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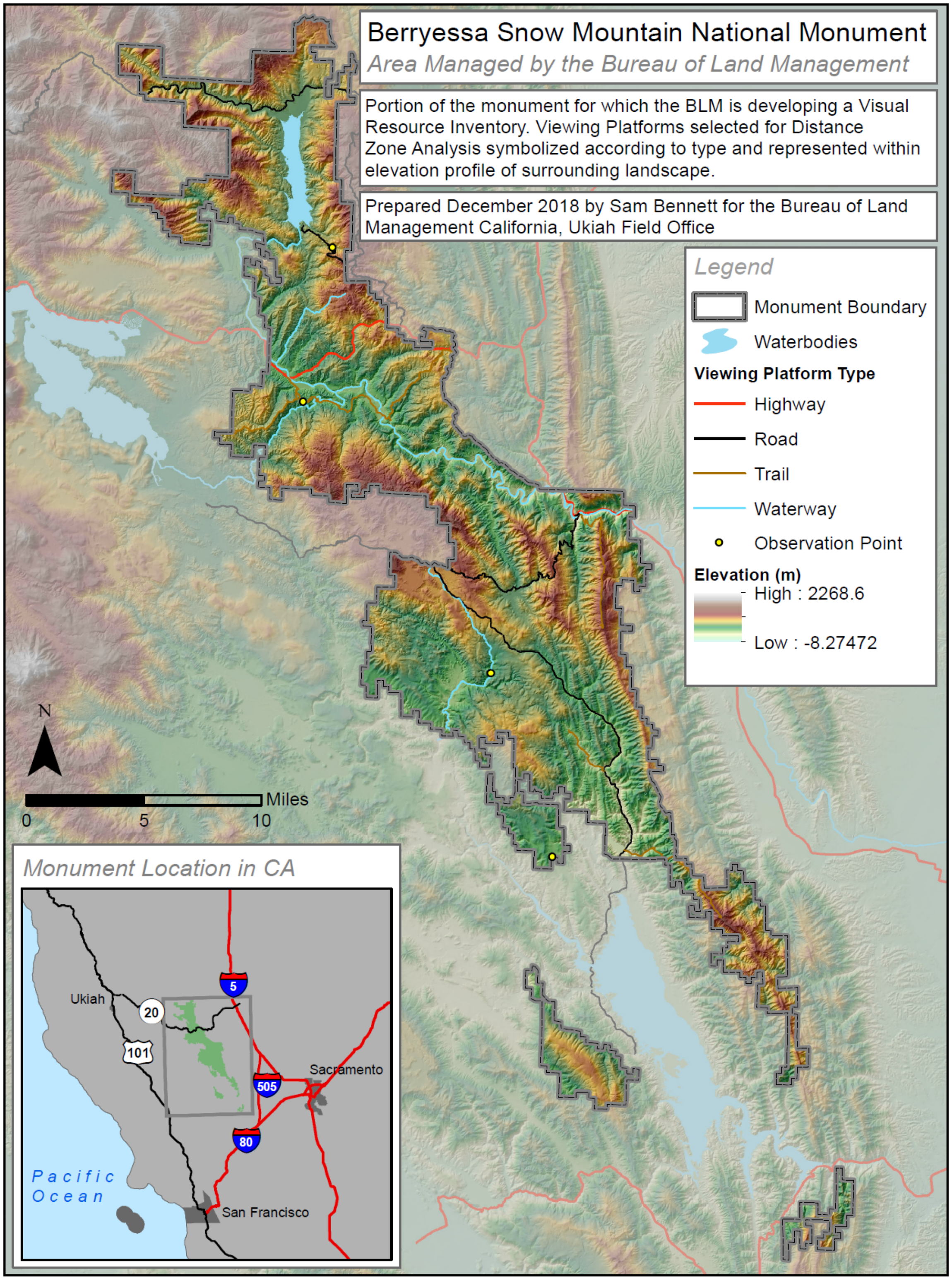
Berryessa Snow Mountain National Monument: Distance Zone Analysis

Project Report



Introduction

Berryessa Snow Mountain National Monument (the monument) lies to northeast of Sacramento in California's coastal range. Designated in 2015 under the Obama administration, the 330,780 acre monument is managed by two separate federal agencies: the northern 197,214 acres are managed by the US Forest Service while the southern 133,566 acres are managed by the Bureau of Land Management (BLM). These agencies are in the process of gathering and analyzing data in order to develop a Resource Management Plan for the monument.

