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# Geology Resources Addendum Specialist Report

## Forest Plan Revision Draft Environmental Impact Statement (DEIS)

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# Executive Summary

This specialist report evaluates and discloses the potential environmental consequences on Geologic Resources focusing on Geologic Special Areas that may result with the adoption of a revised land management plan. It examines, in detail, four different alternatives for revising the 1987 Coconino National Forest Land Management Plan (1987 Plan).

The overall consequence of implementing Alternative A, the 1987 Plan, is that the Red Mountain Geologic Area is managed to promote conservation of its interpretative, scientific and aesthetic values. The lack of roads open to the public within the geologic areas and the closure to off road driving is very protective of the soils, geology, botanical and ecological resources of the area. There would be no new geological or botanical special areas. Other unique geologic areas or features on the forest would not have this degree or level of conservation and would not be designated as special areas. There would be no special area management for other geologically important areas such as the Cottonwood Basin Fumeroles or other potential geological special areas. The consequences of this would be that unique or special geological resource values could be impacted by human activities such as recreation or management activities such as logging or grazing etc. Other consequences would be that there would be less opportunity for research, education and interpretation of the geology of the unique or special areas.

Alternative A, the 1987 plan recognized the remarkable geological, glacial and volcanic features of the Strawberry Crater and Kachina Peaks, Kendrick Mountain Wildernesses. The various other MAs outside of the volcanic wilderness areas have variable management. The Cinder Hills volcanic area with its cinder cones lava fields is managed as an off highway vehicle use area emphasizing this type of recreational opportunity. The Craters MA is another volcanic area with many cinder cones and pumice craters and is managed for a more remote and dispersed recreation opportunities. Deadman Wash MA is also comprised of volcanic terrain featuring cinder cones and pinyon juniper woodlands and grasslands. Its management focus is to protect and maintain and restore grasslands and maintain a largely untracked/unroaded landscape. The Craters and Deadman Wash MAs are both managed for the maintenance of volcanic cinder ecosystems and for maintenance of untracked cinder cone slopes. Forestwide direction for logging on cinder cones is that logging activities are restricted to slopes less than 25% using conventional skidding. In addition, cinder cone or other slopes (pumice fields) having a severe potential for sheet and gully erosion require specific management practices to avoid any impairment of their soil productivity.

The consequences of implementing Alternative A are that the lava fields, volcanic cinder cones and the associated vegetation, wildlife, scenery and water resources associated with the volcanic areas in the northern and eastern edge of the forest would continue to be managed within several MAs and as described in management area direction in the 1987 Plan. The management direction proposed in these MAs is specific about discouraging off trail use outside the Cinder Hills area and also describes the level of scenic integrity that would be maintained. There are many considerations for retention of the scenic values, wildlife and endemic plant species adapted to cinder cones and lava flows. In addition, maintenance of soil productivity and slope stability is built in to the management direction as well which would promote the preservation of the geological integrity of the volcanic areas.

Alternative B would provide for another unique geologic area to be managed as a special area, consisting of the Cottonwood Basin Fumeroles (about 926 acres). This would be in addition to

the Red Mountain Volcano special area. Alternative B has guidelines that provide a broad framework for minimizing impacts from recreational uses, wildfire management and suppression actions, and grazing management. Forest management actions would be evaluated on how they are consistent with the desired conditions for special areas where natural conditions are emphasized and disturbances to the natural conditions are restricted or minimized. In general Alternative B is fairly similar to Alternative A, the 1987 plan. A major difference is that rock removal from geological areas is prohibited unless it is carried out through a permitted research or scientific activity.

Alternative B emphasizes the aesthetic and scenic quality of the volcanic woodlands management area including the young cinder cones, volcanic craters and vents and rugged nearly barren of vegetation, lava flows. Desired conditions for this management area are to have the distinctive volcanic features maintain their landform integrity, form and natural processes. The consequences of this are that ongoing or proposed management activities in this area would generally not disturb these features or cause noticeable changes in the scenic integrity and aesthetic quality of the landforms. The Volcanic Woodlands Management Area of Alternative B provides for recognition of the aesthetic and scenic quality of the young volcanic features of the area which is also recognized in Alternative A but in several different Management Areas. Implementation of the desired conditions for the Volcanic Woodlands Management Area would protect the volcanic features during forest management and would provide for the maintenance of their form, function and integrity. This would help to preserve of the aesthetic qualities of the important landforms. The consequences of Alternative B would be similar to Alternative A but there would be much less specific management direction. Maintaining or progressing towards desired conditions is key to Alternative B and would achieve the same consequences as Alternative A.

