An

Environmental History

of the

Kane

and

Two Mile

Ranches

in

Arizona

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A report prepared for the

Grand Canyon Trust

by

Joseph M. Trudeau

submitted

on the seventeenth day of March, 2006

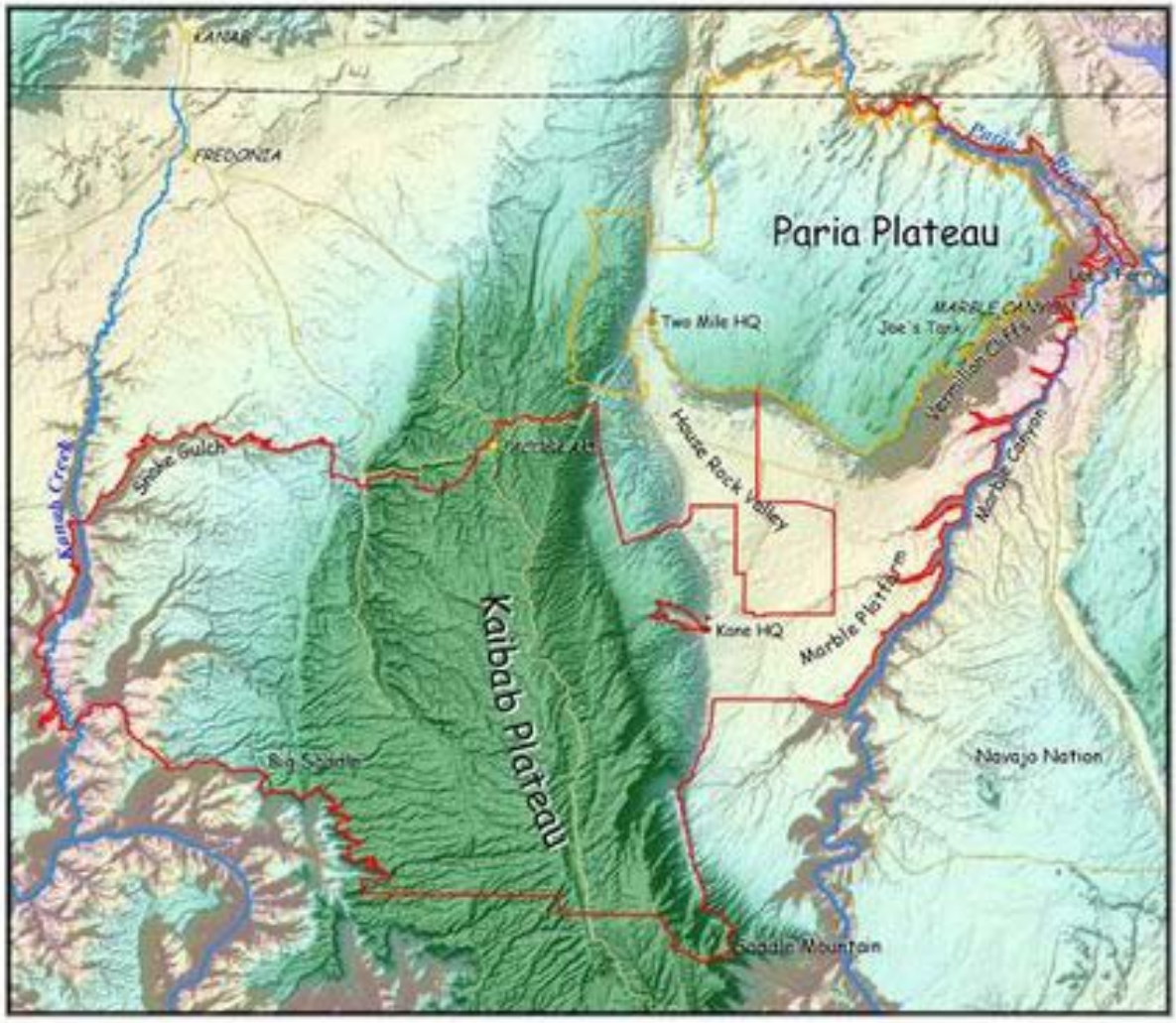


Figure i.i *The Kane and Two Mile Ranches in northern Arizona*

A Dedication

I dedicate this document to the land north of the Grand Canyon that we now call the Kane and Two Mile Ranches. The land there has been given many names through time, and before names there was only land; never empty, but without story. Someday, perhaps, our human presence there will end, the maps will fade, and the written records will become brittle like desert shale. Then the land will find itself again. Beyond the age of man, the wild, broken terrain will remain. This environmental history will be one of many attempts to find truth in our being. Without the gift of that place, none of these stories would have come to life; to that place I am obliged to extend my deepest gratitude for fostering this story as well as my own.

"Men will come and go, cities rise and fall,
entire civilizations will disappear.
The Earth remains.
Only rock is real."

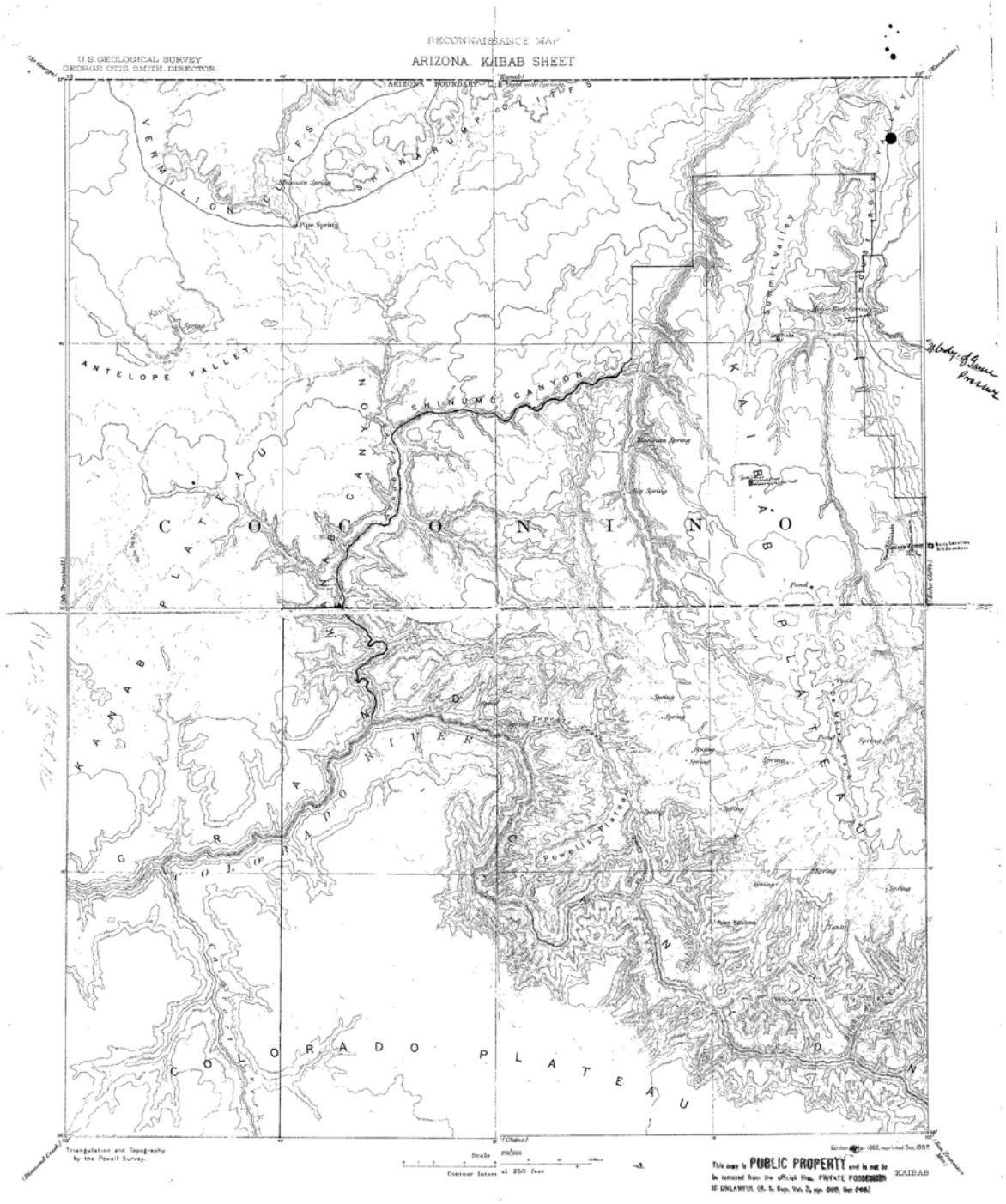
-Edward Abbey, Desert Solitaire

Acknowledgements

Completion of this project would have been much more difficult if not for the generosity of a handful of open minded individuals who found the time to point me in the right direction and open doors along the way. First, I thank Ethan Aumack and the rest of the Grand Canyon Trust for giving me the opportunity to tackle this research as well as providing generous funding and logistical support. The staff and student employees at Northern Arizona University's Cline Library Special Collection and Archives; Doug Alder and Bonnie Percival at Dixie State Colleges Special Collections and Archives in St. George, Utah; and Scott Anderson at the Sharlot Hall Museum in Prescott, Arizona were all very helpful as I poured through thousands of pages of historic documents and images. Britt Betenson and Dustin Burger at the North Kaibab Ranger District office in Fredonia, Arizona, and Linda Price and Bob Sandberg at the Bureau of Land Management Arizona Strip Field Office in St. George offered valuable personal knowledge and procured important historic documents. Former North Kaibab Officer Dennis Lund at the Ecological Restoration Institute in Flagstaff, Arizona was especially helpful in providing his intimate knowledge as well as many historic photographs. A wonderful afternoon with Thom Alcoze from the NAU School of Forestry provided insights into the rich Native American history that is largely ignored and forgotten. Jim Mead from NAU Laboratory of Vertebrate Paleontology and Lisa Floyd from Prescott College generously allowed me to use unpublished manuscripts and reports and provided good conversation. I thank my four housemates who dealt with my compulsive attitude while completing this project, and especially my love Amber Fields who shared ideas and experiences with me that ultimately allowed me to maintain my own headspace as I organized thousands of years of stories into one fluid version of history. Finally, I am deeply grateful to my parents who raised me to be a tenacious son of a bitch willing to dig in and do the best job possible.

"…don't you 'spose when you do a job you should do it the best way you know how?"

-some old yankee



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Produced during the John Wesley Powell surveys, published 1885

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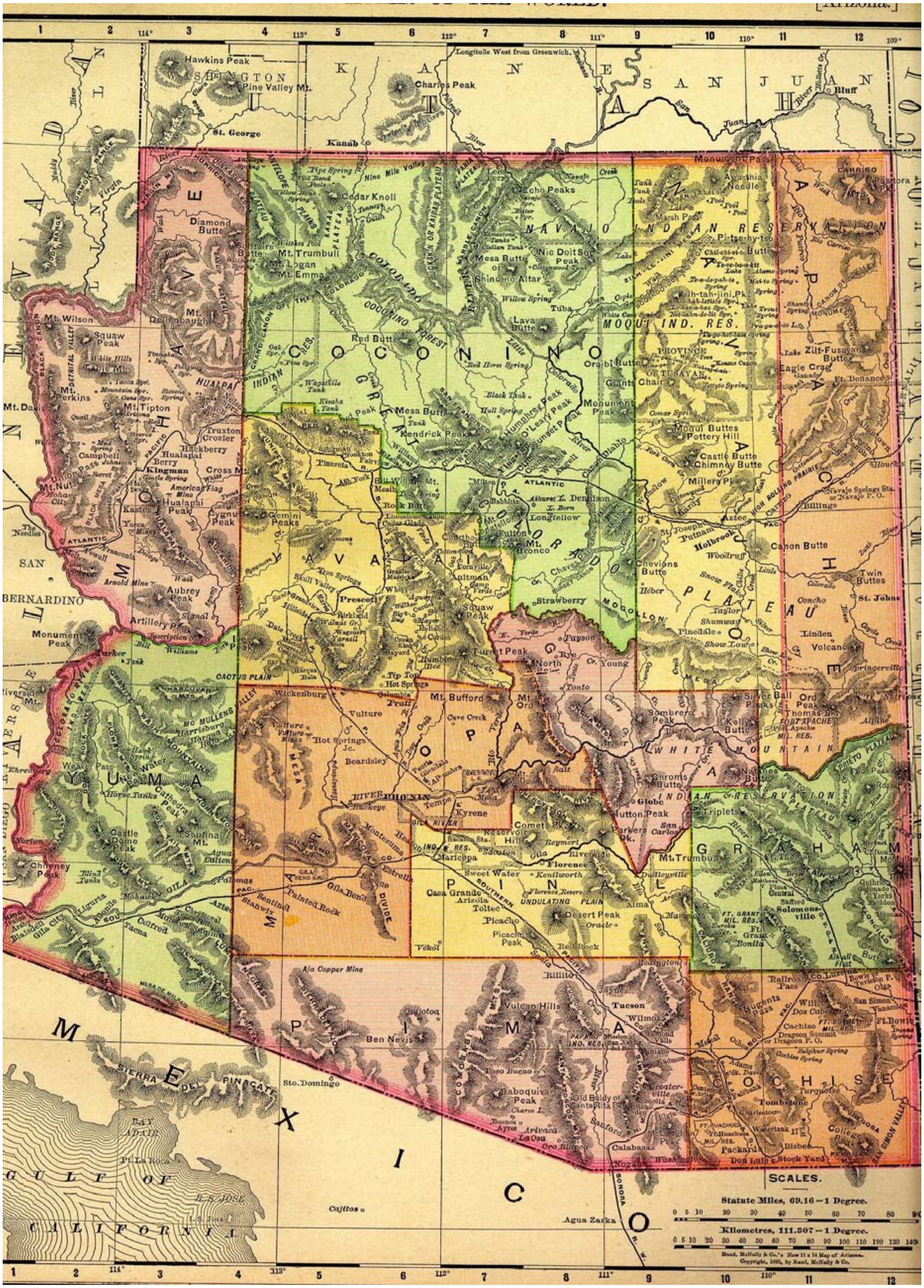

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Introduction

This document is the result of two and a half months of intense critical research and review of the multiple historical components of the development of human and ecological communities and associated ecological impacts for the portion of the eastern Arizona Strip known as the Kane and Two Mile Ranches (Figure i.i). Owing to the short period of time (two months) spent investigating this environmental history some facts or stories have not been included. However, to spend any more time searching for additional documentation may be an exercise in futility. There is no more detailed document available, quantitatively or qualitatively, to provide historic contextual and factual information for the area specified.

Seven chapters are presented that can be used in two ways: 1) a complete read through the entire document describes all aspects of the environmental and human history of the Kane and Two Mile Ranches, or 2) reading individual chapters allows the reader to answer specific questions regarding certain aspects of the areas ecological and human history. Because of the nature of this format, some overlap exists from chapter to chapter and there is some repeated information.

Each chapter is written to answer what I feel are some of the pressing ecological questions faced by resource managers on the Kane and Two Mile Ranches. Chapter 1 describes the history of Native American occupation and use of the area. There is a specific slant towards evaluating what is known and drawing conclusions about those peoples effects on the landscape and their role as determinants of ecosystem structure, function, or composition. A substantial portion of the chapter focuses on Kaibab Paiutes use of fire as an ecosystem management tool and their interactions or reliance on mule deer.

Chapter 2 reviews historical information related to House Rock Valley for the purpose of providing reference guidance to range managers and ecologists who seek to maintain or restore functional desert grassland and shrub ecosystems within their range of natural variability. Included in this chapter are reviews of pertinent paleoecological studies, historical accounts of the valley, impressions and impacts of Mormon colonists and settlers, and descriptions left by the John Wesley Powell surveys and early tourists.

Chapter 3 provides an extensive compilation of the history of livestock grazing at the ranches and surrounding area. Agency records, accounts of explorers and surveyors, and personal narratives and journals combine to present important facts pertaining to the development of grazing infrastructure, stocking levels, areas of prolonged intensive use, and effects on ecosystem health. Also, this chapter reviews what is known about the indigenousness of bison, and reviews the Kaibab deer irruption.

Chapter 4 is a review of historical accounts of the Kaibab Plateaus forest and the impressions and data from the earliest forest inventories and ecological studies. Ecological processes such as insect disturbance and windthrow are discussed in detail. Also discussed are predators, changes in overstory structure, ground flora in meadows, pine, and spruce-fir ecosystems, and points to consider when interpreting historical descriptions.

Chapter 5 takes a more scientific approach than previous chapters. I review the history of fire on the plateau in all forest types. Ample peer-reviewed studies provide important reference information regarding fire regimes, scale of past fires, effects on understory plants, and generally discuss the range of natural variability of fire on the Kaibab Plateau. Also included is a discussion of the development of roads and fire suppression infrastructure, recent fire activity and behavior, and management implications.

Chapter 6 attempts to define the natural range of variability of fire, ground flora, overstory structure, and biological soil crusts in pinyon-juniper woodlands. Relict site studies from the southern Colorado Plateau and studies of paleoenvironments are analyzed for patterns in ecological processes and composition. Information regarding blackbrush communities is included in this chapter, as well as historical accounts of pinyon-juniper woodlands and data tables to make comparison of relict sites to ranch sites less complicated.

Chapter 7 discusses what is known about arroyo cutting, the effect of long-scale climatic cycles on erosion, and implications for future erosional events. Following the last chapter is a complete bibliography, a short annotated bibliography of what I determined to be the most substantive pieces of literature to answer specific questions, and several appendices. Throughout the document are historic photographs that can be used for reasons of nostalgia or reference. Also included with this report are three supplemental items: 1) all literature that was copied or printed during the research for future reference, 2) a CD of all historic images collected during

research, and 3) a CD of electronic literature collected during research such as PDF's and Word Documents.

It was my intent to provide a thorough review and analysis of historic information to inform the Grand Canyon Trust to greatest extent practicable as they embark on a path of stewardship of the Kane and Two Mile Ranches. Each chapter stands alone as well as compliments each other chapter. The views expressed herein are solely those of the author and may not reflect views or opinions of the Grand Canyon Trust.

Chapter 1.

A Native American land use history of the Kane and Two-Mile Ranch area

Introduction

The Arizona strip still presents one of the great challenges to archaeology in the American Southwest. Little research has taken place compared to other regions, and much of it has not been published, is incomplete, or is very limited in scope or inference (Altschul & Fairley, 1989). The eastern Arizona Strip, most of which falls within the permitted lands of the Kane and Two Mile Ranches, has seen little archaeological and ethnographic research compared to nearby areas south of the Grand Canyon. This is due in part to the majority of funding going to the more visited and easily accessed South Rim districts of the Kaibab National Forest and Grand Canyon National Park, and that historically such studies were confined to timber sales and other land use projects which have been limited in scope and confined to the forested Kaibab Plateau (Brit Betenson, Kaibab National Forest, personal communication, 2/14/06).

The purpose of this paper is to summarize the historical land use and settlement patterns of the various cultures that have occupied or passed through the Kane and Two Mile Ranch project area, and to speculate on their effects on ecosystem development and maintenance. Several sources were of special importance and should be referred to if additional detail beyond what I have prepared is sought. Altschul and Fairley's (1989) document *Man, models, and management: An overview of archaeology on the Arizona Strip and the management of its cultural resources* is the most comprehensive compilation of existing knowledge regarding all aspects of human use on the Strip. However, recent research has yielded new information and re-interpretations of existing knowledge that has prompted some experts to feel that an updated document should be procured (Brit Betenson, Kaibab National Forest, personal communication, 2/14/06). The following paper in no way should serve as that document as it relies heavily on the Altschul and Fairley review. J. Donald Hughes' book *In the House of Stone and Light* (1991) is the one of the most oft-cited sources of information regarding prehistoric human settlement in the region. While this piece does not represent original field research it does review important facts and assumptions regarding past cultures and serves to support and add to Altschul and Fairley's document. The completion of this work would not have been possible without the

support of and conversations with Thom Alcoze of the Northern Arizona University School of Forestry and Brit Betenson at the Kaibab National Forest North Kaibab District Office in Fredonia, Arizona.