Within this process, the BLM is developing a Visual Resource Inventory wherein the visual resources inside their portion of the monument are delineated, analyzed, and catalogued. An important part of this inventory is Distance Zone (DZ) analysis. For this analysis, BLM guidance requires landscapes to be subdivided into 3 DZs based on their visibility from designated high-traffic travel routes or observation points (viewing platforms). The first of these is the foreground-midleground (FM) zone which is all land within 5 miles of any viewing platform. The second is the background (BG) zone which is all land greater than 5 miles but no more than 15 miles from any viewing platform. Finally, there is the seldom-seen (SS) zone, which is any land within either the FM or BG zones that is not visible from any viewing platform due to the topography of the landscape.

Background and Goals

The goal of this project was to develop and analyze Distance Zones (DZs) in accordance with relevant BLM procedures[1] for the BLM-managed portion of Berryessa Snow Mountain National Monument. It was carried out on behalf of the BLM California's Ukiah Field Office and is part of that office's larger ongoing project to develop a Visual Resource Inventory for the monument.

The intent behind delineating DZs is to determine in which sections of the monument management activities might have a higher impact on visual resources due to their visibility. The specific goal is to determine where – not necessarily how much of – the monument is visible from high-visitation routes and points. However, this investigation can easily be posed in quantitative terms. Useful questions that can easily be answered by this analysis include: What is the area in square miles of FM, BG, and SS zones? And what percentage is each of the total monument area?

Process

The first step in this project was to coordinate with BLM staff to determine viewing platforms. As mentioned, these must be high-visitation routes and points within the monument for which GIS data exists or can reasonably be created. All viewing platforms should be mutually exclusive, as visibility from any single platform excludes land from the SS zone. Discussions resulted in the following list of viewing platforms.

Observation Points

Campgrounds

- Blue Oak Camp
- Cement Creek Camp
- Hunting Creek Camp

Scenic Overlooks

- Inspiration Point

[1] BLM Manual H-8410-1 §IV

Travel Routes

Roads

- Bartlett Springs Road
- Berryessa Knoxville Road
- CA State Highway 16
- CA State Highway 20
- CA State Highway 128
- Indian Valley Reservoir Road
- Walker Ridge Road
- Yolo County Road 40

Trails

- Berryessa Peak Trail
- Blue Ridge Trail
- Cache Creek Ridge Trail
- Judge Davis Trail
- Perkins Creek Trail
- Redbud Trail
- Zim Zim Falls Trail

Waterways

- Cache Creek
- Indian Creek
- Indian Valley Reservoir
- Hunting Creek

GIS data for some of these features were supplied by the BLM (as well as a shapefile of the extent of BLM-managed section of the monument), while others were gathered from a variety of sources (see Appendix B). In all cases, data for the designated viewing platforms existed in GIS files and databases that contained data on many other unnecessary features (in some cases tens of thousands). In files with only a few other features, viewing platforms were located by cross-referencing published maps and manually selecting desired features. In files with a large number of other features, viewing platforms were isolated using SQL queries within relevant attribute tables intended to retrieve close matches to feature names. In cases where output queries returned multiple features, viewing platforms were again located by cross-reference and manual selection. In all cases, isolated and selected viewing platforms were exported from their larger files as independent shapefiles.

At this point, a single shapefile existed for each viewing platform. These were manipulated for clarity and operability as follows. The 'Batch Project' tool was used to project each in the NAD 83 California Teale Albers Meters Projected Coordinate System (PCS) required by BLM California for all GIS analysis. The polygon shapefile for the Indian Valley Reservoir viewing platform was converted to a polyline shapefile using the 'Polygon to Line' tool, as viewsheds calculated from the reservoir's banks will be inclusive of viewsheds from any point within the polygon and can reasonably be presumed to require less computing. For each shapefile, the 'Merge' function within the 'Editor' toolbar was used to reduce attribute tables to a single row. Then, all fields except 'Shape' were cleared from the attribute tables and replaced with fields:

- ‘VP_Name’ (the viewing platform’s name)
- ‘OFFSETA’ (the value in Z map units (meters) by which the viewshed analysis is to be offset from the z value of the viewing platform; set to ‘1.5’ per BLM guidance)
- ‘RADIUS2’ (the value in XY map units (meters) away from viewing platforms to which viewshed analysis is restricted; set to ’24,140.2’ per BLM guidance)

All point and polyline shapefiles were then merged into single respective shapefiles according to type using the ‘Merge’ tool, resulting in a single shapefile containing all line features and another containing all point features. These were clipped to a 15 mile buffer of the monument boundary per BLM guidance. The cleaned and standardized attribute tables for each are shown below in *Figure 1*.