Alternative C proposes a new special area, the Cottonwood Basin Botanical and Geological area with a total area of about 2,559 acres. This special area overlaps with a portion of the Hackberry proposed Wilderness area which is also proposed in this alternative. The special area would be managed as one contiguous area. The combined botanical and geological area of the Cottonwood Basin Fumeroles would provide a greater opportunity for interpretation of the interrelationships between bedrock, soils and vegetation in a broader context of ecology and ecosystems management. The larger botanical and geological area would provide more opportunity for scientific research on the plant communities and the geology of the area. In all other respects, Alternative C is the same as Alternative B regarding management of botanical and geological special areas.

Alternative D recommends no new wilderness areas, but otherwise is the same as Alternative B. The only difference from Alternative B is that it allows mechanized recreation such as bicycles on designated trails in botanical and geological areas. The development of designated trails for either non-mechanized or mechanized travel within the interiors of the botanical and geologic areas would have consequences of localizing the disturbances to the landforms, soils and plants.

Trails have similar effects to roads with respect to soil and slope stability, water diversion potential and erosion and sedimentation. Trails like roads, decrease slope stability on steep slopes, increase water diversion potential and erosion and sedimentation on most all slopes. On steep terrain in the headwaters of watersheds or above stream channels and watercourses, trails cut into the slopes would decrease the slope stability of the areas; alter surface hydrology of the slopes and cause erosion and sedimentation into channels. Proper trail design with attention to

grade and water drainage would be critical to reducing erosion potential and maintaining slope stability. Trail maintenance would also cause impacts to the soils and vegetation from clearing, brushing and tread grading. Trails where mechanized travel is allowed such as using bicycles have greater impacts than foot trails to the ground surface where the bicycle wheel digs into the trail and loosens up soil and rock. Off-trail biking may become an issue in areas that have inviting hills and challenging obstacles such as the Cottonwood Basin Fumeroles. The brushing height would also be greater on trails that are used by bicycles. A positive benefit of designated trail systems is that they can be routed away from where rare plants are growing or where there is a geologic feature that is eroding or sensitive to disturbance. Trails can be routed around permanent obstacles such as rock outcrops or large trees. Another positive benefit of trails within geological and botanical areas is that interpretative signs can be constructed along the trail route to foster knowledge and appreciation of the botany and geology. In summary, shared use trails for hiking and bicycling have both positive and negative benefits within geological and botanical areas.

The cumulative effects of Alternatives B, C and D are that they recognize and protect unique geologic and botanical areas in addition to the Red Mountain Volcano. This would add additional sites to the other outstanding geological and botanical sites inside and outside of the forest such as Fossil Creek, Montezuma Well, and Walnut Canyon and Sunset Crater National Monuments. Designation of Cottonwood Basin Fumeroles as a geological area or a combined botanical and geological area would add another example of volcanic influenced terrain as a special feature of the forest. It would increase the interpretative and educational opportunities that the forest can provide the public about the interrelationships between botany and geology. It would provide for increased opportunities to develop partnerships with the scientific community, researchers and conservationists interested in the areas and would expand our collective knowledge about the features and characteristics of the areas. Alternative B, C and D also designate the Volcanic Woodlands Management Area which would increase the protection and consideration of the volcanic features during forest management and provide for greater collaboration on scenery and other issues with the other nearby national monuments such as Sunset Crater.

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## Introduction

This addendum specialist report evaluates and discloses the affected environment of potential Geologic Resources specifically, Geologic Special Areas (GSAs) and designation of the Volcanic Woodlands Management Area that may result with the adoption of a revised land management plan. It examines, in detail, four different alternatives for revising the 1987 Coconino National Forest Land Management Plan (1987 Plan).

This report will discuss the affected environment for the existing and proposed GSAs on the forest and Volcanic Woodlands Management Area. Environmental consequences of the alternatives analyzed are described in the EIS in Chapter 3 under Geological Resources and Special Areas. Please see other separate specialist reports for Minerals and Energy, Caves, Cliffs and Talus Slopes Resources, and Paleontology Resources for analyses of these resources. This report is very limited in scope. Geologic hazards of landslides, debris flows, rockfalls, floods, volcanoes, earthquakes, avalanches and radon occur on the forest, however, these hazards are not analyzed because no issues have been brought forward internally or externally concerning them to date. Groundwater resources are addressed in the Water and Watershed Specialist Report.

## Relevant Laws, Regulations, and Policy that Apply

All alternatives are designed to guide the Coconino NF's management activities in meeting all applicable Federal and State laws, regulations, and policies. The following is a list of key policies, laws and regulations that guide geologic resource management as applicable to the Forest.