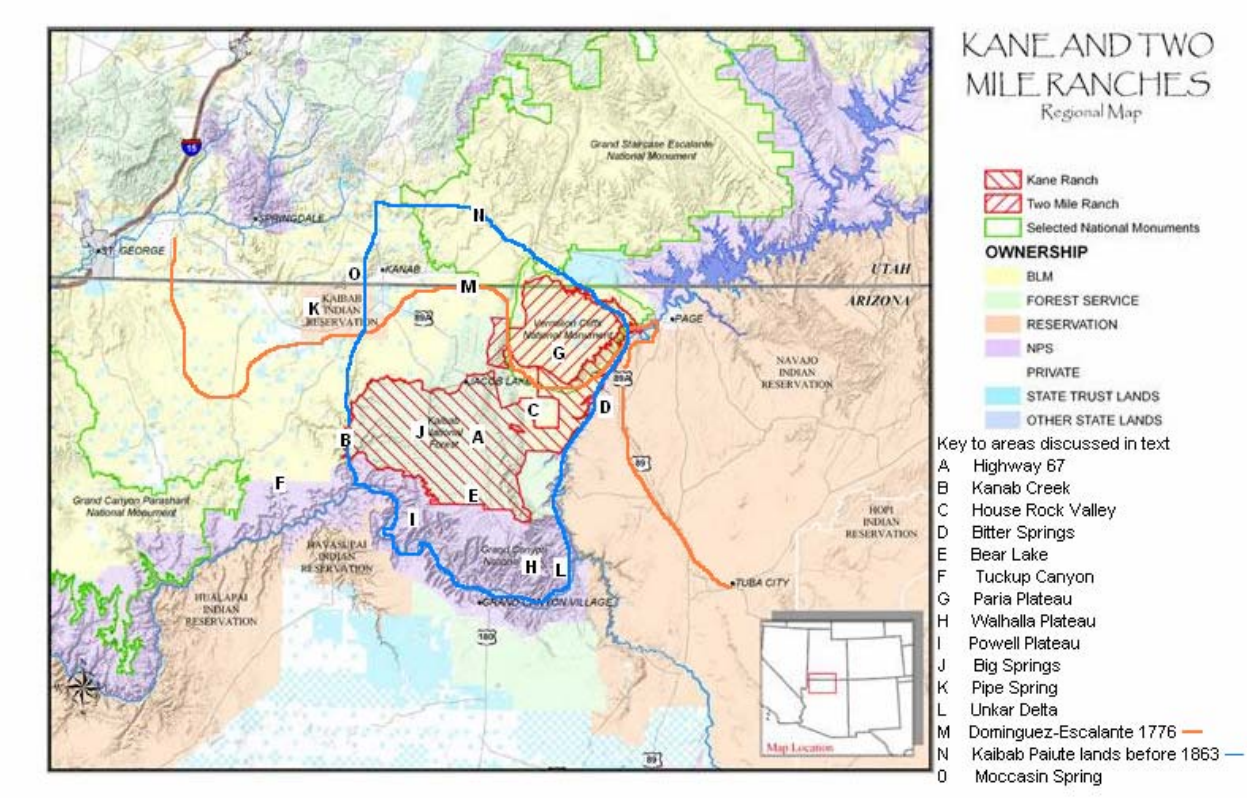


Figure 1.1 *Locations of sites and areas discussed in chapter 1*

Paleoindian and Archaic Periods: ca. 10,000 to 2,300 years before present

General history of Paleoindian occupation

The earliest evidence of a human presence in the Kane and Two Mile project area is currently a disputed topic. Azar (2005) suggested that the earliest evidence, stone points dating to ca. 6,000 years before present (BP), were uncovered during a 1984 archaeological survey of the Highway 67 right-of-way. Altschul and Fairley (1989) cite personal communication with National Park Service staff suggesting that a Folsom Point, dating to the Paleoindian Period (ca. 10,000 years BP) was discovered from Tuckup Canyon on the North Rim of Grand Canyon National Park. Although very little evidence exists for a Paleoindian presence on the Arizona Strip as a whole, use or occupation of the project area is highly possible as stone points have

been found to the west of the Kanab Creek drainage and just across the Colorado River from House Rock Valley at Bitter Springs (Altschul & Fairley, 1989). Possible exploitation by amateur artifact hunters, the covering of Pleistocene surfaces by wind borne deposits, and erosion and loss of artifacts may account for the sparse evidence. It is also possible that due to the remote nature of the eastern Arizona Strip, use of the area was never widespread or common.

Figure 1.2 *Petroglyphs in Snake Gulch, 1937*

Paleoindian land use patterns and ecological effects

The role of these people in affecting the trajectory of ecosystem development was probably limited. The Paleoindian was a hunter-gatherer who arrived at the Arizona Strip at a time of rapid and unique environmental change. Climatic changes of the early Holocene, including increasing intensity of summer monsoons (Weng & Jackson, 1999) and the arrival of two contemporary forest dominants, the pinyon and ponderosa pines (Swetnam et al., 1999; Weng & Jackson, 1999), would in all likelihood have been more responsible for determining

ecosystem composition or structure than the impacts of limited hunter-gatherer use. If evidence provided support for intensive Paleoindian use of the regions flora or fauna, then it would be possible that their presence would have been less benign, but very little evidence exists.

Archaic Period general history

Following the Paleoindian was the arrival or evolution of a slightly more advanced hunter-gatherer people; the Archaic Indians. The arbitrary line that separates the Archaic Period (ca. 9,000 to 2,300 years BP) from the Paleoindian Period is based on advancing methods of procuring, processing, and storing food (Altschul & Fairley, 1989). Archaic Period use of the area is substantiated by points made of Kaibab chert which would have been quarried from limestone on the Kaibab Plateau, and split twig figures recovered from the inner Grand Canyon. Archaeologists have suggested that more sites on the Kaibab from this period are waiting to be discovered (Buckley, 2004).

Land use patterns and ecological effects of Archaic Period Indians

Similarly to the Paleoindian Period, I would venture to say that the net effect of these people on ecosystem development, maintenance, or health would have been small. Cole (1985) found that the rate of change in species composition for the greater Grand Canyon region was more rapid during the Archaic Period than in the previous 14,000 years, suggesting that climate would have been a more powerful force than nomadic humans in shaping the flora and fauna of the area. Also, the local climate of the Kaibab Plateau was very dry during the period of 6,800 to 2,700 years BP, with Bear Lake at its lowest levels detectable in its paleohistory (Weng & Jackson, 1999) which may have made the region unsuitable for extensive or intensive human use. Ultimately, so little is known about the movements, dietary constituents, and culture of these people that is impossible to define their effects on prehistoric ecosystems without uncertainty.

Formative Period: ca. 2,300 years BP to 1250 A.D.

General patterns in Basketmaker Anasazi settlement and land use

Following the Archaic, the Formative Period spanned approximately 2,000 years, from the end of the Archaic Period to the abandonment of the region around 1250 A.D. The groups aligned with this period are the Basketmaker and Puebloan Anasazi, who throughout their occupation developed continually more sophisticated methods of crop cultivation, and slowly relied less and less on collecting wild foods (Altschul & Fairley, 1989; Azar, 2005). The Basketmaker Anasazi occupied the North Rim area from about 1 A.D. to 700 A.D., mastering the art, and necessity, of weaving fine baskets from grass and yucca, and waterproofing them with pinyon sap (Hughes, 1991). While they still relied heavily on hunting and gathering, they adopted corn farming early in their tenure which allowed them to become the first sedentary people to inhabit the area, living primarily in cliff dwellings (Altschul & Fairley, 1989). Their utilization of the resources in the area is clearer than previous humans, although many knowledge gaps exist. They hunted with atlatl's, women wore aprons of juniper bark, and rabbits were probably a very important source of food and skins (Hughes, 1991).

Cultural evolution of the Puebloan Anasazi

As these people further developed their farming techniques, their population expanded rapidly, possibly concurrent with favorable climate, and they started erecting house-like structures in communal units and making elaborate and functional pottery. At this point, around 700 A.D., the Basketmaker culture evolves into the Puebloan (Altschul & Fairley, 1989; Hughes, 1991). Significant additions to the technology of this group are the development of the bow and arrow for hunting (Azar, 2005), and the cultivation of a wider array of crops, including corn, beans and squash that were becoming more adapted to growing in the arid climate of the southern Colorado Plateau.

The Pueblo II is the best known group in Arizona Strip prehistory. They occupied all arable areas across the strip except for interior grass and sage valleys, though some evidence of farming in those areas exists. Their habitation sites are concentrated on the Paria, Walhalla, and Powell Plateaus, as well as to the east and west flanks of the Kaibab Plateau and the east and south rims of the Kanab Creek drainage. An abundance of check dams, irrigation ditches,

terraces, and stone walls, as well as architecture with abundant storage space, indicates that agriculture was very important, but in the spring and summer wild foods would have played a very important role because by then the previous year's crop would have been consumed. For the most part, these people were probably seasonally mobile, but year round habitation would have occurred at sites where dependable springs flowed, such as Pipe Springs (Altschul & Fairley, 1989) and possibly Big Springs, although that location was probably too cold in the winter.

Structural sites of this period are uncommon in the forested areas of the Kaibab Plateau, but abundant in the pinyon-juniper woodlands below (Britt Betenson, U.S. Forest Service, personal communication, 2/14/06). Quarrying sites are common on the Kaibab Plateau where they would quarry chert from the Kaibab Limestone. Most use of the plateau appears to have been seasonal hunting and gathering use (Altschul & Fairley, 1989). The Walhalla and Powell Plateaus seem to be the exceptions to this rule. In the early 20th century Edward T. Hall and others surveyed the Walhalla Glades area and located numerous water control structures and other agricultural evidence that pointed to the use of that area as a summer farming location (Hughes, 1991). Subsequent studies revealed that Puebloan people would migrate from the summer location on the cool and moist Walhalla Plateau to the Unkar Delta in the eastern Grand Canyon for the winter. In similar fashion, a separate group would farm the surface of the Powell Plateau, and winter in cliff dwellings just below the rim. The lower elevation of the Powell Plateau would have made it unnecessary to retreat deep into the canyon during the winter. Houses were typically one to four room structures with occasional larger buildings with more rooms, perhaps for social gatherings (Altschul & Fairley, 1989).

The Paria Plateau was surveyed extensively in 1967 and 1968 by researchers from the Museum of Northern Arizona which was the first comprehensive survey of the eastern Arizona Strip. The Paria surveys inventoried 498 sites of the Pueblo II and early Pueblo III Periods. The plateau was intensively used by these people from ca. 1000 to 1200 A.D., with some use prior to then, but very limited (Figure 1.3). Any prior use is probably obscured by the abundant Anasazi evidence over it which included structures and agricultural evidence similar to that found on the Powell Plateau. Similar sites of this period were located in the lowest three miles of the Paria River Canyon where the canyon bottom is wide and suitable for agriculture, and numerous check dams have been identified in the upper reaches of House Rock Valley (Brit Betenson, U.S.

Forest Service, personal communication, 2/14/06). After 1300 A.D., very little evidence provides support for any use of the Paria Plateau (Altschul & Fairley, 1989).

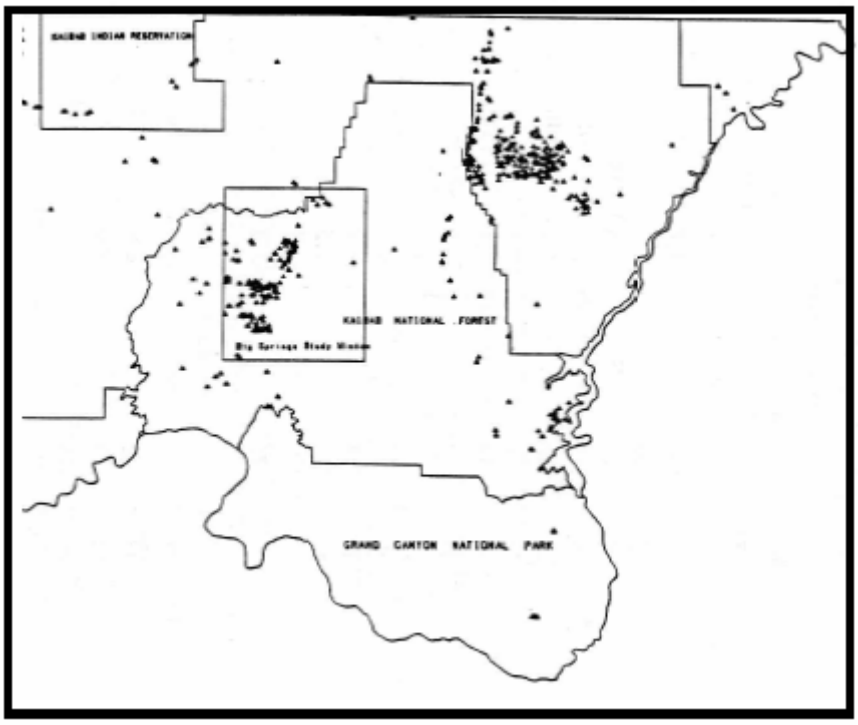


Figure 1.3 *Habitation sites for all periods (Altschul & Fairley, 1989: p. 256)*

Puebloan Anasazi land use patterns and ecological effects

The Puebloan Anasazi had a significant impact on the land. By the time their culture began to flourish the climate had already stabilized after the Wisconsinan Glaciation and the introduction of a summer monsoon flow, and vegetation communities had established that may be considered similar to modern assemblages (Weng & Jackson, 1999). Climate would no longer be the dominant force acting on the landscape, because now the human occupants were actively manipulating the land to their benefit. Historian J. Donald Hughes suggested that the "Pueblo Indians developed a well-balanced ecology in the Grand Canyon area, finding sources of water, growing crops in every available spot, carefully practicing erosion control and other conservation measures, and supplementing their food supply by hunting and gathering" (Hughes, 1991: p.11). Investigating the severe arroyo cutting on the late 19th and early 20th centuries across the Colorado Plateau, A.B. Reagan provided this insight into the possible long-term implications of the Anasazi's stewardship of the land:

> "…[T]he intensive farming and use of water for irrigation and the reservoiring of every side mountain canyon for village use and for irrigation in the days when the [Anasazi] swarmed the land caused the master streams to be filled up and the valleys to be aggraded, a process which continued even to our own time….The aggrading of the valley floors and the often laking of the same was evidently directly due to man's work….That this valley filling occurred since the coming of the [Anasazi] is evidenced by the presence of pottery, corn cobs, kitchen refuse, and occasional walls of rooms, buried beneath the filling of the terraces, now exposed in the banks of the present streams….The region then remained in a state of equilibrium as they left it for hundreds of years ….Then the Navajo came with his stock and the white man with his roads and trails" (Reagan, 1924: p. 284-285).

Reagan's assumptions of the cumulative effects of Anasazi agriculture may not be entirely accurate if we view arroyo cutting and aggradation as a natural cyclical process (Webb et al., 1991; Hereford, 2002) (see chapter 7), but it provides a novel insight into the potential of a culture that lasts for a thousand years to create a functional humanized landscape within the parameters of natural law.

Despite the conservation measures employed by these occupants, however, they abandoned all their settlements by ca. 1150 A.D. with some groups possibly holding out a bit longer. The commonly accepted reason behind their departure was a drought of enough duration that it exceeded their ability to store food and water (Altschul & Fairley, 1989). Hughes (1991) offers some alternative reasons, including that they exhausted their supply of fuelwood, game, or farmland; the population had exceeded its carrying capacity; or perhaps Paiute tribes moving in from the north and west succeeded in out-competing them for available resources. The latter has generally been disproved (Altschul & Fairley, 1989), but the former two, while extremely difficult to prove, could shed light onto the limits of contemporary human occupation of the area. We can never know exactly what degree of land management the Anasazi employed to sustain themselves for over 1,000 years on the eastern Arizona Strip beyond their agricultural practices, but given the intimate nature of their occupation, it is likely that a well developed understanding of land management techniques and the limits of human manipulation and management was shared throughout the culture.

Paiute occupation: ca. 1300 A.D. to present

Early Paiute settlement patterns

Whether or not the Paiute actually displaced the Anasazi in northern Arizona, they had arrived by at least 1300 A.D. and took the place of the Puebloan Anasazi as occupants of the Arizona Strip. If drought was the factor that caused the Anasazi culture to crash, the Paiute would have been better adapted to it as they were less dependent on agriculture. Originating in the Great Basin, the various bands of Shosonean ancestry were less sedentary, living out of temporary camps in easy-to-build primitive structures called wikiups (Stoffle & Evans, 1976). A great deal is known about the Paiute compared to previous cultures of the region, but they remain one of the least understood surviving Native American cultures of the desert southwest. The remoteness of the region that may have delayed exploitation by early Paleo and Archaic Indians also acted to delay exploration and settlement by Euro-Americans. The Paiute were essentially free of European influence and contact until the late 1850's which benefited them by allowing their lifestyle to proceed unencumbered by whites, but it also may have resulted in great losses of life from introduced diseases that traveled between tribes before detailed ethnographic studies could be done (Stoffle & Evans, 1976).

Paiute land use and ecological effects

Our contemporary understanding of Paiute lifestyle is shaped more by ethnographies than by archaeology. This is reflected in the literature where ethnographic descriptions (formal studies or informal accounts) are more common than archaeological descriptions. The earliest accounts of the Paiute people were the journals of Silvestre Vélez de Escalante and Francisco Atanasio Domínguez, who passed through northern Arizona and southern Utah in the autumn of 1776 (see Appendix 4). The journals have been transcribed and annotated by Bolton (1950) and Briggs (1976), and cited often as the definitive source of pre-settlement anecdotal data for the region. The Franciscan Fathers and their party of seven other men left Santa Fe, New Mexico hoping to pioneer a trade route to Monterey, California. After enduring extreme hardships crossing the middle of the Colorado Plateau, they arrived at the Great Basin and decided that to continue would be unwise, and they began their journey back to Santa Fe. The expedition

frequently relied on Native Americans for advice on where to find water sources as well as the best routes through the rugged landscape, and the Paiute were no exception.

The journals reveal some useful observations of the still isolated culture, especially related to their use of fire and of local flora and fauna. Escalante wrote that:

> "We found the grass of the plains where we came recently burned over and others burning, from which we inferred that these Indians had thought us to be Comanches, or other enemies; and as they had probably seen that we were bringing animals, it had been their intention to destroy the pasturage along the way" (in Stewart, 1941: p. 369).

The burnt grasslands they described are north of the Arizona Strip, but may suggest a use of fire that was common to indigenous groups of the region. The inference that the plains were burnt to destroy pasturage reflects the lack of understanding by the Spaniards of the benefits of fire to grasslands. In addition, they encountered the fires in the autumn, presumably after the year's grass seed harvest had been collected which would have been the opportune time set fire to grasslands (Thom Alcoze, Northern Arizona University School of Forestry, personal communication, 2/13/06). Soon after that, the expedition entered the lands of the Kaibab Paiute. The boundaries of the Kaibab Paiute territory are the Paria River to the north, the Colorado River to the east and south, Kanab Creek to the west, north from Kanab Creek across the Virgin River to the Kolob Plateau, and from there east back to the Paria River (Stoffle & Evans, 1976) (Figure 1.1). Generally the Kaibab Paiute would migrate seasonally within their territory but they would frequently venture further to trade with the Hualapai and Havasupai across the Grand Canyon, the Hopi and Navajo to the east, and the many tribes that lived south of the Grand Canyon along the Colorado River (Knack, 1993).

