*Abies lasiocarpa/Vaccinium scoparium/Valeriana sitchensis* Woodland
***Pinus albicaulis–(Abies lasiocarpa)/Vaccinium scoparium–Luzula glabrata*** **Woodland**
***Pinus albicaulis/Calamagrostis rubescens*** **Woodland**
*Pinus albicaulis/Festuca viridula* Woodland
***Pinus albicaulis/Juniperus communis*** **Woodland**

**M17W**
Dry Subalpine Forest and Woodland

*Abies lasiocarpa–(Pinus contorta)/Juniperus communis–Lomatium martindalei* Woodland
***Abies lasiocarpa–(Pinus contorta)/Lupinus arcticus*** **Woodland**
*Abies lasiocarpa/Erythronium montanum* Forest
*Abies lasiocarpa/Polemonium pulcherrimum–Pedicularis racemosa* Woodland

**M24**
Subalpine Larch-Subalpine Fir Woodland

***Abies lasiocarpa–Picea engelmannii/Vaccinium scoparium*** **Woodland**
*Larix lyallii/Cassiope mertensiana–Luetkea pectinata* Woodland
***Larix lyallii/Vaccinium scoparium/Luzula glabrata*** **Woodland**
***Larix lyallii/Vaccinium deliciosum*** **Woodland**

**M15**
Krummholz

*Abies lasiocarpa* Krummholz Shrubland
*Arctostaphylos (nevadensis, uva–ursi)–Juniperus communis* Dwarf-shrubland
*Pinus albicaulis* Krummholz Shrubland
***Tsuga mertensiana*** **Krummholz Shrubland**

**M50**
Vine Maple Talus Shrubland

*(Pseudotsuga menziesii)/Acer circinatum-(Holodiscus discolor)* Woodland
*Abies lasiocarpa–(Pseudotsuga menziesii)/Acer circinatum* Talus Woodland
*Cupressus nootkatensis–(Acer circinatum–Alnus viridis)/(Paxistima myrsinites)* Shrubland
*Populus tremuloides* Shrubland


**M51**
Dry Tall Shrubland

*Ceanothus velutinus–(Spiraea betulifolia)/Calamagrostis rubescens* Shrubland
*Prunus emarginata–Amelanchier alnifolia–Ceanothus velutinus/(Maianthemum racemosa–Thalictrum occidentalis)* Shrubland
*Salix* spp.*–Acer glabrum–(Sorbus scopulina)/Paxistima myrsinites* Shrubland

**M18**
Low Elevation Deciduous Tall Shrubland

***Acer circinatum–(Alnus viridis–Cornus sericea)/(Pteridium aquilinum)*** **Shrubland**
***Acer circinatum/Athyrium filix-femina–Tolmiea menziesii*** **Shrubland**
*Acer* spp.*–(Corylus cornuta)/Paxistima myrsinites* Shrubland

**M21**
High Elevation Deciduous and Mixed Tall Shrubland

***Alnus viridis/Pteridium aquilinum–Athyrium filix-femina*** **Shrubland**
***Alnus viridis–Oplopanax horridus*** **Shrubland**
***Alnus viridis–Rubus spectabilis/(Athyrium filix-femina)*** **Shrubland**
***Alnus viridis–Sambucus racemosa/(Thalictrum occidentalis)*** **Shrubland**
*Cupressus nootkatensis–Alnus viridis–(Oplopanax horridus)/(Erythronium montanum)* Shrubland
***Rubus spectabilis–Ribes bracteosum–(Oplopanax horridus)*** **Shrubland**
*Salix sitchensis–Alnus viridis/(Chamerion angustifolium–Heracleum maximum)* Shrubland

**M61**
Mesic Tall Forbs

***Heracleum maximum–(Thalictrum occidentale–Saussurea americana)*** **Herbaceous Vegetation**
***Rubus parviflorus/Pteridium aquilinum–Chamerion angustifolium*** **Shrubland**
*Symphoricarpos albus–Malus fusca* Shrubland

**M52**
Mixed Forb and Graminoid Herbaceous Meadow

***Antennaria lanata*** **Herbaceous Vegetation**
*Danthonia intermedia* Herbaceous Vegetation
***Festuca viridula–Lupinus arcticus*** **Herbaceous Vegetation**
*Juncus parryi–(Polygonum bistortoides)* Herbaceous Vegetation

**M62**
Olympic Mountain Aster Herbaceous Meadow

*Eucephalus paucicapitatus* Herbaceous Vegetation

**M67E**
Green Fescue–Cascade Aster Dry Herbaceous Meadow

*Festuca viridula–(Phlox diffusa–Arenaria capillaris)* Herbaceous Vegetation
***Festuca viridula–Eucephalus ledophyllus*** **Herbaceous Vegetation**
*Paxistima myrsinites–Phlox diffusa* Dwarf–Shrubland
*Vaccinium deliciosum–Festuca viridula* Dwarf-Shrubland