Lines Attribute Table

FID	Shape *	Viewing Platform Type	OFFSETA	RADIUS2
0	Polyline ZM	Bartlett Springs Rd	1.5	24140.2
1	Polyline ZM	Berryessa Knoxville Rd	1.5	24140.2
2	Polyline ZM	Berryessa Peak Tr	1.5	24140.2
3	Polyline ZM	Blue Ridge Tr	1.5	24140.2
4	Polyline ZM	CA Hwy 128	1.5	24140.2
5	Polyline ZM	CA Hwy 16	1.5	24140.2
6	Polyline ZM	CA Hwy 20	1.5	24140.2
7	Polyline ZM	Cache Cr Ridge Tr	1.5	24140.2
8	Polyline ZM	Cache Cr	1.5	24140.2
9	Polyline ZM	Hunting Cr	1.5	24140.2
10	Polyline ZM	Indian Cr	1.5	24140.2
11	Polyline ZM	Indian Valley Rsvr	1.5	24140.2
12	Polyline ZM	Indian Valley Rsvr Rd	1.5	24140.2
13	Polyline ZM	Judge Davis Tr	1.5	24140.2
14	Polyline ZM	Morgan Valley Rd	1.5	24140.2
15	Polyline ZM	Perkins Cr Ridge Tr	1.5	24140.2
16	Polyline ZM	Red Bud Tr	1.5	24140.2
17	Polyline ZM	Walker Ridge Rd	1.5	24140.2
18	Polyline ZM	Yolo Co Rd 40	1.5	24140.2
19	Polyline ZM	Zim Zim Falls Tr	1.5	24140.2

Points Attribute Table

FID	Shape *	VP_Name	OFFSETA	RADIUS2
0	Point ZM	Blue Oak Camp	1.5	24140.2
1	Point ZM	Cement Cr Cmp	1.5	24140.2
2	Point ZM	Hunting Cr Cmp	1.5	24140.2
3	Point ZM	Inspiration Pt	1.5	24140.2

Figure 1. Standardized Viewing Platform attribute tables

Next, FM and BG DZs were created from the final viewing platform shapefiles. 5 and 15 mile buffers (corresponding to FM and BG DZ’s, respectively) from the point and line viewing platform shapefiles were created using the ‘Buffer’ tool with ‘Dissolve’ argument set to ‘ALL’. This way, each of the resulting two 5 mile and two 15 mile buffers would render as continuous polygons with single outlines. The two 5 mile and two 15 mile buffers were then respectively appended using the ‘Append’ tool, resulting in a single shapefile for each buffer size. However, the ‘Append’ tool resulting in each shapefile containing multiple parts, which posed an issue for the eventual calculation of their areas within the monument. To fix this, the ‘Merge’ function within the ‘Editor’ toolbar was used to merge the multiple parts in each shapefile.

The existing DZs had to be made mutually exclusive and collectively exhaustive for accurate area calculations. This was done by clipping each to the area of the monument using the ‘Clip’ tool, isolating the BG area by erasing the overlapping FM area using the ‘Erase’ tool, then using the ‘Erase’ tool again to isolate the FM by erasing the overlapping isolated BG area. The resulting logic is outlined in *Figure 2.*