### *Forest Service Manuals and Handbooks*

#### *FSM 2800 Minerals and Geology*

Chapter 2880 Geologic Resources, Hazards and Services – Section 2882.8 describes objectives of Geologic Special Interest Areas and Research Natural Areas.

#### *FSM 2300 Recreation, Wilderness and related Resource Management*

Chapter 2370 Special Recreation Designations describes management direction for geological and botanical special areas

## Methodology and Analysis Process

### *Scope of Analysis and Units of Measure*

The analysis focuses on the affected environment of existing designated GSAs on the forest, that is the Red Mountain Volcanic Geologic Special Area and a proposed geologic and botanical special area, the Cottonwood Basin Fumeroles. The Volcanic Woodlands Management Area is proposed in Alternative B, C and D. The Cottonwood Basin Fumeroles is proposed as a geologic special area in Alternative B and in Alternative C as a much larger geologic and botanical area. The areas are described using information from available literature and from field visits conducted at the Cottonwood Basin Fumeroles over the period 2006- the present. The geologic history of both of the areas is described as well as the scientific and research interest and significance. Management concerns are also identified.

The alternatives are compared on the basis of how they would protect and preserve the geologic features and conserve the scientific values of the areas. This will be a qualitative analysis. To address the issue of mechanized use on designated trails, the alternatives will be compared as to the potential

resource impacts and from mechanized recreation (bicycle use) on designated trails in geological and botanical special areas. This will be a qualitative analysis. See sections of Geological Resources and Special Areas in Chapter of the EIA for the analysis of environmental consequences.

## **Revision Topics and Issues Addressed in this Analysis**

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund or carry out any project activity. There are implications or longer term environmental consequences of managing the forest under this programmatic framework. The focus of this environmental analysis is on the consequences of the alternatives on the desired conditions for the geological and botanical special area resources.

### ***Revision Topics***

The Analysis of the Management Situation (Forest Service May 2010) identified several forest revision topics related to special area management. These are listed below.

- The AMS recognized that the Forest is special because of its elevation differences that support different animal and plant life, climate, seasonal opportunities, and geology (p. 44).
- Listed various Special Area Proposals including the Cottonwood Basin Fumeroles Geologic and Botanical Area (p. 68).

### ***Issues and Concerns***

The following issue was brought forward by the public and resulted in the development of Alternative D.

- Mechanized use on trails may create no more impact than foot traffic in Botanical and Geological Areas, so should not warrant prohibition.

Please see the scope of Analysis and Units of Measure section above for how this issue will be analyzed.

### ***Assumptions***

The following assumptions have been made as part of this analysis:

#### ***Forest Plan***

- The land management plan provides a programmatic framework for future site-specific actions.
- Land management plans do not have direct effects. They do not authorize or mandate any site-specific projects or activities (including ground-disturbing actions).
- Land management plans may have implications, or environmental consequences, of managing the forests under a programmatic framework.
- The plan decisions (desired conditions, objectives, standards, guidelines, management areas, monitoring) will be followed when planning or implementing site-specific projects and activities.
- Laws, regulations, and policies will be followed when planning or implementing site-specific projects and activities.
- Monitoring will occur and the land management plan will be amended, as needed.
- We will be funded similar to past budget levels (past 5 years).



- The planning timeframe is 15 years; other timeframes may be analyzed depending on the resource (usually a discussion of anticipated trends into the future).

#### *Geological and Botanical Special Areas*

- Management plans will be developed as directed by the designated line officer with the appropriate NEPA process once new geologic or botanical special areas are authorized under the revised Forest Plan.

## **Summary of Alternatives**

Four alternatives are analyzed in detail in the EIS: Alternatives A through D. Alternative A is the current 1987 Coconino National Forest Plan as amended (Forest Service 1987) and Alternative B is the Preferred Alternative/Proposed Action, drafted over the past several months and refined with several periods of internal and informal public feedback. Alternative C considers increases in the amount of wilderness and special areas, as well as increased opportunities for quiet semi-primitive recreation, while Alternative D considers slightly fewer restrictions than Alternatives B and C on human access and use of the Forest and its resources.

The following summaries of the alternatives focus on the components that may have consequences on designation or management of geologic and botanical special areas and management of specific geologic landforms.

### *Alternative A, 1987 Plan*

Special Areas are covered under Management Area 17. The 1987 Plan designated one geological special area and recommended it for mineral withdrawal: the Red Mountain Geologic Area (1,201 acres). There are no Volcanic Woodlands Management Areas designated in Alternative A.