The expedition had endured great hunger and thirst in the deserts of the Colorado Plateau and this is reflected in the journal with their descriptions of the food they received from the Kaibab Paiute. Most of the Paiute diet consisted of roasted hares, pinyon nuts, prickly-pear cactus (*Opuntia* spp.) pads, which the Spaniards called 'tunas,' Indian ricegrass (*Oryzopsis hymenoides*) seeds and occasional hunting of desert bighorn sheep. The journals only briefly mention cultivation of corn, and interestingly never mention the Paiute having or sharing venison with them (Bolton, 1950). A California-bound Mexican trading party led by Antonio Armijo in 1829 passed through Kaibab Paiute lands utilizing the route pioneered by Escalante and recorded nothing of the Paiute except this: "The gentiles of the Payuche [Paiute] nation…live on grass

seeds, hares and rabbits, using the skins of the latter to cover a small part of their body" (Hayfen, 1947: p. 90). John Wesley Powell, who visited the Arizona Strip on numerous expeditions between 1869 and 1874 (see Appendix 5), described the Kaibab Paiute diet as heavily dependent on hares, at times single hunts returning with hundreds, and sunflower seeds were as widely collected and consumed as pinyon nuts. Also, Powell never mentions venison as a staple food, but that on occasions of festival they had clothing of tanned deer and antelope skins. Men's robes were of "wildcatskin" and wolf skin, whereas women would wear robes of rabbit skin (Powell, 1961).

A debatable topic in Kaibab Paiute history is the degree to which they harvested deer. Powell's writings and Escalante's journals mention nothing about eating venison, yet numerous sources suggest that they regularly used the Kaibab Plateau as an autumn hunting ground. For example, Onstott (1970) claimed that they killed 800 deer a year on the plateau, but she does not offer a primary source of that information, though it may have been from Rasmussen (1941) who reported that locals of the area claimed that at the most, 800 deer were killed annually, mostly during the fall. More importantly, Rasmussen also reported that

> "The Indians were primarily interested in the deer for their hides, and although a few were killed in all seasons, the bulk were killed in the fall, when the hides were thickest and best….The piutes [sic]…have always been great rabbit eaters, and the blacktailed jack rabbit…was their main source of meat, venison being of minor importance" (Rasmussen, 1941: p. 235).

It almost 'common knowledge' that the Kaibab Paiute traded their deer skins for Navajo wool rugs and blankets (Knack, 1993) and a story told by C.A. McCue in 1904 focused on annual Indian burning to push deer herds (Buckley, 2004). However, after a thorough review of the literature it becomes apparent that they relied more on small game than deer for subsistence. Why would they have killed small rabbits and rattlesnakes when they could have large deer? The answer may be in convenience: Quag-unt, a Kaibab Paiute who resisted assimilation until long after the arrival of Mormon's, said once to Brigham A. Riggs, a Mormon friend, that

> "There were not many rabbits. We kept them killed off for food....There was always deer on the Buckskin [Kaibab Plateau] and antelope down in the valleys but they were wild and hard to get till we got guns, and then lots of times we didn't have any powder" (Larsen, 2000: p. 22).

Perhaps then, the Kaibab Paiute only started to harvest deer *abundantly* after guns came with Mormon settlers in the 1860's. If this is the case, there are obvious implications for the modern management of the Kaibab deer herd which is predicated on thousands of years of traditional deer hunting. Interestingly, a history of the Forest Service in the southwest claims that

> "One noteworthy aspect of the early wildlife inventories is the relative scarcity of deer, a fact duly noted by foresters and wildlife conservationists, and which led to game laws and restocking and a remarkable regeneration of deer herds, the most famous of which became the Kaibab deer" (Baker et al., 1988: p. 10).

Another complicating factor in this debate is that young Hopi men would go to Moccasin Spring to kill their first deer. They would then return to the Hopi Mesa's and present the tanned hide to their elders. This showing of strength and skill would permit them to enter the Kiva for the first time (Larsen, 2000). Why the Hopi would bypass the Kaibab Plateau deer herds and travel an additional several days to Moccasin Spring seems odd and without reason. Whatever the historic utilization of deer was, it seems secondary to collection of the variety of plants that grew within the wide elevational range of their territory. Summer migrations to the plateau were concurrent with chokecherries, strawberries, and raspberries fruiting (Woodbury, 1944) and deer would be hunted too, provided it wasn't an excessive expenditure of energy.

Paiute ethnographies provide additional insights into pre-settlement conditions in the eastern Arizona Strip. Stoffle & Evans (1976) briefly mentioned that the Kaibab Paiute harvested elk at some point in their history, which is contradictory to the widely held belief that the Kaibab Plateau is the nation's foremost deer-only big game range. This is further supported in the diary of Sharlot Hall which says how the Kaibab Plateau lion hunter Jim Owens found elk antlers on the plateau on several occasions in the early 1900's (Hall, 1975). Elk are migratory herd animals capable of traveling long distances through dry terrain which would have made it feasible that they could travel to and from the high plateaus of southern Utah. Furthermore, a herd of twenty to thirty elk now reside on the Kaibab Plateau and they arrived under their own means from the aforementioned plateaus, further proof that the Kaibab deer range may have historically supported a wider range of herbivores than current management strives to maintain. Additional proof of at least the occasional presence of elk is the Paiute word *Paria*, which translates to 'elk water' (Barnes, 1935), although Wilson (1941) argues that the original spelling of the word is *Pah-reah*, which translates to 'dirty water'. This confusion illustrates the relative ease of losing valuable ethnographic information through time.

Paiute Forestry

Stephen Pyne, one of the foremost authorities on fire in the past and the present, describes 'Paiute Forestry' as an blanket term for the use of fire by Native Americans in ecosystem management (Pyne, 1982). It is interesting that although there is a term that directly attributes the use of fire to the Paiute, uncertainty still exists over whether or not they actually used it! As contemporary views of Native America continue to evolve, enlightened interpretations of Paiute land management begin to surface. For instance, a recent government document asserts that the Kaibab Paiutes primary influence in the pinyon-juniper woodlands

> "was the use of fire for ceremonial purposes and to aid in hunting. Additionally, fire *may* have been used to encourage plant growth. The Paiute use of fire not only created new openings in the woodlands, but also may have maintained some of the open areas created by earlier cultures. Adjacent sagebrush desertscrub habitat on the Buckskin Mountains was probably burned for a variety of reasons by Native Americans for hundreds or even thousands of years" (USDI Bureau of Land Management, 2004: p. 31, my emphasis added).

According to Northern Arizona University Forestry Professor Thom Alcoze, who is of Cherokee ancestry, this sort of statement only begins to describe the use of fire by Native Americans. Alcoze believes that to doubt that the Paiute used fire to shape the ecosystem is *ethnocentric racism.* He begs us to ask, why wouldn't the Paiute have used fire? Fire is a basic human character; it is part of what allowed us to move out of caves and into societies. Furthermore, the Kaibab Paiute believed fire to be a living creature, and to suggest that their use was for ceremonial purposes is consistent with stewardship of the land to provide food and shelter. It is also a basic human character to do what's best for you and your family, and maintaining ecosystem productivity through frequent burning would have done just that. It took nearly a century for the US Forest Service to develop an understanding of the role of fire in ecosystem maintenance, so the potential for a knowledge that developed over nearly one thousand years is immense. Through time, inhabitants of a place develop technologies and ethics that match that place, and without a doubt, this is what the Kaibab Paiute did (Thom Alcoze, Northern Arizona University School of Forestry, personal communication, 2/13/06).

Alcoze, after years of research into fire and Paiute land management practices, has determined that the Kaibab band developed such an intimate knowledge of fire that they would prescribe certain *types* of fire to provide desired outputs. They would burn at certain seasons to favor certain plants and they would burn under certain weather conditions to control the intensity

and rate of the fire to meet resource goals. In addition, this was an organized management tool. In the pinyon-juniper woodlands families would 'manage' multiple separate units probably based on topographic features, not arbitrary political designations. They would burn on four year cycles which would maximize the production of pinyon nuts and make collection easier. Early settler Bob Vaughn told of how the Paiute would burn below pinyon to make nut collection easier (Buckley, 2004) further supporting their use of fire.

In addition to furnishing food and supplies for basketry, Alcoze suggests that the Paiute would also burn in the ponderosa pine forest to prevent fuel accumulations that would support higher intensity fire that could possibly endanger their resource. In modern times, prescribed fires are typically set in the spring and fall when moisture levels are sufficient to prevent escape and loss of control. Typically, we assume that pre-settlement fires burned in the hottest and driest part of the summer when conditions allowed lightening strikes to cause the fires (see Wolf & Mast, 1998 and Laughlin et al., 2004 for examples on the interpretation of fire scars). Provided human influence was absent, this is entirely accurate because the likelihood of natural fires starting in wetter seasons is small. However, we may be entrenched in dogma that this is the *only* history of fire in the southwest. For example, Sesnie (2001) cites Mormon settler Nate Adams of Kanab saying that fires burned all summer on the Kaibab Plateau; however, returning directly to the primary source, Adams actually says this: "The smoke would be almost continuous from *early spring until late autumn*" (McHenry, 1994; p. 75, my emphasis added). Adams settled in Kanab in 1871 (Woodbury, 1944), prior to complete ousting of the Paiute from their traditional use of the plateau. This suggests that the Paiute very likely set fires during the safest times of the year to encourage desired plant growth and prevent conflagrations. Furthermore, in 1776 when the Spaniard Francisco Garcés traveled with the Hopi to the South Rim of the Grand Canyon (see Appendix 4) he wrote on July 26th: "were there seen on the north some smokes, which my companions said were those of whom they name Payuches, who live on the other side of the river" (Coues, 1900: p. 351). The smokes of which he saw were those of the Paiute according to his Hopi guides, and this was in the middle of the summer suggesting that perhaps Paiute burning actively burned throughout the year, as I suspect smoke visible from that distance would have to be a fire larger than that of just a campfire.

Conclusion

The earliest inhabitants of the Kane and Two Mile Ranch region arrived ca. 10,000 years ago and were primarily hunter-gatherers with less effect on ecosystem development after the Wisconsinan Glaciation than regional climatic regimes. The following period of human use, beginning around 2,300 years ago marked a significant transition in cultural land use patterns and societal organization. The Anasazi, who survived until drought forced abandonment around 1150 A.D., were successful farmers who also utilized wild food and material resources. The net effect of this culture is not negligible as they engaged in widespread manipulation of the environment to serve societal needs. Following the abandonment of the area by the Puebloan Anasazi, early Paiute hunter-gatherers inhabited the region and remain indigenous in modern times.

The Paiute developed sophisticated means of living in a hostile and oppressive environment which included limited agriculture, using fire to manage resources for their benefit, and maintaining mobility to allow resources in one area to recover while they exploited resources in areas with enhanced forage and game resources. Stoffle and Evans (1976) estimated that no less than 5000 Kaibab Paiutes inhabited the roughly 4,824 square miles of their territory prior to the introduction of European diseases from southerly Mojave tribes. By the time of Mormon settlement approximately 500 had survived the waves of disease, and by 1873 eighty-two percent of the remaining tribe had died due to resource competition with Mormon cattle and sheep (Stoffle & Evans, 1976). Creation of the Grand Canyon Game Preserve in 1893 effectively cut the Paiute off from traditional hunting and foraging grounds on the Kaibab Plateau which served to put an abrupt end to resource utilization and habitat enhancement activities that had supported the tribe and significantly affected the ecology of the plateau and surrounding lands. By 1907 when the Kaibab Paiute Indian Reservation was created at Moccasin Spring slightly more than 100 people remained, and their condition was destitute (Hughes, 1991). What little we know about their utilization and management of the resource base is gleaned from several accounts of early explorers and ethnographers, and stories passed on through generations. It is important to recognize that their continued intensive use and modification of the area is directly tied to our notions of pre-settlement conditions, and may be fundamental in understanding the role of active or passive management in fostering the recovery of ecosystem health and integrity.

Literature Cited

Altschul & Fairley. 1989. Man, models, and management: an overview of archaeology on the Arizona Strip and management of its cultural resources. Report prepared for USDA Forest Service and USDI Bureau of Land Management. Prepared by Statistical Research, Plateau Archaeology, and Dames & Moore, Inc.

Azar, J.S. 2005. Buckskin Mountain. Pages 53-56 In Anderson, Michael F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, Arizona.

Baker, R.D, R.S. Maxwell, V.H. Treat, and H.C. Dethloff. 1988. Timeless heritage: a history of the Forest Service in the southwest. US Department of Agriculture Forest Service, FS-409, College Station, TX.

Barnes, W.C. 1935. Arizona place names. University of Arizona Bulletin 6(1). General Bulletin No. 2. University of Arizona, Tucson, AZ.

Bolton, H.E. 1950. Pageant in the Wilderness: The story of the Escalante expedition to the interior basin, 1776. Utah State Historical Society, Salt Lake City, UT.

Briggs, W. 1976. Without noise of arms: The 1776 Dominguez-Escalante search for a route from Santa Fe to Monterey. Northland Press, Flagstaff, AZ.

Buckley, S. 2004. Mountain lying down: Restoration, bioregionalism, and the indigenous Kaibab Plateau. Master of Liberal Studies Thesis, Northern Arizona University, Flagstaff, AZ.

Cole, K. 1985. Past rates of change, species richness, and a model of vegetative inertia in the Grand Canyon, Arizona. The American Naturalist 125(2): 289-302.

Coues, E. 1900. On the trail of a Spanish pioneer: The diary of Francisco Garcés. Frances P. Harper Company, New York, NY. Two volumes.

Hall, S.M. 1975. Sharlot Hall on the Arizona Strip: A diary of a journey through northern Arizona in 1911. Compiled by C.G. Campton. Northland Press, Flagstaff, AZ.

Hayfen, L. 1947. Armijo's journal. Huntington Library Quarterly 11: 87-101.

Hereford, R. 2002. Valley-fill alluviation during the Little Ice Age (ca. A.D. 1400-1880), Paria River basin and southern Colorado Plateau, United States. Geological Society of America Bulletin 114(12): 1550-1563.

Hughes, J.D. 1991. In the house of stone and light: A human history of the Grand Canyon. Grand Canyon Natural History Association, University of Denver Press, Denver, CO.

Knack, M.C. 1993. Interethnic competition at Kaibab during the early twentieth century. Ethnohistory 40(2): 212-245.

Larsen, W. 2000. Arizona strip stories as told in their own words. Draft manuscript on file at Dixie State College, Special Collections, St. George, UT.

Laughlin, D.C., J.D. Bakker, M.T. Stoddard, M.L. Daniels, J.D. Springer, C.N. Gildar, A.M. Green, and W.W. Covington. 2004. Toward reference conditions: Wildfire effects on flora in an old-growth ponderosa pine forest. Forest Ecology and Management 199: 137-152.

McHenry, D.E. 1994. Quaking aspen-its future in the park. Pages 75-76 in S. Lamb. (ed.) The best of Grand Canyon Nature Notes. Grand Canyon Natural History Association, Grand Canyon, AZ.

Onstott, T.A. 1970. Man and the northern Kaibab Plateau. MA Thesis, New Mexico State University, Las Cruces, NM.

Powell, J.W. 1961. The exploration of the Colorado River and its canyons. Dover Publications, New York, NY.

Pyne, S.J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton University Press, Princeton, NJ.

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecological Monographs 11(3): 229-275.

Reagan, A.B. 1924. Recent changes in the Plateau region. Science 60: 283-285

Sesnie, S.E. 2001. Environmental histories: a foundation for adaptive forest management on the Kaibab Plateau in northern Arizona. MS Thesis, Northern Arizona University, Flagstaff, AZ.

Stewart, G. 1941. Historic records bearing on agricultural and grazing ecology in Utah. Journal of Forestry 39: 363-375.

Stoffle, R.W. and M.J. Evans. 1976. Resource competition and population change: A Kaibab Paiute ethnohistorical case. Ethnohistory 23(2): 173-197.

Swetnam, T.W., C.D. Allen, and J.L. Betancourt. 1999. Applied historical ecology: using the past to manage for the future. Ecological Applications 9(4): 1189-1206.

USDI Bureau of Land Management. 2004. Landscape assessment for the Buckskin Mountain area. Grand Staircase-Escalante National Monument. Bureau of Land Management, Kanab, UT.

Webb, R.H., S.S. Smith, and V.A.S. McCord. 1991. Historic channel change of Kanab Creek, southern Utah and northern Arizona. Grand Canyon Natural History Association, Monograph No. 9.

Wolf, J.J. and J.N. Mast. 1998. Fire history of mixed-conifer forests on the North Rim, Grand Canyon National Park, Arizona. Physical Geography 19(1): 1-14.

Weng, C. and S.T. Jackson. 1999. Late Glacial and Holocene vegetation history and paleoclimate of the Kaibab Plateau, Arizona. Paleogeography, Paleoclimatology, Paleoecology 153: 179-201.

Woodbury, A.M. 1944. A history of southern Utah and its National Parks. Utah State Historical Quarterly 12: 111-209.

Chapter 2.

Valley seldom seen: what do we know about historical conditions in House Rock Valley, Arizona?

Preface

To the modern traveler, House Rock Valley is seldom a destination. Forty-some miles of US Highway 89A pass along the northern edge of the valley, skirting the moonscape flanks of the Vermilion Cliffs; hugging the crumbling façade of the Paria Plateau. Certainly, most drivers pass through on their way to places more appealing. Places like the North Rim of the Grand Canyon, the Colorado River at Lee's Ferry, or one of the small but rapidly growing desert cities of Page, Kanab, or St. George. Modern travelers, except for the hardy few who tour by bicycle, power their V-8's through the empty grasslands and shrub-steppes to the south and east. The narrow highway requires near constant attention and the undulating plain blurs while drivers strain to see to the horizon. Thirty miles south, beyond the rolling span and wide, dry washes, a massive notched mound breaks through the tilted platform. It's Saddle Mountain and the eastern Grand Canyon. The eyes that don't focus on the broad, low angled slopes of that far away crest of the Kaibab Plateau will be drawn the opposite direction, toward the steep, impregnable walls of the Paria. To most, House Rock Valley is another great western expanse; just another long drive that we make on our way to better places.

This is not a new phenomenon. To early Eoro-American settlers, House Rock Valley was a hot, dry plain where traveling was difficult if not arduous. Few dependable watering holes, some of which had bad water, and deep sand made the going tough. Prior to 1928, when Navajo Bridge finally broke the isolation of the Arizona Strip by spanning Marble Canyon, enduring adventurers were forced to cross the Colorado River by ford or ferry. Then they pushed over the powdery shalestone grades of the eastern end of House Rock Valley and made the sweeping arc south and west around the forbidding Vermilion Cliffs. Their eyes and hearts must have been set on the high, cool country of the Kaibab Plateau, or if coming from the west, on the shade and rest to be found at the mouth of the Paria River at Lee's Ferry. Few accounts of the trip through House Rock Valley were made in great detail, probably because of the

exhaustive rigors of the several days spent making the trip. Long, tiring days under an oppressive sun, with blowing sand stinging the eyes of horse and rider kept early explorers and settlers moving towards the comforts of what lay beyond the valley. With their eyes peering towards that goal, few noticed what lay to the south, far out into that grassy plain, in a valley seldom seen.

