

Final Report

for

Accuracy Assessment of the Great Basin National Park Vegetation Map

Prepared for:



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Executive Summary

Logan Simpson Design Inc. (LSD) conducted field work to support an accuracy assessment (AA) of the Great Basin National Park (GRBA) vegetation map. The primary purpose of conducting the map accuracy assessment was to provide the map user an index of the reliability that the vegetation type previously mapped matches the actual vegetation growing at the same point on the ground.

A total of 1,128 AA Points were computer generated from 52 vegetation map classes identified in GRBA. With a goal of 800 to 1,000 AA Points, a total of 872 AA Points were actually sampled. Data on the composition and cover of dominant and diagnostic plant species was collected at an observation area between 0.5 hectare (ha) and 0.1 ha defined for each plot, and the vegetation was keyed to map class and association. One hundred eight-five AA Points had to be remotely sampled due to access difficulty.

Of the 872 sampled AA Points, 589 (68 percent) had good conformance to the map class key; 43 points failed to key to a map class. Nearly half of the AA Points (46 percent) had a good conformance to the association key; 113 AA Points (13 percent) failed to key to an association. Physiognomic types which were difficult to key included wooded shrubland, sparse vegetation, and shrub herbaceous vegetation.

Twenty-seven associations were identified that were not previously reported in the GRBA classification, but were previously described in the revised US National Vegetation Classification (rUSNVC) system. Two new map classes were recommended. Two plant species new to the park flora were confirmed.

During field surveys, specific ambiguities in both the map class and association class were encountered. Recommendations for improving the keys and the procedures used to collect and computerize AA data were identified.

Introduction

Vegetation mapping is an inventory process that documents the composition, distribution, and abundance of plant communities across a landscape. It is one of the 12 baseline inventories to be completed for all 250 national park units within the National Park Service (NPS) Inventory and Monitoring Program. The Mojave Desert Network Inventory and Monitoring (MOJN I&M) is coordinating the development of a vegetation map for GBNP.

A vegetation mapping project is a multi-step and multi-year process. Major phases of each project are: 1) planning; 2) preliminary vegetation classification; 3) field data collection; 4) final vegetation classification; 5) imagery acquisition and preparation; 6) mapping; 7) map accuracy assessment; and 8) final reports and deliverables. Each project involves the skills and interactions of several parties, including NPS staff, a classification team, a mapping team, and a field ecology team to provide an independent third party assessment of the accuracy of the products. The classification team develops the vegetation classification, vegetation descriptions,

and field key to vegetation types. The mapping team coordinates all aspects of the mapping including photograph interpretation, image segmentation, creating the digital vegetation map, and typically completes the accuracy assessment analysis and prepares the final project deliverables. The field ecology team is responsible for field data collection and all post-field season data processing.

The ultimate goal of the vegetation mapping project at GRBA is to produce a vegetation map that provides accurate information on plant community composition, distribution, and abundance that meets the management needs of GRBA and the baseline vegetation inventory needs of MOJN I&M. MOJN I&M proposes to create a vegetation classification to the association level of the rUSNVC and spatial database (i.e., the vegetation map) to approximately the alliance level. An Alliance is the diagnostic species, including some from the dominant growth form or layer, and moderately similar composition that reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes; and an Association is the diagnostic species, including some from the dominant growth form or layer, and moderately similar composition that reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes. Map class identifies the finest level of the classification hierarchy to which vegetation can be identified from the aerial imagery. Depending on the vegetation, this can be as fine as the association level, but is more typically at the alliance or group layer of the vegetation classification hierarchy.

The primary purpose of conducting a vegetation map accuracy assessment is to provide the map user an index of the reliability that the vegetation type mapped matches the actual vegetation growing at the same point on the ground. Map classes with a high percent accuracy will have greater reliability than map classes with low percent accuracy.

The NPS Vegetation Inventory Program uses the PLOTS Database, v3.2, as an integral part of data management. PLOTS is a relational database designed to store vegetation inventory field data for taxonomy and accuracy assessment. It includes geo-referenced plot locations, species abundance and cover data per plot, plot classification, and accuracy assessment point data.

The MOJN I&M contracted with LSD to complete an AA of the previously developed vegetation map for GRBA. This report: 1) summarizes the field procedures used; 2) describes the data collected and entry of this data into the PLOTS database; 3) presents the results of the field data collected; 4) summarizes ambiguities identified in the field keys when keying points; 5) lists challenges encountered in the operation of the PLOTS database; and 6) discusses procedural innovations that made fieldwork more efficient.

Methods

Accuracy assessment is a quality control process conducted to assess the percent accuracy of each map class (i.e., thematic class) delineated on a vegetation map.

The selection of the observation area locations take into account a minimum spacing of 50 meters between points, a 10-meter buffer from any polygon (map class) boundary, observation area size requirements, and field positioning error. The final set of AA Points was provided in digital format for uploading into Global Positioning System (GPS) units. Field maps did not delineate the mapped polygon boundaries.

AA Point locations were pre-determined based on the initial vegetation map. The number of AA samples per map class reflects the total area of each map class in the project area. In order to make reasonably precise statements about the accuracy of each map class, a target sample size of 27 observation points were allotted to more abundant map classes. Rarer map classes have smaller target sample sizes, with a minimum sample size of five.

The AA Point was based with an observational area equivalent to or smaller than the minimum mapping unit of 0.5 ha. The default observation area size was 0.5 hectares, but was reduced for map classes based on the spatial attributes of the vegetation stands represented by the classes. Map classes with observation areas other than the standard 0.5 hectares were identified prior to the start of field work and are listed in Table 1.

Table 1. Map classes with alternate sample area sizes.

Map Code	Map Name	Standard Obs. Area size (ha)	Circle radius length (m)
DS_GUSA	Gutierrezia sarothrae Dwarf-shrubland Alliance	0.1	18
H_AINV	Western Annual Invasive Grassland Herbaceous Alliance	0.1	18
H_PINV	Perennial Invasive Grassland Alliance	0.1	18
H_WET	Montane Wet Meadow Complex	0.1	18
S_ERNA	Ericameria nauseosa Shrubland Alliance	0.1	18
F_POAN	Populus angustifolia Riparian Forest & Woodland Alliance	0.25	28
H_AVAL	Southern Rocky Mountain Avalanche Chute Herbaceous	0.25	28
H_MESC	Montane Mesic Meadow Complex	0.25	28
S_MOTA	Montane Talus and Rock Outcrop Shrubland Complex	0.25	28
S_RIP	Montane Riparian Shrubland Complex	0.25	28
S_RT	Mixed Talus and Rock Shrubland Complex	0.25	28
S_SAVE	Sarcobatus vermiculatus Shrubland Alliance	0.25	28
W_PJRP	Pinus monophylla - Juniperus osteosperma / Betula occidentalis - Rosa woodsii Woodland	0.25	28

The default shape of the observation area around each observation site was circular. However, field observers were given some discretion, as necessary, to minimally relocate and/or reshape the observation area in order to eliminate excessive heterogeneity (more than one clearly distinct vegetation type) within the observation area. Reshaping the observation area (i.e.,

creating a rectangular plot) was necessary in vegetation types occurring in linear bands such as riparian areas.

Field Procedures

The MOJN I&M provided a set of 1,128 geographic coordinates representing AA Points to be sampled. An additional 102 alternate points were provided in the event some of the original points were inaccessible. The number of AA points provided per pre-defined map class reflected the abundance of each map class in the project area. Both a key to map classes and a key to associations was provided. Using each key, field observers assigned a map class and association to the vegetation within the observation area. The field observation is considered the reference values against which the mapped value is compared. Comparison of all points sampled per map class is used to calculate the percent accuracy per map class.

The AA Points were sampled to determine if the existing vegetation at each point matched the vegetation predicted to occur at that point on a vegetation map created for the NPS by Cogan Technologies. Point sampling procedures were completed at, or as near as possible to, the points provided. Completed points were sampled to an observation area of 0.1, 0.25, or 0.5 hectares. Observation area shapes were generally circular, with rectangular areas used for stands of vegetation with linear shapes, such as riparian areas. Observation area size and shape was determined at each point with procedures outlined in the field data collection manual (National Park Service 2011). Remote observations were made when access to a site was hazardous, difficult, or particularly time consuming.

Difficult-to-access points were sampled remotely with a spotting scope or binoculars. Determining if a point could be sampled remotely depended on the quality and magnification capability of the scope or binoculars, the weather conditions, the ability to identify and key the vegetation, and if the observer had sufficient supporting aerial photography to locate the circular observation area limits. All of the remotely sampled points had 1:865 scale ArcMap aerial imagery to supplement visual assessments.

The project field work was completed between August 17 and September 15, 2011. The field crew consisted of up to eleven field biologists and three base camp coordinators (list of personnel is provided at the end of the report). Field-work planning was driven by a GIS-based analysis of the distribution of AA Points. Each day, a biologist was assigned a cluster of points located in the same general vicinity to facilitate efficient field work. Biologists worked in teams of two or more, but independently conducted AA assessments for increased productivity. To insure safety, each individual worked within radio contact of another and kept a partner informed of their location and progress.

To aid in navigation and locating AA Points, background geo-spatial data (topography) was loaded on Garmin GPS units. For many of the observation areas known to include heterogeneous vegetation, field biologists were provided a 1:865 scale ArcMap aerial image with 10-meter contours. Heterogeneous vegetation was defined as an observation area that had

more than one association present. The map aided the observer in identifying the areas occupied by each association, determining the target association, and finding a point where the observation area could be best sampled if doing a remote observation. The background imagery was from a 2007 flight contracted by the Southern Nevada Water Authority. These aerial imagery maps combined the AA Point location with a 40-meter diameter circular buffer (i.e., observation area). When biologists were expected to encounter hard-to-access points requiring remote observation, they were given 1:13,000 scale aerial imagery with 50-foot topographic contours.

In order to maximize the accuracy of the Garmin GPS units, waypoints were obtained in signal averaging mode. The unit was left in place for whatever period of time was necessary to reasonably reduce the displayed error in accuracy. In general, this required capturing 30-100 signals, although sometimes units were left in place during the entire time a point was sampled, resulting in many hundreds of signals being averaged with a corresponding error rate of 0.9 to 1.5 meters.

Field observations at each AA Point were written on an Accuracy Assessment Field Form, developed by the Mojave Desert Network Vegetation Classification and Mapping Program (Appendix A). The forms were pre-labeled with the AA Point number and the Park Site Name to ensure consistency in naming. These data were organized into five thematic groups. Section 1 included accuracy assessment point, GPS, and photographic information. Section 2 included observation area size, shape, and location comments. Section 3 provided a vegetation description that listed dominant and diagnostic species, as well as stratum (i.e., vegetation layer) and percent cover. Section 4 reported the results of field keying to association. Section 5 reported the results of field keying to map class.

Photographs were taken at each observation point to photo-document the current state of the vegetation. These photographs were generally taken looking out from the center of the observation point, noting on the field form the direction the image was taken. Sign boards were not used in field photography. This was to make the images useful for a multitude of purposes, including publication. Instead, photographs of the field form for the site was taken before and after the pictures of the observation area. This procedure identified sequential sets of images by AA Point. It ultimately proved helpful in managing and labeling photographs.

At various stages during the project field sheets were reviewed by and guidance offered by the MOJN I&M. This included: 1) after the first session of field sampling; 2) after 10 percent of the data was entered into PLOTS; and 3) after UTM coordinates, map class, and association was entered in PLOTS for all AA Points.

Data Validation Procedure

Validation of the field data sheets insured that the data followed the map class and association keys as closely as possible. This was accomplished by examining each field form for conformance of the species list and cover estimates to the map class(es) and association(s)

chosen by the field observer. If there was conformance to the parameters required in the key, the determinations were validated and transcribed into PLOTS. If they differed, the recorded species and cover data was reapplied to the keys and any discrepancies noted, with a new determination if necessary. The conformance to key evaluation (i.e., good, fair, or poor) was edited, if necessary, to reflect a redetermination. Specific problems in using the keys were noted, such as couplets found to not be dichotomous, or a parameter orphaned in subsequent couplets. An orphaned plant in a vegetation key is one which is abruptly dropped after reference to it in the text of a dichotomous couplet. Orphans represent omissions in the keys which prevent or compromise keying AA Points where that species is dominant or diagnostic. Because the study will lead to statistical analysis of accuracy, logic rather than intuition was used during data validation. The degree to which the keys logically led to a map class or association was reflected in the conformation to key choice. AA Points dominated by *Symphoricarpos oreophilus*, *Glossopetalon*, *Ericameria discoidea*, *Poa secunda*, and *Purshia* had instances where they were orphaned in the keys. Thus, the vegetation logically did not key. Some observers approached this logically and wrote “Does not key.” Others approached it intuitively and read ahead to see what couplet sounded best, or consulted the list of map class or associations for a best match. This same situation occurred with associations and map classes using the terms avalanche chute or non-vascular. These were also orphaned in the keys.

Data validation edits were written on the field forms and titled “Data Validation Notes” using red ink to help differentiate them from data recorded in the field. Validation of the map class and associations entered onto each field form was done without knowledge of what map class the AA point had been classified to by Cogan Technologies when generating AA sampling points. This permitted an unbiased review of the field forms. For approximately 10 percent of the points, the validation was aided by viewing the observation area associated with the AA Point in ArcMap and using the 1:865 scale aerial imagery as background. Comments were typically noted in the PLOTS database under a Data Validation Comments header in the General Comments section of the map class or association record. ArcMap validation was most typically used when there was a question on exact location of an observation area.

Following NPS AA protocol (Lea and Curtis 2010), field biologists had no knowledge of the map class or association of any AA Point as assigned based on the vegetation map; nor did they know how the various associations taxonomically matched their corresponding map classes. The field biologists keyed out map class and association in separate keys. Thus the primary and alternate (secondary) map classes determined in the field sometimes taxonomically differed from their corresponding associations. Field biologists were free to offer nomenclatural innovations for stands that did failed to key to an association, or did not key well. When the map classes or associations identified in the field did not appear to match the exact wording of the keys, changes to the field determination were explained under the Data Validation Comments. Changes during the validation process to key conformance were carefully made, when necessary, to reflect findings from rereading the key and to achieve consistent scoring between field biologists for similar circumstances.

Data Entry Procedures

Data entry templates were provided in PLOTS to transcribe most of the data fields. PLOTS v3.2 is a database created by the Colorado Natural Heritage Program (CNHP) for the NPS National Vegetation Inventory Program to store classification plot, observation point, and accuracy assessment data collected as part of NPS vegetation classification and mapping projects. The database was structured with two data entry templates: “Edit and QC Plots” and “Edit and QC AA Pts”, both templates had multiple tabs for data entry. In order to use PLOTS for entry of both map class information and association information, it was necessary to split each record into two parts. A suffix was added to either of two additional records per AA Point to indicate which record was for the map class (i.e., 01) and which record was for the association (i.e., 02). Guidelines for data entry into PLOTS followed the NPS procedure manual and are provided in Appendix B.

Fields within Section 1 of the field form that were not transcribed included: GPS Unit, [GPS] Model, Waypoint number, and whether the GPS was within stand, the location at which a remote observation was made [easting, northing, and error], slope [not collected], aspect [not collected], declination [assumed to be 12.5 degrees east], and camera number. The reason for intentional offsets of points was not recorded into PLOTS.

In the “Edit and QC AA Pts” template of the PLOTS database, on the “AA Point Location and Description” tab, the General Comments text field of the 01 record includes: coordinate, observation area size (i.e., plot size), observation area shape (i.e., plot shape), and azimuth data for remote observations. In the same General Comments text field, a “Surveyors Comments” subheading was also added to the 01 record to combine: 1) AA Point Location Comments/Environmental Comments; 2) GPS Comments; and 3) Conformance to Key Comments. In the 02 record, “Surveyor’s Comments” are strictly for comments about the association. Information entered into the “Data Validation Comments” subheadings for both the 01 and 02 records represent comments generated in the data validation stage of the project. Alternate physiognomy, where applicable, was typed into the General Comments text field for the 02 record.

Results

Data was collected on field forms for 869 pre-assigned AA Points, plus 3 AA Points identified during field work. These data support field determinations and an assessment of conformance to both the map class key and the association keys. Fifty-two map classes and 137 associations are represented in the data set.

Map Classes

Table 2 provides an analysis of the number of AA Points sampled per map class. For each map class, it provides the number of AA Points identified for that map class, based on the preliminary vegetation classification and mapping. It also provides a summation of the number of times

each map class was ranked as good, fair, or poor conformance to key. Good conformance was recorded for 589 AA Points (68 percent), 211 fair conformance for 211 AA Points (24 percent), and poor conformance for 72 AA Points (8 percent). One hundred eighty-five AA Points (21 percent) were sampled remotely. Non applicable conformances to rankings were treated as good. They represented 29 instances where conformance was not determined because some parameter required in the key could not be confirmed from a remote observation point.

Table 2. AA Points completed by map class as classified in the field.