### *Alternative B, Modified Proposed Plan*

The proposed revised forest plan is the preferred alternative. It would provide strategic, program-level guidance for managing the Forest and its natural resources over the next 10 to 15 years. Within the Special Areas section of the plan, desired conditions are presented for these resources to guide management and one new geologic special area is proposed. Components of the Modified Proposed Plan that have bearing on geological special areas and geologic landforms are listed below:

- Proposing the Cottonwood Basin Fumeroles as a geological special area (926 acres)
- Including desired conditions in the Volcanic Woodlands management area that highlights the scenic and cultural importance of the volcanic features in the area, and that cinder cones outside of the Cinder Hills OHV area maintain their integrity, form, and natural processes. A management approach is also included to foster collaboration with the National Park Service on projects that could affect their lands and/or mission.

### *Alternative C*

The Forest proposes Alternative C to be responsive to public recommendations for more wilderness areas on the Forest, as well as other special and management areas to provide additional protection to botanical and wildlife resources. A combined geological and botanical special area is proposed:

- Expands the Cottonwood Basin Fumeroles geological area to be a geological and botanical area that highlights the outstanding botanical diversity of the area (2,559 acres). All standards

and guidelines for the Cottonwood Basin Fumeroles geological area and botanical areas in general as detailed in Alternative B would also apply.

All other components of the alternative that have bearing on geology resources, specifically the desired conditions for the Volcanic Woodlands management area are the same as in Alternative B.

## ***Alternative D***

Alternative D differs from the other alternatives in the following ways:

- Allows mechanized recreation (e.g., bikes) on designated trails in botanical and geological areas.

In the analysis for this Alternative, it was assumed that the Cottonwood Basin Fumeroles would be designated as a geological special area only and not as a combined geological and botanical special area. However, analysis of the consequences of this alternative on botanical areas will be generally described. All other components of the alternative that have bearing on geology resources, specifically the desired conditions for the Volcanic Woodlands management area are the same as in Alternative B.

## **Description of Affected Environment**

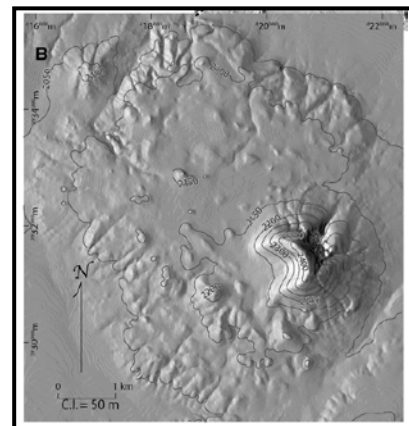
### ***Red Mountain Geologic Area***

Red Mountain is an unusual volcanic cinder cone located in the northwest corner of the forest within the San Francisco Volcanic Field. It rises 1,000 feet above the surrounding volcanic lava field and the crest is at 7,965 feet in elevation. Red Mountain erupted roughly 740,000 years ago. It is an unusual cinder cone in that it is not the typical cone shaped volcano with a lava flow that ensued from the base of the cone. Red Mountain shows the internal structure of the cinder cone and scientists have conducted much research in interpreting its complex history and geologic features (Priest et al. 2002; Riggs and Duffield 2008). The Red Mountain cinder cone grew on a nearly flat surface which was gradually covered by a lava flow that came out of the base of the cone. During the later stages of the eruption, volcanic cinders on the western side of the cone were rafted away on the lava flow. This rafting resulted in the U-shaped landform open to the west exposing the interior of the cone (Figure 1).

On the northeast side of the cinder cone is the “amphitheater” which may have been blasted away by steam explosions resulting from a reaction of groundwater along a regional fault and hot rock from subsurface magmatic activity. The amphitheatre has interesting erosional features called “hoodoos” which are 10-20 feet tall pinnacles of well-cemented cinders capped by a “sombrero cap” of denser lava rock. These pinnacles, spires and ridges were sculpted by water and wind erosion that occurred after the eruption ceased (Figure 2)

Red Mountain is accessed by US Highway 180 and there is turnoff onto FR9023V. A quarter mile on this road there is a parking area and a 30 minute hike on Trail #159 from the parking area brings forest visitors to the amphitheater area on the NE side of the Red Mountain. See Figure 7 for a