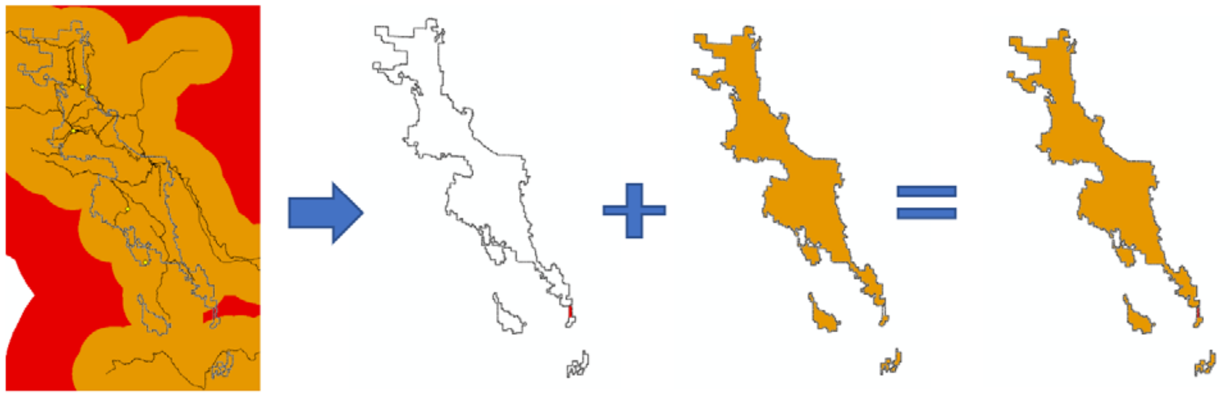


Figure 2. Mutual exclusion and collective exhaustion in FM and BG DZ area creation

At this point, Digital Elevation Models (DEMs) became necessary for interpolating Z values for all viewing platforms and performing viewshed analyses from them. BLM guidance requires the use of 10m DEMs for viewshed analysis. Relevant 10m DEMs from the National Elevation Dataset were retrieved from the USGS, combined using the 'Mosaic to New Raster' tool, and then projected to the required PCS using the 'Project Raster' tool with the 'Technique' argument set to 'BILINEAR' as this ensures any smoothing occurs within the extant pixel range (no new values are extrapolated outside that range)[2]. A hillshade raster was then derived using the 'Hillshade' tool. Z values for the point and line shapefiles were then interpolated from the underlying DEM using the 'Interpolate Shape' tool. Viewing platform shapefiles were ready for viewshed analysis.

Viewshed analyses were attempted using the interpolated point and line viewing platform shapefiles and the underlying 10m DEM by way of the 'Viewshed' tool. This tool takes an interpolated shapefile as its "observer" input and looks in the attribute table of that shapefile for certain key field names, the values of which it takes as constraints. Among these are the 'OFFSETA' and 'RADIUS2' fields mentioned earlier, which here acted as constraints on viewer height (1.5m) and viewing radius (15mi). The output is a new raster in which cells are given values according to how many cells underlying the observer features achieve a line of sight to them given the topography between them. In this way, the SS DZ is determined by the extent of cells with the value '0' – those that fall within the line of sight of 0 observer cells. Some additional raster math is involved in the final SS DZ determination and will be outlined below.

Before getting to the final calculations, it must be noted that the viewshed analyses using the 10m DEM were ultimately unsuccessful. The 'Viewshed' tool quickly produced results from the point viewing platform shapefile, but took an excessively long time processing the much larger line viewing platform shapefile: the process was manually cancelled after over 13 hours of execution time. With no certainty of how long the process could take, alternative measures were taken. The DEM manipulation and shapefile interpolation outlined above were repeated using ASTER 30m DEMs retrieved from the USGS. At 1/9th the resolution, it was assumed they would take significantly less time to process while successfully providing a proof of concept for the overall analysis. Viewsheds were calculated again using the 'Viewshed' tool with constraints identical to those used earlier. The processes ran successfully, with the raster resulting from line viewpoint shapefile input taking just over 24 hours to execute.

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[2] *Properly Reprojecting Elevation Rasters*. ArcUser, Esri News. 2013 (link)

The process using 30m DEMs produced two separate viewshed rasters, one apiece for the point and line viewing platform shapefile inputs. These needed to be combined to accurately represent the total SS DZ. This had to be done in such a way that in the case where a cell in one raster had a value of 0 while the same cell in the other had a value >0, the >0 cell value would override the 0 cell value. It was determined that this effect could easily be achieved using an addition operator between the two rasters within the 'Raster Calculator' tool. However, upon attempt, the error '000539: Error running expression: rcexec()' was produced. Esri technical support notes that this known error results from the 'Raster Calculator' tool not being exposed to Python when used as a tool within Arcmap, and recommends coding a solution in Python.[3] The following python script was drafted as a solution and resulted in the additive logic outlined in *Figure 3* wherein colored cells = 0 and blank cells > 0.

```
import arcpy
from arcpy import env
from arcpy.sa import *
env.workspace = "G:/GIS/VRI_Project/Viewshed"
inRaster1 = "30_lines_view"
inRaster2 = "30_pt_view2"
arcpy.CheckOutExtension("Spatial")
outPlus = Plus(inRaster1, inRaster2)
outPlus.save("G:/GIS/VRI_Project/Viewshed/outplus")
```