Code	Map Classification Name	Conformance to Key as Classified in Field			Classified Total	Number of AA Points Sampled Based on Preliminary Vegetation Classification
		Good	Fair	Poor		
DS_GUS A	Gutierrezia sarothrae Dwarf-shrubland Alliance		1		1	5
F_ABPO	Abies concolor - Populus tremuloides Forest Complex	22	4		26	22
F_FIRE	Post-fire Forest	3	2		5	
F_PIEN1	Picea engelmannii Forest Complex	18	7		25	8
F_PIEN2	Picea engelmannii Riparian Forest & Woodland Alliance	18	4	1	23	24
F_PIEN3	Picea engelmannii - Populus tremuloides Forest Complex	20	1	1	22	24
F_PIPT	Pinus flexilis - Populus tremuloides Forest Alliance	6	2		8	11
F_POAN	Populus angustifolia Riparian Forest & Woodland Alliance	10			10	11
F_POTR1	Rocky Mountain Populus tremuloides Forest & Woodland Alliance	24	4		28	22
F_POTR2	Rocky Mountain Populus tremuloides Riparian Forest & Woodland Alliance	12	2		14	26
G_ROCK	Unvegetated Rock Cliff and Outcrop			1	1	
G_TALS	Bare Talus, Scree and Fellfield	2			2	
H_AINV	Western Annual Invasive Grassland Herbaceous Alliance	2	3		5	5
H_AVAL	Southern Rocky Mountain Avalanche Chute Herbaceous	1		1	2	3
H_MESC	Montane Mesic Meadow Complex	5	1		6	17
H_PINV	Perennial Invasive Grassland Alliance	5			5	5
H_SRMT	Southern Rocky Mountain Montane-Subalpine Grassland Group	4	2		6	22
H_WET	Montane Wet Meadow Complex	16	7	2	25	26
S_AMAR TV	Amelanchier utahensis - Artemisia tridentata (ssp. vaseyana, ssp. wyomingensis) Shrubland	8	4	1	13	29
S_ARAR	Artemisia arbuscula ssp. arbuscula Shrub Herbaceous Alliance	19	5	1	25	23
S_ARNO	Artemisia nova Shrubland Alliance	18			18	25

Table 2. AA Points completed by map class as classified in the field.

Code	Map Classification Name	Conformance to Key as Classified in Field			Classified Total	Number of AA Points Sampled Based on Preliminary Vegetation Classification
		Good	Fair	Poor		
S_ARPA	Arctostaphylos patula Shrubland Alliance	5	3		8	19
S_ARTR	Artemisia tridentata ssp. tridentata Shrubland Complex	25	7	3	35	28
S_ARTR V	Artemisia tridentata ssp. vaseyana Shrubland Alliance Complex	31	5		36	23
S_AVAL	Populus tremuloides - (Picea engelmannii, Abies spp. , Pseudotsuga menziesii) Avalanche Chute Shrubland Alliance	10	3		13	9
S_CEIN	Cercocarpus intricatus Shrubland Alliance	19	5		24	17
S_CHVI	Chrysothamnus viscidiflorus Shrub Herbaceous Alliance				0	11
S_ERNA	Ericameria nauseosa Shrubland Alliance	3	2		5	5
S_FIRE	Post-fire Shrubland	10	15	8	33	18
S_MOTA	Montane Talus and Rock Outcrop Shrubland Complex	3	3	1	7	23
S_PERA	Peraphyllum ramosissimum - Artemisia tridentata Shrubland			1	1	25
S_PIEN	Picea engelmannii - (Pinus flexilis) Great Basin Krummholz Shrubland Alliance	9	4		13	14
S_RIMO	Ribes montigenum Shrubland Alliance	11	5	1	17	23
S_RIP	Montane Riparian Shrubland Complex	24	2	1	27	27
S_RT	Mixed Talus and Rock Shrubland Complex	1	1		2	18
S_SAVE	Sarcobatus vermiculatus Shrubland Alliance	3	3		6	5
SV_FELL	Alpine Cushion Plant Fellfield Complex	3	2		5	11
SV_TURF	Alpine Turf Complex	11	5	2	18	15
W_ABCO 1	Abies concolor - Pseudotsuga menziesii Forest Complex	36	4	2	42	12
W_ABCO 2	Abies concolor Riparian Forest & Woodland Alliance	21	4	3	28	16
W_CELE	Intermountain Basins Curl-leaf Mountain-mahogany Woodland & Shrubland Group	25	9		34	15
W_PIFL	Great Basin Pinus flexilis Woodland Alliance	5	5	1	11	6
W_PILO1	Pinus longaeva Subalpine Woodland	16	2	4	22	16
W_PILO2	Pinus longaeva Montane Woodland Complex	3	7		10	16
W_PIPO1	Pinus ponderosa Woodland Complex	5	2		7	27
W_PIPO2	Pinus ponderosa Riparian Woodland Alliance	9	2		11	19
W_PJGR	Pinus monophylla - (Juniperus osteosperma) Grass Understory Woodland	23	11	4	38	25

Table 2. AA Points completed by map class as classified in the field.

Code	Map Classification Name	Conformance to Key as Classified in Field			Classified Total	Number of AA Points Sampled Based on Preliminary Vegetation Classification
		Good	Fair	Poor		
	Complex					
W_PJMT	Pinus monophylla - Juniperus osteosperma / Cercocarpus ledifolius Woodland	2	5	2	9	20
W_PJMX	Pinus monophylla - (Juniperus osteosperma) Mixed Shrub Woodland Complex	8	8	1	17	22
W_PJRP	Pinus monophylla - Juniperus osteosperma / Betula occidentalis - Rosa woodsii Woodland [Park Special]	5	8		13	21
W_PJSG	Pinus monophylla - (Juniperus osteosperma) / Artemisia spp. Woodland Complex	29	13	1	43	27
W_PJSP	Pinus monophylla - (Juniperus osteosperma) Sparse Understory Woodland	21	3		24	28
NA	Did not key		14	29	43	
	Totals	589	211	72	872	869*

* Three additional points were sampled without a pre-existing AA point number

Table 2 also includes five AA Plots classified to F-FIRE, one of two new map classes recommended. The other new map class recommended was *Symphoricarpos oreophilus* Shrubland Alliance, but no AA Plots list it as the primary map class choice. Forty-three AA Points failed to key to any map class (i.e. does not key).

Table 2 provides a comparison of the number of AA Points identified in the field to a particular map class versus how many of those points were previously classified for that map class. For example, the *Gutierrezia sarothrae* Dwarf-shrubland Alliance (D_GUSA) map class was predicted at five sampled AA Points, but was ultimately determined as a fair compliance representation at only one AA Point. *Peraphyllum ramosissimum* - *Artemisia tridentata* Shrubland (S_PERA) map class was found at only one of 25 AA Points where it was predicted. Other map classes attaining less than 66 percent completion to the predicted map class include: F_POTR2, H_MESC, H_SRMT, S_AMARTV, A_ARPA, S_MOTA, S_RT, SV_FELL, W_PIL02, W_PIP01, W_PIP02, W_PJMT, and W_PJRP. *Chrysothamnus viscidiflorus* Shrub Herbaceous Alliance (S_CHVI) was not present at any of the eleven AA Points where it was predicted.

The AA points sampled for 18 map classes were classified in the field more often than the predicted number of AA points. This was especially true for *Artemisia tridentata* shrublands, landscapes burned since 2000; forests and woodlands dominated or co-dominated by *Abies concolor*, *Cercocarpus ledifolius* woodlands and shrublands; and *Pinus monophylla*-*Juniperus osteosperma* woodlands with *Artemisia tridentata* or grass understory.

Associations

Table 3 provides an analysis of the number of AA Points sampled per association, along with summations of conformance to key rankings. One hundred thirty-seven different associations were keyed in the field. Four hundred-three (46 percent) points had a good or non-applicable conformance to the key; 332 points had fair conformance to the key; 137 points had poor conformance to the keys; and 113 AA Points failed to key to an association. Non applicable conformance represents 20 instances where conformance was not indicated but were treated as good. This represented instances where conformance was not determined because some parameter required in the key could not be confirmed from a remote observation point.

Reduced key conformance was most common for AA Points lacking a necessary dominant in the association key. For example, Key III, Couplet 17a, which required either of the *Ribes* species, or *Ericameria discoidea*. Points with only *Ericameria discoidea* present had poor key conformance, since an omission in the key prevented keying such stands past Couplet 16.

It typically took 40 minutes of data gathering per AA Point, not including walking from one plot to the next. Recording individual species and cover estimates by species at each observation area took additional time, as did identifying plots that needed to be resized/ resighted and then resizing them. Additional time was also necessary to dual key the observation area to separate map class and association keys and to record species data.

In addition, a cost surface was not fully applied to the generation of AA Points resulting in many points which took considerable time to access. Following the NPS (2011) 12-Step Guidance for Vegetation Inventories, a typical accuracy assessment does not require gathering detailed information as is done for the vegetation characterization plots.

Table 3. AA Points completed by association class as classified in the field.

Primary Code	Association Name	Conformance to Key as Classified in Field			Classified Total
		Good	Fair	Poor	
CEGL005418	Abies concolor - (Populus tremuloides) / Salix boothii / Carex scopulorum Forest	1			1
CEGL005419	Abies concolor - Populus tremuloides / Carex scopulorum Forest		1	1	2
CEGL005420	Abies concolor - Populus tremuloides Avalanche Chute Shrubland	2		1	3
CEGL000431	Abies concolor - Pseudotsuga menziesii / Carex rossii Forest	1	1		2
CEGL000242	Abies concolor / Arctostaphylos patula Forest	3	2		5
CEGL000885	Abies concolor / Cercocarpus ledifolius Woodland	4	1	2	7
CEGL000263	Abies concolor / Symphoricarpos oreophilus Forest	12	2		14
CEGL001062	Acer glabrum Drainage Bottom Shrubland	1			1

Table 3. AA Points completed by association class as classified in the field.

Primary Code	Association Name	Conformance to Key as Classified in Field			Classified Total
		Good	Fair	Poor	
CEGL005354	Achnatherum lettermanii Herbaceous Vegetation	1	2	1	4
CEGL005266	Agropyron cristatum - (Pascopyrum smithii, Hesperostipa comata) Semi-natural Herbaceous Vegetation	2			2
CEGL005422	Arctostaphylos patula / Ceanothus martinii Shrubland	3			3
CEGL002696	Arctostaphylos patula Shrubland	2	3		5
CEGL001412	Artemisia arbuscula ssp. arbuscula / Pseudoroegneria spicata Shrub Herbaceous Vegetation	13	9	1	23
CEGL001422	Artemisia nova / Achnatherum hymenoides Shrubland	1	1	1	3
CEGL002698	Artemisia nova / Poa fendleriana Shrubland	4	2		6
CEGL001424	Artemisia nova / Pseudoroegneria spicata Shrubland	2	2		4
CEGL002699	Artemisia tridentata - (Ericameria nauseosa) / Bromus tectorum Semi-natural Shrubland	13	6	4	23
CEGL002820	Artemisia tridentata (ssp. vaseyana, ssp. wyomingensis) - Amelanchier utahensis Shrubland	2	10	2	14
CEPS009566	Artemisia tridentata ssp. tridentata / Agropyron cristatum Semi-natural Shrubland	4	4		8
CEGL002966	Artemisia tridentata ssp. tridentata / Hesperostipa comata Shrubland		1		1
CEGL001016	Artemisia tridentata ssp. tridentata / Leymus cinereus Shrubland		1		1
CEGL002200	Artemisia tridentata ssp. tridentata / Sporobolus airoides Shrubland			1	1
CEGL001034	Artemisia tridentata ssp. vaseyana - Symphoricarpos oreophilus / Elymus trachycaulus ssp. trachycaulus Shrubland	2	1	1	4
CEGL001037	Artemisia tridentata ssp. vaseyana - Symphoricarpos oreophilus / Poa secunda Shrubland		1		1
CEGL001038	Artemisia tridentata ssp. vaseyana - Symphoricarpos oreophilus / Pseudoroegneria spicata Shrubland	4			4
CEGL001020	Artemisia tridentata ssp. vaseyana / Balsamorhiza sagittata Shrubland	1			1
CEGL001027	Artemisia tridentata ssp. vaseyana / Leymus cinereus Shrubland	1			1
CEGL005423	Artemisia tridentata ssp. vaseyana / Poa (glauca, secunda) Shrubland	2			2
CEGL002812	Artemisia tridentata ssp. vaseyana / Poa fendleriana Shrubland	7	1		8
CEGL001030	Artemisia tridentata ssp. vaseyana / Pseudoroegneria spicata Shrubland	1			1
CEPS009597	Astragalus kentrophyta- Eriogonum holmgrenii Herbaceous Vegetation [Park Special]	1	1		2

Table 3. AA Points completed by association class as classified in the field.

Primary Code	Association Name	Conformance to Key as Classified in Field			Classified Total
		Good	Fair	Poor	
CEPS009598	Balsamorhiza sagittata Herbaceous Vegetation [Park Special]	2			2
GRBA000025	Betula occidentalis - Rosa woodsii Shrubland	1	1		2
CEGL001161	Betula occidentalis / Cornus sericea Shrubland	2			2
CEGL002654	Betula occidentalis / Mesic Graminoids Shrubland	1			1
CEGL005264	Bromus inermis - (Pascopyrum smithii) Semi-natural Herbaceous Vegetation	1			1
CEGL003019	Bromus tectorum Semi-natural Herbaceous Vegetation	5	3		8
CEGL001802	Carex aquatilis Herbaceous Vegetation			1	1
CEGL005424	Carex elynoides - Phlox pulvinata - Poa secunda Herbaceous Vegetation		1		1
CEGL001813	Carex nebrascensis Herbaceous Vegetation	2	2		4
CEGL001822	Carex scopulorum Herbaceous Vegetation	1	3		4
CEGL005425	Carex subnigricans - Geum rossii - Sibbaldia procumbens Snowbed [Provisional]		1		1
CEGL005426	Cercocarpus intricatus - Glossopetalon spinescens Shrubland	9	11	1	21
CEGL005355	Cercocarpus ledifolius / Arctostaphylos patula Woodland [Provisional]	3	3		6
CEGL001022	Cercocarpus ledifolius / Artemisia tridentata ssp. vaseyana Woodland	3	1		4
CEGL000970	Cercocarpus ledifolius / Symphoricarpos oreophilus Woodland	9	2	1	12
CEPS009599	Cercocarpus ledifolius Rock Outcrop Sparse Vegetation [Park Special]	1	1		2
CEPS009601	Dasiphora fruticosa ssp. floribunda / Elymus trachycaulus Shrub Herbaceous Vegetation [Park Special]	1			1
CEGL005427	Elymus trachycaulus Herbaceous Vegetation	1	2	1	4
CEGL002937	Ericameria nauseosa / Bromus tectorum Semi-natural Shrubland	2	1		3
CEGL001964	Geum rossii Herbaceous Vegetation	10	3		13
CEGL001838	Juncus balticus Herbaceous Vegetation	8	2		10
CEPS009603	Juncus nevadensis - Poa secunda Herbaceous Vegetation [Park Special]		1		1
CEGL001479	Leymus cinereus Herbaceous Vegetation	2	1		3
CEGL005430	Peraphyllum ramosissimum - Artemisia tridentata Shrubland	1	1		2
CEGL002740	Phlox pulvinata Herbaceous Vegetation [Provisional]	1		1	2
CEGL005432	Picea engelmannii - (Pinus flexilis) / (Astragalus platytropis) Krummholz Shrubland	1	9		10

Table 3. AA Points completed by association class as classified in the field.

Primary Code	Association Name	Conformance to Key as Classified in Field			Classified Total
		Good	Fair	Poor	
CEGL005433	<i>Picea engelmannii</i> - (<i>Pinus flexilis</i>) / <i>Carex rossii</i> Woodland	2	3		5
CEPS009615	<i>Picea engelmannii</i> - <i>Populus tremuloides</i> / <i>Arctostaphylos patula</i> Forest [Park Special]	2			2
CEPS009587	<i>Picea engelmannii</i> - <i>Populus tremuloides</i> / Mesic Forb Forest [Park Special]	2	4		6
CEGL005431	<i>Picea engelmannii</i> - <i>Populus tremuloides</i> Avalanche Chute Shrubland	3	2		5
GRBA000023	<i>Picea engelmannii</i> - <i>Populus tremuloides</i> Forest Alliance	19			19
CEGL005446	<i>Picea engelmannii</i> / <i>Carex scopulorum</i> Woodland	12			12
CEGL000366	<i>Picea engelmannii</i> / <i>Geum rossii</i> Forest	1	1		2
CEGL005925	<i>Picea engelmannii</i> / <i>Juniperus communis</i> Forest	3			3
CEGL000374	<i>Picea engelmannii</i> / <i>Ribes montigenum</i> Forest	1	4	1	6
CEGL005434	<i>Pinus flexilis</i> - (<i>Populus tremuloides</i>) / <i>Arctostaphylos patula</i> Forest	1	3		4
CEGL000807	<i>Pinus flexilis</i> / <i>Juniperus communis</i> Woodland	3	1	2	6
CEGL005447	<i>Pinus longaeva</i> / (<i>Ericameria discoidea</i> - <i>Ribes montigenum</i>) Woodland	11	5		16
CEPS009591	<i>Pinus longaeva</i> / <i>Arctostaphylos patula</i> Woodland [Park Special]	2	2		4
CEPS009593	<i>Pinus longaeva</i> / <i>Symphoricarpos oreophilus</i> Woodland [Park Special]		1		1
CEGL000830	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Artemisia arbuscula</i> Woodland	2	4		6
CEGL000831	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Artemisia nova</i> Woodland	14	7		21
CEGL005436	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Artemisia tridentata</i> ssp. <i>vaseyana</i> - Mixed Shrub Woodland	5	3	2	10
CEGL000832	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Artemisia tridentata</i> Woodland	3	5	1	9
CEPS009607	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Betula occidentalis</i> - <i>Rosa woodsii</i> Woodland [Park Special]	4	9	1	14
CEGL005437	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus intricatus</i> Woodland	1	3		4
CEGL000828	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Cercocarpus ledifolius</i> Woodland	2	7		9
CEGL005438	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Glossopetalon spinescens</i> - <i>Artemisia tridentata</i> - <i>Purshia stansburiana</i> Woodland [Provisional]		2	1	3
CEGL005439	<i>Pinus monophylla</i> - <i>Juniperus osteosperma</i> / <i>Peraphyllum ramosissimum</i> Woodland	2	2		4

Table 3. AA Points completed by association class as classified in the field.