**Figure 1: Digital Elevation Model (DEM) of Red Mountain**

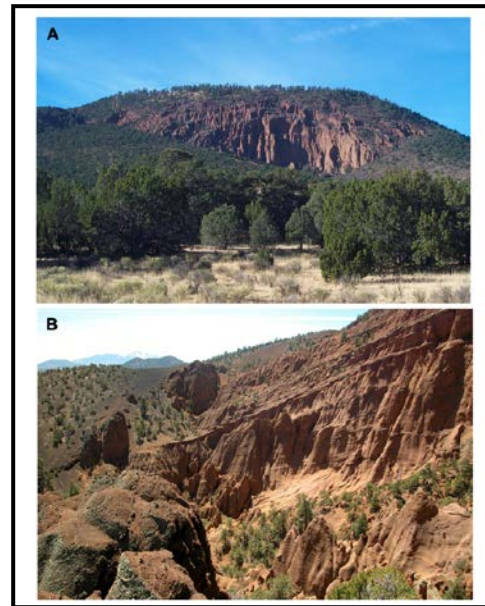


location map of the area showing roads open to public use and roads not open to public use. Two roads enter into the geologic area, FR9023J and FR9029N. A barbed wire fence without a gate limits public access onto these roads. These two roads are closed to public motorized use under the TMR MVUM. There are no camping corridors proposed near the Red Mountain Volcano.

The Red Mountain Geologic Area is was first proposed as a special area in 1977 and had a withdrawal from mineral entry at that time. The mineral withdrawal has since expired. The process for renewing the mineral withdrawal was started in 2003. However, the mineral segregation expired in 2005. The Red Mountain Geologic area is part of Management Area 17 in the 1987 Forest Plan. Off-road driving is prohibited in the geologic special area and a motorized vehicle restriction closure order is in place, Order 04-00-146 (Figure 7). Under the TMR EIS, there would also be no motorized big game retrieval in the special area. Part of the Red Mountain Geologic area is open to grazing (93 acres). Roads are managed next to the geologic area to prevent vehicle intrusion in order to maintain the natural conditions and processes. Roads that entered the geologic area were blocked by fencing and/or obliterated as per the 1987 plan.

A specific management plan for the Red Mountain Geologic Special Area is not known to exist by this author.

**Figure 2: Photos of Red Mountain**



### ***Cottonwood Basin Fumeroles Geologic Area***

The Cottonwood Basin Fumeroles are located in the Cottonwood Basin watershed of the Verde Valley about one half mile south of State Highway 260 and west of FR708 (Figure 8). The fumeroles are distinct, unique, visually attractive and interesting geologic formations that have developed from physical and chemical weathering of volcanic fumeroles that formed within the Towel Creek Tuff (Figure 9). Fumeroles are cracks or vents in the earth's surface through which steam and volcanic gases escape into the environment. The formations resemble tepees or cones with holes or caverns in the rock formed by weathering processes. The tepees themselves are mostly unvegetated and form a dramatic contrast to the valley bottom area which has a variety of grass, shrub, cactus and flower species (Figure 3).

**Figure 3: Photo of Fumeroles in Cottonwood Basin**



The prevailing theories (Conca, 1985; Lewis, 1983; Elston et al. 1974a; 1974b) are that the features of tent rocks formed as fossil fumeroles or vents at the time of the main ignimbrite flow that covered the Cottonwood Basin area (Figure 3). The Towel Creek Tuff is a dacitic (composition between an andesite and rhyolite lava) ignimbrite. An ignimbrite is a pumice rich pyroclastic flow such as what occurred with the Mt. St. Helens volcanic eruption in 1980. The ignimbrite is a sheet flow of hot volcanic pumice up to fist sized and finer grained material – this sheet flow extended over many miles from the volcanic eruptive center. It flowed in the Cottonwood valley and adjacent areas. This ignimbrite or tuff is light colored ranging from white, to beige and pink in color.

The Towel Creek Tuff occurred near the top of the series of volcanic eruptions associated with the Hackberry Volcano (Lewis, 1983; Elston et al. 1974a; 1974b). See also Figure 9. The tuff is overlaid and underlain by the sedimentary Verde Formation sandstones and clastic materials. The tuff dates to between 7.8 and 6.0 million years ago. After deposition of the ignimbrite which was very hot at > 425 degrees C, water within the underlying Verde Formation sediments, rich in calcium carbonate, was driven up by fluid pressure into the ignimbrite sheets where it was heated (flashed into hot water and steam). The water moved up through fractures or vents in the Verde Formation into the tuff and when the waters became oversaturated with calcium carbonate, it deposited calcite into the tuff. We can see evidence of these fossil fumeroles as pipes along the sides of the tents/tepees, or coming up through lower levels of the tuff in the valley. The two pictures, Figures 4 and 5) show cylindrical pipes that carried hot calcium rich fluids into the tuff.

**Figure 4: Photo of Fumeroles in a drainage**



The tent rocks have been present in their form today for a very long time, probably since Pliocene-Pleistocene or a couple of million years (J. Conca, personal communication, May 6, 2011). It is hypothesized that the unroofing of the Verde Formation sedimentary formation happened 2-3 million years ago which exposed the Towel Creek Tuff (Lewis 1983). That started the process of weathering and erosion to form the cones. The unroofing of the Verde Formation probably is associated with activity on the Fossil Creek Road Fault which trends along FR708 just east of the area.