Introduction

There are some important questions that range managers and restoration ecologists today ask about ecosystems like House Rock Valley. It is common to hear questions like, "How have *things* changed since Euro-American settlement and the advent of intense livestock grazing?" Vague questions and answers abound. Numerous assumptions about the past are based on scanty support. First we must define what are the *things* that we want to know about? Are we asking about soils, vegetation, rare small mammals, or human use? Are we asking how biological soil crusts have been affected by introduced heavy-hoofed grazers? Can we award ourselves the ability to determine the distribution, patchiness, and disturbance regimes of a desert grassland that probably changed dramatically over the course of several decades over the turn of the 19th century? The story of the land here is change. To become informed we must ask some very specific questions, but we must grant ourselves the responsibility of carefully interpreting the past. We must make assumptions that are based on as much evidence as possible from diverse sources that account for the myriad stories of the past.

If House Rock Valley was a pristine and lush grassland prior to the impacts of livestock grazing, how long had it been in that *pristine* condition? Under what influences did those conditions evolve? What range of disturbances could have resulted from indigenous humans and native heavy-hoofed grazers that were there, perhaps in great numbers, in pre-settlement times? In reality, there are unlimited questions that could be asked, but there is very limited data to answer those questions. The nature of House Rock Valley, being somewhat of an Empty Quarter between destinations, has by fault of its own geography engendered a legacy of ignorance. Few studies have examined the ecology and biology of the valley's biota, few early travelers took note of the conditions beyond their suffering, and the intricate knowledge of the land held by the resident indigenous groups was largely ignored through a thirty year period of assimilation into a cash and cattle economy.

In the following discussion of the history of House Rock Valley I attempt to synthesize what we do know about historical and pre-historical conditions. Peer-reviewed scientific studies describe the paleoecological environment and the evolution of contemporary ecosystems. Journals and diaries of early explorers and exploiters provide enchanting glimpses into a place where predators roamed and Indians raided. Published works and archived manuscripts interpret clues left behind by ancient cultures and pioneer tales. And intuitive graduate students' theses through the last sixty years provide creative revisions of the past as our collective understanding of the land story expands. By sifting through the lot of stories narrated by a spectrum of tellers we can uncover details in pattern and process. Ultimately, a review of these changes through time will allow us to understand where in the big picture the valley is today, where it may be going, and how we can maintain and restore ecological health to a place that until today, as our culture awakens to the conservation of biodiversity and open space, has been perceived as a place between.

A context for change: packrat midden studies

Geologist and explorer Clarence Dutton wrote that the Colorado Plateau is an open book to be read by those who seek to understand the past (Dutton, 2001). He and those who followed in his footsteps studying stratigraphy, structure, and fossilized life have opened our eyes to the deep history of the regions landforms and biota. Flipping through these pages of time we arrive at a story told by a small rodent, the packrat. Packrats (*Neotoma* spp.) live in alcoves and caves, and collect artifacts of their immediate environment, usually within 30m of their nests (Cole, 1985) but sometimes from up to 100m away (Van Devender & Mead, 1976). Generally, the packrat will collect samples of most plants within its range, although woody species may be preferred over grasses and forbs. In addition, they will collect animal remnants, such as bones, hooves, dung, or teeth, for the purpose of dousing their midden with the scent of another animal, perhaps to confuse or ward off potential predators (Jim Mead, Laboratory of Paleoecology and Quaternary Sciences, Northern Arizona University, personal communication, 2/22/06). The rats urinate and defecate in their nest, and after decades, centuries, or millennia of use, a midden becomes a rock-hard recording of the flora and fauna of that time, easily dated by carbon 14 analysis.

Packrat midden analyses have been undertaken throughout the arid southwest, anywhere where alcoves permit the middens to stay dry and undisturbed. Reviewing a range of these studies would provide guidance to regional changes in vegetation and climate, but I have narrowed the scope of this review to those nearest House Rock Valley to avoid making ill-founded conclusions. Several studies within the Grand Canyon (Van Devender & Mead, 1976; Mead & Phillips, 1981; Cole, 1985; Coates, 1997) provide insights into paleo-environments which can offer a context for modern ecological organization and anthropogenic impacts through time.

Coates (1997) examined twenty-two packrat middens in the Little Nankoweap drainage in the eastern Grand Canyon. The middens ranged from 1005-1170m elevation, making the sites comparable to lower and middle elevations in House Rock Valley. In addition, modern plant communities at those sites are similar to the Inter-Mountain Basins Semi-Desert Grassland and Colorado Plateau Blackbrush-Mormon-tea Shrubland ecosystems found in House Rock Valley (see Chiquone, 2005 for descriptions). The middens revealed plant remnants dating to almost 40,000 years before present (BP). The only grass species detected was Indian ricegrass (*Oryzopsis hymenoides*) and it was present throughout the entire record, indicating that it has been an important plant in the area for some time. Other species that were common throughout the record were *Lithospermum, Lappula,* and *Cryptantha* spp., most of which were hardy perennial specimens. Very few annuals were detected. Some plants showed a vertical displacement of up to 1200m, including Rocky Mountain maple (*Acer glabrum*) and dwarf juniper (*Juniperus communis*) which are common at the highest elevations on the Kaibab Plateau to the west, but the average displacement was 600m lower than modern vegetational limits.

Interestingly, plants showed individualistic responses to climatic fluctuations, and *anomalous assemblages* were present many times throughout the record. These anomalous plant groupings are communities we would not expect to see today; for instance Douglas fir (*Pseudotsuga menziesii*) and limber pine (*Pinus flexilis*) were present at the sites until about 14,000 years BP along with Indian ricegrass. Today, Indian ricegrass is restricted to lower and mid-elevations, while Douglas fir is found near the highest elevations of the Kaibab Plateau, and limber pine is uncommon in the area. Also, Utah juniper (*Juniperus osteosperma*) was common throughout most of the record while other plants moved up or down in elevation as climate changed (Coates, 1997).

Mead and Phillips (1981) conducted a packrat midden study at Vulture Cave, in the western Grand Canyon near the Grand Wash Cliffs. The site was at 645m in the Muav limestone in Vulture Canyon on the south side of the Colorado River. This record went back 30,000 years with a gap from 11,000 to 2,000 years BP when the middens were not occupied. One midden from 1,000 years BP was recovered. Similar to Coates (1997), these authors found a vertical displacement of 600-1000m, with 57% of the recorded plants still found at the site. Providing additional support for the anomalous assemblages' concept, they found that prior to 23,000 years BP the site was a Juniper-single leaf ash (*Juniperus-Fraxinus anomalous*) woodland, and by 2,000 years BP the site was similar to modern a Mojave Desert community, yet most plants (57%) remained as a component of the ecosystem through climatic changes.

Perhaps the most important point to pull from these studies, which represent a small sample but characterize the findings of many inquires in the region (see Cole, 1985 for a thorough review) is that there are species that come and go with the warming and cooling of the earth, and there are species that seem well-rooted in a place, despite what climatic fluctuations and external influences occur. The Pleistocene House Rock Valley may have supported a vegetational community unlike any possible today. Could the valley have been a Douglas fir and Utah juniper woodland with scattered dwarf juniper and Indian ricegrass? I will venture to say yes, it may have been since the locality of the Little Nankoweap cave was like that.

During the period of the full Wisconsinan Glaciation (21,000 to 15,000 years BP) species typically grew 600-1000m lower (Mead & Phillips, 1981; Cole, 1985). As the glaciation came to an end and the climate became warmer and drier most species retreated upslope onto the Kaibab Plateau, but some remained. Species richness was lowest 12,000-9,000 years BP, as glacial dominants receded more rapidly than dry-adapted plants could move in, due to vegetational inertia and constrained rates of propagation (Cole, 1985). Species richness remained fairly steady from the early Holocene until the present time, though the composition changed most rapidly from 10,000-6,000 years BP (Cole, 1985), possibly related to strengthening summer monsoons and increased precipitation from the Gulf of Mexico and the Pacific Ocean (Weng & Jackson, 1999). Modern plant assemblages developed during the late Holocene from 4,000 to 2,000 years BP, and have changed very little since then. Cole's (1985) model of vegetational inertia is important to consider as modern climate is rapidly becoming warmer and drier. Species movements are constrained by their rates of propagation, and if the rate of warming exceeds the

ability of plants to move up in elevation, a decrease in richness can be expected. Additionally, anomalous assemblages could possibly develop if species of lower elevations and latitudes capable of rapid migration move up into House Rock Valley.

Early accounts of House Rock Valley

The first recorded descriptions of House Rock Valley are found in the journal of Silvestre Vélez de Escalante and Francisco Atanasio Domínguez who crossed the valley in the autumn of 1776. The journals have been transcribed and annotated by Bolton (1950), Briggs (1976), and others. The Franciscan Fathers and their party of seven other men left Santa Fe, New Mexico hoping to pioneer a trade route to Monterey, California. After enduring extreme hardships crossing the middle of the Colorado Plateau, they arrived at the Great Basin and decided that to continue would be unwise so they began their journey back to Santa Fe. The party crossed the Kaibab Plateau just south of the present day state line and entered House Rock Valley in its upper reaches where it is a narrow belt of sagebrush and grass between the Kaibab and Paria Plateaus. The party encountered a small band of Paiute Indians camped in the upper reaches of the valley, with whom they stayed with for several days while some members recovered from illness. The illness was apparently caused from eating Indian ricegrass seeds given to the party by some Paiutes in the vicinity of Pipe Springs, Arizona. They continued on with advice from the Indians on how and where to cross the Colorado River, which at that time provided much consternation to the traveler (Bolton, 1950; Briggs, 1976).

As they left the Indian camp and dropped into the great expanse of House Rock Valley Escalante wrote that “the land here is poor, for the part which is not sandy is a kind of soil which on the surface has about four fingers of gravel and beneath it loose soil of a different color” (Bolton, 1950: p. 110). Further on, as they rounded the eastern side of the Vermilion Cliffs they continued with “excessive difficulty because the animals, breaking through the surface gravel, sank in the ground clear to their knees” (Bolton, 1950: p. 112). The “surface gravel” encountered by this earliest expedition may have been a well-developed biological soil crust that grew over the fine sands blown off the Vermilion Cliffs, or perhaps it was a desert pavement formed by the clay-laden soils of the lower cliff layers. Whatever the surface was composed of, it was not mentioned by subsequent parties, most of which passed through the area after the

arrival of livestock. The following week the group attempted crossing the Colorado River several times before they succeeded at El Vado de los Padres (The Crossing of the Fathers) several miles upstream from Lee's Ferry.

The next reported expedition through House Rock Valley was the party of Antonio Armijo. In December, 1829, Armijo and a group of Mexican traders successfully pioneered a route to California, crossing the Colorado at El Vado de los Padres. Besides mentioning some encounters with Native Americans and the location of their camps, the party left no descriptions of that passage or their return in early 1830 (Hayfen, 1947; Crampton, 1972). Over the next few decades, the height of the Rocky Mountain Fur Trade era, several groups of trappers ventured onto the Arizona Strip and into the Grand Canyon, but there is little factual information on them. Moreover, the region was still under Mexican rule and trapping was illegal without permission of the Mexican authority which may have pressured these early adventurers to remain silent about their travels and exploits (Wilson, 1941). Whether these trappers explored or passed through House Rock Valley is unknown, but it is possible as the Paria River and others in the area were known to support beaver and otter prior to the arroyo cutting events of the late 19th century (Gregory & Moore, 1931) (see chapter 7).

Mormon exploration and early development of infrastructure

The next few decades saw increased travel through House Rock Valley as Mormon pioneers and missionaries pushed into Arizona from southern Utah. Apparently in 1847 William Bailey Maxwell of the Mormon Battalion crossed the Kaibab Plateau through deep snow and lost a mule crossing the Colorado River, but left nothing of his impressions of House Rock Valley (Larsen, 2000). Soon after that Jacob Hamblin made his first mission to the Hopi village of Oraibi in 1858 (Crampton, 1972) (see Appendix 4). On his early travels Hamblin's experiences served to develop names for the water sources along the route. Badger Creek is so named because Hamblin killed a badger there, and Soap Creek is so named because he attempted to make stew of the badger, but after boiling it all night in the alkaline water the stew was more soap than soup (Wilson, 1941).

Unfortunately, Hamblin left no written descriptions of his journeys through House Rock Valley. In fact, of Hamblin's thirteen missions to the Hopi he left virtually no impressions of the

landscapes through which he traveled. Hamblin's companions, however, did leave behind some interesting notes. On October 29, 1859, Thales Haskell wrote that their party "…camped on a small saleratus creek….Grass scarce, water bad, very little cottonwood…" (Brooks, 1944: p. 76). The creek was probably Soap Creek judging by the miles traveled. Just a few days earlier, on the 26th of October, Haskell, Hamblin, and a Mr. Crosby located the spring that now bears Hamblin's name: Jacob's Pools. The three dug out a hole and walled it in with soil to form a pool where their horses could drink (Cleland & Brooks, 1983).

A few years later, in 1863, Kanab, Utah was settled (Knack, 1993) and Mormon travel through House Rock Valley increased even more. Hamblin was actively promoting a route through the valley to reach the Colorado, and he first crossed at the outlet of the Paria River in 1864 in a driftwood raft (McClintock, 1921). By that point Hamblin and John D. Lee had built a small adobe structure at Jacob's Lake (Azar, 2005) and within the next several years a spring would be located at the southwest corner of the Vermilion Cliffs near two large boulders that had fallen in such a way as to create a makeshift shelter. This place would become the Rock House Hotel after a charcoal inscription above the entrance. The spring later became officially known House Rock Springs when it went down on one of John Wesley Powell's maps, and the whole valley then took on the name (Dellenbaugh, 1965). By then, Mormon settlements at Pipe Spring, Moccasin Spring, and Short Creek had put heavy pressure on the resident Kaibab Paiute Indians and resource competition had severely reduced their numbers (Stoffle & Evans, 1976). In 1866, the year Navajo raiders stole cattle from James Whitmore who had settled at Pipe Spring, there were two families of Paiute left living in House Rock Valley (Larsen, 2000). Apparently the family of Quag-unt resided there and almost all were wrongly killed by a Mormon posse in retaliation for the cattle stolen by Navajo's. Quag-unt and his younger sister survived the massacre and fled from the posse, spending the next 2 months walking around the southern end of the Kaibab Plateau, through the Grand Canyon, and north through the Kanab Creek drainage to join the few remaining families of Natives that were living in the vicinity of Pipe Springs (Larsen, 2000). This was the last group of Kaibab Paiute to live in House Rock Valley.

The John Wesley Powell surveys

After water sources had been mapped and a route well marked, the stage was set for the next big wave of travel through House Rock Valley; the John Wesley Powell explorations and surveys of 1871 and 1872. Powell's crew made frequent trips through the valley following a route that by then had become an established highway of sorts. From the Colorado River, the route jumped from water source to water source; Soap Creek, Badger Creek, Jacob's Pools, House Rock Spring, and then up onto the Kaibab Plateau to Jacob's Lake, basically following a route attributed to Jacob Hamblin, but in all likelihood used for centuries by Hopi, Navajo, and Paiute Indians as they traded with each other frequently. While camped at House Rock Springs in November, 1871, Walter Clement Powell wrote that

> "Wolves are plenty and we see them often…[they] come around our tent every night, around our fire, and around the beef, picking up scraps here and there, but still they are shy….[One night] we heard unearthly howls from all parts of the valley, first one, then another, and then all joined the chorus" (Powell, 1871: pp. 365-366).

His journal then goes on to describe how their group, who had become bored while stationed at House Rock for several weeks, would give chase to the wolves and set traps for them around their camp; a venture that was successful at least once. W.C. Powell's writing, which was eloquent and well crafted, often times elaborated on his disdain for the way the elder Powell was running the expedition.

While most of his writing says little about the valley he was forced to remain in for weeks, he did note on two occasions the deep and heavy sand along the route from spring to spring (Powell, 1872). Interestingly, the most common descriptions of early travels through House Rock Valley were complaints of the drudgery of toiling through deep sand for several days, such as in the diary's of Levi Mathers Savage (Savage, 1936) and Samuel Claridge (Ellsworth, 1987). Some travelers, however, took interest in the flora along the route, albeit sparse. In 1872, J.H. Beadle crossed the Colorado River and spent several days resting at Lee's Ferry with John D. Lee. After a thorough explanation of what *really* happened at Mountain Meadows, Beadle

> "hurried through the fifteen miles to the first gulch containing water and grass, where I rested until 2 P.M. Thence over another barren mesa twenty miles brought me to Jacob's Pool, *where the pasture lands begin*. The Pool is a clear,

> cold spring, at the head of a gulch, sending out a stream the size of one's wrist, which runs two or three hundred yards down the plain before it disappears" (Beadle, 1873: p. 654, my emphasis added).

From this description the route through House Rock Valley was through a barren desert until one arrives at Jacob's Pools, where good pasture could be found. According to Beadle, Lee only had twenty cows at his ranch at Jacob's Pools, so overgrazing can't be blamed for eliminating vegetation. After an overnight visit with Rachel Lee and her family, Beadle left

> "from Jacob's Pool [and] rode eighteen miles nearly straight west to the first water [House Rock Spring], and camped for the night in the midst of splendid pasture…. The grass on the plains here consists of two species of bunch grass, the common yellow [*Stipa comata*?] and the white-topped varieties [*Oryzopsis hymenoides*]. The last is by far the richest, the top containing small black seeds which, with its husk, is considered as nutritious as grain. *Neither of these grasses form a sod or sward, or give more than a faint tinge of green to the landscape*" (Beadle, 1873: p. 656, my emphasis added).

John D. Lee settles at Lonely Dell

While the Powell expeditions were making surveys of the distinctive landforms around the Grand Canyon, John D. Lee, famous for participation in the slaughter of 150 pioneers at Mountain Meadows in 1857, was homesteading the mouth of the Paria River and the springs along the Vermilion Cliffs. Lee's life was one of fleeing the law. He moved to the Paria more out of necessity than desire, for at that point it was still far from any who would seek to arrest him. His journal entry of Sunday, December 3, 1871 which tells of his forty mile trek through Paria Canyon to its confluence with the Colorado River should make modern canyoneers feel a bit less rugged:

> "We concluded to drive down the creek, which took some 8 days of toil, fatigue & labour, through brush, water, ice, & quicksand & some time passing through narrow chasms with perpendicular Bluffs on both sides, some 3,000 feet high, & without seeing the sun for 48 hours, & every day Some of our animals Mired down….Mud & Ice every day. We finally reached within 3 ms. of the mouth with 12 head, leveing [sic] the remainder to feed some 10 ms. above. 4 days had Elapsed since our provisions has exasted [sic]…" (Cleland & Brooks, 1983: p. 178).

Later when one of Lee's eleven wives Emma arrived at the place that would be her new home, she remarked, "Oh, what a lonely dell," and from then on the place came to be known as Lonely

Dell. Lee and family got to work and soon built a small home of driftwood pine that had washed down the Colorado River, and an earthen dam on the Paria River, which would be knocked out frequently by floods, filling their irrigation ditches with silt (Cleland & Brooks, 1983). Jacob Hamblin accompanied Lee to Lonely Dell and on his way back to Utah he met a band of Navajo and Paiute Indians who offered him a piece of land in House Rock Valley at the outlet of Kane Canyon which he accepted and later established some sort of ranch there (Creer, 1958).