Primary Code	Association Name	Conformance to Key as Classified in Field			Classified Total
		Good	Fair	Poor	
CEGL005440	Pinus monophylla - Juniperus osteosperma / Poa (fendleriana, secunda) Woodland	13	3	4	20
CEGL000836	Pinus monophylla - Juniperus osteosperma / Prunus virginiana Woodland		3		3
CEPS009608	Pinus monophylla - Juniperus osteosperma / Purshia tridentata Woodland [Park Special]	1	2		3
CEGL000829	Pinus monophylla - Juniperus osteosperma / Sparse Understory Woodland	26	3		29
CEGL005442	Pinus ponderosa - Abies concolor / Symphoricarpos oreophilus Woodland [Provisional]	2	1		3
CEPS009609	Pinus ponderosa - Abies concolor Riparian Forest [Park Special]	6	3		9
CEGL000842	Pinus ponderosa / Arctostaphylos patula Woodland	2	1		3
CEPS009611	Poa secunda - Arenaria congesta Herbaceous Vegetation [Park Special]		1		1
CEPS009612	Poa secunda - Cirsium eatonii Post-burn Herbaceous Vegetation [Park Special]	1	2		3
CEPS009613	Polygonum bistortoides Herbaceous Vegetation [Park Special]	3			3
CEGL002664	Populus angustifolia / Cornus sericea Woodland	1			1
CEGL000651	Populus angustifolia / Prunus virginiana Woodland		3		3
CEGL000653	Populus angustifolia / Rosa woodsii Forest	5	1		6
CEGL000522	Populus tremuloides - Abies concolor / Arctostaphylos patula Forest	6	1		7
CEPS009586	Populus tremuloides - Abies concolor / Mesic Graminoid Forest [Park Special]	1	2		3
CEGL000523	Populus tremuloides - Abies concolor / Symphoricarpos oreophilus Forest	6	3	2	11
CEGL000540	Populus tremuloides - Pinus flexilis Forest	3	1		4
CEGL000572	Populus tremuloides / Artemisia tridentata Forest	2			2
CEGL002650	Populus tremuloides / Betula occidentalis Forest	1	1		2
CEGL000573	Populus tremuloides / Bromus carinatus Forest	1			1
CEGL000587	Populus tremuloides / Juniperus communis Forest	5			5
CEGL000596	Populus tremuloides / Prunus virginiana Forest	2			2
CEPS009589	Populus tremuloides / Ribes spp. Woodland [Park Special]	2			2
CEGL003149	Populus tremuloides / Rosa woodsii Forest	2			2
CEGL000610	Populus tremuloides / Symphoricarpos oreophilus Forest	2	1		3
CEGL005444	Prunus virginiana - Mixed Shrub Talus Shrubland [Provisional]	1	2	1	4

Table 3. AA Points completed by association class as classified in the field.

Primary Code	Association Name	Conformance to Key as Classified in Field			Classified Total
		Good	Fair	Poor	
CEGL001679	Pseudoroegneria spicata - Hesperostipa comata Herbaceous Vegetation		3		3
CEGL001660	Pseudoroegneria spicata Herbaceous Vegetation		1	1	2
CEGL001054	Purshia tridentata - Artemisia tridentata ssp. tridentata Shrubland	1	1		2
CEGL005445	Ribes (cereum, montigenum) - Ericameria discoidea Shrubland [Provisional]	5	5	11	21
CEGL001133	Ribes montigenum Shrubland			1	1
CEGL001126	Rosa woodsii Shrubland	6	4		10
CEGL001181	Salix boothii / Mesic Graminoids Shrubland	3	1		4
CEGL001203	Salix exigua / Mesic Graminoids Shrubland	1			1
CEGL001359	Sarcobatus vermiculatus / Artemisia tridentata Shrubland	3	3		6
CEGL001357	Sarcobatus vermiculatus Disturbed Shrubland			1	1
CEGL002951	Symphoricarpos oreophilus Shrubland	11	10		21
GRBA000020	Unclassified Abies concolor - (Pseudotsuga menziesii) Forest or Woodland with a shrub layer		9		9
GRBA000018	Unclassified Abies concolor - (Pseudotsuga menziesii) Forest or Woodland with an herbaceous or a sparse understory	1	6	2	9
GRBA000016	Unclassified Abies concolor - Populus tremuloides Forest or Woodland with a shrub layer	1	5	2	8
GRBA000014	Unclassified Abies concolor - Populus tremuloides Forest or Woodland with an herbaceous or sparse understory	2	3		5
GRBA000007	Unclassified Cercocarpus ledifolius Woodland	2	3		5
GRBA000008	Unclassified Cercocarpus ledifolius Woodland or Shrubland		2	1	3
GRBA000010	Unclassified Juniperus osteosperma Woodland	1			1
GRBA000006	Unclassified Picea engelmannii Forest or Woodland with a shrub understory		1		1
GRBA000005	Unclassified Picea engelmannii Woodland with a sparse or herbaceous layer	1	10	1	12
GRBA000004	Unclassified Pinus flexilis Woodland with a herbaceous or sparse understory	1			1
GRBA000001	Unclassified Pinus flexilis Woodland with a shrub layer			2	2
GRBA000003	Unclassified Pinus longaeva Woodland	2	8	1	11
GRBA000011	Unclassified Pinus monophylla - Juniperus osteosperma Woodland with a herbaceous layer		9	1	10
GRBA000012	Unclassified Pinus monophylla - Juniperus osteosperma Woodland with a shrub layer		2	1	3

Table 3. AA Points completed by association class as classified in the field.

Primary Code	Association Name	Conformance to Key as Classified in Field			Classified Total
		Good	Fair	Poor	
GRBA000013	Unclassified <i>Pinus ponderosa</i> Woodland		3		3
GRBA000009	Unclassified <i>Populus angustifolia</i> Woodland	1	2		3
GRBA000002	Unclassified <i>Populus tremuloides</i> Woodland	7	7		14
GRBA000017	Unclassified <i>Pseudotsuga menziesii</i> - <i>Populus tremuloides</i> Forest or Woodland with a shrub layer		1		1
GRBA000015	Unclassified <i>Pseudotsuga menziesii</i> - <i>Populus tremuloides</i> Forest or Woodland with an herbaceous or sparse understory			1	1
GRBA000021	Unclassified <i>Pseudotsuga menziesii</i> Forest or Woodland with a shrub layer		1		1
NA	Did not key	8	29	76	113
Total:		403	332	137	872

Associations present but not previously reported in the park

There were many associations found within GRBA which had not been previously reported in the final GRBA classification. Twenty-seven associations described in the rUSNVC had repeat occurrences in the park. Some appear only under Secondary Veg (marked * below) because the field observer did not suggest the association, rather they were identified during data validation. In those cases the observer's determination was retained as the Primary Veg choice.. The following associations are recommended for addition to the GBRA classification.

CEGL002698	<i>Artemisia nova</i> / <i>Poa fendleriana</i> Shrubland
CEGL001003	<i>Artemisia tridentata</i> - <i>Ephedra viridis</i> Shrubland*
CEGL002966	<i>Artemisia tridentata</i> ssp. <i>tridentata</i> / <i>Hesperostipa comata</i> Shrubland
CEGL002200	<i>Artemisia tridentata</i> ssp. <i>tridentata</i> / <i>Sporobolus airoides</i> Shrubland
CEGL001037	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i> - <i>Symphoricarpos oreophilus</i> / <i>Poa secunda</i> Shrubland
CEGL001020	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i> / <i>Balsamorhiza sagittata</i> Shrubland
CEGL001027	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i> / <i>Leymus cinereus</i> Shrubland
CEGL003019	<i>Bromus tectorum</i> Semi-natural Herbaceous Vegetation
CEGL001802	<i>Carex aquatilis</i> Herbaceous Vegetation
CEGL001768	<i>Carex douglasii</i> Herbaceous Vegetation*
CEGL001792	<i>Carex microptera</i> Herbaceous Vegetation*

CEGL000963	<i>Cercocarpus ledifolius</i> / <i>Holodiscus dumosus</i> Woodland*
CEGL000966	<i>Cercocarpus ledifolius</i> / <i>Prunus virginiana</i> Shrubland*
CEGL002085	<i>Erodium cicutarium</i> Semi-natural Annual Herbaceous Vegetation*
CEGL002801	<i>Holodiscus dumosus</i> Rock Outcrop Sparse Vegetation*
CEGL001838	<i>Juncus balticus</i> Herbaceous Vegetation
CEGL000734	<i>Juniperus osteosperma</i> / <i>Cercocarpus ledifolius</i> Woodland*
CEGL000366	<i>Picea engelmannii</i> / <i>Geum rossii</i> Forest
CEGL000807	<i>Pinus flexilis</i> / <i>Juniperus communis</i> Woodland
CEGL003073	<i>Pinus longaeva</i> - <i>Pinus flexilis</i> Woodland [Placeholder]*
CEGL001925	<i>Poa fendleriana</i> Herbaceous Vegetation*
CEGL003081	<i>Poa pratensis</i> Semi-natural Seasonally Flooded Herbaceous Vegetation [Placeholder]*
CEGL000648	<i>Populus angustifolia</i> / <i>Betula occidentalis</i> Woodland*
CEGL000594	<i>Populus tremuloides</i> / <i>Mahonia repens</i> Forest*
CEGL000442	<i>Pseudotsuga menziesii</i> / <i>Mahonia repens</i> Forest*
CEGL001133	<i>Ribes montigenum</i> Shrubland
CEGL001134	<i>Rubus idaeus</i> Scree Shrubland*

The GRBA occurrences of *Rubus idaeus* Scree Shrubland have weak conformance to the existing rUSNVC description, but occurrences not on scree slopes are undefined in the rUSNVC. *Rubus idaeus* Shrubland would be a more appropriate inclusion in the GRBA classification, albeit as a placeholder association. *Rubus idaeus* was locally a post-burn dominant in Lincoln Canyon (e.g., AA Point 1006) and may have spread from a residence associated with a historic mine.

Some of the previously listed associations are discussed in the section titled “Errors and Omissions in the Keys.”

Provisional Associations in GBNP

There were three associations which were repeatedly listed as secondary associations by multiple biologists, even though these associations were not in the association key. Rather than reduce those nomenclatural innovations to comments, as was done with the many other non-replicated innovations which biologists offered, these associations were added to the xVegAssociation_lu table in the PLOTS database.

***Artemisia nova* / *Bromus tectorum* Semi-natural Shrubland**

This association repeats in the park as AA Points 284, 300, 303, 310, 311, and 316. *Bromus tectorum* invasion of a wide diversity of shrublands and dwarf-shrublands is widespread across Nevada and Utah, but few of these semi-natural communities have been described in the rUSNVC. This provisional association appears in the PLOTS data as *Artemisia nova* / *Bromus tectorum* Semi-natural Dwarf-shrubland

***Betula occidentalis* - *Rosa woodsii* Shrubland**

Trees such as *Pinus monophylla*, *Juniperus osteosperma* or *Populus angustifolia* were occasionally absent or accidental in this shrub community. This association was not sampled in any of the datasets used to create the vegetation classification for GRBA. It is now known to repeat in the park as shrublands at AA Points 116, 117, 121, 124, 583, and 943.

Betula occidentalis - *Rosa woodsii* was a "species group" identified through the ordination of 229 plots in a vegetation classification of riparian woody vegetation in GRBA (Smith et al. 1995.) sampled in 1992. NatureServe was unable to obtain the original plot data or plot locations for that study. In that study: "Species Group C lacked a well developed tree canopy, was characterized by an abundance of shrub species such as Woods rose, water birch, and chokecherry, and occupied lower intermediate elevations." Ten plots from that study were established as permanent monitoring plots and resampled in 2001 (Beever et al. 2005).

***Pinus monophylla* - *Juniperus osteosperma* / *Bromus tectorum* Semi-natural Woodland**

This association would be a placeholder in the rUSNVC, since a *Juniperus osteosperma* / *Bromus tectorum* Semi-natural Shrubland association is already recognized. It is one of the most widespread semi-natural woodland associations in the Intermountain West. The type was not previously sampled in GRBA. It was found in GRBA during AA sampling and repeats as AA Points 868, 924, 975, 986, 995, 1055, 1214, & 1215. AA Point 1055 is representative of a cluster of points prescribed burned in 2005 as part of the Grey Cliffs Ecological Restoration Project. Recommend further investigation on how many AA Points from that area were mapped based on data from 2003 sample plots. Comparisons of 2003 plot to 2011 classification data might reveal how well the burn has met management goals.

Additional recommendations by the survey team for new associations and some alliances appear in the PLOTS database in the general comments box for AA plot records. Field crews applied their experience to offering potential new types.

Nomenclatural innovations were not suggested, despite replicated plots, when the type would require a substrate modifier. For example, AA Points 789 and 794 were annotated as *Pinus longaeva* - (*Pinus flexilis*) Rock Outcrop Woodlands. Substrate modified associations require an especially rigorous analysis of rangewide composition and distribution information. The general comments to the PLOTS database will show many other innovations, some of which may have been replicated among the sampled AA Points.

There were a few observations recorded in general comments where new associations were seen in the vicinity of, or in route to an AA Point. For example, at Lincoln Peak, 250 meters beyond AA Plot 754 an undocumented *Pinus flexilis* / *Ericameria discoidea* stand was observed, and 100 meters south of AA Plot 45 an undocumented *Pinus flexilis* / *Petadorea pumila* stand was noted.

rUSNVC Associations Without Replication in the Accuracy Assessment

There were eight associations sampled a single time within the park which are also classified in the rUSNVC. These types are not in the final park classification. They were not entered into the PLOTS database since they lacked replication in the AA plot set:

CEGL001010	<i>Artemisia nova</i> / <i>Hesperostipa comata</i> Shrubland Plot 320
CEGL002345	<i>Artemisia nova</i> – <i>Purshia tridentata</i> / <i>Poa fendleriana</i> Shrubland Plot 1120
CEGL002931	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i> / <i>Hesperostipa comata</i> Shrubland Plot 359
CEGL001037	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i> - <i>Symphoricarpos oreophilus</i> / <i>Poa secunda</i> Shrubland Plot 261
CEGL003853	<i>Juniperus communis</i> var. <i>depressa</i> Shrubland Plot 746
CEGL000734	<i>Juniperus osteosperma</i> / <i>Cercocarpus ledifolius</i> Woodland Plot 910
CEGL003154	<i>Pinus monophylla</i> / <i>Artemisia tridentata</i> / <i>Elymus elymoides</i> Woodland Plot 875
CEGL000619	<i>Populus tremuloides</i> / <i>Thalictrum fendleri</i> Woodland Plot 1000
CEGL002888	Sparse (on rock and unconsolidated substrates) Nonvascular Vegetation Plot 619

Note that there could be additional stands of any of these associations within the park, especially CEGL002888 which is ubiquitous in the alpine.

There were five alpine associations in the final park classification which were based on a single classification plot and subsequently not replicated on any AA plots. These single plot associations included:

CEGL001853	<i>Carex elynoides</i> - <i>Geum rossii</i> Herbaceous Vegetation
CEPS009600	<i>Cymopterus nivalis</i> - <i>Erigeron leiomerus</i> - <i>Poa secunda</i> Herbaceous Vegetation [Park Special]

CEPS009602	<i>Geum rossii</i> - <i>Calamagrostis purpurascens</i> Herbaceous Vegetation [Park Special]
CEGL005429	<i>Hulsea algida</i> - <i>Selaginella watsonii</i> Herbaceous Vegetation [Provisional]
CEPS009604	<i>Lomatium graveolens</i> var. <i>alpinum</i> Herbaceous Vegetation [Park Special]

It is possible that these associations might ultimately be replicated if additional alpine AA plots are sampled.

Naming Conflicts

Various associations and a mapping unit have apparent naming conflicts between the rUSNVC and the final park classification. The *Pinus monophylla* - *Juniperus osteosperma* / *Cercocarpus ledifolius* Woodland (W_PJMT) mapping unit conflicts in the PLOTS database with the CEGL000828 association, assigned to *Pinus monophylla* / *Cercocarpus ledifolius*. *Pinus monophylla* - *Juniperus osteosperma* / *Cercocarpus ledifolius* was the former name. These two types are elevationally distinct elsewhere in Nevada.

Arctostaphylos patula / *Ceanothus martinii* Shrubland is an incorrect use of a slash as opposed to a dash, in the rUSNVC. While the original plots used to establish this association had these two shrubs as different heights (i.e., mid-range vs. dwarf shrub), GRBA stands have more uniform heights, thus should be written as *Arctostaphylos patula* - *Ceanothus martinii*.

Suggested Revisions to the Keys

Ambiguous statements or omissions in the construction of keys led to numerous map classes, associations, and physiognomic groups in which these statements inhibited the proper classification of AA Points. Some errors and omissions arose due to greater diversity in stands encountered through the larger sample size of the AA Plot sampling versus the smaller sample size of classification plots sampling. Other errors were due to sampling transitional physiognomic stages (i.e., phases) to vegetation associations. The most prevalent examples were sampling wooded shrubland AA Points, but the mapping treated them as shrublands and the classification as woodlands.

When map classes or associations were less than a good fit to the key, observers were instructed to alternately key the stand, as well as provide comments on why the conformance was fair or poor. Additional comments were provided to explain why observer records on field forms were changed during data validation procedures. Many of the data validation comments were from alternate keying and attempting to achieve correspondence between map class and association. Unfortunately, field workers had no way of knowing the intended correspondence. Crews were provided a review of field forms, from the first session in the field, in which a lack of correspondence was noted. Upon returning to the field, there was a much higher rate of correspondence attained. However, the first session field forms needed to be brought into

correspondence. Comments were also provided to explain most of the changes in classification from types which had been determined in the field.

Due to various errors and omissions in the keys for some of the types listed below, or for the types under certain circumstances, the map class and association keys unfortunately “became the classification” (i.e., the classification description does not matter if the keys are written in a way that describes something different, *sensu* Lea and Curtis 2010). Associations and map classes chosen on any given AA Point represent the way the key presently reads, whether or not the key was “correct.” Many of the observers shared their thoughts regarding keying ambiguities on the field forms. To better classify their points, they offered secondary (and even tertiary) choice map class and association types, as well as nomenclatural innovations of types. The latter were previously discussed in this report.