**Figure 5: Example of erosion effects on fumarole pipes**



Other similar types of tent rocks are found at the Kasha-Katuwe Tent Rocks National Monument on the Pajarito Plateau in north-central New Mexico. This geologic area was designated as a National Monument in 2001. These tent rocks formed from pyroclastic flows from the Jemez Volcano about 6-7 million years ago. Other similar volcanic areas showing cavernous weathering and fossil fumeroles are known at Crater Lake National Park in Oregon, and the Valley of Ten Thousand Smokes associated with Katmai Volcano in Alaska.

The proposed geologic area includes habitat for some of the unique native plant community in the area. Recently, botanists and volunteers have documented many plant species within the proposed boundary (Phillips and Crisp 2011, Botany Specialist Report for Forest Plan Revision) including a high level of diversity of episodic desert spring annuals. Although no threatened, endangered or sensitive (TES) plant species or analysis species have yet been collected in the area, botanists find new species upon each return trip. The geological area would preserve desert spring annuals and other plant species within that small area. The unique soil compositions of rocky shallow soils that were formed by a combination of lake bed sediments and volcanic activity which are the focus of the geologic area are able to support this unique plant community.

The proposed Cottonwood Basin Fumeroles area is within Management Area 11, Verde Valley in the 1987 Forest Plan. No mention is made of the Cottonwood Basin Fumeroles or geological resources in this management area section of the plan.

The Cottonwood Basin Fumeroles (Figure 8) was proposed as both a geologic and botanical special area in 2007 as part of the early stages of the Forest Plan Revision Process (Haessig, 2007a, 2007b).

OHV use is the major disturbance to the area. Livestock grazing has been a past disturbance to the area. Also occurring is the loss of small fumerole formations by removal, degradation of the formations by people shooting paintballs and using the area for target shooting in the area, and people moving small formations around to make rock piles. Rock formations may have also been removed by the public. Trash dumping also occurs in the area off of the 500A road. ATVs are also riding down the steep slopes of the stream valley on the hardened tuff. The tracks formed by the ATVs are accelerating erosion of the slopes.

The proposed geological special area lies within the Hackberry Range Allotment. Currently and since the 2010 NEPA decision on the allotment, grazing in the Tepee Pasture is deferred until such a time as soil and vegetative conditions improve to allow grazing. Disturbances such as livestock grazing, cross country OHV activity, dispersed camping and drought have contributed to reduce on-site vegetative and soil conditions both adjacent to and on the slopes of the Tepee rocks.

The geologic area is accessed by FR708. Parts of the proposed geologic area are within Forest Order 04-00-146 which prohibits off-road driving (Figure 8). With TMR, all off road driving is prohibited. A camping corridor is designated along the southwest side of this road in the 2013 MVUM Map. Road 500A takes off the FR708 and accesses the interior of the geologic area. This road ends on the top of ridge above the valley floor where the fumeroles are located. It is common to see recreational vehicles parked on this ridge top for the night as the views are outstanding. Recreational fires and camping is occurring at this location. The 500A road is open to motorized vehicles on the 2013 MVYM map. FR 500 traverses the northern boundary of the geologic area. This road is also open to motorized vehicles off the 2013 MVUM map. One other road is known within the geologic area, X-28462. The road is closed to public motorized on the 2013 MVYM Map – it is not shown. Under the TMR, off road motorized big game retrieval would not occur within most of the proposed Cottonwood Basin Fumeroles geological special area because of the existing closure order to off-road driving.

### *Cottonwood Basin Fumeroles Geologic and Botanical Area*

Establishment of the Cottonwood Basin Fumeroles Geologic and Botanical Area would increase the size of the special area from 926 acres to 2,559 acres and would recognize the unique native plant community in the area as well as the previously described geologic features. The combined geologic and botanical area would preserve desert spring and riparian vegetative communities and episodic desert spring annuals. The area contains several free-flowing springs which are unique features in desert environments. These springs include Cottonwood Spring, Mesquite Spring and an unnamed spring. The plant communities associated with these springs are especially unique and diverse. Recently, botanists and volunteers have collected 282 species from 66 plant families from within the proposed boundary (Phillips and Crisp 2011, Botany Specialist Report for Forest Plan Revision) representing a high level of diversity for the area covered. No TES plant species or analysis species have been collected in the area. The larger geological and botanical area includes more of the Verde Valley Formation which contains fossil vertebrate animal tracks including camel tracks. The presence of camel tracks has been noted by Barbara Phillips in the proposed botanical special area outside of the geologic area. They have not been mapped and recorded, however.