**M67W**
Roemer's Fescue Dry Herbaceous Meadow

*Dasiphora fruticosa–(Phlox diffusa)* Dwarf-Shrubland
*Festuca roemeri–(Phlox diffusa–Arenaria capillaris)* Herbaceous Vegetation
*Juniperus communis–(Phlox diffusa)* Dwarf-Shrubland
*Juniperus communis* Shrubland
*Phlox diffusa–(Lomatium martindalei– Carex phaeocephala)* Herbaceous Vegetation
*Saxifraga bronchialis* Lithomorphic Vegetation


**M86**
Showy Sedge–Sitka Valarian Mesic Subalpine Meadow

***Carex spectabilis–(Lupinus arcticus–Polygonum bistortoides*** **Herbaceous Vegetation**
*Spiraea splendens/Carex spectabilis–(Polygonum bistortoides)* Shrubland
***Valeriana sitchensis–Carex spectabilis*** **Herbaceous Vegetation**
***Valeriana sitchensis–Ligusticum grayi*** **Herbaceous Vegetation**
***Valeriana sitchensis–Veratrum viride*** **Herbaceous Vegetation**

**M85**
High Elevation Dry Shrubland

*Sorbus sitchensis/Phyllodoce empetriformis–Vaccinium deliciosum* Shrubland
*Vaccinium* spp.*/Xerophyllum tenax* Shrubland
*Vaccinium membranaceum–(Sorbus sitchensis–Paxistima myrsinites)* Shrubland
*Vaccinium membranaceum/Calamagrostis rubescens* Shrubland
*Vaccinium scoparium* Dwarf-Shrubland

**M74S**
Subalpine Mountain Heather Dwarf-Shrubland

***Arctostaphylos uva–ursi–(Dasiphora fruticosa)*** **Dwarf-Shrubland**
***Phyllodoce empetriformis–(Vaccinium deliciosum)–Lupinus arcticus*** **Dwarf-Shrubland**
***Phyllodoce empetriformis–Vaccinium deliciosum–(Cassiope mertensiana) Subalpine*** **Dwarf-Shrubland**

**M74A**
Alpine Mountain Heather Dwarf-Shrubland

***Carex nigricans–(Luetkea pectinata)*** **Herbaceous Vegetation**
***Cassiope mertensiana–Phyllodoce empetriformis*** **Alpine Dwarf-Shrubland**
***Empetrum nigrum–Lupinus sellulus*** **Dwarf-Shrubland**
***Phyllodoce glanduliflora–(Cassiope mertensiana)*** **Dwarf-Shrubland**


**M73**
Sparsely Vegetated Talus and Fellfield

*Artemisia ludoviciana–Lomatium martindalei* Herbaceous Vegetation
***Athyrium americanum–Cryptogramma acrostichoides*** **Lithomorphic Vegetation**
*Chamerion latifolium–Oxyria digyna–(Valeriana sitchensis)* Lithomorphic Vegetation
*Elmera racemosa–(Senecio neowebsteri)* Lithomorphic Vegetation
*Eriogonum pyrolifolium–Polygonum davisiae* Lithomorphic Vegetation
*Phlox diffusa–Lupinus sellulus–(Pedicularis contorta)* Herbaceous Vegetation

**M63**
Sparsely Vegetated Alpine Herbaceous Vegetation

*Luetkea pectinata–Carex spectabilis* Lithomorphic Vegetation
***Saxifraga tolmiei–(Luzula piperi–Carex nigricans)*** **Lithomorphic Vegetation**

**M39H**
Lowland Wet Meadow

*Carex aquatilis–(Menyanthes trifoliata–Equisetum* spp.*)* Herbaceous Vegetation+

**M39S**
Lowland Wet Shrubland

***Cornus sericea*** **Shrubland**
*Salix sitchensis–Spiraea douglasii/Carex aquatilis–Lysichiton americanus* Shrubland+


**M58**
High Elevation Wet Meadow

*Carex (nigricans, spectabilis)–Caltha leptosepala–(Leptarrhena pyrolifolia)* Herbaceous Vegetation
*Carex nigricans–(Kalmia microphylla–Vaccinium deliciosum)* Herbaceous Vegetation+
*Carex nigricans–Carex lenticularis–(Calamagrostis canadensis)* Herbaceous Vegetation
***Carex spectabilis–Carex nigricans–(Potentilla flabellifolia)*** **Herbaceous Vegetation**
*Salix commutata/(Valeriana sitchensis–Senecio triangularis)* Shrubland
***Salix commutata*** **Shrubland**
*Trichophorum caespitosum* Herbaceous Vegetation

**M81**
Coastal Bog

*(Thuja plicata)/(Ledum groenlandicum)/Carex obnupta–(Sphagnum* spp.*)* Bog+
***Thuja plicata–Tsuga heterophylla/Lysichiton americanus/Sphagnum*** **spp. Woodland**

+Represents multiple associations that were lumped prior to map classification, mostly because of low plot numbers in component associations.