The following physiognomic groups, associations, and map classes are arranged alphabetically. AA Point numbers supporting the observer comments are referenced to aid in evaluating these findings. Not every instance has been accounted for in this report, but can be found in PLOTS. Associations in the key not represented by points in the AA data set should be considered untested.

***Abies concolor* / *Cercocarpus ledifolius* Woodland**

When the physiognomic group was wooded shrubland (e.g., AA Points 844 and 1189), map class Key II only allowed this association to be keyed as a woodland. But it was not keyable in the woodland map class key, since Couplet 4 leaves *Abies concolor* and *Cercocarpus ledifolius* co-dominance as undefined.

Likewise, the association is not keyable in association Key II, Couplet 3, which leaves *Cercocarpus ledifolius* and *Abies concolor* co-dominance as undefined. Furthermore, *Cercocarpus ledifolius* first appears in the White fir / Douglas fir key at Couplet 15a, but no prior text cites *Cercocarpus* as a dominant to lead one there. As a result, this association is presently undefined to map class, thus not properly mapped (e.g., AA Points 735, 822, 823, and 1189).

***Abies concolor* Forest and Woodland Alliance (W_ABCO1)**

Map class Key II, Couplet 4a is ambiguous where it states “other trees such as *Abies concolor*...may be present with low cover (not codominant).” This couplet needs a more quantitative statement regarding cover percentage. Keying to map class can depend entirely on how this couplet is interpreted (e.g., AA Point 793).

***Abies concolor* Riparian Forest and Woodland Alliance (W_ABCO2)**

The word “riparian” is not written into Key II, Couplet 1b, which could lead to miskeying a stand (e.g., AA Point 165) as a *Populus tremuloides* Temporarily Flooded Forest Alliance (F_POTR2). Map class Key II, Couplet 2b prevents some riparian stands from reaching Couplet 24a, which identifies this map class (e.g., AA Point 155). Specifically, Couplet 2b requires less than 25

percent relative cover for non-deciduous trees. However, later in the key Couplet 24a allows for *Populus tremuloides* and *Abies concolor* co-dominance. Precisely stating a cover range for *Populus tremuloides* is important in this alliance given that statistically significant changes in the proportion of *Abies concolor* to *Populus tremuloides* had been detected after only nine years in permanent vegetation plots at GRBA (Beever et al. 2005).

***Abies concolor* – *Populus tremuloides* Avalanche Chute Shrubland**

Trees in avalanche chutes were not always less than 5 meters tall. In AA Points 179 and 398, they are over 5 meters tall. Height depends on the time since the avalanche, species composition, and the site index (i.e., growth potential). Aspen, in particular, can be fast growing in high site index habitats without frequent avalanches.

Map class physiognomic group Key I, Couplet 3a places avalanche chutes in the woodland group (Key II). But avalanche chute habitat is immediately orphaned (suddenly dropped in subsequent couplets) in Key II, Couplet 1b. This forces a “Does not key” situation, which results in reduced mapping accuracy for treed avalanche chute habitats.

***Abies concolor* – *Populus tremuloides* Forest Alliance (F_ABPO)**

Map class Key II, Couplet 2b prevents some upland stands from reaching Couplet 24a, which identifies this map class (e.g., AA Point 155). Specifically, Couplet 2b requires less than 25 percent relative cover for non-deciduous trees. However, later in the key Couplet 24a allows for *Populus tremuloides* and *Abies concolor* co-dominance.

Map class Key II, Couplet 1a is not quantitative. For example, in AA Point 166, what qualifies as “co-dominant” considering the phrase in the key: “*Pinus ponderosa* is diagnostic?”

***Achnatherum lettermanii* Herbaceous Vegetation**

When *Achnatherum lettermanii* co-dominates with *Elymus trachycaulus*, neither this association nor *Elymus trachycaulus* Herbaceous Vegetation can be properly keyed (e.g., AA Point 477).

Alpine Cushion Plant Fellfield (SV-FELL)

Map class Key I, Couplet 2a allows for as low as 5 percent tree cover, but Couplet 3a qualifies that as only when the stand is sparse vegetation. This needs to be stated in the same couplet, or a wooded herbaceous vegetation physiognomy needs to also be recognized. A good example of a poor fit to physiognomic group is AA Point 630, which is Wooded Herbaceous Vegetation. The best fit key choices offer only a fair key conformance by being limited to either a cushion plant fellfield or a woodland.

Geum rossii is missing from the key for this map class. It is dominant in cushion plant fellfield at AA Point 659.

***Amelanchier utahensis* - *Artemisia tridentata* (ssp. *vaseyana*, ssp. *wyomingensis*)
Shrubland**

In association Key III (Sagebrush Shrublands), Couplet 9a, the plants are listed in reverse order as compared to this map class. Associations with sagebrush and another shrub as co-dominants should be moved to, or duplicated, in a mixed shrub type key. *Amelanchier utahensis* is excluded from early couplets, making unkeyable those stands (e.g., AA Points 254 and 257) which are dominated by *Amelanchier utahensis*. For example, this association keys to map class Key III, Couplet 9a, so long as *Artemisia* is considered the dominant shrub in Couplet 6a. But there is no mention of *Amelanchier* in Couplet 11b. The type reappears, without connection to Couplet 11b. Couplet 13a needs a pathway which has *Amelanchier* as the dominant shrub.

***Aquilegia scopulorum* – *Eriogonum holmgrenii* Alpine Fellfield**

Association Key IV for Alpine Herbaceous Vegetation, Couplet 9, does not allow for co-dominance by *Aquilegia scopulorum* and *Astragalus kentrophyta*. This occurred on AA Point 617, which did not properly key.

***Artemisia arbuscula* ssp. *arbuscula* / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation**

Locally, *Poa fendleriana* is more dominant than *Pseudoroegneria spicata* (e.g., AA Point 287). Some AA Points were better characterized as wooded herbaceous vegetation (e.g., AA Point 1065), wooded dwarf-shrubland (e.g., AA Point 275), sparse dwarf-shrublands (e.g., AA Points 208, 288, and 1122) and dwarf-shrublands (e.g., AA Points 282, 287, and 1121). This association appears to be undergoing the most rapid tree invasion of any association in the park. Invading species include *Abies concolor*, *Pinus monophylla* and *Cercocarpus ledifolius*. There is presently a distinct gap in characterizations of the vegetation on landscapes supporting *Artemisia arbuscula* ssp. *arbuscula*. Areas of tree invasion (e.g., AA Points 275 and 280) cannot be mapped in this classification without identifying phases of this association. , . This over estimates the acreage of high quality wildlife habitat for sagebrush obligate species.

***Artemisia tridentata* ssp. *tridentata* Shrubland (S_ARTR)
and *Artemisia tridentata* ssp. *tridentata* Shrubland**

Map class Key III lists *Artemisia* among the desert scrub species at the Administrative Site in Baker. However, the *Artemisia tridentata* ssp. *tridentata* Shrubland association is not keyable through the Desert Scrub key (e.g., AA Point 345). It should be cross-listed under Desert Scrub and map class Key III, Couplet 5b modified to recognize it apart from a co-dominant with *Sarcobatus vermiculatus*.

***Artemisia tridentata* ssp. *tridentata* – (*Ericameria nauseosa*) / *Bromus tectorum* Shrubland**

The Sagebrush Shrublands key lacks reference to *Ericameria* in key statements leading to Couplet 5a. Association Key III directs stands with *Ericameria* dominance to the Couplet 16a, which identifies them as *Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland. Thus stands (e.g., AA Point 457) in the type which have more *Ericameria* than *Artemisia* may be miskeyed, unless the observer has presupposed knowledge of both associations.

***Artemisia tridentata* ssp. *vaseyana* / *Balsamorhiza sagittata* Shrubland**

AA Point 190 is a sparse shrubland expression of an intergrading community which varies in physiognomy at Big Spring, in Lexington Canyon, along Baker Creek, and in Timber Creek Canyon. These reportedly post-fire successional vegetation ensembles range from the early successional *Balsamorhiza sagittata* Herbaceous Vegetation (e.g., AA Point 452), to *Artemisia tridentata* ssp. *vaseyana* / *Balsamorhiza sagittata* Shrub Herbaceous Vegetation (e.g., AA Point 1153), to *Artemisia tridentata* ssp. *vaseyana* / *Balsamorhiza sagittata* Sparse Shrubland, and to the late successional *Artemisia tridentata* ssp. *vaseyana* / *Balsamorhiza sagittata* Shrubland (e.g., AA Point 1152).

***Astragalus kentrophyta* – *Eriogonum holmgrenii* Fell-field Herbaceous Vegetation**

Association Key IV for Alpine Herbaceous Vegetation, Couplet 9, does not allow for co-dominance by *Aquilegia scopulorum* and *Astragalus kentrophyta*. This occurred on AA Point 617, which did not properly key.

Bare Talus, Scree and Fellfield (G_TALS)

Map class Key V, Couplet 4 is not dichotomous: both parts of the couplet indicate scree fields and less than 2 percent total vegetation. There is no indication in the key if the vegetation cover it references should be vascular, nonvascular, or both. Recording non-vascular cover was not a requirement, thus physiognomic group was determined from vascular cover only. If nonvascular cover were to be included, some observations areas may have more vegetation cover than the sparse vegetation (e.g., AA Point 559) or non-vegetated (e.g., AA Points 565 and 619) physiognomic groups into which they were classified. For AA Points like 619 with only nonvascular sparse vegetation, the park classification should include association CEG002888 Sparse (on rock and unconsolidated substrates) Nonvascular Vegetation.

***Cercocarpus intricatus* Shrubland Alliance (S_CEIN)**

Map class Key III, Couplet 15a indicates that stands can be dominated by *Cercocarpus intricatus* and/or *Glossopetalon spinescens*. However, *Glossopetalon spinescens* is not mentioned in the keys until that couplet, thus a stand with only that species cannot be properly keyed out (e.g., AA Point 429). Likewise, Couplet 15a does not allow for co-dominance of

Cercocarpus intricatus with any other species than *Glossopetalon spinescens*, leaving mixed shrub stands like AA Point 597 unkeyable to map class.

***Cercocarpus intricatus* – *Glossopetalon spinescens* Shrubland**

Stands which best fit this association often lack one or the other dominant species, suggesting that (*Cercocarpus intricatus*, *Glossopetalon spinescens*) Shrubland could be a more inclusive name. For example, *Glossopetalon* is absent in AA Points 429, 441, 445, 505, 507, 511, 513, 523 and 597, leaving Key III, Couplet 10b a dead end. *Cercocarpus intricatus* is absent in AA Point 429.

***Cercocarpus ledifolius* Woodland Alliance (W_CELE)**

"Low cover" was not quantitatively defined in map class Key II, Couplet 4a. Sparse woodland examples of this alliance (e.g., AA Point 1041) are especially prone to key ambiguously. Routinely low cover values in the dominant trees made multiple tree species seem to be "low cover." Because of this key ambiguity, it was difficult to determine when a stand was in the *Cercocarpus ledifolius* Woodland Alliance versus the *Pinus monophylla* – *Juniperus osteosperma* / *Cercocarpus ledifolius* Woodland Alliance. The same is the case for *Abies concolor* / *Cercocarpus ledifolius* Woodland, when *Cercocarpus* is dominant. Essentially, stands had to be keyed through the shrublands key to arrive at a *Cercocarpus ledifolius* Woodland Alliance or any *Cercocarpus ledifolius* association (e.g., AA Point 735). This was one of the reasons there is a high percentage of stands in this map class with reduced key conformance.

Map class Key II, Couplet 2a has *Juniperus scopulorum* listed, rather than *Juniperus osteosperma*. In data validation, it was assumed that the latter was correct. In contrast, map class Key I, Couplet 3a simply reads "*Juniperus*." This leads to mis-keying associations with *Juniperus osteosperma* as the only other tree in a *Cercocarpus ledifolius* dominated stand.

Mountain Mahogany Woodlands (and Shrublands) association key Couplet 1 does not accommodate equal cover in shrub and herb layer (e.g., AA Point 881), nor are there any subsequent options in the keys for sparse understory associations.

Cercocarpus ledifolius is the only montane species in the keys treated as both a shrub and a tree. However, *Pinus monophylla* and *Juniperus osteosperma* often are less than 5 meters tall, thus technically a "tall shrub." It is inconsistent to only recognize *Cercocarpus ledifolius* as having a tall shrub phase and therefore is a shrubland physiognomic type. Since the convention has already been established that tree species can be recognized as shrubs in krummholz and avalanche chutes, *Pinus monophylla* and *Juniperus osteosperma* ought to be recognized when they are mature and grow as pygmy phase (i.e., stunted stature where under 5 meters tall, such as AA Points 602 and 913) on xeric and low nutrient habitats in the Intermountain and Colorado Plateau regions.

***Chrysothamnus viscidiflorus* Shrub Herbaceous Vegetation**

This provisional association was not encountered among the AA Points sampled, is based on one classification plot (GRBA 316), and was not discussed in the GRBA vegetation classification (Schulz and Hall 2011). Associations in the rUSNVC with shrub herbaceous vegetation physiognomy are almost exclusively written with the dominant or diagnostic shrub preceding the dominant or diagnostic herbaceous species. Recommend that this association be reviewed for conformance to that standard and for its relationship to the *Chrysothamnus viscidiflorus* / *Pseudoroegneria spicata* dominated plots at Golden Spike National Historic Site.

***Dasiphora fruticosa* / *Elymus trachycaulus* Shrub Herbaceous Vegetation**

This park special association is not specifically described in the park classification document and is based on only GRBA Classification Plot 740 (Schultz and Hall 2011). AA Point 224 sampled this association, but required a 0.1 hectare rectangular observation area to isolate a stand. That observation area size resulted in artificially elevating the very localized *Dasiphora* cover to 6 percent, thus qualifying the observed stand as a shrub herbaceous vegetation physiognomy. But this stand had to be under the minimum mapping unit in order to properly key to *Dasiphora fruticosa* / *Elymus trachycaulus* Shrub Herbaceous Vegetation.

Classification Plot 740 was not sufficiently large to meet minimum mapping unit requirements. Since none the occurrences of this association were found in the AA Point set, are there other 0.5 hectare or larger stands with a shrub herbaceous physiognomy? A potential occurrence is immediately north of AA Point 1087 in the Wheeler Peak Campground. But like AA Point 224 along the Baker Creek Trail, it may have had hydrological modification from adjacent trails/roadways which caused an increase in *Dasiphora fruticosa* cover. Thus, this park special type could primarily (exclusively?) be a result of land disturbance and an artifact of mapping below the 0.5 hectare threshold.

***Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland**

Association Key III, Couplet 16a states “may have scattered *Artemisia tridentata*,” but the statement is neither quantitative nor dichotomous. When *Artemisia tridentata* is a significant associate (e.g., AA Point 457), it requires keying under Sagebrush Shrublands. Thus knowledge of both keys is presupposed in order to properly key such stands.

***Geum rossii* Herbaceous Vegetation**

The park classification places this in the Alpine Turf Complex (H_TURF). H_TURF is not a map class in the GRBA classification and key, only SV_TURF. SV_TURF signifies sparse vegetation, but *Geum rossii* Herbaceous Vegetation is defined as having 10 percent or greater cover (i.e., not sparse vegetation). Thus, mismatches between map class and association are unavoidable for this association. Furthermore, observers noted on their field forms that *Geum rossii* does not necessarily form turf (e.g., AA Points 642 and 659).

Montane Mesic Meadow Complex (H_MESC)

The *Juncus nevadensis* – *Poa secunda* Herbaceous Vegetation association imperfectly keys to this map class because *Poa secunda* is orphaned in map class Key IV, Couplet 7b. All of the dominant or diagnostic species (including *Poa secunda*) for associations characterized by Couplets 8a and 8b should be included in Couplet 7a; otherwise a user of the map class key may incorrectly choose Southern Rocky Mountain Montane-Subalpine Grassland Group (H_SRMT).

Montane Talus and Rock Outcrop Shrubland (S_MOTA)

This map class forms a landscape mosaic which is not readily sampled by 0.5 to 0.1 hectare observation areas. The associations assigned to any given AA Point within the complex are artifacts of how the point was sampled. Changes in AA Point position, as well as observation area size and shape, become the main determinants of species composition and cover values.

This map class is characterized by areas of homogeneous vegetation which are linear, or smaller than the minimum mapping unit for the study. Reducing the observation area size and shape to the required 28-meter diameter circle exacerbated the problem, since 0.25 hectare is too small to encompass within a single plot the typical range of microhabitat variability in the landscape. Typically, the largest stands of homogeneous vegetation were chosen for AA Point sampling. This tended to artificially inflate the vegetation cover values, forcing communities which are sparse vegetation on the landscape to have greater than 25 percent cover within the radius of the observation area. Thus, the predominant physiognomic group was misdetermined for many associations.

Reduced accuracy in assigning the correct map class to Montane Talus and Rock Outcrop stands was due, in part, to the physiognomic key (Key I) forcing wooded shrubland stands into the woodland group. This type was not listed in the woodland group (Key II), thus some Montane Talus and Rock Outcrop Shrubland stands had no chance of matching vegetation mapping when their tree cover was 10 percent or greater. If wooded shrublands had their own key, Montane Talus and Rock Outcrop Shrublands could more accurately be mapped. Another reason for reduced key conformance was that this shrubland type was based on classification plots from Big Wash. The type description needs to be expanded for stands outside Big Wash (e.g., AA Point 500 along Wheeler Peak Scenic Drive).