Lee, in typical Mormon pioneer fashion, quickly set out to claim and develop the water sources in House Rock Valley. He wrote on Sunday, April 7th, 1872 that he

> "Staked off the Springs [Jacob's Pools]. Built 3 feet wall of a House by noon. Here another co. of Miners came up on their return trip. Said that they had intended to secure those Springs, But we were ahead of them" (Cleland & Brooks, 1983: p. 186).

Over the next two months Lee and his wife Rachel whom he "installed" there built two willow-pole and mud shelters, a rock corral, a thirty-five by thirty foot stone house with cellar, two parlors, two bedrooms, and a kitchen, and a rock enclosure for a five acre garden (Larsen, 2000). It is here in the historical literature that the name changes from Jacob's Pools to Rachel's Pools. The miners he ran into while staking off the springs were a common sight in those days. His journals reveal that during his tenure at Lonely Dell from 1871 to 1874, many miners and Navajo's crossed the river, either to pan for gold in the washes feeding the Colorado, or to trade with Mormons and Paiutes to the west of the Kaibab Plateau. In addition, his journals reveal that as late as February, 1873 seven lodges of Indians were camped fifteen miles south of Rachel's Pools (Cleland & Brooks, 1983). The journal doesn't give an exact location or describe which group of natives it was, but presumably the camp was at the only source of good water, Kane Springs, and the people were Paiutes who were trying to escape the competition from the Mormon settlements to the north and west.

In June of 1872 Lee caught wind of a posse coming from Utah to arrest him for his participation in the Mountain Meadows Massacre. He quickly fled to Jacob Hamblin's farm at the southern end of the Echo Cliffs at Moenave. Soon thereafter they traded properties, with Hamblin ending up owning Rachel's Pools, and Lee acquiring Kane Springs which Hamblin had acquired from the band of Indians (Creer, 1958), though it is unlikely it was developed to any great degree since he was away on missions so often. Hamblin never used the pools and they soon fell into disrepair. Lee returned to Lonely Dell later that summer and rode, along with one

of Powell's men, Almon Harris Thompson, to Kane Springs to evaluate the ranching possibilities there (Larsen, 2000). Sadly, his journal says nothing of his impressions of Kane Springs or the range thereabouts.

At this point, it is unlikely that the range had been over-utilized by livestock because Lee, being the primary landholder in the valley, never had too many animals. He made his initial trip through the Paria River gorge with somewhere between twelve and thirty cattle, and by 1874 he kept 125 head at his ranch , but according to his journals he could at best locate 114 of them, attributing the loss to depredations by Indians and miners (Cleland & Brooks, 1983). Harsh winters would also have kept herds at a minimum. Reading Lee's journal one gets a sense of a pioneer trying his best to settle a place that suffers under harsh winters, not the contemporary situation where House Rock Valley seems to be a desert of relentless summers. In the middle of May, 1872, while staying at Rachel's Pools, Lee writes: "Snow and rain incessantly & for the last 10 days it has been stormy & disagreeable" (p. 196). He goes on to describe during the following February "Heavy winds and 2 snow storms…" (p. 225), and that "The snow on the Kaibab was 2 to 3 ½ feet deep…" and on March 27, 1874: "Found snow in abundance [crossing the Kaibab], some places 4 feet, though melting fast" (Cleland & Brooks, 1983: p. 334). Deep snow is no surprise at high elevations on the Kaibab Plateau, but the standard route of travel over it then was by Jacob's Lake or sometimes even further north along the old Navajo Trail (Larsen, 2000) where today it would seem rather uncommon to see four feet of snow in March! The cold winters hung on for quite some time, as several years later, in January, 1878, Anthony Ivins and Erastrus B. Snow crossed the frozen Colorado River at Lee's Ferry on ice for the first and possibly only time in recorded history. Ivins went on to cross the ice thirty-two times, and once with a wagon loaded to 2,500 pounds. A short distance above and below the crossing, the river flowed freely and rapidly (McClintock, 1921). And nine years after that, a devastating blizzard during the winter of 1886-1887 resulted in huge losses of cattle all through the winter ranges from House Rock Valley to the Uinkaret Plateau seventy-five miles to the west (Niehuis, 1983).

John D. Lee (or perhaps really his extremely strong wives who did most of the work while Lee roamed from property to property) had made his mark on House Rock Valley when he finally fled south into the Valley of the Little Colorado in 1874, soon to be arrested and hung back in Utah at the site of the massacre. Emma remained at Lee's Ferry, assisting travelers with the river crossing for another year, and then Warren Johnson and family took over the ferry for

the next twenty years, maintaining the orchards and gardens that Emma installed, but never venturing into cattle or sheep raising with any great intensity. But it was the late 1870's when House Rock Valley would begin to see change at a scale unlike any in the last several thousand years, and a change that we shoulder to this day.

The Honeymoon Trail and the heyday of ranching

With the completion of the Mormon Temple in St. George in 1877, the Honeymoon Trail became one of the most traveled routes in Arizona history until the 1890's, when a temple in Mesa, Arizona was built (Thomas, 1974). Originally used by the Navajo who traded woven blankets for Paiute buckskins (Knack, 1993; Larsen, 2000), this is the trail that Jacob Hamblin developed for Mormon use (see Appendix 5). The Honeymoon Trail was heavily used during those two decades and the impact from that period of use may have been the first significant trampling of the valley. Ricketts (2001) sifted through the journals and stories of hundreds of the newlywed Mormon couples who followed the sandy road to St. George and back. Many accounts tell of the terrifying descent down "Lee's backbone" from the Echo Cliffs to the east side of Lee's Ferry, and then there are accounts of the difficult fight to get wagon and team through the steep and rough terrain of the Kaibab Plateau. But, in standard fare, the three to five days through House Rock Valley are devoid of comment. Along with their teams and wagons, some cattle and horses would be herded alongside for food and spares, which would have represented a significant level of use for an area that had seen perhaps a total of 150 cattle thus far.

Figure 2.1 *Old Lee's Ferry Road, east side of the Colorado River*

It was during this period that ranching became a serious investment for the Mormon colonists who by then had effectively decimated the Paiute and claimed essentially all of the

Arizona Strip as Mormon Territory. The purpose of this chapter is not to provide a detailed history of livestock use in House Rock Valley, so I won't go into great detail (see chapter 3). The important facts are that from 1877, when the Mormon Church introduced large herds by wintering 500 cattle and 5000 sheep in the valley (Coker, 1978; Rider & Paulsen, 1985; Buckley, 2004), the number of head increased until 1897, when the Kaibab Land and Cattle Company ran 33,000 head of cattle on the Kaibab Plateau and House Rock Valley (Buckley, 2004). After this point, the numbers began to come down, the damage had been done, and the travelers of the early 20th century would bear witness to a range far different than what Escalante and his party saw as they came around the bend at House Rock Springs 120 years earlier.

Figure 2.2 *Buffalo in House Rock Valley, no date*

Early 20th century impressions

In 1911 Arizona Territorial Historian Sharlot Hall and a companion made a six week journey by wagon around the Grand Canyon with the purpose of recording the story of the geographically and politically isolated Arizona Strip (Figure 2.3). Her journal entries mark the first mention of petrified wood which is a common component of the Chinle formation (Akers, 1960). She remarked on the abundance of full-size logs, entire petrified trees, strewn across the valley at the base of the Vermilion Cliffs (Hall, 1975). This forest of long ago was also encountered in October of 1854 by an exploratory expedition led by David Lewis that included, among others, Jacob Hamblin. Lewis wrote that they "found large specimens of petrified wood, almost entire trees as hard as stone…" but the journal isn't clear about which side of the Kaibab Plateau there were on (Larsen, 2000: p. 25). While it is still common to find small pieces of petrified wood in House Rock Valley, a century of pillaging has denied modern travelers the privilege of seeing these whole trees.

Figure 2.3 *Sharlot Halls Route in northern Arizona, 1911*

It was August, 1911, and through passing showers Sharlot Hall gazed out into the abused valley and wrote: "just now the bottom is green as paint with the crop of weeds and grass following the abundant summer rains" (Hall, 1975: p. 58), and "This has been a great cattle

country and the whole valley is furrowed with old trails; the range has evidently been overstocked for most of the grass is gone and weeds grow in its place as farther south in Arizona" (Hall, 1975: p. 59). Her observations of House Rock Valley are consistent with others of that era, such as Vernon Iverson who moved to the Arizona Strip west of Kanab Creek in 1917: "the land sure has changed since I first saw it. It's a real desert now. When I first came in 1917 there was grass all over the place. Tall lush grass and buffalo grass too" (Iverson, n.d.). However, state Board of Control surveyors who toured the Arizona Strip to assess the potential for economic development saw a different House Rock Valley, reporting that it "…supports a fine growth of grass composed of the various gramas, and giletta [*Hilaria jamesii*] seems to be the predominating species" (McOmie et al., 1913: p. 25).

Two years later, through continued heavy use of the range, former President Theodore Roosevelt made a trip to the Grand Canyon Game Preserve to hunt lions and see firsthand the wild wonders of the North Rim. After a successful hunt with game warden Jim Owens he turned his horse east and made the descent off of the Kaibab Plateau into House Rock Valley. Roosevelt's prose is strikingly romantic and conjures up images of the days of the Wild West, all while sharply contrasting with the Board of Control report:

> "At noon of the first day we had come down the mountain side, from the tall northern forest trees at the summit, through the scattered, sprawling pinyon and cedars of the side slopes, to the barren, treeless plain of sand and sage-brush and greasewood….All around, dotted with stunted sage-brush and greasewood, the desert stretched, blinding white in the sunlight; across its surface the dust-clouds moved in pillars, and in the distance the heat-waves danced and wavered….On the sand grew the usual desert plants, and on some of the ridges a sparse growth of grass….There was little save the sand and the harsh, scanty vegetation. In one place a little stream trickled forth at the bottom of a ravine, but even here no grass grew-only little clusters of a coarse weed with flaring white flowers that looked as if it throve on poisoned soil" (Roosevelt, 1913: pp. 309-310).

Conclusion

House Rock Valley has in some ways slipped through time barely noticed. Today the conservation community sees desert grasslands like House Rock Valley as one of the most endangered ecosystems, and severely deserving of increased protection and restoration. The challenge with restoring such places is that so little is known about their condition prior to

livestock grazing, fire suppression, road building, and other invasive anthropogenic impacts. Many assumptions are made regarding the 'lush' grasslands of the on relatively little evidence. The evidence compiled in this chapter should help in envisioning what House Rock Valley was once like.

Understanding that at long temporal scales the valley has possibly ranged from desert to woodland to forest should place contemporary change in relation to livestock grazing and climate change in an appropriate context. Still, adjusting to and managing for ecosystem health in the face of such changes presents an incredible challenge. Human use of the valley may have been significant for thousands of years depending on the degree of resource utilization and manipulation that Native Americans had (see chapter 1), however, such effects may be considered null when compared to the impacts of the last 140 years. Water sources at the base of the Kaibab and Paria Plateaus have certainly been known of for millennia but their development for livestock watering has been the most invasive use yet.

Numerous accounts of early explorers, travelers, and settlers mention the deep sand and generally barren nature of the valley, and only a few describe any lush grasslands. Our notions of the past must take into consideration the fact that House Rock Valley is a desert grassland, and there must be limits to the extent of highly productive grass and shrub ecosystems. Conversely, the degradation of some productive areas has occurred, many large native mammals including predators have been eradicated, and exotic weeds have been introduced; all factors that have altered the trajectory of the valley. To what degree we have departed from a natural range of variability I'm not so sure we can answer with the available data that I have presented. House Rock Valley is no longer just a valley seldom seen, for now the eyes of a true steward are locked in a contemplative gaze at the health and future of this rare piece of Earth. The intensity of our modern queries into this valleys ecology will have to be great in order to understand our role there today as well as how we can sustain it for tomorrow.

Literature Cited

Akers, J. P. 1960. The Chinle formation of the Paria Plateau, Arizona and Utah. MS Thesis, University of Arizona, Tucson, Arizona.

Azar, J.S. 2005. Buckskin Mountain. Pages 53-56 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Beadle, J.H. 1873. The undeveloped west. National Publishing Company, Philadelphia, PA.

Bolton, H.E. 1950. Pageant in the Wilderness: The story of the Escalante expedition to the interior basin, 1776. Utah State Historical Society, Salt Lake City, UT.

Briggs, W. 1976. Without noise of arms: The 1776 Dominguez-Escalante search for a route from Santa Fe to Monterey. Northland Press, Flagstaff, AZ.

Brooks, J. 1944. Journal of Thales H. Haskell. Utah Historical Quarterly 12: 69-98.

Buckley, S. 2004. Mountain lying down: Restoration, bioregionalism, and the indigenous Kaibab Plateau. Master of Liberal Studies Thesis, Northern Arizona University, Flagstaff, AZ.

Coates, L. L. 1997. Middle to late Wisconsinan vegetation change at Little Nankoweap, Grand Canyon National Park, Arizona. MS Thesis, Northern Arizona University, Flagstaff, AZ.

Coker, E. 1978. Historical resources of the Kaibab National Forest. USDA Forest Service, Kaibab National Forest, Williams, Arizona.

Cole, K. 1985. Past rates of change, species richness, and a model of vegetative inertia in the Grand Canyon, Arizona. The American Naturalist 125(2): 289-302.

Chiquone, L. 2005. Ecosystem descriptions. Unpublished report on file at Grand Canyon Trust, Flagstaff, Arizona.

Cleland, R.G., and J. Brooks. 1983. A Mormon chronicle: The diaries of John D. Lee. Vol 2. University of Utah Press, Salt Lake City, UT.

Crampton, C.G. 1972. Land of the living rock: The Grand Canyon and the high plateaus: Arizona, Utah, Nevada. Alfred A. Knopf Company, New York, NY.

Creer, L.H. 1958. The activities of Jacob Hamblin in the region of the Colorado. University of Utah Anthropological Paper #33.

Dellenbaugh, F.S. 1965. The Romance of the Colorado River. Rio Grand Press, Chicago, IL.

Dutton, C.E. 2001. Tertiary history of the Grand Canyon district. University of Arizona Press, Tucson, AZ. (reprint)

Ellsworth, S.G. 1987. Samuel Claridge: Pioneering the outposts of Zion. Self-published, Logan, UT.

Gregory, H.E. and R.C. Moore. 1931. The Kaiparowits region: A geographic and geologic reconnaissance of parts of Utah and Arizona. United States Geologic Survey Professional Paper 164. US Government Printing Office, Washington, DC.

Hall, S.M. 1975. Sharlot Hall on the Arizona Strip: A diary of a journey through northern Arizona in 1911. Compiled by C.G. Campton. Northland Press, Flagstaff, AZ.

Hayfen, L. 1947. Armijo's journal. Huntington Library Quarterly 11: 87-101.

Iverson, V. no date. Oral History of Vernon and Nora Iverson, on file at Sharlot Hall Museum, Prescott, AZ.

Knack, M.C. 1993. Interethnic competition at Kaibab during the early twentieth century. Ethnohistory 40(2): 212-245.

Larsen, W. 2000. Arizona strip stories as told in their own words. Draft manuscript on file at Dixie State College,

Special Collections, St. George, UT.

Mace, W. M. 1990. Will Mace memoirs: A letter to Gifford Pinchot dated February 9, 1940. Pages 65-73 in People and Places of the Old Kaibab. USDA Forest Service Cultural Resources Management Report No. 10. Southwestern Region.

McClintock, J.H. 1921. Mormon settlement in Arizona. University of Arizona, Tucson, AZ.

McOmie, A.M., C.C. Jacobs, and O.C. Bartlett. 1913. The Arizona Strip: Report of reconnoissance [sic] of the country north of the Grand Canyon. Arizona Board of Control.

Mead, J.I. and A.M. Phillips. 1981. The late Pleistocene and Holocene fauna and flora of Vulture Cave, Grand Canyon, Arizona. Southwestern Naturalist 26: 257-288.

Niehuis, C.C. 1983. Strip characters, strip cronies. Arizona Highways, August 1983.

Powell, W.C. 1871/1872. In Kelly, C. (ed.) 1948-1949. Journal of W.C. Powell. Utah Historical Quarterly 16-17: 257-478.

Ricketts, N.B. 2001. Arizona's honeymoon trail and Mormon wagon roads. Cox Printing, Mesa, AZ.

Rider, R.W., as told to D.M. Paulsen. 1985. The roll away saloon: cowboy tales of the Arizona strip. Utah State University Press, Logan, UT.

Roosevelt, T. 1913. Across the Navajo desert. The Outlook 105(11): 309-317.

Savage, L.M. 1936. Journal of Levi Mathers Savage 1876-1935. Compiled by Juanita Brooks and others as a Works Progress Administration project. Mimeographed by Brigham Young University Extension Division, Provo, Utah. On file at Dixie State College, Special Collections, St. George, Utah.

Stoffle, R.W. and M.J. Evans. 1976. Resource competition and population change: a Kaibab Paiute ethnohistorical case. Ethnohistory 23(2): 173-197.

Thomas, R.L. 1974. Couples made trek over romantic trail. Arizona Republic, 10-5-74.

Van Devender, T.R. and J.I. Mead. 1976. Late Pleistocene and modern plant communities of Shinumo Creek and Peach Springs Wash, Lower Grand Canyon, Arizona. Journal of the Arizona Academy of Science 1:16-22.

Weng, C. and S.T. Jackson. 1999. Late Glacial and Holocene vegetation history and paleoclimate of the Kaibab Plateau, Arizona. Paleogeography, Paleoclimatology, Paleoecology 153: 179-201.

Wilson, A.K. 1941. History of the Arizona strip to 1913. MA thesis, Arizona State Teachers College, Flagstaff, AZ.

Woodbury, A.M. 1944. A history of southern Utah and its National Parks. Utah State Historical Quarterly 12: 111-209.

Chapter 3.

A history of livestock grazing on the Kane and Two Mile Ranches

Introduction

The history of grazing on the Kane and Two Mile Ranch can be broken down into six periods: I) from 1871 to 1877 there was limited grazing by individual families on the northwestern portion of the Kaibab Plateau; II) from 1877 to 1887 the United Order of Orderville (UOO) grazed large herds of cattle, sheep, and horses over the entire Kaibab Plateau and began using House Rock Valley; III) from 1888 to 1897 the Kaibab Land and Cattle Company (KLCC) controlled the entire Kane Ranch range and increased the intensity of cattle grazing while lessening their interest in sheep; IV) in 1897 the KLCC sold out to Benjamin Franklin Saunders who operated the Bar-Z ranch until 1907 or 1909. Also during that period use of the Paria Plateau began in earnest on what is now known as the Two Mile Ranch; V) around 1909 E.J. Marshall set up the Grand Canyon Cattle Company and controlled most of the range until 1924, but around 1911 a forty mile drift fence was put up to keep Bar-Z cattle to the east of the crest of the Kaibab and allow smaller interests to use the west side, and VI) after 1924 and the signing of the Taylor Grazing Act the range was continually divided into more and smaller allotments to different land owners and permittees, and steady use of the Paria Plateau carried on until recent times. This period could be further subdivided into multiple distinct eras where large outfits controlled significant portions of the area, climaxing with the current situation where one permittee controls the whole area, but for simplicity I won't break it down any further. Also discussed is the deer herd irruption that peaked around 1924 and had major impacts on livestock grazing and the integrity of ecosystems.