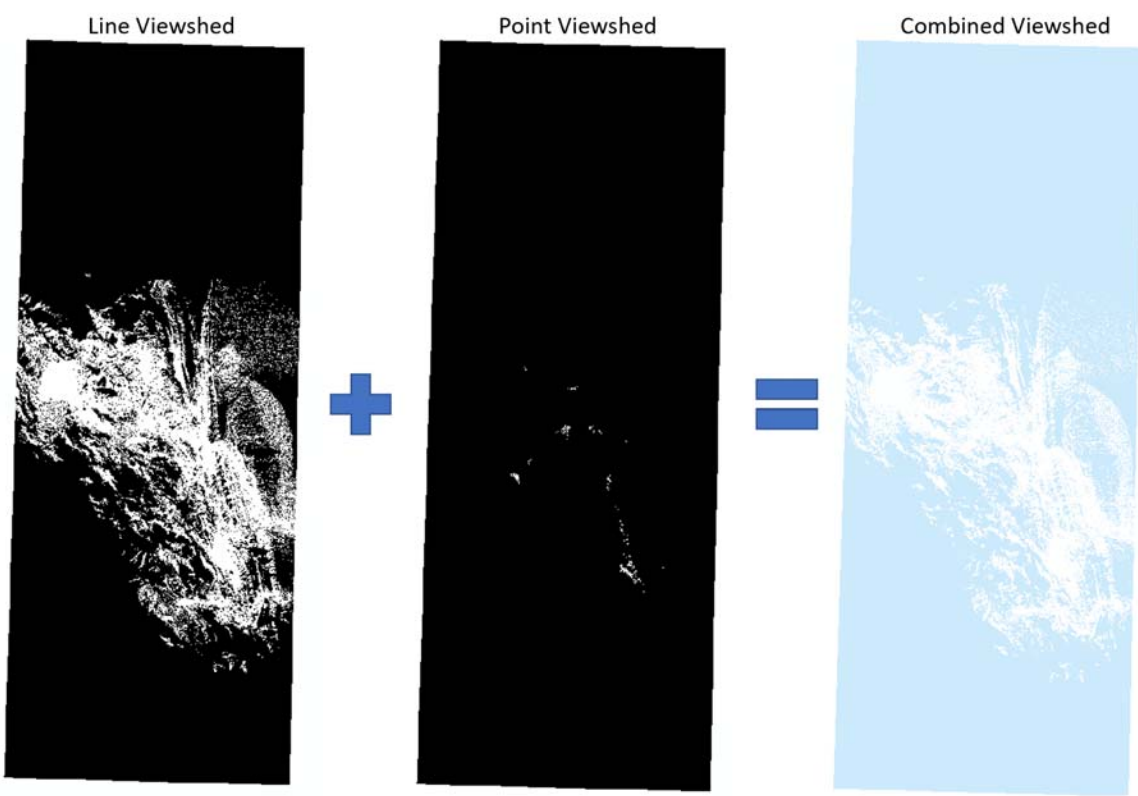


Figure 3. Viewshed Raster Addition

[3] *Error 000539: Error running expression: rcexec()*. Esri Technical Support Note. (link)

The resulting raster was then used to the determine the SS DZ as follows. In the raster attribute table, the single row representing all cells with the 'VALUE' = 0 was selected. Then, the 'Raster to Polygon' tool was used to with the 'Field' argument set to 'VALUE' and the 'Simplify Polygon' box checked in order to smooth jagged raster edges. The resulting polygon shapefile was clipped to the extent of the monument using the 'Clip' tool. Finally, the rows in the shapefile attribute table were merged into a single row using the 'Merge' function in the 'Editor' toolbar.

At this point, FM, BG, and SS DZs were manipulated to ensure their mutual exclusion and collective exhaustion as components of the monument area. The SS DZ's area was removed from the areas of both the FM and BG DZs using the 'Erase' tool. Then, a field called 'Area' was added to the attribute table of each and calculated in square miles using the 'Calculate Geometry' function from the field drop down menu.