Montane Talus and Rock Outcrop Shrublands dominated by *Holodiscus dumosus* had reduced conformance to the map class key since *Holodiscus* was not listed in Key III until Couplet 20a. It needed to first appear in Couplet 14a, to encompass associations such *Holodiscus dumosus* Rock Outcrop Sparse Vegetation. This association was also a good example of how AA sampling tended to report these stands at higher vegetal cover (e.g., AA Point 501) than they are within the context of their talus and rock outcrop physical landscape.

Montane Riparian Shrubland (S_RIP)

Rosa woodsii Shrublands are not necessarily riparian in Nevada. For example, AA Point 390 is upslope from a dry wash.

Non-vascular vegetation

Association Key I, Couplet 1b references non-vascular vegetation as belonging in Key V, but the termed is orphaned at that point and no types are offered in Key V. This makes extensive alpine areas with only non-vascular vegetation (e.g., AA Point 619) not keyable to association, even though associations exist in the rUSNVC.

***Peraphyllum ramosissimum* – *Artemisia tridentata* Shrubland (S_PERA) and *Peraphyllum ramosissimum* – *Artemisia tridentata* Shrubland**

This map class had twenty-five AA Points predicted. S_PERA had perhaps the lowest accuracy rate of any map class. Only one AA Point was determined to be S_PERA. Furthermore, *Artemisia tridentata* was not always present in stands (e.g., AA Point 524).

***Picea engelmannii* Forest Alliance (F_PIE1)**

Map class Key II, Couplet 13b is easily misread (e.g., AA Point 765). The second sentence should be rewritten to read: “*Pinus longaeva* is absent and/or *Pinus flexilis* has less than 50 percent relative cover, or is absent.” Observers found that mixing relative and absolute cover in the key could cause occasional misinterpretations.

***Picea engelmannii* - *Populus tremuloides* Avalanche Chute Shrubland**

Populus tremuloides was not always present (e.g., AA Points 406, 412, 417, and 647), as required in association Key 3, Couplet 3a. Perhaps an (*Abies concolor*, *Picea engelmannii*, *Populus tremuloides*) Avalanche Chute Shrubland association would be inclusive of the temporal variability in vegetation since last avalanche.

***Picea engelmannii* - *Populus tremuloides* / Mesic Forb Forest [Park Special]**

This association appears to also have a “mesic graminoids” understory (e.g., AA Plots 9 and 1093), thus may be worthy of splitting into two types based on the life form of the understory.

***Picea engelmannii* / *Ribes montigenum* Forest**

Association Key II for Engelmann Spruce Forests and Woodlands, Couplet 8b, unintentionally allows a shrub to be dominant, but Couplet 6a limited shrubs to less than 5 percent cover. This constraint reduced key conformance in AA Point 792.

***Pinus flexilis* - (*Populus tremuloides*) / *Arctostaphylos patula* Forest**

This association can have *Cercocarpus ledifolius* as the understory dominant (e.g., AA Point 91), but this co-dominant is not recognized in the key.

***Pinus flexilis* / *Juniperus communis* Woodland**

During the August 18th training, Keith Schulz wrote a rapid assessment for AA Point 31 and classified the association as a *Pinus flexilis* / *Juniperus communis* Woodland. Field workers subsequently wrote this into association Key II (Bristlecone and Limber Pine Forests and Woodlands), Couplet 13c.

***Pinus longaeva* Montane Woodland (W_PILO2)**

Cercocarpus ledifolius should be added to map class Key I, Couplet 16b, since it is diagnostic of western exposure cliff-faces where montane species composition extends into the subalpine zone for AA Points 789, 794, 801, 804, 814, and 817. These stands suggest that using altitudinal limits, like in Couplet 16, are misleading.

***Pinus longaeva* Subalpine Woodland (W_PILO1)**

Ribes cereum should be added to map class Key II, Couplet 16a, since it often replaces or co-occurs with *Ribes montigenum*.

***Pinus longaeva* / (*Ericameria discoides* – *Ribes montigenum*) Woodland**

Ribes cereum should be added to key, or even to the name of an alliance since it either co-occurs with *Ribes montigenum*, or replaces it in some stands (e.g., AA Point 74).

***Pinus monophylla* - (*Juniperus osteosperma*) Grass Understory Woodland Complex**

Map Class Key II, Couplet 8 is not dichotomous at 5 percent cover (e.g., AA Point 919), where stands could also key to *Pinus monophylla* - (*Juniperus osteosperma*) Sparse Understory Woodland.

***Pinus monophylla* - (*Juniperus osteosperma*) Mixed Shrub Woodland**

Map Class Key II is not dichotomous for this and *Pinus monophylla* - (*Juniperus osteosperma*) Sparse Understory Woodland when understory totals 10 percent (e.g., AA Point 918). *Symphoricarpos oreophilus* is in the GRBA classification, not *Symphoricarpos longiflorus*, as in the map class Key II, Couplet 12b.

***Pinus monophylla* - (*Juniperus osteosperma*) Sparse Understory Woodland**

Technically, sparse woodlands (10-25 percent tree cover) cannot be sparse understory woodlands, such as AA Points 913, 919, and 987. Sparse understory woodlands are restricted to stands which are greater than or equal to 25 percent tree cover. The map class key does not

make this distinction, thus sparse understory woodlands are likely over represented in the GRBA vegetation map

***Pinus monophylla* - (*Juniperus osteosperma*) / *Artemisia* spp. Woodland Complex (W_PJSG)**

Map Class Key II, Couplet 9 is ambiguous when both shrub and grass strata exceed 10 percent cover (e.g., AA Point 907). The key is ambiguous on what constitutes a dominant understory stratum, thus lowering key conformance for some stands (e.g., AA Points 958 and 970).

***Pinus monophylla* – *Juniperus osteosperma* / *Artemisia tridentata* ssp. *vaseyana* – Mixed Shrub Woodland**

For GRBA, this association would better fit the data if described as a *Pinus monophylla* – (*Juniperus osteosperma*) / (*Artemisia tridentata* ssp. *vaseyana*) – Mixed Shrub Woodland. An example with *Amelanchier utahensis* as the sole dominant is AA Point 1061. An example with *Holodiscus dumosus* and *Prunus virginiana* co-dominant is AA Point 487.

***Pinus monophylla* – *Juniperus osteosperma* / *Betula occidentalis* – *Rosa woodsii* Woodland**

AA Points 942, 943, 945, 946, and 948 lack *Betula occidentalis*, thus a (*Betula occidentalis*, *Rosa woodsii*) nomenclatural innovation for the understory seems to be a better fit to the AA data set. The lack of *Betula* results in lessened key conformance at Couplet 6a.

***Pinus monophylla* – *Juniperus osteosperma* / *Cercocarpus ledifolius* Woodland (W_PJMT) and *Pinus monophylla* – *Juniperus osteosperma* / *Cercocarpus ledifolius* Woodland**

These were generally difficult to key to map class and association. Map class Key II, Couplet 4b and association Key II, Couplet 3b requires low cover of *Cercocarpus ledifolius*, but does not quantify amount. Is 10 percent "low cover," especially when *Juniperus osteosperma* has less cover (e.g., AA Point 889)? When *Pinus monophylla* and *Cercocarpus ledifolius* are co-dominant, map class Key II, Couplet 4 and association Key II, Couplet 3 cannot key the stands out. This resulted during data validation in both the map class and association being unclassifiable for AA Points 884, 888, 891, 896, and 899. Stands lacking *Juniperus osteosperma* are present elsewhere in Nevada (including sampled as classification plots on the Spring Mountains National Recreation Area), thus a *Pinus monophylla* – *Cercocarpus ledifolius* Woodland seems justified for inclusion in the rUSNVC.

Where *Amelanchier utahensis* is the sole dominant under a *Pinus monophylla* woodland canopy, users cannot key to a map class due to a dead end at Key II, Couplet 11a, which requires *Cercocarpus ledifolius* co-dominance (e.g., AA Point 1061). Nor can they key to an association, since *Amelanchier* is not an option in Key II (Pinyon Pine and Juniper Woodland),

Couplet 7. Co-dominance with *Artemisia nova* is also ambiguous in Couplet 11a (e.g., AA Point 370).

***Pinus monophylla* - *Juniperus osteosperma* / *Purshia tridentata* Woodland [Park Special]**

Pinus monophylla - *Juniperus osteosperma* / *Purshia tridentata* Woodland [Park Special] is a fire suppressed expression of the *Purshia tridentata* - *Artemisia tridentata* Shrubland. In keying this association, AA Points 949, 956, and 961, with *Artemisia tridentata* ssp. *tridentata* technically do not key because only *Artemisia tridentata* ssp. *vaseyana* is an option in the Pinyon Pine and Juniper Woodlands Key, Couplet 16a.

***Poa secunda* – *Cirsium eatonii* Post-burn Herbaceous Vegetation [Park Special]**

Not all the taxa listed in association Key IV, Upland Dry Herbaceous Vegetation Couplet 7b are abundant, much less abundant in the same place. The statement should replace "...and *Symphotrichum spathulatum*." with "...or *Symphotrichum spathulatum*."

Cirsium eatonii commonly occurs in post-burn areas with other grasses co-dominant, or as a sole dominant. Perhaps a nomenclatural alternative of (*Cirsium eatonii*) - *Poa (secunda, fendleriana)* Post-burn Herbaceous Vegetation better characterizes this Park Special association, which was based on only one classification plot. An even broader nomenclatural innovation of *Cirsium eatonii* - Mixed Grasses Herbaceous Vegetation would account for much more acreage of post-burn vegetation around Mt. Washington. It allows for the wider diversity of grasses seen, thus including post-burn stands with *Koeleria cristata* or *Trisetum spicatum* (e.g., AA Points 202 and 206).

This association is seamlessly transitional to shrub herbaceous vegetation (e.g., AA Point 221) and sparse shrubland physiognomy. These transitions occur on burns of the same origin. Areas can have any of the aforementioned herbaceous species with shrub dominance by *Ribes cereum*, *Ribes montigenum*, and/or *Ericameria discoidea* (e.g., AA Point 215). In at least the first decade after fire, the affected landscape is a temporal and a spatial mosaic of reestablishing species. Attempting to segment it into discrete associations may prove problematic, with some types proving to be ephemeral to a particular burn and its spontaneous recovery.

***Populus tremuloides* Temporarily Flooded Forest Alliance (F_POTR2)**

The word "riparian" was not written into map class Key II, Couplet 1b, which could lead to miskeying a stand as a *Populus tremuloides* Temporarily Flooded Forest Alliance (F_POTR2).

***Populus tremuloides* – *Abies concolor* / *Poa pratensis* Semi-natural Forest**

AA Point 861 has characteristics of this association and *Abies concolor* – *Populus tremuloides* / *Carex scopulorum* Woodland. The dichotomous statement in association Key II, Couplet 3 is insufficient to determine when a stand is semi-natural versus natural.

Post-fire Shrubland (F_FIRE)

F_FIRE was created as a map class nomenclatural innovation to recognize alternate successional paths leading to shrublands, especially for upland types. For those occurrences in which post-fire succession led to a non-*Prunus virginiana* shrubland, F_FIRE was listed as the alternate map class. It was also used for stands with the combination of post-fire and sparse vegetation, which are undefined in the keys (e.g., AA Point 1143). Fire scarred lands with sparse regrowth represent substantial acreage on 10 year old burns at Lincoln Peak, Lincoln Canyon and Mt. Washington. Likewise, some burns only impacted a portion of the tree stand (e.g., AA Point 816). F_FIRE was used to classify points not precisely fitting the description of S_FIRE (see below).

F_FIRE was also intended to slightly broaden the limited post-fire time span S_FIRE represents. Since vegetation maps and classifications tend to be long-lived products, a narrow time span map class like S_FIRE will not necessarily serve users once the regrowth vegetation succeeds to another association or physiognomy. Wildfires have created a mosaic of disturbance patterns on the landscape of GRBA. This is evidenced in the AA data set by the many field observations of historic fires. These include AA Point 8 at Strawberry Creek, AA Points 15 and 689 at Snake Creek/Shoshone Campground, AA Point 730 in the Kious Basin, and AA Point 754 on the Highland Ridge.

For the F_FIRE and S_FIRE map classes, twenty more actual versus predicted recently burned points were found (i.e., 38 versus 18). In contrast, there were twenty less predicted points than identified points (71) for *Artemisia tridentata* dominated shrublands. This difference may have been due to signs of recent fire not being evident on aerial imagery for *Artemisia tridentata* shrublands. The Shoshone Campground was one area where it appeared that shrubland burns were not identified. Areas of prescribed burning, such as Grey Cliffs and lower Baker Creek Road, may have also gone undetected as recent burns in GRBA vegetation mapping.

Post-fire Shrubland (S_FIRE)

The map class vegetation key treats S_FIRE as successional to either *Prunus virginiana* (Couplet 20b in Key III), or to various herbaceous types (Couplet 2a in Key IV). S_FIRE occurs too deep into the shrub key to encompass the diversity of post fire shrubland types present within the park. One observer commented that S_FIRE should be restricted to "Post-fire Herbaceous" because it is dominated by herbaceous associations. However, a diversity of physiognomic groups are to be found in post fire landscapes, including shrub herbaceous vegetation (e.g., AA Points 206 and 1113) and sparse shrubland (e.g., AA Points 215 and 1112).

Lands impacted by wildfires and prescribed burning represent a more diverse set of associations than are presently recognized in the classification. It appears that only burns from 2000-2001 were considered in S_FIRE mapping. Burns from 2007 to 2010 (e.g., AA Points 132 and 989) as well as older burns poorly fit this map class. A post-1992 burn between Wheeler

Peak Scenic Drive and the Lehman Cave Visitor Center was not classified as a post-fire map class in the GRBA vegetation map (see AA Points 343, 344, 362 and 1107). That area appears to be post-fire successional to *Artemisia tridentata*. *Symphoricarpos oreophilus* Shrublands and Sparse Shrublands (e.g., AA Points 1111 and 1144) are rapidly developed associations which establish after wildfires. Many AA Points which keyed to the S_FIRE and F_FIRE map classes were *Symphoricarpos oreophilus* Shrublands or Sparse Shrublands. However, the map class key orphans *Symphoricarpos oreophilus* at Key III, Couplet 18b, preventing the user from even reaching Couplet 20 which references a post-fire map class. (See also *Symphoricarpos oreophilus* Shrubland).

***Purshia tridentata* - *Artemisia tridentata* Shrubland**

Map Class Key I, Couplet 3b prevents stands with 10-25 percent tree cover and greater than 25 percent shrub cover (i.e., wooded shrubland) from being classified as a shrubland. AA Point 949 is a wooded shrubland which better fits a *Purshia tridentata* - *Artemisia tridentata* Shrubland, rather than *Pinus monophylla* - *Juniperus osteosperma* / *Purshia tridentata* Woodland.

Purshia dominated stands are orphaned in the map class key at Couplet 15b. Since the *Purshia tridentata* / *Hesperostipa comata* Shrub Herbaceous Vegetation association is also missing from the park classification document, the map class was unknown at the time of transcription (e.g., AA Point 260).

***Ribes (cereum, montigenum)* – *Ericameria discoidea* Shrubland**

Seventy-six percent of the 21 AA Points keyed to this association had fair or poor conformance to the key. This was the lowest conformance of any association in GRBA. One reason for this was that *Ericameria discoidea* was often missing from this association (e.g., AA Point 479), creating reduced association key performance because a *Ribes (cereum, montigenum)* Shrubland was not defined. Another reason was that sparsely vegetated stands dominated by *Ribes* do not key because there were no *Ribes* dominated types among the sparse vegetation types in Association Key V (e.g., AA Points 565 and 571). Note that *Ribes (cereum, montigenum)* – *Ericameria discoidea* Shrubland is described in the park classification as, in part, a sparse vegetation type.

A third reason for reduced key conformance was that Association Key III, Couplet 16a, orphans *Ericameria discoidea* when it is dominant in a *Ribes (cereum, montigenum)* – *Ericameria discoidea* Shrubland. Thus the association can only be properly keyed when *Ribes* is dominant.

***Ribes montigenum* Shrubland Alliance (S_RIMO)**

Many *Ribes montigenum* dominated stands couldn't properly key to association because they lacked *Ericameria discoidea*. This alliance needs to include additional associations reflecting the diversity sampled in the AA Points. Some observers offered suggestions on substrate modifiers to better classify these stands in the park (see AA Points 562 and 1178).

Riparian Forest

Unless a surveyor had written in "riparian" under Couplet 1b of Key II to the map classes, they would be less likely to identify combinations of mixed conifer and deciduous trees and more likely to select from the alliances in Couplets 2 and 3. This was an omission in the key discovered by a field crew member after crews were well into the fieldwork.

***Rosa woodsii* Shrubland**

Rosa woodsii is a medium height (i.e., S2 strata) shrub. It does not characterize a "tall shrubland" as stated in the Montane Riparian Shrubland association key. Couplets 1, 8, and 9 in the association key are not dichotomous with respect to height of shrubs. This can cause lowered key conformance when present with tall shrubs (i.e., S1 strata) which seem visually more dominant, such as *Betula occidentalis* on AA Point 117, or *Salix exigua* on AA Point 1182.

In Nevada, *Rosa woodsii* var. *ultramontana* increases in dominance under natural and artificial disturbances. *Rosa woodsii* Shrublands are not necessarily riparian (e.g., AA Point 188), thus need to be included in the mixed upland shrubland associations in the first 20 couplets of association Key III. Without a hierarchy of diagnostic values to riparian shrubs, like provided in the Instructions to the key for species characteristic of rocky slopes, uplands, and alluvial landscapes, some *Rosa woodsii* stands may classify as riparian stands because they simply represent disturbance.

***Sarcobatus vermiculatus* / *Artemisia tridentata* Shrubland**

This association cannot be keyed to a map class, since Key III, Couplet 4 does not allow for co-dominance of these species.