The history presented in this paper becomes less detailed approaching the 1980's because of the unavailability of documentation and the limited changes that have occurred since the mid 1900's. Some dates presented here may not necessarily be entirely accurate since the variety of sources used to compile this history are often only consistent in their inconsistencies. Also, the number of livestock on the range at any one time is suspect to the estimates of cowboys and early settlers, whose tales have been passed down, and like a fish story, probably grew with each

telling. However, a pattern emerges that is evident despite inflated estimates and tall tales, and that is severe overuse of the range until government intervention in the mid 1900's. Throughout the report the reader should refer to Figure 3.1 frequently to help envision the chronological development of this history.

It is widely assumed that the area under consideration has evolved in the absence of large herbivores. That may not necessarily be true however. Antelope (*Antilocarpus americanus*) were once probably the most numerous large herbivores on the Arizona Strip (Wilson, 1941) and they are mentioned by numerous early explorers (see for example Powell, 1961). However, considerable evidence exists that suggests bison (*Bison bison*) may have occurred under natural conditions in the vicinity of the Kane and Two Mile Ranches. Mead et al. (1991) documented bison remains in Arches National Park in southeastern Utah from as recent as 1605. In fact, bison remains were the most numerous large mammal remains in the alcove they studied (Mead et al., 1991). The authors suggested that the bison may have passed through the area and may not have been resident, but indeed the evidence points to some bison presence at that time.

Late Pleistocene bison remains are common throughout the Colorado Plateau (Mead et al., 1991), but how recently have they been at or near the Arizona Strip? Wilson (1941) quotes a letter from an Arizona Game and Fish Officer that claims bison were seen by beaver trappers, probably early 1800's, near Hurricane Ledge at the western edge of the Arizona Strip. Near to that site, a panel of rock art at the Grand Wash Cliffs depicts a bison being chased by riders on horseback, which would have been made after the 1700's when horses were introduced to the Native Americans (Mead, 2002). Several early Spanish explorer missionaries encountered bison in Utah and eastern Arizona, and many in New Mexico, but not in northern Arizona (Mead, 2002).

Jim Mead, paleontologist at Northern Arizona University, believes bison may have been occasional visitors to the Arizona Strip and the Grand Canyon during the late Holocene (Jim Mead, Laboratory of Paleontology, personal communication, 2/10/06). Abundant dung has been recovered from sites in Glen Canyon, a skull was recently discovered at river level in the Grand Canyon that dated to around 1100 AD, and numerous unidentified bone remnants from studies throughout the 20th century from the Grand Canyon north to Kanab are actually bison remains that date between 1100 and 1400 AD (Jim Mead, Laboratory of Paleontology, personal communication, 2/10/06). Mead (2002) concludes that given the available evidence, bison were

occasionally present in the area up until the 1500s when climate no longer permitted their residence. Additionally, he believes that given enough grassland, they could have been common on the rim areas (Mead, 2002) and if funding became available he is sure that Holocene remains could be found on the Paria Plateau (Jim Mead, Laboratory of Paleontology, personal communication, 2/10/06). These points are currently being considered by the National Park Service as they deliberate on what actions to take with managing the herds that have recently migrated from House Rock Valley into the forests of Grand Canyon National Park. If bison were residents or at the least occasional visitors to the Arizona Strip then that implicates a minimal level of ecosystem adaptation to heavy-hoofed grazers on the Kane and Two Mile Ranches. However, the herds of livestock introduced in the late 1800's were probably beyond any native ungulate herd the area had seen any time before.

The earliest livestock

In 1863, livestock found their way to the eastern Arizona Strip, thanks to the efforts of James M. Whitmore, a Mormon settler who brought his family to Pipe Spring, Arizona from St. George, Utah (Schlegel, 1992). Other Mormon settlers soon set up ranches at Moccasin Spring and Short Creek in that year (Stoffle & Evans, 1976). Mormon leader Brigham Young chose Pipe Spring as a headquarters for the churches expansion because of its prime pasturage and reliable water. Pipe Spring was chosen over others, namely Moccasin Spring because, owing to the patchy nature of vegetation, there was little valuable pasture at Moccasin whereas at Pipe Spring it was abundant. This should serve as a testament to the fact that not all areas were lush grasslands prior to the arrival of cattle (Olsen, 1965). Ranching was a relatively new venture for the Mormons. They had spread westward supporting themselves primarily by farming, but as they moved into southern Utah and northern Arizona they discovered that farming was difficult in the nutrient poor sandy soils and the only way to adequately provide for their large families was to start raising cattle (Alder & Brooks, 1996). Typically, Mormon communities sought to be self-sufficient enclosed units that intensively stewarded the resources of their town and its immediate surroundings, but again, the Arizona Strip threw them a curveball and they were forced to graze their herds over large areas since small areas were so easily overused (Alder & Brooks, 1996). Because of the fragility of the forage resource, the Mormon communities

continually sought new places to graze their ever-growing herds and flocks. As early as 1872, feral horses had made well-defined trails throughout the range, and they congregated around watering holes (Stoffle & Evans, 1976), furthering the damage. Horses graze primarily on grasses and select forbs only when grasses are unavailable (Reiner & Urness, 1982), so the effect of great herds of horses on grasslands would have been enormous.

By 1883, the range between Pipe Spring and Short Creek that was utilized by the Canaan Stock Company had been overused to the point that their stock-raising efforts were no longer profitable, and the company divested their interests of 4,200 cattle (Alder & Brooks, 1996). In 1887 Clarence Dutton noticed the severe overgrazing at Pipe Spring and wrote that

> "Ten years ago the desert spaces out-spreading to the southward were covered with abundant grasses, affording rich pasturage to horses and cattle. To-day hardly a blade of grass is to be found within ten miles of the spring, unless upon the crags and mesas of the Vermilion Cliffs behind it" (Dutton, 2001: pp. 78-79).

Period I. Family ranches

During the time that the Canaan Stock Company was overgrazing the area west of Kanab Creek, Mormon settlers were spreading further east and introducing cattle to new areas of seemingly everlasting forage. By 1871, ranches were established at Big Springs in Nail Canyon on the western Kaibab Plateau by the Stewart and Naegle families (Azar, 2005). Professor Harvey DeMotte from Illinois Wesleyan University saw cattle grazing in that area in 1871 while he accompanied John Wesley Powell to the Kaibab Plateau (DeMotte, 1872).

DeMotte Park and the highest portions of the Kaibab Plateau had probably not been grazed by the autumn of 1872 because John D. Lee, who ran a ranch of around 125 cattle at Jacob's Pools, (Cleland & Brooks, 1983) wrote: "I learned through our Indian guide a Splendid Ranch could be Made on the Buckskin or Kaibab Mountain in a valley 15 Ms. long & ¾ wide with 3 Springs eaqueally dividd. 2 of the Springs forms quite Lakes with heavy meadow land..." (Cleland & Brooks, 1983: p.215). Soon thereafter the first herds made their way onto the plateau and ranch headquarters were set up at 8-mile, Oak, and Pine Springs, and Jacob's Lake by sometime in 1872 (Woodbury, 1944). By the late 1870's, David King Udall kept around two-hundred cattle at VT Park (Altschul & Fairley, 1989) which was soon changed to DeMotte Park on J.W. Powell's maps although locals still called it VT Park.

Period II. United Order of Orderville

In 1877, when the UOO established a dairy in Orderville Canyon (Coker, 1978), John W. Young, son of the Mormon leader Brigham Young, quickly set out to acquire the plateau, and did so by trading a gun and some ammunition for the rights to the entire Kaibab with a Paiute Indian named either Quarats (Buckley, 2004) or Tuahgants (Coker, 1978). The UOO grazed the summer range on the Kaibab Plateau at least as far south as DeMotte Park (D.K. Udall either sold out to or incorporated into the UOO) and wintered their herd in House Rock Valley. In June of 1872, John D. Lee caught wind of a posse coming from Utah to arrest him for his participation in the Mountain Meadows Massacre. He quickly fled from House Rock Valley to Jacob Hamblin's farm at the southern end of the Echo Cliffs at Moenave. Soon thereafter they traded properties, with Hamblin ending up owning Lee's Ranch at Jacob's Pools, and Lee acquiring Kane Springs which Hamblin evidently owned since around 1870 (Woodbury, 1944), though it is unlikely it was developed since he was away on missions to the Hopi so often. Hamblin never used the pools and they soon fell into disrepair. Lee returned to his home at the mouth of the Paria River later that summer and rode, along with one of Powell's men, Almon Harris Thompson, to Kane Springs to evaluate the ranching possibilities there (Larsen, 2000) but there is no mention in his journal about his impressions. Lee fled permanently in 1874 (Cleland & Brooks, 1983), leaving whatever ranch there was at Kane Springs vacant, so the UOO probably found it that way in the late 1870's. By 1881 The United Order controlled all of House Rock Valley up to Soap Creek and wintered around 5000 sheep, 500 head of cattle, and numerous horses there (Coker, 1978; Rider & Paulsen, 1985; Mitchell & Freeman, 1993; Buckley, 2004), with most use concentrated near the few available water sources since no pipes had been installed yet.

Beyond Soap Creek the range was controlled by John D. Lee until 1874 when he fled south towards the Little Colorado River. No actual numbers exist, but Lee probably never kept more than enough cattle and horses for personal use and consumption since his main ranching interests were at Lee's Ranch at Jacob's Pools where he kept between 40 and 125 head (Cleland & Brooks, 1983). After the Lee family left Lee's Ferry around 1875 the family of Warren Johnson took over the ferrying business but never ventured into raising livestock beyond their personal needs.

Grazing chronology

Figure 3.1

The mid 1880's represent a period when numerous parties were utilizing the range and deals and transfers of rights went through many times with no real accurate record of who-owned-what-when. It is during this period that confusion surfaces as to the origin of the VT brand. F.C. Dellenbaugh, who was a member of J.W. Powell's surveys, claimed that VT means Van Slack and Thompson who in 1886 ran VT park as their headquarters (Barnes, 1935), but the brand has also been said to mean "Valley-Tanned" to imply the local origin of Kaibab leather (see Coker, 1978 for a more thorough discussion on the VT origin). It has also been suggested that John W. Young created the VT brand to cover up some dirty business conducted by the UOO (Buckley, 2004) or that Young bought the brand in 1887 from the original owners which may have been Van Slack and Thompson (Onstott, 1970).

In November, 1884, an aspen pole fence five and a half feet tall was built around most of VT Park which was the first fence built besides corals on the Kaibab Plateau (Larsen, 2000). Woodbury (1944) states that the UOO controlled grazing on the Kaibab Plateau until 1888, suggesting that the multiple parties involved and deals that transpired all went through under the auspices of Young's leadership. Evidently, a devastating blizzard occurred during the winter of 1886-1887 that killed tremendous numbers of livestock (Niehuis, 1983) which would have further complicated the deals going through and the estimates of livestock use. Young bought the Church herd of 2,400 cattle at Pipe Spring in 1887 and brought those to the UOO range (Coker, 1978; Buckley, 2004), perhaps to replace cattle lost over the winter, which would bring a conservative estimate of UOO cattle on the Kaibab Plateau in the late 1880's to around 4,000 head, as well as several thousand sheep, and probably several hundred horses.

Period III. Kaibab Land and Cattle Company

In 1887 the Kaibab Land and Cattle Company (KLCC) bought the rights and assets from the UOO and VT outfits (Coker, 1978). The KLCC was a business venture of John W. Young's funded with money borrowed from wealthy New York bankers (Onstott, 1970), but may have been another face for the financially struggling Mormon Church. At this point, between 1887 and 1889, some 200,000 sheep and 20,000 cattle were using the Arizona Strip from House Rock Valley to the Uinkaret Plateau (McOmie, 1913), though through time this figure has been used to represent the use on the Kaibab Plateau (see, for example Mann & Locke, 1931, Russo, 1964,

and Mitchell & Freeman, 1993). It is likely that many of these animals used the plateau from time to time, but not consistently. Young increased his interest in horses (Figure 3.2) and in 1888 he may have herded as many as 1000 across the Colorado River at Lee's Ferry for sale at one time (Onstott, 1970). Young's interests were expanding west too, for in 1890 the Stewart's gave their land and water rights in Nail Canyon to Young (Azar, 2005) which gave him and the KLCC nearly complete control of the Kaibab Plateau and House Rock Valley.

In November, 1892, Young tried to establish the Kaibab as a hunting ground for English nobility when he invited Buffalo Bill Cody and two rich Englishmen to a hunt. The men made it to the North Rim by the 26th, and were so exhausted from the rigorous travel that they soon left and the Kaibab never became the exotic destination that Young envisioned (Azar, 2005), at least not yet. In the late 1890's a fence on the Walhalla Plateau was erected to contain horses (Buckley, 2004) which were reproducing rapidly. By 1903 close to 5,000 wild horses roamed the vicinity of Kanab, which the stockmen claimed did more damage than cattle or sheep (Mead, 1903).

Figure 3.2 *Horses on the Kaibab range in 1913, from Graves (1913)*

Period IV. The Bar-Z Ranch

Young finally sold the KLCC in 1897 to one of the biggest land baron's in the southwest, Benjamin Franklin Saunders. Saunders, a partner of Preston Nutter who controlled most of the range west of Kanab Creek, began a "concerted, well-organized campaign to secure control of the prominent watering places throughout that entire portion of Arizona lying north and west of the Colorado River" (Younghans & Rogers, 2003: p.7). Saunders and his Bar-Z Ranch ran an estimated 33,000 head of cattle on the Kaibab and House Rock Valley in 1897 (Buckley, 2004) and attempted to push out the rest of the communal users of the range so he could maintain that level of stocking. Roland Rider, a cowboy who worked for Saunders, estimated that Bar-Z ran 60,000 to 100,000 head of cattle on the range in the early 1900's (Rider & Paulsen, 1985). This number seems almost too high to believe but some former agency employees feel it was certainly possible (Dennis Lund, former USDA Forest Service employee, personal communication, 2/9/06).

Figure 3.3 *Bar-Z Ranch buildings in DeMotte Park, ca, 1910*

In the early 1900's Saunders hired Jim Owens and Charles "Buffalo" Jones to breed buffalo and cattle on the plateau to create a superior breed. The idea stemmed from the devastating blizzard of 1886-1887, and they hoped to breed an animal capable of enduring harsh winters (Niehuis, 1983). Jones arrived in 1905 with permission from the President to survey the area for a suitable cattalo ranch site (Easton & Brown, 1961). He settled on an area near Bright Angel Point, received a permit to fence the site on January 8, 1906, and then brought in the buffalo (Easton & Brown, 1961; Onstott, 1970). Jones' long-term vision for the newly dedicated Grand Canyon Game Preserve was to introduce elk, moose, camels and zebras in addition to the buffalo (Goldman & Locke, 1923). In 1907 or 1908 the buffalo were moved into House Rock Valley, where the experiment was ruled a failure and by 1909 he drove most of them off for sale. Fifteen to twenty of these hybrids were left under the care of the newly appointed Game Warden Jim Owens who spent most of his time on the plateau eradicating predators (Easton & Brown, 1961). Around 200 of these animals survive today but they have moved to greener pastures higher on the Kaibab Plateau.

Figure 3.4 *Jim Owens at the House Rock Ranch, one of Bar-Z's many ranch headquarters, 1915*

Period V. Fencing the Kaibab

B.F. Saunders' attitude towards complete control of the range upset stockmen from Kanab, Utah to the point that they arranged a meeting with F. Kneipp of the Office of Grazing in Washington, D.C. The result of the meeting was a decision to split the summer range in half, with Bar-Z taking the east side and House Rock Valley, and Kanab stockmen taking the west side to Kanab Creek (Mace, 1990). In 1909 a fenceline was blazed that kept Bar-Z's 9,500 *permitted* head and the combined Kanab stockmen's 6,000 *permitted* head separated (Mace, 1990) and the fence was finished by 1911 (Menninghaus & Jensen, 1967). William Mace, who helped blaze the fenceline, recalled seeing hundreds of horses ranging all over the Kaibab Plateau, but lamented when he learned that they were removed later on (Mace, 1990). Also in

Figure 3.5 *House Rock Ranch, ca.1910. Note the open nature of the Kaibab Plateau in the distance*

1909, the Secretary of Agriculture set the grazing limit for the Kaibab at 14,000 cattle and 7,500 sheep (Goldman & Locke, 1923), though trespass cattle probably equaled that number (Mitchell & Freeman, 1993). Bar-Z also bought out the rest of House Rock Valley, from Soap Creek to

Figure 3.6 *Horses near a lake on the Kaibab Plateau,1913, from Graves (1913)*

Lee's Ferry, from Jim Emett that year. Emett had used the range there since 1895 and grazed a fair number of horses on the bench above the valley that ran the length of the allotment (Rider & Paulsen, 1985). Bar-Z then had control of the entire range in House Rock Valley from Lee's Ferry to South Canyon.

The days of the Bar-Z wouldn't last forever, though. Saunders transferred ownership over to E.J. Marshall and the Grand Canyon Cattle Company around 1909 (Reilly, 1999), which kept the brand, but much to the stockman's chagrin they were entering an era of increased government control. The Kaibab was decimated, House Rock Valley was stripped, and the range just couldn't support the herds. William Mace recalled seeing "one of the last big herds" come through the corrals at Jacob's Lake in 1911 when Bar-Z brought 2,200 beef steers off of the Kaibab range (Mace, 1990), but the numbers were still high. On their 1910 timber survey, Lang and Stewart witnessed the grazing situation and wrote this in their report:

> "The position now taken by grazing is confined chiefly to cattle, a few hundred wild horses (500 -600) and about 5,000 head of sheep. The sheep are allotted to a small area extending over the northwest corner of the main plateau,

> approximately from the east edge of the mountain, north of Jacob's Lake westward, and from a line between Jacob's Lake and Three Lakes westward to Naegle [Nail] Canyon, comprising approximately 52,000 acres or an allotment of 10 acres per head….The few hundred horses graze in scattered bands practically over the entire mountain. In addition to the wild bands approximately 300 - 400 saddle horses owned by the Grand Canyon Cattle Co., and West Side grazers find range. Most of the saddle horses are confined to fenced pastures or herded during the "round up" season and hence form an inconsiderable factor in the grazing proposition" (Lang & Stewart, 1910: p.21).

The use by the Grand Canyon Cattle Company was high, but may not have been as high as when John W. Young controlled the range. Increases in cattle started again in 1915 (Mitchell & Freeman, 1993), but around then the problem with too many horses was becoming evident. G.C. Fraser toured the Kaibab Plateau in 1916 and wrote that on Powell's Plateau "deer were tremendously plentiful, also horses and mules….The whole of Powell's [Plateau] is a horse pasture run by Uncle Jim Owens, [Bob] Vaughn, and Uncle Jim's other boy" (Fraser, 1916: p.54). In 1922, two hundred-fifty horses were killed on the plateau, and between 1923 and 1933 another 1,300 were killed (Mitchell & Freeman, 1993). Also, in 1923 the Secretary of Agriculture set the limits much lower, to 5,685 cattle and 3,650 sheep (Goldman & Locke, 1923). The cuts in permits were in large part due to the tremendous numbers of deer browsing the forest nearly to death. Roland Rider said that there were "so dang many deer, they just cleared out this forest; you could see through it for miles" (Rider & Paulsen, 1985: p.96). Jim Owens successfully reduced the predators on the plateau to such a degree that the deer herds irrupted and by 1924 close to 100,000 deer used the range from Marble Canyon to Kanab Creek (Mitchell & Freeman, 1993). As a result of the diminished range conditions and competition for forage from small owners in House Rock Valley, the Grand Canyon Cattle Company drove all of their head to Mexico in 1924 and the US Forest Service cancelled their permit (Menninghaus & Jensen, 1967; Mitchell & Freeman, 1993).