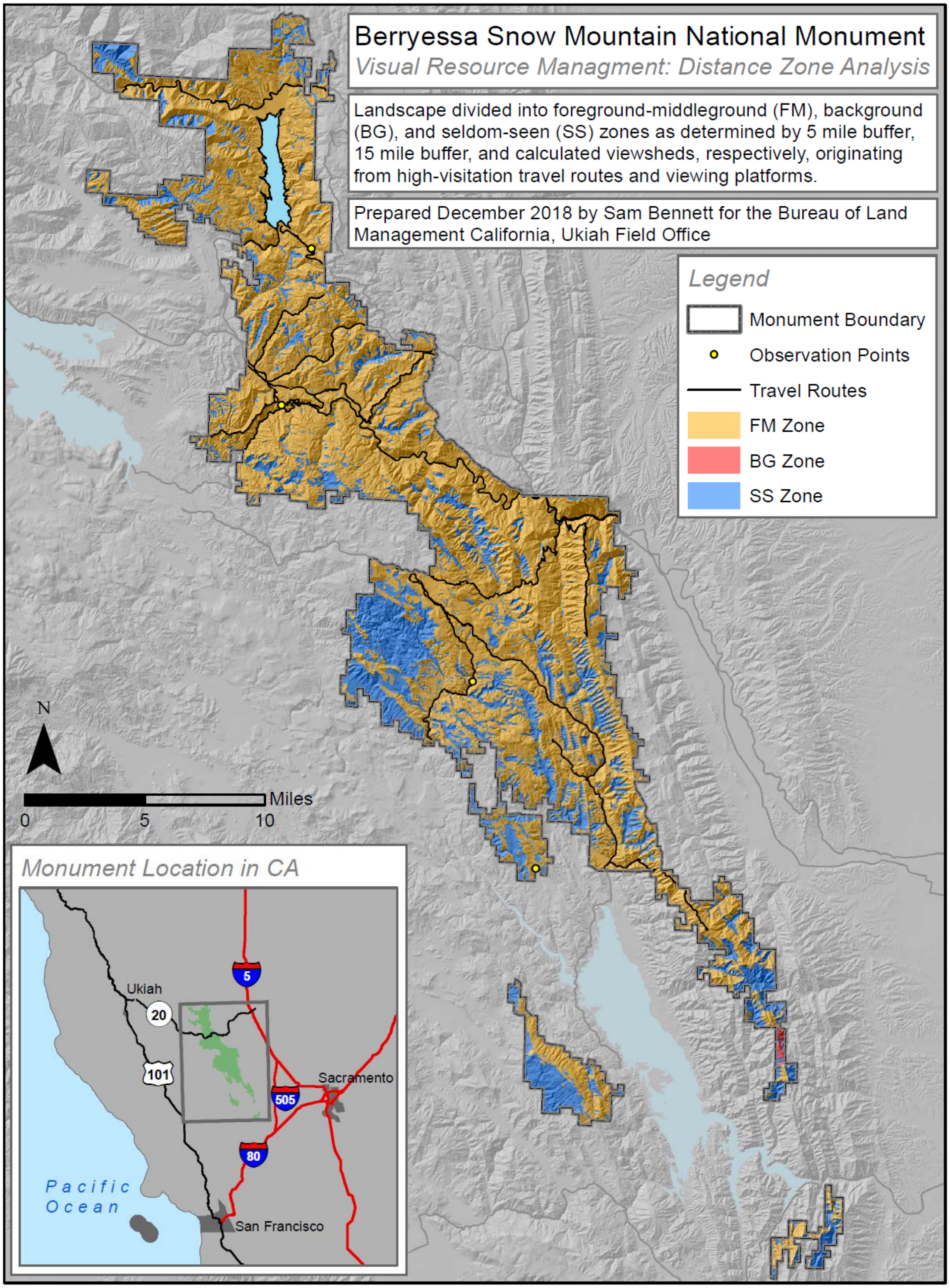
Results

As mentioned in the *Background and Goals* section, the purpose of this analysis was to determine and represent the actual locations of the different DZs to aid in the management of visual resources. These areas are represented in detail in the final map presented in *Appendix A*. However, the quantitative questions posed in *Background and Goals* section can also be easily answered by the performed area calculations. The results of these area calculations are outlined below in *Table 1*.

Distance Zone	Area (sq. miles)	Percentage of Monument Area
Foreground-Middleground	226.77	75.85%
Background	0.42	0.14%
Seldom Seen	71.8	24.01%
Total	*298.99*	*100%*

Table 1. Distance Zone area results

Appendix A: *Distance Zone Map*



Appendix B: *Data Sources Used*

1. National Elevation Dataset 10m DEM (retrieved from USGS)
2. Advanced Spaceborne Thermal Emission and Reflection Radiometer 30m DEM (retrieved from USGS)
3. National Hydrography Dataset Area File Geodatabase (retrieved from USGS)
4. CA Transportation File Geodatabase (retrieved from USGS)
5. Files provided by Bureau of Land Management