Semi-natural associations

In general, not enough guidance was provided in the keys to decide when a semi-natural association should be identified. The AA data set is ripe with opportunity to identify semi-natural types for many montane shrubland associations with exotic *Bromus tectorum* or *Agropyron cristatum* dominating the understory. In managing vegetation on public lands throughout the west, much more mapping of semi-natural types is needed. Mapping these areas provides wildlife managers important knowledge they need to judge the habitat quality for particular wildlife species. Restoration ecologists need these areas mapped to identify opportunities for improving rangelands and woodlands.

Shrub Herbaceous Vegetation

Thirty-five AA Points were determined to have shrub herbaceous vegetation physiognomy, with just 17 percent of these points having a good conformance to the association key. Recommend that map classes and associations in this physiognomic type should have duplicate listings in both shrub and herbaceous keys in order for surveyors to identify this lesser known type. The

field physiognomy keys for map classes and associations were not sufficiently quantitative to key this physiognomic type.

Map class Key I, Couplet 2b forces shrub herbaceous vegetation to key out in Key IV (Herbaceous), but then speaks to the tallest strata “with at least 5 percent cover” being grasses and forbs. The tallest strata in shrub herbaceous vegetation are trees and shrubs, respectively (e.g., AA Point 927). This wording is also ambiguous in the association Key I.

Southern Rocky Mountain Montane-Subalpine Grassland Group (H_SRMT)

Map class Key IV, Couplet 7b does not provide a dichotomous statement when directing users to Key III for stands with greater than or equal to 5 percent shrub cover. Couplet 7b requires duplicate keying in map class Key III (shrublands) when shrubs are greater than or equal to 5 percent cover. But stands which are shrub herbaceous vegetation physiognomy can lack a dominate shrub to key on (e.g., AA Points 475 and 1113), preventing successful keying.

Sparse Shrubland

Sixty-eight (8 percent) of AA Points were determined to have sparse shrubland physiognomy. Only thirty-seven percent of these were rated as having a good conformance to the association key.

Key I to the map classes is ambiguous on which pathway to key a sparse shrubland with 5-9 percent tree cover. It should read: “Scattered trees may be present, but do not form a canopy (<10 percent cover).” Presently key conformance is reduced for areas of low tree density, such as 7 percent tree cover on AA Point 1124. The key needs to state the range in cover values for trees, shrubs and herbaceous vegetation.

Sparse Understory Woodland/Sparse Understory Forest/Sparse Understory Shrubland

Association key II, Pinyon Pine and Juniper Woodland, Couplet 2a does not at entirely match the definition of sparse understory in the GRBA classification document. The former reads: “Neither herbaceous nor shrub species has more than 5 percent cover, and most stands have less than 2 percent total understory cover.” The latter states for the *Pinus monophylla* - *Juniperus osteosperma* / Sparse Understory Woodland that any individual species has to be less than or equal to 5 percent cover and either understory strata less than 10 percent cover. Thus, the key becomes the classification because it leads to classification errors.

Stands with substantial composition of annuals (e.g., AA Point 984) may have a sparse understory in a dry year, but not in a wet year. Another error in the key for the sparse understory associations is that a stand for which the physiognomic group is a “sparse shrubland” or “sparse woodland” cannot, by technical definition, be a “sparse understory shrubland” or “sparse understory woodland.” Without first identifying sparse shrublands or sparse woodlands in the physiognomic key, proper identification of woodland or shrubland stands with sparse understories are compromised.

***Symphoricarpos oreophilus* Shrubland**

This association was determined at 21 AA Points, but no map class was defined in the park classification. AA Point 495 in the Kious Basin is an excellent example of a stand not associated with a recent wildfire. The S_FIRE map class apparently only included AA Points from 2000-2001 wildfires, like the 1,650 acre Phillips Ranch Fire. Pre-1945 wildfires were a likely cause of extensive shrublands and/or herbaceous vegetation which existed until recently in Kious Basin, as noted in AA Point 730.

As a fire successional species, *Symphoricarpos oreophilus* can dominate burned avalanche chutes. AA Point 395 is such an example.

Unvegetated Rock Cliff and Outcrop (G_ROCK)

Map class Key V, Couplet 4 is not dichotomous: both parts of the couplet indicate scree fields and less than 2 percent total vegetation. There is no indication if the vegetation cover it references should be vascular, nonvascular, or both. Recording non-vascular cover was not a requirement on this contract, thus physiognomic group was determined from vascular cover only. If nonvascular cover were to be included, some stands may have more vegetation cover than the sparse vegetation (e.g., AA Point 560) or non-vegetated (e.g., AA Point 566) physiognomic groups into which they were classified.

Wooded Herbaceous Vegetation

Wooded herbaceous vegetation apparently was not considered in writing the physiognomic keys, thus was ambiguous in both the map class and association keys. The keys were not sufficiently quantitative to identify this physiognomic type. Associations and map classes with expressions matching this physiognomic type should have duplicate listings in both shrub and herbaceous association keys in order for surveyor's to pick up this lesser known type.

Wooded Shrubland (and Wooded Dwarf-shrublands)

Wooded shrublands (including wooded dwarf-shrublands) were a widespread physiognomic group in GRBA, representing 57 (6 percent) of all AA Points. However, only 8 percent of the points keyed to association had a good conformance to key rating. Wooded shrublands are defined as having a combination of 25 percent or more cover of 0.5 meter tall or taller shrubs and 10-25 percent cover of any sized tree. Wooded dwarf-shrublands (e.g., AA Points 275, 280, 315, and 317) are characterized by shrubs less than 0.5 meter tall.

In simplifying the physiognomic types recognized in the GRBA classification, wooded shrublands and wooded dwarf-shrublands were forced into the woodlands physiognomic group, as per map class Key I, Couplet 3b. The specific phrase is "Scattered trees may be present, but do not form a canopy (less than 10 percent cover)." In contrast, association Key I, Couplet 3a is ambiguous on wooded shrublands/dwarf-shrublands by excluding that phrase, and thus does

not provide guidance on keying stands to either the shrubland or woodland/forest generalized physiognomic groups.

Apparently the vegetation in GRBA was mapped classifying wooded shrublands/dwarf-shrublands as shrublands, but the map class key was written to classify them as woodland/forest. Separate keys for map classes and associations exacerbated the problem of 1) the map class key having simplified language in contrast to the association key and 2) observers inadvertently mismatching their field choices when keying between the two classifications. A simplified taxonomic key can be expected to lead to more typing errors. Likewise, the simplified physiognomic groups of the rUSNVC have led to more typing errors in GRBA than might have been expected under the expanded set of physiognomic groups in the original USNVC. This mis-matching problem extends beyond just the wooded shrublands, encompassing other physiognomic groups dropped in the recent revision of the USNVC (e.g., sparse woodlands and sparse shrublands).

Wooded shrublands are common in the interior western US. They often occur in landscapes characterized by frequent perturbations. Evidence from rephotographic survey photography and historical aerial photography examination of interior western landscapes reveal that these communities are not so much seral as they are a long-lived, ever-dynamic expression of a stressed environment. The proportion of trees to shrubs ebbs and flows. Wooded shrublands can be extremely hard to map correctly because of the tendency to arbitrarily classify them into either shrublands or woodlands. Recommend that due to the dominance of wooded shrublands evidenced in the GBRA AA dataset, the rUSNVC recognize wooded shrublands at the Division level under D060 Southwestern North American Warm Temperate Scrub & Woodland.

Could Not Key to Map Class or Association

The most significant outcome of errors and omissions in the keys was that the vegetation failed to key to a map class or association. There were 43 instances of this for map classes and 113 instances of this for associations. This outcome most often occurred in situations for which the vegetation observed and cover for individual species or by strata (e.g., mesic graminoides, tall shrubs, trees) did not match the parameters stated in the keys. Another reason for not being able to key an AA Point was when the key stated that the map class or association only occurs in a particular geographical location, or was only described for particular locations. AA Points in other locations didn't necessarily match what was described in the keys. Occasionally, it was not possible to key a remote plot when the understory could not be observed and such an observation was necessary to determine the map class or association.

There were many examples where stands dominated by either *Symphoricarpos oreophilus*, *Purshia tridentata*, *Ericameria discoidea*, or (sparse) *Glossopetalon spinescens* lacked the co-dominants required to conform to the key. These four taxa were orphaned within the map class key. Thus stands dominated by these species couldn't be properly keyed out. *Symphoricarpos oreophilus* disappears after Key III, Couplet 18b. *Purshia tridentata* disappears after Key III,

Couplet 15b. *Ericameria discoidea* is missing in Key III, Couplet 17b. *Glossopetalon spinescens* is missing in Key III, Couplet 14b.

Limitations Due to Landscape Complexes and Succession

Observation areas in the alpine were so small in relation to the landscape complexity that a few meters difference in centering a point resulted in significant differences in vegetation structure and cover. Reduced observation area sizes for map classes such as Mixed Talus and Rock Shrubland Complex (S_RT) and Montane Talus and Rock Outcrop Shrubland (S_MOTA) exacerbated this problem.

The alpine is a landscape complex and field biologists provided some compelling arguments on field forms questioning the validity of some Park Special alpine associations. In essence, some associations may be artifacts of classification plot size. That was especially evident when an alpine point was inadvertently sampled twice, by two different surveyors. Physiognomic group, plant species composition, and plant cover could be dramatically different when the two observers used different observation area sizes because they determined different map classes. Also, many AA plots in the alpine were intermediates between associations. When a stand can key four ways, the associations cannot be very robust.

A number of associations have undergone such rapid succession in recent years that it may confound vegetation classification and mapping. Specific examples of these are listed below:

***Artemisia arbuscula* ssp. *arbuscula* / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation and *Pseudoroegneria spicata* Herbaceous Vegetation**

In some areas, trees are not evident in 1992-94 digital ortho quarter quadrangle aerial imagery, thus indicating a rapid succession to a wooded dwarf-shrubland (e.g., AA Point 275) or wooded herbaceous vegetation (e.g., AA Point 1065) physiognomy. This has been corroborated by Heyerdahl et al. (2011) tree ring and fire scare analysis in the Mill Creek area of GRBA. Type conversions in vegetation communities from 1865 have been confirmed for communities dominated by *Artemisia tridentata*, *Cercocarpus ledifolius*, mixed shrubland, and *Pinus ponderosa*. These have converted under post settlement fire suppression to *Cercocarpus ledifolius*, *Pinus monophylla*-*Juniperus osteosperma*, or mixed conifer woodlands. Classification plot data from 2003 might be out of date for mapping of these associations, since the GRBA classification descriptions do not list any tree species in this association.

***Cercocarpus ledifolius* / *Symphoricarpos oreophilus* Woodland**

In concept, the *Cercocarpus ledifolius* / *Symphoricarpos oreophilus* Woodland association lacks any of the coniferous trees present in GRBA. However, conifers are invading this association within the park. *Pinus flexilis* is invading at the upper elevational range of the association (see AA Point 734). *Pinus monophylla* is invading at the lower elevational range (see AA Point 733). *Cercocarpus ledifolius* is typically successional after fire and does not seem to be a strong

diagnostic species in central and southern Nevada. Throughout Nevada, *Cercocarpus ledifolius* successional proceeds from a shrubland physiognomy to a woodland, ultimately being overtopped by conifers in the absence of fire. But because of the way *Cercocarpus ledifolius* keys out early in map class Key II, Couplet 4a and association Key II, Couplet 3a, it effectively has a higher diagnostic status than any conifer which may be present in a stand. This compromises the classification description and lessens the mapping accuracy for *Cercocarpus ledifolius* stands.

Limitations to the Accuracy Assessment Methodology

The classification of each AA point as originally mapped was not provided; therefore, the “Classified Veg” field in PLOTS has not been populated. Given the key construction challenges previously discussed, it was not always clear what the map class or association should be for an AA Point. Besides the instances of reduced key conformance previously cited, a number of other keying challenges were attributed to the sampling methodology.

Areas which classify as Bare Talus, Scree and Fellfield, or Unvegetated Rock Cliff and Outcrop, are intricately mixed with other alpine types to form a landscape complex (e.g., AA Point 566). Determining the dominant type between these non-vegetated types and the sparse vegetation physiognomic groups, Alpine Cushion Plant Fellfield and Mixed Talus and Rock Shrubland Complex, is too easily determined by observation area size and location. That was very evident in using spotting scopes to remote evaluate areas dangerous to traverse. Unless a detailed aerial photograph delineating the standard 40-meter radius circular observation area boundaries had been printed beforehand, observers had to rely on a best guess for the observation area boundaries. Because observation area size differed between some map classes, it was possible to have multiple map class possibilities at a single AA Point. For example, a 0.5 hectare, 40-meter radius circle might classify to Alpine Cushion Plant Fellfield, whereas a 0.25 hectare, 28-meter radius circular observation area might classify to Mixed Talus and Rock Shrubland Complex.

While remote sampling was believed to be accurate, sampling variability was a distinct possibility between two observers when they are remotely observing steep talus and scree dominated observation areas, as was readily evident for AA Point 562. To avoid the dangers of traversing a glacier, the observation area was viewed using binoculars from approximately 340 meters away. Two observers inadvertently evaluated the same plot. The center points of their observation areas were 22 meters apart and approximately 17 meters away from the center of the intended observation point. Their observation area size was 0.5 hectare, with 40-meter radius circles covering a heterogeneous mix of vegetation and bare ground. Thus, 65 percent of their observation areas overlapped, but their offset from the intended point resulted in an increase in suitable habitat of *Ribes montigenum*. Both identified the vegetation as good conformance to the *Ribes montigenum* Shrubland Alliance map class, and poor conformance to the *Ribes (cereum, montigenum) – Ericameria discoidea* Shrubland association. One observer noted 17 percent vascular cover and the other 9 percent vascular cover, resulting in two

different physiognomic groups: sparse dwarf-shrubland and sparse vegetation, respectively. Thus, there was a difference in cover for two observers attempting to remotely estimate cover. Also noteworthy is that both observers offered nomenclatural innovations to the association, dropping the unseen species and adding substrate modifiers such as scree, talus, and bedrock.

PLOTS Database Recommendations for Improvement

Several recommendations are provided to improve the efficiency of entering data into the PLOTS database. To avoid having to enter data from the same field form into multiple data entry tables, a data entry template could be developed that incorporates all the information on the field form and then filters into several back-end tables. PLOTS 3.2 is presently formatted to fill a small portion of the available data entry screen.

In addition, we suggest that new data fields are allowed to be added to the PLOTS database data tables. An example of where this would have been useful was when the “conformance to key” and “comments” for Sections 4 and 5 of the field form were entered into the General Comments text field for the association and map class records, respectively. Lack of a data field for this specific information made it difficult to sort records and report on conformance to the keys.

Edit and QC AA Points Template

For ease of data entry, PLOTS data entry forms could more closely follow the field form. Having to jump around in both the field form and the PLOTS data entry forms leads to inefficient data entry.

PLOTS 3.2 was not designed for an AA project in which AA Points must be keyed to both map class and association. The database could be set up to handle the entry of both as separate fields within the same form.

Combining the map classes and associations into a single key (*cf.* Lea and Curtis 2010) would have improved efficiency in the field. If future AA projects require two keys, a single data entry template could be developed to accommodate both these types of data.

This project combined data traditionally collected in classification studies with data collected at AA Points. Transcription of the data would have been more efficient if the data had been split into an observation point database and an accuracy assessment database. It was not always apparent which data record (01 or 02) to enter comments into.

The PLOTS database could be modified to include all line items on the field form. Having information combined into a general comments box (e.g., conformance to key, surveyor comments, data validation comments) hampers data analysis since the individual comments are not able to be individually queried. Furthermore, by pasting these subheadings into PLOTS from Windows Notebook and using carriage returns to keep the data separated line by line, the data could not be properly exported. Microsoft Access has no pre-programmed capability to find and

replace hidden carriage return or line break codes with symbols which could properly export (e.g., the | [pipe] symbol).

Specifically, we recommend the following additions to PLOTS data entry fields:

- Following the Primary and Secondary Map Class field there could be fields for each of the following: Conformance to key, Surveyor comments, and Data validation comments;
- Following the Primary and Secondary Association Class field there could be fields for each of the following: Conformance to key, Surveyor comments, and Data validation comments;
- In a section for remote observation points there could be fields for entry of each of the following: Easting, Northing, distance, bearing, and GPS meter error; and
- In a section for non-standard observation area size/shape there could be fields for entry of each of the following: observation area size, length, width, and azimuth.

The plot shape drop down menu should have 0.10 ha as an option in addition to the 0.25 ha, 0.50 ha, and indefinite which are currently included as options. Furthermore, it should not default to a pre-determined value.

Edit and QC Plots Template

Since this project collected both traditional AA Point as well as classification data, there was duplication in fields between the Edit and QC AA Points template and the Edit and QC Plots template. This inevitably resulted in confusion as to which template certain data should be entered into. This was especially true for comments which pertained to species and their cover value. Perhaps for future projects two PLOTS databases could be used when collecting AA Point and Observation Point data.

For the Plot Location and Description tab, the vast majority of the information is duplicated in the Edit and QC AA Points form and therefore not entered here. General comments specific to species and strata and their cover values had to be entered into the General Comments text field in the Environmental Information tab. It would have been easier if those comments could have been entered into the General Comments text field of the Edit and QC AA Points database. Alternately, the General Comments could be entered under the Vegetation Sampling tab, thus eliminating the need to use the Environmental Information tab.

The layout of the Vegetation Sampling tab could follow the field form for ease of data entry. For example, stratum could be located between the taxon name and continuous cover per stratum. The columnar data listed to the left of the tab did not work well as it did not match the field format and therefore had to be mentally reordered. The stratum percent cover on the field form was listed by total tree cover, total shrub cover, total herb, and total nonvascular cover; whereas the fields for percent cover on the Access form were T1, T2, T3, S1, S2, S3 etc. (not total). In

addition, the Access form, did not allow for entry of less than 1 percent (i.e., Trace occurrences) in the Strata percent cover column, as was allowed on the field form.