Period VI. After the Taylor Grazing Act: a system of range management

The Kaibab deer herd and predator control

In 1906 congress established the Grand Canyon Game Preserve which was carved out of the Grand Canyon Forest Preserve that President Benjamin Harrison dedicated in 1893 (Buckley, 2004). With the title of Game Preserve came the mission of eradicating the predators that compromised the health and abundance of the desired game species, or so they thought in those days. The main agent of eradication was a Jim Owens who was personally hired by Theodore Roosevelt to serve as Game Warden and get to work killing everything that might prey on deer (Azar, 2005). In 1907 there were an estimated 100 mountain lions on the Kaibab Plateau and by 1910 Owens had killed 119 (Goldman & Locke, 1923). He stayed on the plateau until 1922 killing predators and showing tourists around to vistas and vales, and by the time he left "…the outside of his cabin was so studded with lion claws that visitors could hardly see the logs" (Easton & Brown, 1961). Starting in 1916 hunters from the US Biological Survey joined Owens in the effort to cleanse to forest of wild beasts (Goldman & Locke, 1923) and by 1931 the government had sponsored the killing of between 674 and 781 lions, around 30 wolves, at least 5,000 coyotes, and at least 500 bobcat on the plateau and surrounding area (McCulloch, 1986; Burnett, 1991; Mitchell & Freeman, 1993), as well as unknown numbers of eagles, hawks, and owls (Hughes, 1991).

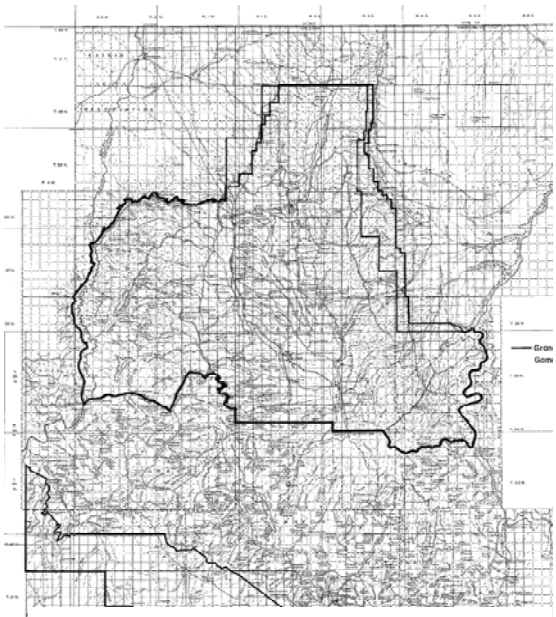


Figure 3.7 *Grand Canyon Game Preserve*

Following the elimination of predators on the Kaibab, the deer population exploded. In 1908 the forest supervisor estimated there to be 4,000 deer on the Kaibab (Young, 2002) and numbers rose rapidly and exponentially until a peak in 1924 of what many thought to be 100,000 deer, one-quarter of them in the southern end of House Rock Valley (Rasmussen, 1941; Mitchell & Freeman, 1993). The effects of the herds on the plateaus vegetation were tremendous. There was "So dang many deer, they just cleared out the forest; you could see through it for miles" said Bar-Z cowboy Roland Rider (Rider & Paulsen, 1985: p.96), and Goldman and Locke (1923) reported that aspen, ceanothus (*Ceanothus fendleri*), white fir (*Abies concolor*), snowberry (*Symphorocarpus* sp.) and locust (*Robinia neomexicana*) were very heavily browsed and it was

unlikely that there were any aspen left under three feet in height. The forest supervisor, Walter Mann, apparently offered a dolar to anyone who could find an aspen less than a foot tall (Mitchell & Freeman, 1993). A significant impact from this period of overuse was the complete loss of scrub willow (species unknown) from the plateau (Baker et al., 1988) which is a fact that rarely appears in the literature. In 1924, an investigating committee formed by the Secretary of Agriculture and comprised of representatives from the Boone and Crocket Club, the National Association of Audubon Societies, the National Parks Association, the American National Livestock Breeders Association, and the American Game Protection Association toured the Kaibab Plateau. They described the conditions as being deplorable and the condition of the range moving swiftly towards utter destruction (Mitchell & Freeman, 1993). Within the next year several factors came together to change the situation. A serious drought from 1924 into 1925, legalized deer hunting for the first time since 1906, and peaking competition between deer and livestock acted to reduce the herd by tens of thousands in just two years (Mitchell & Freeman, 1993; Young, 2002). A side effect of the irruption was a period of rapid development of infrastructure to support hunters, including several camps (Figures 3.3 & 3.4) and Ranger Stations.

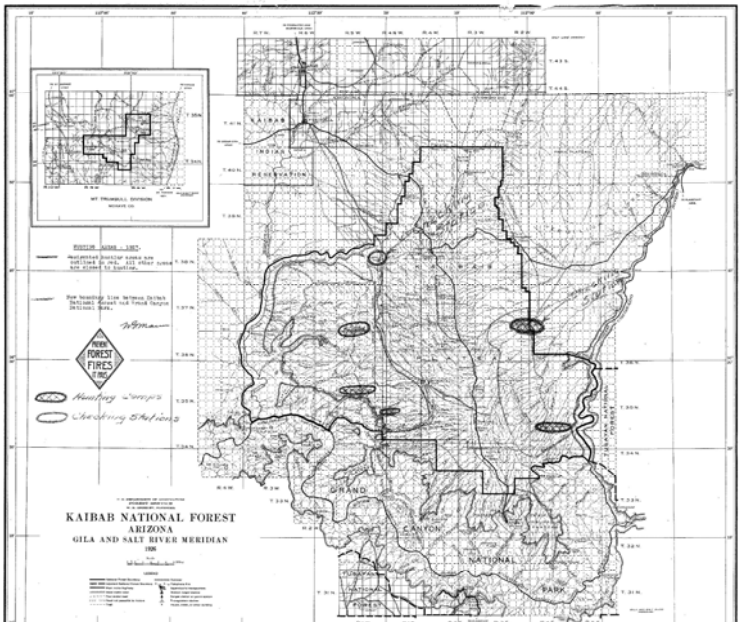


Figure 3.8 *Location of hunting camps in 1927*

Figure 3.9 *Tents were provided for deer hunters during the late 1920's*

The controversy during and following the irruption became a textbook example of predator/prey relationships, but still to this day there are more answers than questions. Young (2002) offers the most thorough examination of the incident yet compiled and made some important points. Regarding lion eradication, he calculated that Owens killed less than one lion per week and he took them from other areas than the Kaibab Plateau, suggesting that perhaps the effect of predator control was overstated, a hypothesis suggested by other authors in other examples. The most important point made by Young (2002) was that the effect of browsing on vegetation was not uniform across the landscape and was subject to human perception. Certain areas such as the Walhalla Plateau and Sowats Point were excessively browsed while nearby areas were almost untouched. He suggests that deer would get trapped by deep snows at some points and weren't able to leave for the whole winter, thus destroying the browse at those locations. Rasmussen (1941) studied the herds population dynamics and its effects on plant communities and reported that: "They fail to distribute themselves evenly over the desirable range. The result is that some of these localities are nearly destitute of suitable food, while

others are available, but out of the main line of drift, have an abundance of food and are hardly touched" (Rasmussen, 1941: p. 245). Ten to twenty percent of the cliffrose at Sowats Point survived the browsing and the rest was killed (Rasmussen, 1941). It is photographs of Sowats point that are often shown to show the effects of the browsing which is not a balanced view. For example, Rasmussen's study site at the northern end of the plateau was hardly browsed while his site at the southern end was severely browsed. Interestingly, he reported that:

> "The excessive numbers of deer have thinned out the shrubbery and favored the growth of certain grasses and herbs which they do not usually select as food….In certain Kaibab areas the whole aspect of the range is changed by a decrease in shrub species and increase in grasses resulting from deer usage" (Rasmussen, 1941: p. 247).

Figure 3.10 *Deer in DeMotte Park in 1930*

Indeed, the browsing and foraging of the immense herd in combination with fire suppression, livestock grazing, and drought did have severe effects throughout the forest and range that were evident to numerous observers and scientists. For a good review of the irruption and deer population dynamics for some years after I suggest Mitchell & Freeman (1993), and if

time permits reading Young's (2002) book offers more in-depth retrospective analysis and consideration of some important points that are often ignored.

On the Paria Plateau

In 1924 the Taylor Grazing Act put the government in a position of being able to dictate the allowable numbers of livestock and who could use the range. Priority was given to those who had invested in upgrades and built ranch headquarters, and this is how most of the modern allotments originated. The Paria Plateau had been used by two men to that point. Joe Hamblin built Joe's Ranch in 1884 and kept cattle, sheep and goats, but besides that nothing else is known. There was so little water in the days before wells and pipes that according to local stockmen it was never overused (Kelsey, 1987). Besides Hamblin, the only other user on the sand hills was Albert Leach who started grazing goats in 1916 on the western portion of the plateau. Leach had a home in Kanab and would winter 3,000 to 4,000 goats on the Paria and the northern end of the Kaibab Plateau; probably in today's Burro Allotment. Leach would use the Coyote Buttes area and stayed close to Pine Hollow Reservoir which he claimed to have bought from the man who built it (Bureau of Land Management a).

The Taylor Grazing Act apparently didn't affect Leach until 1936 when the Advisory Board of Arizona, Grazing District No. 1 asked him to bring his goats down to 2,800 from May to November and 850 in the winter. Leach was no fan of the Fed's telling him what to do so he protested to the Board, claiming that he kept between 20,000 and 40,000 goats on the Paria Plateau prior to their rules and that the sand hills could support those numbers. In a letter dated November 25, 1936 from the Department of the Interior to Mr. Leach, the grazing officer awarded some leeway, and amended his winter permit to 1,850 goats for the entire Paria Plateau and the vicinity of the Burro Allotment, north to the Utah state line. Leach went ahead and grazed 2,800 goats that winter and didn't pay his fees so his permit was revoked in the spring. He reluctantly paid the fees that year, but then went ahead and grazed 2,700 goats the next winter! In 1938 when fences were being put up to divide the Paria into separate allotments, he found himself confined to the Coyote, Kitchen, and Pine Hollow Allotments (Bureau of Land Management a).

In 1926, Johnny Adams bought the rights to the eastern half of the Paria Plateau from Joe Hamblin's son Nephi. Adams grazed the area for some time but cattle could only move beyond

the vicinity of Joe's Ranch and the Lower and Middle Reservoirs in the winter when there was snow on the ground, so he could never keep too many head. In 1935 the Jarvis Ranch house was built, and in 1939 Adams and a few other folks built a trail into the Paria River gorge with the intent of pumping water from the river up to the plateau. By the time they finished the system it started raining and they never got to use the pump (Kelsey, 1987). Soon thereafter Jim H. Jennings foreclosed on Adams but only held the lease until 1941 when he sold out to A.T. Spence. Spence had 693 cows on the Paria Plateau in 1941 but he wanted more. He built most of the cement plugs in the natural sandstone basins on the eastern half of the plateau between 1941 and 1945, and trucked in several metal tanks too (Bureau of Land Management b; Kelsey, 1987). The improvements Spence made allowed Merle Findlay to run 1,172 head on the Jarvis, Adams Reservoir, and Home Ranch Allotments when he bought them from Spence in March of 1945 (Bureau of Land Management b). The Findlay's continued to improve the range infrastructure and brothers "Dunk" and Lynn Findlay drilled the first well in Pinnacle Valley in 1950 (Kelsey, 1987). During this period the Paria probably experienced the most use of its history between Findlay's cattle and Leach's goats.

The Hamblin's still held on to some land on the northeast corner of the Paria, in the Bushhead Allotment. William F., Glen, and Pruda Hamblin were the original owners according to Bureau of Land Management (BLM) records, and between 1940 and 1946 they sold their holdings to Royal B. Woolley who constructed the Shed Valley Reservoir. Back to the west, Bert Leach had given up on goats by 1942 and by 1950 he kept 450 head of cattle in the Coyote Allotment with most use in the winter (Bureau of Land Management a). Bert, and later his son Trevor, maintained 200 to 350 head in the Coyote, Burro, and Pine Hollow Allotments until 1981 when Bud Northcott bought the permits, although Trevor was only permitted for up to 300 cattle year long (Bureau of Land Management c).

In 1953 a range survey saw that conditions on the Paria Plateau were declining so the BLM limited Merle Findlay to 857 cattle year long on the Jarvis, Adams, and Home Ranch Allotments. Merle died in 1960 and his sons Lynn and A.D. "Dunk" Findlay took over (Bureau of Land Management b). At that time The Vermilion Cliffs Cattle Company, owned by Steve Rich from Jacob's Lake, was buying up the Hamblin's Allotments in Bushhead Valley (Bureau of Land Management d), and in 1962 they bought Lynn's share of the Findlay holdings. Up until 1969 "Dunk" Findlay probably kept 60 to 80 cattle on the Jarvis Allotment, but upped the

stocking to 650 in 1970 (Bureau of Land Management b). At that time the Vermilion Cliffs Cattle Company had permits for 650 to 800 head on Pine Pockets, Moquitch, Two Mile and White Pockets (Bureau of Land Management d), so somewhere around 1,200 to 1,500 cattle were kept from October to June during the 1960's and 1970's. The late 1970's and early 1980's saw yet another minor decrease in permitted head. In the spring of 1978 the Vermilion Cliff Cattle Company kept only 570 head and had to provide supplemental feed for the whole herd, and in 1980 "Dunk" agreed to keep only 345 head including horses (Bureau of Land Management b; Bureau of Land Management d) but the Vermilion Cliffs Cattle Company, which at that point controlled the eastern and western thirds of the plateau, brought their whole herd back up to 800. The impact of the cattle drives during this period must have been immense. Every June the Findlay cattle would be herded to Bowman's Corrals in upper House Rock Valley in three or four waves of 50 to 200 cows, and in October they'd all be driven back to the Jarvis ranch in one herd (Bureau of Land Management b). The Vermilion Cliffs Cattle Company probably did the same thing, which would have resulted in a period of extremely destructive trampling to the plants and soil.

Kelsey (1987) claims that in 1980 the Two Mile Corporation bought out "Dunk" Findlay and the Vermilion Cliffs Cattle Company thus gaining control of the whole plateau which they would graze with 1,500 cattle year long, but BLM records show that in March, 1981, Findlay sold 80 acres and 500 cows to the Ramsey Cattle Company of Winslow, Arizona (Bureau of Land Management b), and the Vermilion Cliffs Cattle Company was sold to Ramsey in February, 1987 (Bureau of Land Management d). Perhaps then the Two Mile Corporation was a subsidiary of Ramsey Cattle Company? Either way, the Two Mile Corporation gained control of the whole plateau in the 1980's and from then on rotated 800 to 1,200 head over the various pastures year round (Bureau of Land Management i). In sum, the Paria Plateau was under heavy goat grazing pressure as early as the teen's, and shortly thereafter range infrastructure improvements allowed at least 1,000 head to use the plateau which continued to present times. Agency records don't provide any clues to areas that may have been used less that may represent more natural conditions, nor do they specify areas that were under the most pressure. Those questions could be best answered by looking at the distribution and history of water sources as those places are where the cattle would have congregated, although salt was frequently used to spread herds out and relieve pressure on watering areas.

Kane Ranch/House Rock Valley and the Kaibab Plateau

After the Grand Canyon Cattle Company drove their head to Mexico and their permits were cancelled, the area was open to new investors who were willing to stake their claim, legally, and establish new ranches in House Rock Valley. Despite the vacancy however, several small owners voluntarily removed their stock from the Kaibab Plateau and House Rock Valley between 1920 and 1927 because of a lack of forage and water (Menninghaus & Jensen, 1967). Alex Cram homesteaded 320 acres in Section 4, T37E, R5E in House Rock Valley sometime during that period. Along with 25,380 acres of leased land this was the first large allotment in the valley to be fenced. From 1941 to 1951 Alex Cram kept around 325 cattle; sometime in that period ownership was transferred to Maggie Cram. On December 31, 1951 Maggie Cram sold the property to Sherman Jensen who usually kept fewer cattle than he was permitted for, which was 300 cattle year long as of 1966 (Bureau of Land Management e).

Royal B. Woolley purchased some of the Grand Canyon Cattle Companies holdings in the early 1950's and kept 400 cattle year long in the Kane Allotment and 200 in the Buffalo Allotment which he acquired separately and fenced to make it its own allotment (Bureau of Land Management f). C.H. Vaughn purchased the permit for the Soap Creek Allotment in 1953 and kept 244 cattle there (Bureau of Land Management g). By the mid 1960's Vaughn had 189 cattle on Soap Creek (Bureau of Land Management g) and Woolley had 100 head on his allotments, but within the next decade Woolley would bring his herd up to almost 400 animals (Bureau of Land Management f). In 1977 Vaughn had 90 cows on Soap Creek when Kim Cox from the BLM inspected the allotment. Cox found that the rim of Marble Canyon was in poor condition, but the strip north of the highway was in fair to good condition. From then until 1981 when Vaughn sold most of his allotment to E.J. Graff he kept less than 100 head on the Soap Creek Allotment (Bureau of Land Management g).

The Cram Allotment was purchased in 1969 by A.L. Hawkins of Fredonia, Arizona. Hawkins was only there for a few years and he beat it up while he could. In 1974, Hawkins had between 125 and 150 cattle on that allotment, but he was only permitted for 100 cattle and 5 horses. The BLM rated the allotment at 20% fair condition and 80% poor. Later, in March, 1977, Hawkins sold to Alma Evans of Parowan, Utah, and normal use that year rebounded to around 250 cattle during the summer and 339 in the winter (Bureau of Land Management e), perhaps due to favorable weather. In 1975, Alvin Tso of Page, Arizona purchased the permits

for the Lee's Ferry Allotment in Paria Canyon and sold them in 1981, but he only used the area in 1975 and 1976 because of drought conditions, a heavily abused riparian corridor, increasing conflicts with recreationists, and his interest in another herd elsewhere. Overall, when he did use the allotment he kept between 50 and 75 cattle in the north portion from September to March, and then brought them to the south portion for April through August. In 1978 BLM Range Con Ralph Wolfe sent a letter to Tso stating that grazing in the river bottom was no longer acceptable because the fragile ecosystem was at risk. In February, 1981, a month after Tso sold out to David O. Johnson, Ferron Leavit from the BLM wrote a letter to Tso saying that the allotment looked to be in very good condition and the shrubs and grasses had really responded to the three years of non-use (Bureau of Land Management h).

By 1967 about twelve miles of the drift fence on the east side of the Kaibab Plateau, which was first constructed in 1915, was replaced. At that time six permitees, Elmer Jackson, Rell Little, the Hyrum Roundy Estate, Beryl Vaughn, C.H. Vaughn, and J.O. Vaughn, were running 851 head on the summer range of which 73% was rated in poor condition and only 4% was in good condition. Up until 1964 cattle were permitted to enter the range prior to range readiness which was around the first of July (Menninghaus & Jensen, 1967). In 1975 a new fence was constructed on the Kaibab Plateau, running from Castle Point east to Snipe Lake and on to Telephone Hill. The fence divided the plateau into a southern pasture that was 2/3 of the whole plateau, and a northern pasture where proper use was exceeded by U.S. Forest Service standards (USDA Forest Service, 1980). Past overuse of the meadows led the Forest Service to disk and seed 670 acres of meadows and drill over 600 acres by 1968 (Hungerford, 1970). Encroaching conifers were also thinned back on 2,900 acres of meadow edge. In all, by 1968 30,000 acres of National Forest lands were modified and planted for both livestock and deer use (Hungerford, 1970). By 1980 an additional 8,000 acres of meadows were proposed to be disked and seeded (USDA Forest Service, 1980). Non-native species were often times the preferred species to seed with. Post logging forage enhancement would include *Bromus inermis, Dactylis glomerata,* and some Fabacece plants (Durazo, 1988) and most other seeding projects would use *Melilotus alba, Sanguisorba minor, Lotus wrightii, Dactylis glomerata, Koeleria cristata, Bromus inermis, Phleum pratense, Agropyron cristatum & Agropyron intermedium* (Hungerford, 1970).