The larger proposed botanical area outside of the proposed geological area is accessed by FR708, FR500, FR9241, FR9244 and FR9242. These roads are all open to motorized travel on the 2013 MVUM map. Additional roads are present in the special area that are considered administrative use roads and would be closed to public motorized travel. These roads are FR 9138B, X-28842, X-29011, X-29087. Part of the geological area has a prohibition for off-road driving as part of Forest

Order 04-00-146. With TMR, all off road driving is prohibited. The larger botanical and geological area is within the Hackberry Allotment.

### *Volcanic Woodlands Management Area*

This management area is located in the northern part of the forest and includes the northern western and eastern extent of the San Francisco volcanic field surrounding San Francisco Mountain. It includes areas surrounding the Sunset Crater National Monument. The management area includes the Red Mountain Geologic area as well as many other volcanic cinder cones and lava fields.

**Figure 6: Cinder field and cones in Volcanic Woodlands Management Area**



## References Cited

- Conca, James Louis, 1985, Differential Weathering Effects and Mechanisms, PhD Thesis, California Institute of Technology, Pasadena, CA, 267 pp.
- Conca, Jim, Personal Communication, May 6, 2011, Personal Communication, Email, questions about the fumeroles and the Towell Creek Formation, 4 p.
- Dewitt, E., Langenheim, V., Force, E., Vance, R. K., Lindberg, P. A. and R. L. Driscoll. 2008. Geologic Map of the Prescott National forest and the Headwaters of the Verde River, Yavapai and Coconino counties, Arizona. 100 p.
- Elston, D. P., McKee. E. H., Scott, G. R., and G. Dale Gray. 1974a. Miocene-Pliocene Volcanism in the Hackberry Mountain Area and Evolution of the Verde Valley, North Central Arizona, *In: Geology of Northern Arizona, with Notes on Archaeology and Paleoclimate Part II – Area Studies and Field Guides. Geological Society of America. Rocky Mountain Section Meeting. Pages 604-610.*
- Elston, D. P., Nations, J.D. and G. Dale Gray. 1974b. Field guide for southeast Verde valley – Northern Hackberry Mountain Area, North-central Arizona, *In: Geology of Northern Arizona, with Notes on Archaeology and Paleoclimate Part II – Area Studies and Field Guides. Geological Society of America. Rocky Mountain Section Meeting. Pages 630-644.*
- Forest Service Manual 2800 Minerals and Geology, Chapter 2880, Geologic Resources, Hazards and Services, 2008, September 25, 67 p.
- Forest Service Manual 2300, Recreation, Wilderness, and related Resource management, Chapter 2370 – Special Recreation Designations, 1990, June 1, 18 p.
- Forest Service, U.S .Department of Agriculture. (1987 as amended). Coconino National Forest Land and Resource Management Plan. Flagstaff, AZ: Coconino National Forest. 486 p.
- Forest Service, U.S. Department of Agriculture. (2011). Coconino National Forest Draft Land Management Plan. Flagstaff, AZ: Coconino National Forest.
- Haessig, Polly, 2007a. Special Area Proposal Form for the Cottonwood Basin Fumeroles Geological and Botanical Area. 11 pp.
- Haessig, Polly, 2007b. Cottonwood Basin Fumeroles Special Area, Powerpoint Presentation. 18 pp.
- Lewis, Richard Edwin, 1983, Geology of the Hackberry Mountain Volcanic Center, Yavapai County, Arizona, PhD Thesis, California Institute of Technology, Pasadena, CA, 295 pp.
- Phillips, B. G. and D. L. Crisp, 2011. Botany Specialist Report, Coconino Forest Plan Revision DEIS.
- Priest, S. S., Duffield, W. A., Riggs, N. R., Poturalski B., and K. Malis-Clark. 2002. Red Mountain Volcano – A Spectacular and Unusual Cinder cone in Northern Arizona. *U.S. Geological Survey Fact Sheet 024-02.* 4 p.
- Riggs. N. R. and W. A. Duffield. 2008. Record of complex scoria cone eruptive activity at Red Mountain Arizona, USA, and implications for monogenetic mafic volcanoes. *Journal of Volcanology and Geothermal Research*, Vol. 178, pages 763-776.