The list of USDA unknown species codes could be added to the Species table.

Photos Data

The Photos tab does not conform to normalization rules for data bases. The key field *PHOTO ID* is simply a linking of three duplicated fields. Presently this forces the manual data entry of a redundant field. An update query could be created for the Photo ID column that would build this value based on what is populated in the Plot Code + Photo Bearing + Photo Data columns. That way all appropriate columns are being entered only once, with fewer potential keystroke errors, and all columns are able to be queried.

Alternately, the Photos tab could be eliminated entirely. Hypertext could be used to link the stand photos to the applicable AA Point record, rather than through manual entries into the Photos sub-table. Another alternative would be to embed the pictures in TIFF format within each database record. Since TIFF is a lossless file type, the potential image quality degradation from opening, saving and reopening a lossy format file like JPEG would no longer matter. Ultimately, plot photos (and other records) might better be stored within the personal geodatabase format of ArcGIS, rather than as a standalone application in Microsoft Access. An alternate, graphics application approach would be to use Adobe Photoshop Lightroom to geo-tag the photofile with its approximate UTM coordinates and add any desired plot information into the metadata embedded within each file.

The key field *PHOTO ID* cannot accommodate instances where there were two photos taken with the same bearing *and* the AA Point number was 4 digits *and* the bearing was three digits. This can occur under several circumstances: when one photograph is landscape orientation and the other portrait; when one is a zoomed in view versus the other zoomed out, or when two identical shots were taken under different lighting conditions. The workaround was to drop some underscores from the standard file naming convention.

Additions to the Flora

Erigeron grandiflorus Hook. was observed by Karin Edwards at AA Plot 659, south of Baker Lake. A specimen was collected but not retained.

Muhlenbergia arsenei Hitchc. was observed by Karin Edwards at AA Plot 757, near Lincoln Peak. No voucher specimen was collected.

Discussion

The sample size for AA Points (873) was more than double the sample size for classification plots (402) used to develop the GRBA classification (Schulz and Hall 2011). This study provides the opportunity to utilize a larger data set upon which to improve the GRBA classification. For

some vegetation types, the increase in available data was much greater than doubled. The *Ribes (cereum, montigenum) - Ericameria discoidea* Shrubland association had four times the number of previously collected plots, although 53 percent of the AA Points had poor key conformance. Nonetheless, by examining the reasons cited for poor key conformance, there are opportunities to improve the classification of stands dominated by any one of these shrubs. For instance, LSD recommended creating a *Ribes (cereum, montigenum)* Shrubland or Sparse Vegetation association, as well as some modifications and additions in the association keys.

Considerable progress was made toward a statistically valid accuracy assessment of the GRBA vegetation map. Where data gaps remain, opportunities exist to incorporate other sources of modern and legacy vegetation data from the park. Additionally, archived resource materials can provide insights into vegetation types for which there are poorly understood successional dynamics.

Transitional woodlands and shrublands, such as sparse shrubland, sparse woodland, and wooded shrubland, make up 24 percent of the AA Points sampled in GRBA. On the Ecological Systems level, sparse woodlands, sparse shrublands and wooded shrublands formed a landscape mosaic which defied mapping even when using two different 0.6 meter resolution aerial imagery sources and historical 1 meter resolution imagery dating to 1992. However, no map classes or associations have been named in GRBA which specifically reflect these physiognomic groups. Little is known about the transitional phases of the associations represented in these physiognomic groups. The reduced conformance to the association key for these groups shows that they do not necessarily match the vegetation composition and structure of woodland or shrubland associations classified for GRBA. Sparse shrublands, sparse woodlands, and wooded shrublands in Nevada need further research into how long they persist on the Nevada landscape, what compositional and structural changes are occurring under climatic change, and what their specific disturbance histories are in Nevada's landscapes. Given the frequency they occur in GRBA, this group deserves much more study and recognition than they currently garner.

Determining disturbance history generally requires research into archived records, except for associations which are defined by reoccurring natural disturbance, like avalanche chutes and landslides. Historical aerial photography, at GBNP, provides evidence of past logging and wildfires, among other disturbances. Fire has played a major role in determining plant community distribution in GRBA according to Kitchen (2010), who concluded that the last large fire in GRBA was in 1865. However, he based his conclusions on data from limited geographic areas of GRBA. The BLM produced NV-firehistory.gdb file mapped fire occurrences throughout Nevada from 1910-2007, did not show any fires in GRBA except the Phillips Ranch Fire of 2000. Yet field crews noted AA Points throughout the park where there was evidence of fires from before 2000, such as Kious Basin.

Aerial photography from 1945-46 shows larger areas of shrublands in Kious Basin than presently exist. This is evident from Kious Basin upslope to Horse Heaven in an aerial

photography chronosequence which illustrates landscape changes between 1946 (Figure 1) and 2010 (Figure 2). Chronosequenced aerial imagery is a classic method for identify past disturbances and determining rates of vegetation change in the environment. The north-facing slopes in this chronosequence present an outstanding example of where historical records collaborate photographic evidence to show that catastrophic fire over many square kilometers occurred between 1879 and 1908. This time period was deduced from comparing two sources of information. First, 1908 was the oldest date in which Gruell (1999) was able to obtain a recollection from his informants of a large fire – that of a smaller “200-300 acre burn between 1908 and 1910.” Second, US General Land Office Public Land Survey plats and field notes (BLM 2012) indicate that in 1879, the north-facing slopes were described as “Cedar, Pinyon, and Mahogany.” (i.e., *Juniperus osteosperma*, *Pinus monophylla*, and *Cercocarpus ledifolius*). The Kious Basin illustrates the utility of matching vegetation descriptions in early survey records with historical aerial photography, to provide valuable data on the length of time plant communities persist in various biophysical environments at GRBA. Perhaps similar analysis may be conducted for other areas of the park where 1945-46 aerial photos show the effects of wildfires, logging, and domestic animal concentrations, among other observable disturbances.

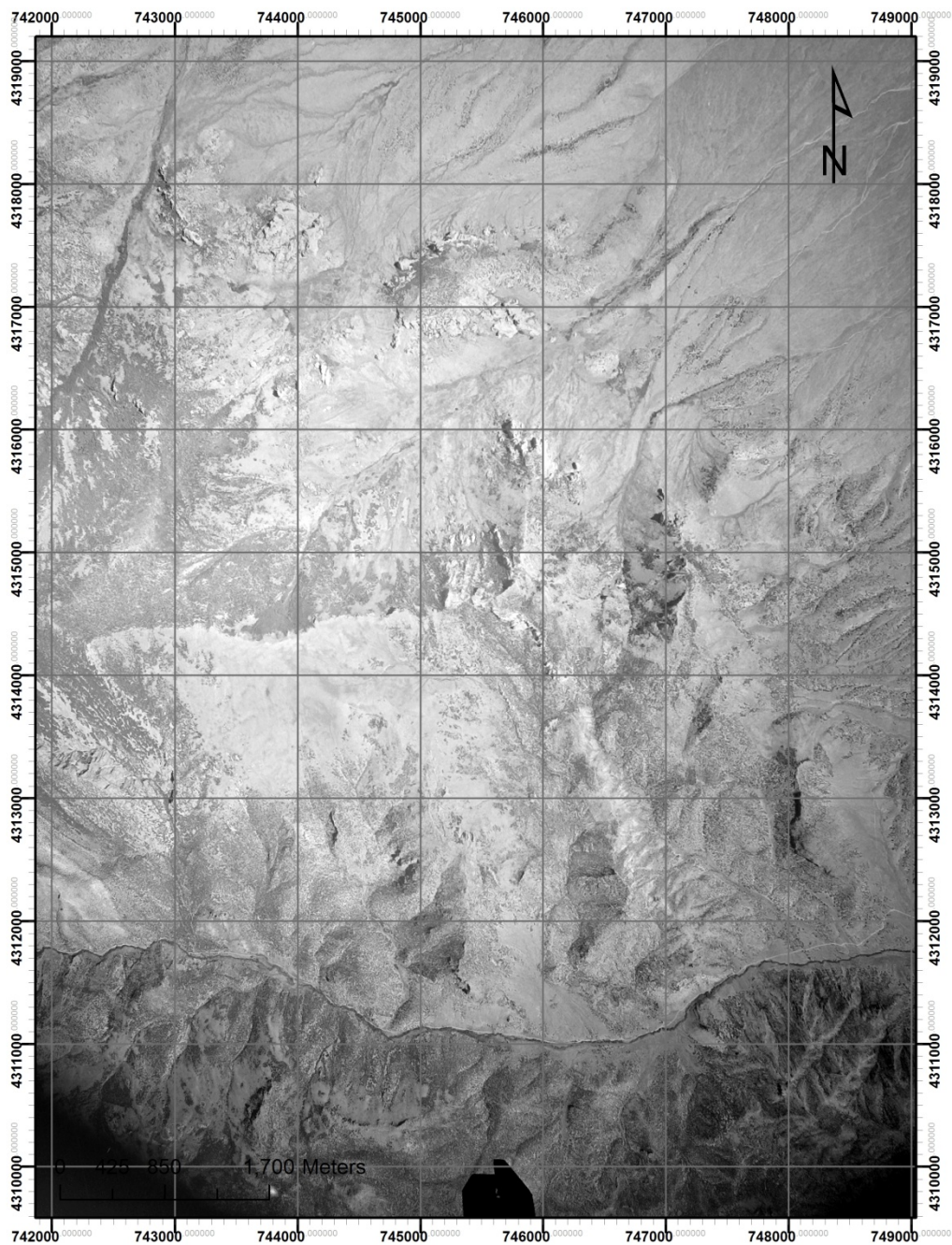


Figure 1. 1946 aerial photograph of Kious Basin south to Snake Creek showing shrublands originating from a burn between 1879 and 1908. The UTM Grid is approximate since limitations in georeferencing the original negative resulted in positional inaccuracies which increase towards the southwest corner of the image.

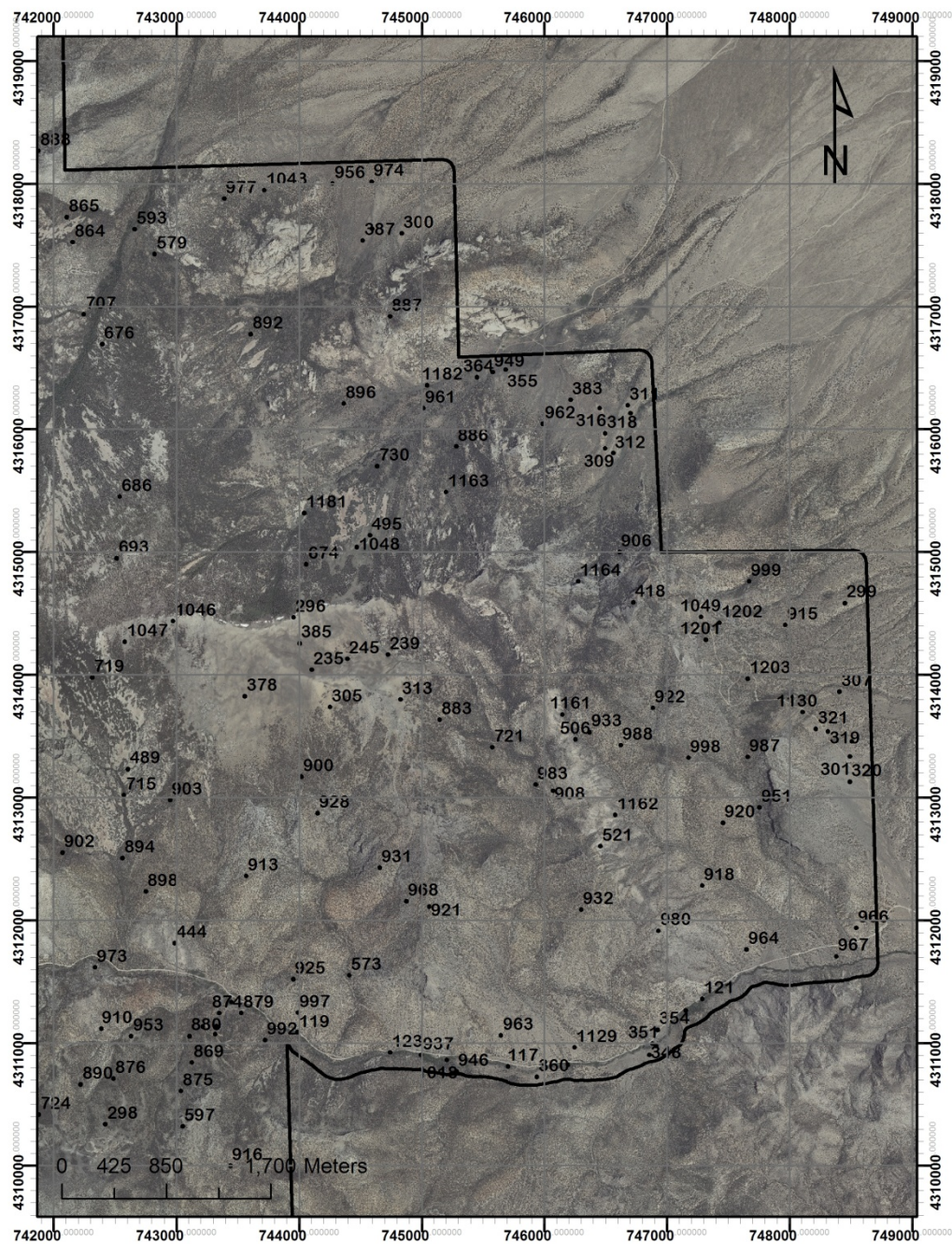


Figure 2. 2010 aerial photograph of Kious Basin south to Snake Creek, showings woodlands where shrublands were evident on 1946 aerial photography. Numbered points indicate the locations of AA Points.

Successional changes to GRBA associations are readily evident in rephotographic survey photography of GRBA using photographs dating from 1900 to 1910. The repeat photography of Gruell (1996) at GRBA showed that with livestock grazing and the absence of fire, shrubs were encroaching on grasslands. A photograph taken in 1903 by C.D. Walcott, which centers on Mill Creek, shows a mid-elevation band of grassland or shrubland, presumably with pinyon-juniper below and subalpine forest above. From this viewpoint at the northeast part of GBNP in 2011, this band showed a type conversion to woodland (primarily *Cercocarpus ledifolius*), substantiating a broader geographic area for the type conversions reported at Mill Creek in Heyerdahl et al. (2011).

Previous vegetation studies in GRBA have established permanent vegetation monitoring plots. Negotiations in the 1990s with GRBA grazing lease holders led to both the withdrawal of cattle grazing and the realization that permanent vegetation monitoring plots were needed to determine the effects of this action. Two different vegetation mapping projects were funded: Eddleman and Jaindl (1994) and Smith, et al. (1994). Both established permanent vegetation plots which have subsequently been resampled. Sixteen of the 20 monitoring macroplots of Eddleman and Jaindl (1994) were resampled for fire scars by Gruell (1999), who concluded there have been few fires since 1900. Beever (2005) resampled ten permanent plots of Smith et al. (1994). They found *Abies concolor* increasing and *Populus tremuloides* decreasing in riparian habitats, increases in *Picea engelmannii* density at high elevations, and total mortality of *Picea engelmannii* in lower elevation riparian habitats. Plot locations and data from none of these studies were referenced in the development of the present GRBA vegetation classification and map. An examination of these data at the University of Nevada – Las Vegas and the USDA Rocky Mountain Forest & Range Experiment Station in Reno, Nevada. These studies could provide additional data on the location of vegetation types and the rates of successional change in GRBA.

Accuracy assessments can be completed with less data collected than was done in this study (Lea and Curtis 2010). Opportunities exist to share recent vegetation data between related projects. Southern Nevada Public Lands Management Act (SNPLMA) funding led to the development of a Landscape Conservation Forecasting™ model for GRBA (Provencher 2011). The Nature Conservancy (TNC) and Spatial Solutions derived (in a parallel effort to this project) a vegetation map from an unsupervised (i.e., computer determined) classification of 2007 Quickbird™ imagery. Twenty-one potential natural communities were mapped, based upon formal training plots and 1,000+ geo-referenced rapid road and hiking observations collected between July 19 and 25, 2009. A large proportion of the park was reported to have been visited, but none of these plots were used to supplement the AA points in this project.

Data from the GBRA map and accuracy assessment could be used to improve the Landscape Conservation Forecasting™ model (i.e., application of VDDT and PATH software programs). Figure 1 shows that as much as 14 square kilometers of the former burn between Kious Basin and Horse Heaven and the subsequent development of shrublands has now developed into pinyon-juniper woodlands, sparse woodlands, and wooded shrublands. The data of dominant

and characteristic species present at various AA Points show that remnants of both *Symphoricarpos oreophilus* and *Purshia tridentata* persist in that landscape. Provencher et al. (2010) reported only 340 acres of degraded *Purshia tridentata* habitat in Kious Basin. The Landscape Conservation Forecasting™ model considered *Purshia tridentata* as a potential vegetation type of limited area due to its unique biophysical environment. However, it appears to better be characterized as a mid-successional type, as evidenced by the aerial photography chronosequence and the field data. By combining the observation points of Provencher et al. (2010) with data from the GRBA mapping, NPS could have a more robust vegetation map to better determine management prescriptions and their costs using Landscape Conservation Forecasting™.

Based on experience in completing vegetation mapping and classification projects elsewhere in the western US, it can be hypothesized that certain physiognomic phases of existing associations at GRBA may be longer lived vegetation communities than previously thought. Observers often identified an alternate physiognomic group when the association name did not properly describe the structure of the vegetation. These were treated as alternate association names, listed after attempting to key out the vegetation; and were transcribed into the general comments section of the map class and association database records, where they were subheaded as "alternate physiognomy".