The central chart represents the resultant crosswalk between mapping associations and map classes. This crosswalk balances user expectation, floristic similarity and model separability. Final modeling, map class prevalence review and accuracy assessments are not yet completed. Map classes may be combined based on accuracy assessment results and map class names are subject to change.

Example plot photos are shown above entries for some map classes. Each photo represents a different component association. Bolded mapping associations are already part of the USNVC, all others are preliminary or provisional and stem from extensive field work and ongoing classification efforts (Crawford et. al. 2009).

## Results

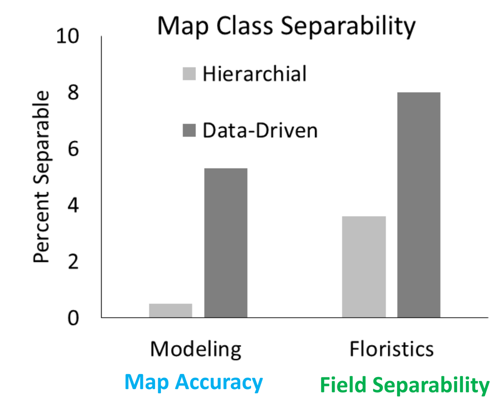



Figure 2. Comparison of map class separability by classification method. Our percent separability metrics are the geometric mean of the margin of victory across all associations and map classes.

We ended up with 44 separable, vegetated map classes, listed in the central chart with their component mapping associations. This classification represents a significant increase in the two metrics of mapability that we worked to maximize. The map class an association was assigned to received 5.3% more model votes than its second best fit, a more than 10 fold improvement over modeling based on NVC hierarchy. Floristic separability also improved markedly: floristics were 8.0% more similar to their assigned class than to their second best fit (up from 3.6%).

Our revised classification also highlights and maintains the key ecological communities that local ecologists and NPS staff expect in these maps. To reflect these expert opinions and expectations, our final classification is a compromise between a pure data-driven agglomeration process and previous methods based on manual assignment based on user expectations and local ecology alone.

We retained parts of the hierarchical classification that were important to managers, in some cases despite an alternative that increased both measures of separability. For example, we retained the alpine heather map class (M74S) as distinct from the alpine sparsely vegetated map class (M63) because of requests from NPS staff.

These three large national parks cover four ecoregions (Figure 1) and span steep elevation (0 – 14,411 feet) and climate gradients (66 – 660 cm annual rainfall). Despite these differences, the parks have similar montane and subalpine forests and National Park Service Inventory and Monitoring efforts are organized at the network scale (North Coast and Cascades Network). We created a consistent map class classification, where all map classes are defined similarly at all parks. Two thirds of the map classes are common enough to be mapped at more than two parks, while one third are unique to just one park (e.g. hypermaritime map classes at Olympic National Park). If a map class was not represented by enough plots to effectively map at a particular park, it was lumped with the next most similar type. This lumping is not expected to have a significant effect on the final maps as it affects under 1% of field plots.

## Conclusions

We created a classification that maximizes separability without sacrificing user experience. Our data-driven approach maintained well-supported NVC hierarchical groupings, increased achievable map accuracy and increased consistency of map class field identification. Our extensive field dataset allowed us to ask the data which associations were most confused. To meet user needs, we seeded map classes with the robust categories (endmembers) that were important to map users, and manually maintained a consistent crosswalk between parks, except where data were insufficient.

Our work showed the benefit of specifically testing and maximizing separability. We suggest that these techniques can help USNVC Hierarchy-based vegetation mapping efforts using modeling or photo-interpretation meet desired accuracy targets by specifically prioritizing separability in the mapping process. Our compromise was toward map classes which do not adhere strictly to USNVC hierarchy but we believe the gains in accuracy and field utility will be valued by the map users.

## Acknowledgments

This work was generously supported by the National Park Service Inventory and Monitoring Program.

Crawford, R. C., C. B. Chappell, C. C. Thompson, and F. J. Rocchio. 2009. Vegetation classification of Mount Rainier, North Cascades, and Olympic National Parks. Natural Resource Technical Report NPS/NCCN/NRTR—2009/211. National Park Service, Fort Collins, Colorado.

NatureServe. 2010. NCCN alliance descriptions: forested and a subset of non-forested alliances from Mount Rainer, North Cascades, and Olympic National Parks. Interim Report, NatureServe, Arlington, VA.