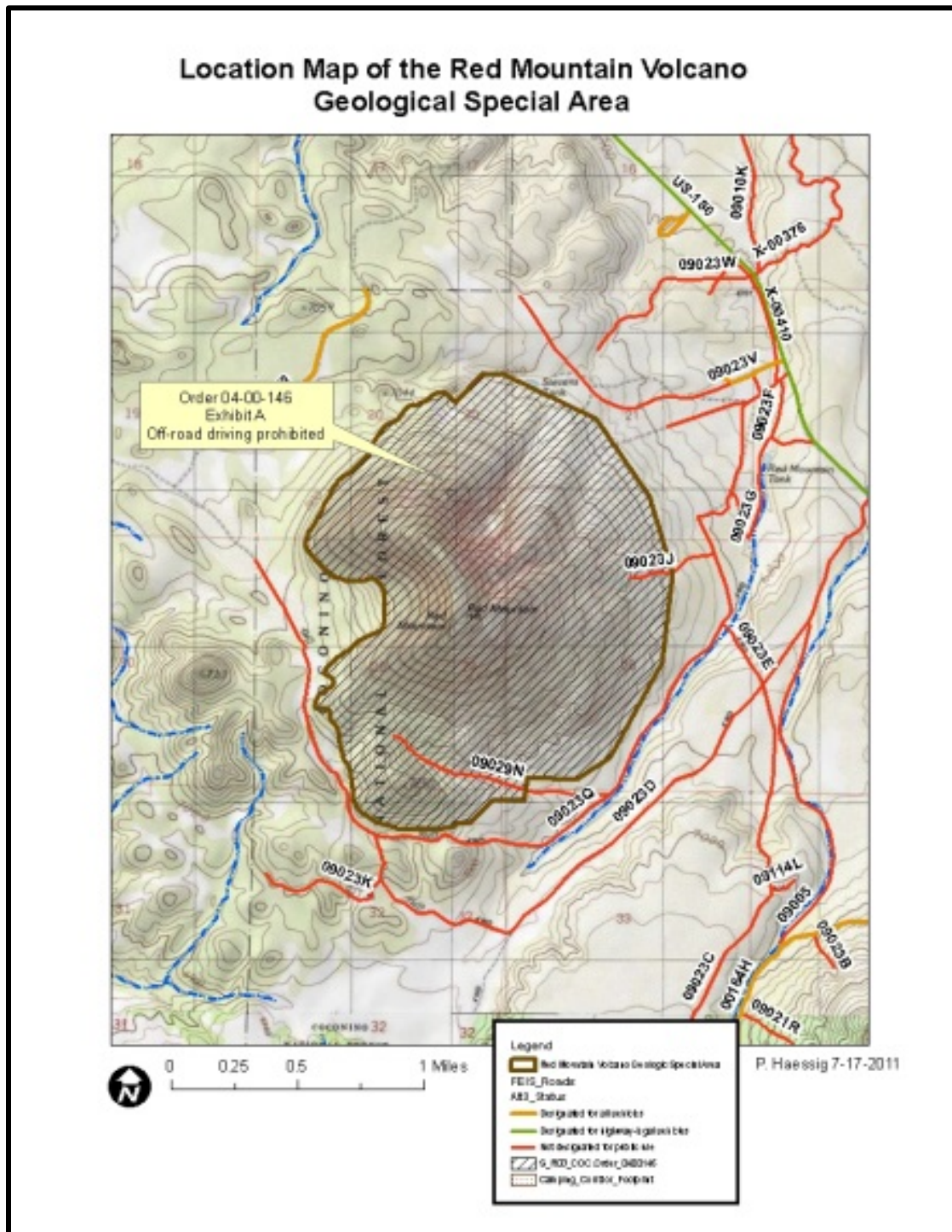
USDA. Forest Service. Southwestern Region. 2010. [Southwestern Region Climate Change Trends and Forest Planning, A Guide for Addressing Climate Change in Forest Plan Revisions for Southwestern National Forests and National Grasslands.](#) 46 pages.



## Education and Professional Experience

I have a Bachelors of Arts degree in Anthropology from Occidental College, in Los Angeles, CA and have studied undergraduate level geology at Occidental College and Washington State University, in Pullman, WA for a combined total of more than 4 years. I have a Master of Science degree in geology from Oregon State University (1988). My professional experience totals 23 years, including more than 17 years working as a geologist for the Forest Service and the Army Corps of Engineers, and more than 6 years working at a NEPA Specialist/Partnership Coordinator. My geologic area of expertise in is landslide mapping and hazard assessment, watershed analysis and restoration, abandoned mine reclamation and minerals administration. I am a registered Geologist in Oregon (#G1170) and California (#6565), and a registered Engineering Geologist in California (# 2313). I have been a contributing author on several unpublished internal Forest Service studies, and have been a senior or contributing author on some short scientific publications relating to geology and forest management and mine reclamation.

Figure 7. Red Mountain Volcano Location Map



[illegible]



Figure 9. Bedrock and Surficial Geology Map of the Cottonwood Basin Fumaroles