LSD provided NatureServe with comments on the vegetation key at the time field biologists were trained. These comments pointed out areas where prior experience suggested that keying problems might arise. One of the major areas predicted was in the proper recognition of wooded shrubland. Subsequently the keys were used as provided, noting on the field forms instances where there were deviations in keying. There proved to be a relationship between fair to poor key conformance and an alternate interpretation of the physiognomic group in the data. The same relationship was also found when the physiognomy of the stand did not match the physiognomic group stated in the association name. Recommend that the frequency to which each association falls into various physiognomic groups be studied, so that alliance and association names better reflect the most typical physiognomy encountered in the field.

There were 256 transitional stands (e.g., wooded shrublands, wooded herbaceous vegetation, shrub herbaceous vegetation, sparse shrublands, and sparse woodlands) encountered in the study. Generalization of physiognomic groups to a few major types can lead to difficulties in keying stands. Recommend that the physiognomic key be more quantitative in the development of couplet dichotomies.

The rUSNVC does not have a very large base of classification plots from Nevada. Using descriptions for map classes and associations developed from stands outside Nevada sometimes resulted in reduced key performance in GRBA. For example, one reason that only 58 percent of the AA Points predicted to be *Pinus longaeva* Montane Woodland Complex were identified as this map class in the field, can be readily explained because the rUSNVC description does not reflect how this vegetation community is expressed in Nevada. In the upper

montane zones in Nevada, *Pinus longaeva* is typically invading *Pinus flexilis* stands (Tavares 2009). This mix presents difficulties in the keys because the classification requires one or the other (association key II, Bristlecone and Limber Pine Forests and Woodlands, Couplet 2). Co-dominance is common in upper montane zones in southern Nevada (Nachlinger and Reese 1996). Because the southern Nevada stands have not been incorporated into the rUSNVC, co-dominant montane zone stands remain undefined in the rUSNVC.

Much of the data validation editing was the result of taking an alternate pathway through the keys. Exploring alternate pathways was specifically requested (in the manual and in MOJN I&M data review of the first field session), but often was not an apparent task to complete by an observer who assumed they were viewing a specific physiognomic type. Key I (physiognomy group) was of little help here because the wording differed between Key I in the map class key and Key I in the association key, with neither being sufficiently quantitative. It is suggested that the alternative physiognomic groups that were entered into the PLOTS database be used as a guide for determining where to add redundancy to the keys that would account for all the successional stages identified in the AA sampling. In another words, types which encompass multiple physiognomic types should have entries in each physiognomic group key. This would allow the full range of physiognomy to be accounted for in the keys. At present, such cross-listing is inconsistently applied and mostly limited to associations defined by *Cercocarpus ledifolius* dominance.

The Field Form Instructions provided no guidelines on how to rank conformance to the keys. It was particularly difficult for observers to consistently rank conformance to key when an AA Point keyed to a unclassified type in the association key. Over 10 percent of all AA Points keyed to an unclassified association (e.g., Unclassified *Populus tremuloides* Woodland). Table 3 shows 20 such unclassified types, with 19 AA Points where key conformance was recorded as good, despite the AA Point keying to an unclassified type. LSD recommends that guidelines be developed to aid observers in choosing conformance to key rankings. In particular, does keying to an unclassified type constitute good key conformance because it led to a type, or fair conformance because it led to a type prefixed as unclassified?

Remote sampling of difficult to access AA Points was necessary to safely sample some plots. There were many instances in which an observer could not safely get to a point. For example, the Phillips Ranch Fire of 2000 burned extensive areas of a steep slope below Lincoln Peak, which is now laced with fallen logs. There is no lower elevation exit point to that slope; the only passable cut in the cliffs is choked with a log jam. The climb back up to Mt. Washington would have been exceeding steep. Thus the points were sampled from across Lincoln Canyon on the Mt. Washington Road.

In retrospect, the use of 1:835 scale maps at heterogeneous AA Points proved so valuable that all points should have had maps printed. Biologists reported that the maps allowed them to more easily find plot centers; determine what features were in versus outside a plot; determine where to offset a plot; and identify the actual extent of a plot in a remote observation. Biologists

often used them to sketch out their alternate plot sizes and shapes, providing a valuable addition to the field forms to aid in determining what area they sampled. Some biologists used the maps to sketch the boundaries of associations on heterogeneous plots. The maps also maximized the chances that the biologist could find a plot center when GPS signals were weak or erratic. These may provide an important tool to determine/ validate recent cover.

Changes to the vegetation since the 2007 imagery were validated, when necessary, using 2010 National Agricultural Imagery Program 1:4,000 scale color infrared digital imagery. An example of the need for this was when biologists reported new burns and avalanche chutes not apparent on the 2007 imagery. The new avalanche chutes were either newly scoured historical chutes, or chutes widened by avalanches occurring since the 2007 imagery was flown.

This report has provided a detailed account of the multiple challenges encountered in keying map classes and associations, transcribing field forms, and performing a validation of the data collected. By citing the key and couplet where difficulties were encountered, we hope we can aid in resolving proper map class and association determinations and aid the continued development of a useful classification and key to the vegetation of GRBA.

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Appendix A

Accuracy Assessment Field Form

ACCURACY ASSESSMENT FIELD FORM

(August 9, 2011)

Section 1. Accuracy Assessment (AA) Point/GPS/Photographic Information

Park Code: GRBA Park Site Name: Strawberry Creek/Cluster 1B AA Point #: GRBA_AA_225
 Surveyor(s) _____ Survey Date: _____
 GPS Unit: _____ Model _____ 3D Differential: WAAS on! Waypoint #: _____
 Datum: NAD 83 UTM: ZONE 11N UTM E _____ UTM N _____ Error +/- _____ m
 Is GPS within stand? Yes / No. If No, site from GPS point to stand, the distance _____ (m) and bearing _____ (degrees)
 Projected AA point location: UTM E _____ UTM N _____ Error +/- _____ m
 GPS comments: _____
 Slope: _____ degrees Aspect: _____ degrees (use 360 for N) Elev. (m) _____ Declination: 12.5° E
 Camera# _____ Photo #/ Dir (take photos in direction that best captures the stand): _____

Section 2. Observation Area Size/Shape/Location Comments

- ☐ Standard Observation Area: 0.5 ha Shape: circular (a circle with a radius of 40m)
☐ Alternate Observation Area: _____ ha Shape: _____ Length _____ Azimuth _____ Width _____
☐ If the AA Point location is an intentional offset from the original point coordinates, circle the explanation:
 a. The stand is too heterogeneous to key because there are one or more clearly distinct types within the observation area
 b. Physical constraints in reaching waypoint
 c. Other (explain) _____

AA point location comments/Environmental Comments: _____

Section 3. Vegetation Description: Species and Stratum % Cover (Record the full scientific species name and cover values for the dominant and/or diagnostic species in each stratum and the total cover by stratum)

Species Name				Stratum	Percent Cover
</					

Strata: T1 Emergent, T2 Canopy, T3 Sub-canopy, S1 Tall Shrub, S2 Short Shrub, S3 Dwarf Shrub, H1 Graminoids, H2 Forbs, H3 Ferns, H4 Seedlings,
 N=non-vascular, E=Epiphyte Height classes: 1=<0.5m, 2=0.5-1m, 3=1-2m, 4=2-5m, 5=5-10m, 6=10-15m, 7=15-20m, 8=20-35m, 9=35-50m, 10=>50m
 Cover classes (for reference): 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-%

Section 4. Field Key to Association

- ☐ Primary Association: _____
☐ Alternate Association: _____
 Conformance to Key (☐Good ☐Fair ☐Poor): _____

Section 5. Field Key to Map Class

- ☐ Primary Map Class: _____
☐ Alternate Map Class: _____
☐ More than one association? (i.e. map class is a complex or mosaic) _____
 Conformance to Key (☐Good ☐Fair ☐Poor): _____

For office use only
 Mapped as:

Appendix B

Data Entry Guidelines

Fields populated during Batch import

Code prefix: GRBA_AA_

UTM Zone: 11

Elevation Units: meters

AA Code

Elevation

Survey Date

X and Y coordinates

Three records have been created for each AA Point:

1. GRBA_AA_0001a – for entering primary and secondary association information
2. GRBA_AA_0001m – for entering primary and secondary map class information
(These records are accessed from the Main Menu by selecting the Edit and QC AA Pts button.)
3. GRBA_AA_0001v – for entering the species and stratum cover data for each AA Point
(These records are accessed from the Main Menu by selecting the Edit and QC Plots button.)

Each record has already been populated with the AA Code, Survey Date, UTM Zone, Elevation, Elevation Units, X and Y coordinates.

Association information data entry screen

The first data entry screen for each AA Point will be the AA Point Location and Description Window accessed from the Main Menu by selecting the Edit and QC AA Pts button. The first record to enter for each AA Point is the record followed by a small 'a' (e.g. GRBA_AA_0001a).

Fields to enter:

- Surveyor name
- GPS error
- Plot size (NOTE: When the observation area size is other than 0.5 ha or 0.25 ha select 'Indefinite' and note in the General comments field: Observation area = 0.1 ha)
- Plot shape

- General Comments.

Any information recorded in the AA Point location comments\Environmental comments field should be recorded in the General Comments box as well as any information regarding the conformance to association key or species information.

Other information to be recorded in the General Comments box:

- o Park Site Name
- o Projected point
- o Observation area = 0.1 ha
- o Conformance to key = Good\Fair\Poor
- o Any comments on the lines following Conformance to key for Section 4. Field Key to Association

Choose what level you will identify the AA Point:

- Select Associations or communities

Chose how you want to select communities:

- By Name

Primary Veg

- Record the primary association.

NOTE: You can begin typing the association name and then select the correct association from the drop-down list. For example, typing *Sarcobatus* takes you to the *Sarcobatus* types within the list.

Secondary Veg

- Fill in if recorded

Classified Veg

- Leave blank. To be filled in after all data entered.

Photos Screen

Check the box next to 'This AA Point has associated photos'. Fill in all fields in this screen.

NOTE: The photo I.D. should be the renamed photo name (e.g. vmap_GRBA_AA_0001_360_20110823). The original DSC number of the photo shall be recorded in the column 'Image filename or film roll frame #' on the far right of the screen. The DSC number should be the number recorded on the datasheet. You may have to use the right arrow or the scroll bar at the bottom of the window to scroll to the right.

Map class data entry screen

Once you have completed the data entry for the association information, move to the bottom of the screen where it says 'Record # of ###'. Select the right arrow button to advance to the next record for that AA Point.

The next record will be the same AA Point number followed by an 'm' (e.g. GRBA_AA_0001m). All of the map class information will be entered in this record.

Fields to enter:

Because this information has already been entered under the association information record for the same AA Point, it is not necessary to enter data for:

- Surveyor name
- GPS error
- Plot size
- Plot shape
- General Comments

Enter any comments on the lines following Conformance to key for Section 5. Field Key to Map Class or anything noted on the data sheet relevant to determining the map class.

Other information to be recorded in the General Comments box:

- o Conformance to key = Good\Fair\Poor

Choose what level you will identify the AA Point:

- Select Map units

Chose how you want to select communities:

- By Code

Primary Veg

- Record the primary map class. You can begin typing the map class code and then select from the drop-down list (for example, typing 'S' takes you to all shrub map classes on the list.)

Secondary Veg

- Fill in if recorded

Classified Veg

- Leave blank. To be filled in after all data entered.

Species data entry screen

When you have completed entering the map class data you will enter the species data. To enter the species data you have to select the Back to Main Menu button in the upper right hand corner of the AA Point Location and Description screen. From the Main Menu select the Edit and QC Plots button.

Plot Location and Description Screen

Note that the AA Code, UTM Zone, Land Owner, Elevation, Elevation Units, X and Y coordinates and Survey Date have already been populated for each record. These records have been uploaded as observation points as indicated by the checked box next to 'Observation Points.' In order to indicate these records contain species information a small 'v' follows the AA Point code (e.g. GRBA_AA_0001v).

Fields to enter:

- State: NV
- Plot Directions: Enter the Park Site Name in this field
- Surveyors: Enter the last name of the surveyor(s)
- Provisional community name: Enter the association name recorded for this AA Point.

NOTE that correct spelling is important in this field. Unless you are an excellent typist, it is best to cut and paste the association names from the list of associations occurring within Great Basin National Park. Note that on some AA Points new associations not recorded on the classified list of associations were encountered. In these instances, type in the new association name and be sure to carefully proof your spelling of species names. Also be sure that species in the same stratum are separated by a hyphen. Species in different strata are separated by a forward slash (e.g. *Pinus monophylla* – *Juniperus osteosperma* / *Artemisia nova* Woodland).

Environmental information Screen

Most of the fields in this screen will remain blank. When necessary record any comments in the General Comments box in the lower right side of the screen.

Comments may include:

- o Notes on uncertain species identification
- o Point sampled remotely - total shrub and herb cover not recorded

Vegetation Sampling Screen

In this screen only the Strata % Cover, stratum by species, species name and species percent cover need to be entered.

In the far left column of the screen, record the total tree cover and/or shrub cover in the stratum that most typifies the stand. For a forest or woodland, most often, this will be the T2 stratum. For shrublands, this will most often be the S2 stratum, though in some instances, such as in an *Artemisia nova* stand, the dominant stratum might have been S3. Since stratum height was not recorded, no information is recorded for max Hgt.

!!NOTE!! If there is no cover value recorded for a stratum leave the field blank. If the cover for a stratum was T or <1 enter 0.2. The program will round the value to 0. Zeroes in the Strata % over field will then represent <1 or T and a blank field means no data.

In the Plant Species box, enter the stratum, species name and percent cover for each species recorded on the data sheet.

NOTE: Percent cover must be entered in the 'Continuous Cover per Stratum' column. When entering the species name, you can begin by typing the genus name. Before moving to the next field, be sure you have selected the correct species. For example if you type *Sarcobatus*, the first species to come up in the list is *Sarcobatus baileyi* rather than *S. vermiculatus*.

Photos screen

Check the box next 'This plot has associated photos.' Since the photos were entered in the AA Point data entry screen for association information, it is not necessary to re-enter the photo information here.

AT THE CONCLUSION OF EACH DATA ENTRY SESSION, ALLOW TIME TO PROOF YOUR WORK.

DATA VERIFICATION INSURES S 100% ACCURATE TRANSCRIPTION FROM DATA SHEET TO DATA BASE. DATA VERIFICATION IS DONE BY COMPARING EVERY FIELD ON THE DATA SHEET AGAINST THE SAME FIELDS IN THE DATABASE AND MAKING CORRECTIONS WHEN THE ENTERED DATA DOES NOT MATCH THE DATA ON THE DATA SHEET.

DATA VALIDATION IS A REVIEW OF THE DATA TO MAKE SURE IT MAKES SENSE.

Appendix C

Key to Physiognomic Groups

Key for determining physiognomy codes for the USNVC

1	Trees >5m tall 60-100% cover	3
3	Understory <20% cover.....	
	 <u>Sparse Understory Forest</u> (association level mapping only)	
3'	Understory =>20% cover	<u>Forest</u>
1'	Trees >5m tall less than 60% cover	4
4	25-60% cover of trees >5m tall.....	5
5	Understory <10% cover in shrub and/or herbaceous strata, with no individual species >5% cover	<u>Sparse Understory Woodland</u> (associations only)
5'	Understory >= 10% cover in shrub and/or herbaceous strata, with no individual species >5% cover	<u>Woodland</u>
4'	Trees >5m 0-25% cover.....	6
6	0-25% cover of any size trees.....	7
7	25% or more cover of 0.5-5m shrubs <u>and</u> 10-25% cover of any size trees	8
8	Shrubs average =>0.5m tall.....	<u>Wooded Shrubland</u>
8'	Shrubs average <0.5m tall.....	<u>Wooded Dwarf Shrubland</u>
7'	25% or more cover of 0.5-5m shrubs <u>and</u> <10% cover of any size trees .	10
7''	Less than 25% cover of 0.5-5m tall shrubs <i>and</i> 0-25% of any size trees ...	9
9	10-25% cover of trees >5m tall	<u>Sparse Woodland</u>
9'	<10% cover of trees >5m tall	10
6'	Greater than 25% cover of trees <5m tall	10
10	25-100% cover of 0.5-5m tall woody vegetation	11
11	Understory <10% cover	
	<u>Sparse Understory Shrubland</u> (associations level mapping only)	
11'	Understory =>10% cover	<u>Shrubland</u>
10'	less than 25% cover of 0.5-5m tall woody vegetation	12
12	>25% cover of <5m tall woody vegetation	<u>Shrubland</u>
12'	0-25% cover of <5m tall woody vegetation	13
13	10 to 25% cover of 0.5-5m tall woody vegetation	

.....	<u>Sparse Shrubland</u>
13' less than 10% cover of 0.5-5m tall woody vegetation	14
14 25-100% cover of <0.5m tall woody vegetation	
.....	<u>Dwarf Shrubland</u>
14' less than 25% cover of <0.5m tall woody vegetation	15
15 >25% cover of <5m tall woody vegetation ..	<u>Dwarf Shrubland</u>
15' 0-25% cover of <5m tall woody vegetation	16
16 10-25% cover of <0.5m tall woody vegetation	
.....	<u>Sparse Dwarf Shrubland</u>
16' less than 10% cover of <0.5 tall woody vegetation	17
17 >10% cover of herbaceous, perennial vegetation ..	18
18 1 to 10% cover of any sized trees or shrubs....	19
19 More shrub cover than trees.....	
.....	<u>Shrub Herbaceous Vegetation</u>
19' More tree cover than shrubs.....	
.....	<u>Wooded Herbaceous Vegetation</u>
18' 0 to 1% cover of any sized trees or shrubs	
.....	<u>Herbaceous Vegetation</u>
17' 0-10% cover of perennial vegetation at peak growing season of a typical year	20
20 >1-10% cover of vegetation	<u>Sparsely Vegetated</u>
20' 1% cover, or less	<u>Non-Vegetated</u>