Increased management of the plateau's range led to excavating multiple lakes and basins

for livestock tanks. Dry Park Lakes, Lookout Lakes, Glenn Lakes, and Murrays Lake all had multiple basins excavated, and Joes Mud Hole, Tater Sink, Dog Lake and the Marble Sinkhole were also excavated to some degree (Jackson & Smith, 1994). By 1980 three permittees were using the summer range on the Kaibab Plateau totaling 844 head of cattle, which was the lowest use since the 1870's. By 2004, 64 cattle were permitted to use the Burro Allotment from July to September with utilization capped at 40% (USDA Forest Service, 2004a), again, probably the least utilization since before the United Order of Orderville began grazing there in the late 1870's.

In 1934, the west side drift fence that separated the summer, winter, and Ryan allotments was constructed (Menninghaus & Jensen, 1967). By 1967 six permitees kept 848 cattle in the Central Winter Allotment and 137 in the Sowats Allotment (Menninghaus & Jensen, 1967). Throughout that period the condition of the Central Winter Allotment was rapidly declining with range managers reporting that

> "past heavy use by deer and livestock seriously depleted some areas, particularly on the winter range and the north end of the summer range. These areas do not appear capable of recovering on their own in a reasonable length of time, even if completely rested from livestock grazing. Revegetation is necessary to bring them back into production and to pretoect the soil" Menninghaus & Jensen, 1967: p.5).

Menninghaus and Jensen (1967) reported that 95% of the winter range was in poor condition in 1964, and only 2% was trending up. A summary of long-term conditions and trends showed that from 1954 to 1997 almost 80% of monitoring transects showed no improvement or were trending down. Most transects were rated to be in poor or very poor condition, with some decline attributed to the 1996 Bridger Complex Fire that burned over 50,000 acres (USDA Forest Service, 1997).

From 1950 to 1980 around 14,000 acres in Central Winter were treated by burning, pushing, and seeding, but even those efforts weren't able to slow the pace of degradation. Most areas were observed to rapidly revegetate back to sagebrush or pinyon-juniper (USDA Forest Service, 1997). In the 1950's 2,110 acres of pinyon and juniper were eradicated in the White Pockets and Table Rock areas, and an additional 5,907 acres of eradication occurred at those areas and at Slide, Ranger Pass, Bone Hollow, and Willow Point in the 1960's (Steffensen, 1997). Also during the late 1960's 2,200 acres of sagebrush was plowed and seeded with crested

wheatgrass (Menninghaus & Jensen, 1967). Range improvement projects in the 1960's were designed to correlate with wildlife needs, but in reality they really only focused on the needs of deer. Seeded species were to be palatable to deer and islands of trees were to be left in thinning areas to provide cover for deer. The only treatment that would benefir a variety of species was that new fences would have smooth bottom wires at least 18" high (Menninghaus & Jensen, 1967). Treatments in pinyon-juniper woodlands on the Kaibab had variable effects on other wildlife, not always were they beneficial. Turkowski and Reynolds (1970) reported that deer mice were the only rodent to use an area seeded with crested wheatgrass and brush and pinyon mice preferred stands that weren't treated by bulldozing. However, the total number of individuals caught was higher on treated plots treated areas and four species were found exclusively there because uprooted trees provided cover and nest sites and openings had more forage (Turkowski & Reynolds, 1970). The 1970's and 1980's saw around 1,000 acres burned in prescribed fire and mechanical and herbicide treatments on 2,154 acres (Steffensen, 1997), and in 1980 two thousand acres of pinyon-juniper in the Burro Allotment were scheduled for removal and revegetation with non-native species (USDA Forest Service, 1980).

This area has probably seen the most grazing of anywhere on the Kane Ranch because it would absorb the full brunt of the huge sheep herds in the late 1880's as well as continued heavy use until the 1996 fire that stalled grazing on the allotment for several years. Despite the deplorable conditions on the winter range, the Carter family was permitted to run just under 300 head of cattle from 1992 to 1996, mostly on the Little Mountain, Slide, and Ranger Pass pastures (USDA Forest Service, 1997). Currently, the Kane Ranch Decision of 2001 allows 800 head of cattle, although according to agency records 1,136 used the range in 2004 (USDA Forest Service, 2004b). The 800 head limit could go up to 1,187 if post-fire repairs are done and range conditions improve, but use would not be allowed in Jump-up pasture or the Kanab Creek Allotment (USDA Forest Service, 2004b).

Conclusion

Like any attempt to pull together stories and facts from a century and a half into one concise and accurate document, this history is fraught with uncertainty. How many cattle did the Bar-Z really manage to hide from government counters? In the times of extreme stocking, how

much were the highest elevations of the Kaibab Plateau used? How many sheep flocked the flanks of the Kaibab in 1889? Did Bert Leach really have 40,000 goats on the Paria Plateau? These are questions that will never be answered, and each year that passes more of the history is lost. I believe this document is the most detailed description of grazing on the Kaibab Plateau, Paria Plateau, and House Rock Valley yet compiled, but these questions still remain unanswered. If a more accurate account has been written, I was not able to locate it in three months of careful and tenuous research. Much more could be uncovered about the last half of the 1900's but BLM staff were uneasy about handing over documentation involving individuals that were still alive, and for good reason.

The moral of this story is the overall trend that emerges in Figure 3.1. It has been a classic example of western boom and bust cycles. The heyday of shepherding was short lived, and ended in 1944, and the heyday of cattle ranching has passed, and its intensity has slowly been grinding to a near halt. Today's range management is literally ten-fold better than that of a century ago, but is it good enough? The Bureau of Land Management and US Forest Service have succeeded in bringing permits down to the lowest levels since the 1870's, and have evolved to the point where balancing multiple interests is a mandate, but again, is it enough? The culture of the Arizona Strip is that of the old west, and cultures don't die easy, nor should they. But the history here tells of one whose slow death began in the 1920's. Time will tell if deferred and rest-rotation allotment management will be the answer to balancing the multiple interests and needs of the land and society. For now, we'll have to rejoice that we're not stuck in the patterns of days long gone.

Literature Cited

Alder, D.D. and K.F. Brooks. 1996. A history of Washington County. Utah State Historical Society, Salt Lake City, UT.

Altschul & Fairley. 1989. Man, models, and management: an overview of archaeology on the Arizona Strip and management of its cultural resources. Report prepared for USDA Forest Service and USDI Bureau of Land Management. Prepared by Statistical Research, Plateau Archaeology, and Dames & Moore, Inc.

Azar, J.S. 2005. Buckskin Mountain. Pages 53-56 In Anderson, Michael F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Barnes, W.C. 1935. Arizona place names. University of Arizona Bulletin 6(1). General Bulletin No. 2. University of Arizona, Tucson, AZ.

Bureau of Land Management a. File of Bert Leach, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management b. File of A.D. Findlay with supplementary files, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management c. File of Trevor K. Leach, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management d. File of Vermilion Cliff Cattle Company, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management e. File of Arnold L. Hawkins, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management f. File of Royal B. Woolley Estate, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management g. File of C.H. Vaughn, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management h. File of Alvin C. Tso, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management i. Compiled grazing use summaries on file at Grand Canyon Trust, Flagstaff, AZ.

Buckley, S. 2004. Mountain lying down: restoration, bioregionalism, and the indigenous Kaibab Plateau. Master of Liberal Studies Thesis, Northern Arizona University, Flagstaff, AZ.

Cleland, R.G. and J. Brooks. 1983. A Mormon chronicle: the diaries of John D. Lee. Vol 2. University of Utah Press, Salt Lake City, UT.

Coker, E. 1978. Historical resources of the Kaibab National Forest. USDA Forest Service, Kaibab National Forest, Williams, AZ.

DeMotte, H. 1872. Six days on the Kaibab. Alumni Journal of Illinois Wesleyan University 2(10): 233-239.

Dutton, C.E. 2001. Tertiary history of the Grand Canyon district. University of Arizona Press, Tucson, AZ. (reprint)

Easton, R. and M. Brown. 1961. Lord of the beasts-the saga of Buffalo Jones. University of Arizona Press, Tucson, AZ.

Goldman, E.A. and S.B. Locke. 1923. The mountain of twenty thousand deer. American Forestry 29: 649-653.

Jackson, S.T. and S.J. Smith. 1994. Pollen dispersal and representation on an isolated forested plateau. New Phytologist 128: 181-193.

Kelsey, M. 1987. Hiking and exploring the Paria River. Kelsey Publishing, Provo, UT.

Lang, D.M. and S.S. Stewart. 1910. Reconnaissance of the Kaibab National Forest. Available on-line at www.nau.edu/library/speccoll/manuscript/kaibab_recon.

Mace, W. M. 1990. Will Mace memoirs: a letter to Gifford Pinchot dated February 9, 1940. Pages 65-73 in People and Places of the Old Kaibab. USDA Forest Service Cultural Resources Management Report No. 10. Southwestern Region.

Mann, W.G. and S.B. Locke. 1931. The Kaibab deer-a brief history and recent developments. Unpublished report on file at North Kaibab Ranger District, Kaibab National Forest, Fredonia, AZ.

McCulloch, C.Y. 1986. A history of predator control and deer productivity in northern Arizona. The Southwestern Naturalist 31(2): 215-220.

McOmie, A.M., C.C. Jacobs, and O.C. Bartlett. 1913. The Arizona Strip: report of reconnoissance [sic] of the country north of the Grand Canyon. Arizona Board of Control.

Mead, E. 1903. Report of irrigation investigations in Utah. USDA Office of Experiment Stations, Bulletin No. 124. Government Printing Office, Washington, D.C.

Mead, J., S.E. Sharpe, and L.D. Agenbroad. 1991. Holocene bison from Arches National Park, southeastern Utah. Great Basin Naturalist 51(4): 336-342.

Mead, J. 2002. Bison of the Grand Canyon Region: An overview assessment. A report to the Grand canyon National Park, Arizona. Unpublished and not for general distribution.

Menninghaus, F.F. and D.B. Jensen. 1967. Central Summer, Central Winter and Sowats Allotment Management Plan. Unpublished report dated October 16, 1967 on file at Kaibab National Forest, North Kaibab Ranger District, Fredonia, AZ.

Mitchell, J.E. and D.R. Freeman. 1993. Wildlife-livestock-fire interactions on the North Kaibab: a historical review. Gen. Tech. Rep. RM-222. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Niehuis, C.C. 1983. Strip characters, strip cronies. Arizona Highways, August 1983.

Olsen, R.W. 1965. Pipe Springs, Arizona, and thereabouts. The Journal of Arizona History 6(1): 11-20.

Onstott, T.A. 1970. Man and the northern Kaibab Plateau. MA Thesis, New Mexico State University, Las Cruces, NM.

Powell, J.W. 1961. The exploration of the Colorado River and its canyons. Dover Publications, New York, NY. (reprint)

Reilly, P.T. 1999. Lee's Ferry: From Mormon crossing to National Park. Utah State University Press, Logan, UT.

Reiner, R.J., and P.J. Urness. 1982. Effect of grazing horses managed as manipulators of big game winter range. Journal of Range Management 35(5): 567-572.

Rider, R.W. as told to D.M. Paulsen. 1985. The roll away saloon: cowboy tales of the Arizona Strip. Utah State University Press, Logan, UT.

Russo, J.P. 1964. The Kaibab North deer herd-its history, problems and management. State of Arizona Department of Game and Fish. Wildlife Bulletin #7.

Schlegel, P.A. 1992. A history of the cattle industry in northern Arizona, 1863-1912. MA Thesis, Northern Arizona University, Flagstaff, AZ.

Steffensen, D. 1997. Current conditions and trends of vegetation on Central Winter: focusing on the pinyon-juniper woodlands. Unpublished USDA Forest Service report on file at Grand Canyon Trust.

Stoffle, R.W. and M.J. Evans. 1976. Resource competition and population change: a Kaibab Paiute ethnohistorical case. Ethnohistory 23(2): 173-197.

Turkowski, F.L. and H.G. Reynolds. 1970. Response of some rodent populations to pinyon-juniper reduction on the Kaibab Plateau, Arizona. The Southwestern Naturalist 15(1): 23-27.

USDA Forest Service. 1980. Environmental analysis report. Central Summer Allotment Management Plan. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

USDA Forest Service. 1997. Current Condition Report. Central Winter Allotment. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

USDA Forest Service. 2004a. Burro Allotment Annual Operating Instructions for 2004. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

USDA Forest Service. 2004b. Central Summer, Central Winter, Kane, and C & H Allotments Annual Operating Instructions for 2004. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

Wilson, A.K. 1941. History of the Arizona strip to 1913. MA thesis, Arizona State Teachers College, Flagstaff, AZ.

Woodbury, A.M. 1944. A history of southern Utah and its National Parks. Utah State Historical Quarterly 12: 111-209.

Younghans, G. and K. Rodgers. 2003. A short history of Kane Ranch. Unpublished report on file at Grand Canyon Trust, Flagstaff, AZ.

Chapter 4.

Important historical accounts of the Kaibab Plateau

Preface

The Kaibab Plateau was one of the last forested areas of the southwestern United States to be explored by European Americans. Around 1864, when the Mormon missionaries Jacob Hamblin and John D. Lee built a small adobe shelter with a sod roof at Jacob's Lake, the Rocky Mountain fur trade had largely passed, the forests of New Mexico were well known by the Spanish, and geologist Clarence King had just summited Mt. Tyndall in California's Sierra Nevada, once thought to be the highest peak in the continental United States. The Kaibab Plateau was a fortress, protected on all sides by deep canyons and arid deserts. Despite its isolation and the difficulty in reaching it, let alone exploring its one thousand square miles of forest and woodlands, it was penetrated with increasing intensity beginning in early November, 1776, just a week before General George Washington would cede Manhattan Island to the British Navy.

Introduction

This chapter presents two types of early accounts. First, I review qualitative descriptions of the Kaibab forest left by a handful of early explorers and travelers. The images created by the writers reflect their impressions of the forest which were shaped by their experience getting there, their perceptions of ideal forest conditions, and the route taken through the forest. Early explorers may have wandered more than later travelers who followed an established road or path. This can further complicate our understanding of historic conditions because written descriptions may focus on the more scenic or easily traversed areas where the roads were established.

Following a review of people's impressions, Part II provides a review of the earliest forest inventories and ecological studies of the Kaibab Plateau. These studies describe a forest that had not been significantly altered by logging, but had been grazed heavily for several decades at the least. Active fire suppression was not initiated until around 1910, but the effects of grazing may have played a prominent role in reducing the ability of fires to spread and burn within their natural range of variability.

Part I. Early impressions of the Kaibab forest

In the first week of November, 1776, the Spanish missionaries Silvestre Vélez de Escalante and Francisco Atanasio Domínguez crossed the Kaibab Plateau just a few miles south of the present day Arizona/Utah state line. The expedition journal mentions that numerous gulches made the traveling difficult, but this is the extent of their description (Briggs, 1976). With no water for their party of nine men and horses, they would have kept pushing on with no interest in the forest that rose steadily to the south for the next fifty miles. Another fifty-three years would pass before the next recorded expedition passed over the plateau. It was the 12th of December, 1829 when a sixty man party led by Mexican trader Antonio Armijo summited the Kaibab along the route pioneered in 1776. Armijo's journal is "aggravatingly brief," (Hayfen, 1947: p. 89) and only says: "At the top of the tree covered ridge: no water" (Hayfen, 1947: p. 96).

In 1847, William Bailey Maxwell crossed the Kaibab through deep snow (Larsen, 2000), and around that time a two week expedition into Arizona led by a Mormon from Utah named James Andrus crossed somewhere near the state line, but no journals or stories have survived (Woodbury, 1944). The journal of Thales H. Haskell, a companion of Jacob Hamblin on many of his missions to the Hopi Mesa's, discloses some clues to what crossing the Kaibab before roads was like: "Sunday, October 23, 1859….traveled to the top of the mountain…. [Brother] Pearce's pack horse got stubborn and the timber being so thick he soon got off the track and got lost…" (Brooks, 1944: p. 75). His entry that night tells of how they killed a badger and cooked it at their camp in the pines, and they next day he writes of the difficulties of descending off of the mountain: "After toiling and plunging over rocks and oak brush for 2 or 3 hours [we] managed to find our way out." They spent the next two nights at a spring which they dug out and named Jacob's Pool (Brooks, 1944: p. 76). Haskell's comment on the timber being so thick that their party became separated is of particular interest since our modern notion of pre-settlement ponderosa pine forests is that they were predominantly open with lush grassy spaces between trees, such as Clarence Dutton's ca. 1871 description of the Kaibab which is often cited as *the* pre-settlement ponderosa pine forest:

> "The trees are large and noble in aspect and stand widely apart, except in the highest part of the plateau where spruces predominate. Instead of dense thickets where we are shut in by impenetrable foliage, we can look far beyond and see the

> tree trunks vanishing away like an infinite colonnade. The ground is unobstructed and inviting. There is a constant succession of parks and glades, dream avenues of grass and flowers winding between sylvan walls, or spreading out in broad open meadows. From June until September there is a display of wildflowers which is quite beyond description" (Dutton, 1887).

Similarly, one of John Wesley Powell's earliest impressions of the Kaibab Plateau was that

> "…It is covered with a beautiful forest, and in the forest charming parks are found…." (J.W. Powell, ca. 1870, in Burnett, 1991: p. 45).

The Powell expedition of 1872 spent considerable time on the Kaibab Plateau. They arrived to it from their headquarters in the young Mormon village of Kanab, which had been settled for less than a decade. A sense of anticipation must have been prevalent that day in late February, 1872, when they first ventured southeast towards it, because as the party neared the plateau and eventually entered the forest through Nail Canyon, their journals begin to expound on the beauty and topography in tones used sparingly while they worked in the deserts below. Frederick Dellenbaugh wrote that

> "all day long we traveled through sandy hills gradually rising toward the plateau, the foot-hills of which we reached in late afternoon….A little while before sunset we came to the brink of a steep slope, almost a cliff, where a picturesque, a romantic view opened before us." (in Azar, 2005: pp. 53-54).

The group had arrived at the outlet of Nail Canyon where it turns sharply to the west and begins a rapid descent into deep canyonlands, eventually joining Kanab Creek. Stephen Vandiver Jones described the scene as "looking nearly south [into] a broad canyon, or narrow valley surrounded by high snow-covered mountains, on which grow pine, fir & cedar (Jones, 1872: p. 112), and Dellenbaugh wrote that Nail Canyon "stretched away to the south a narrow, deep, and sharply defined valley or canyon one-eighth mile wide, the bottom of which seemed perfectly flat" (Azar, 2005: p. 54).

The party began the gradual ascent up Nail Canyon, which at the time they called Stewarts Canyon, towards their destination of Levi Stewarts Ranch at Big Springs.

> "After four miles up the valley through beautiful pines of great height, we came to a deserted log cabin only half roofed over, and there we stopped to make our temporary headquarters. The Stewarts of Kanab had started a saw-mill at this place but as yet the work had not gone very far (F.C. Dellenbaugh, in Azar, 2005: p. 54).

The forest that grew in the deep valley-bottom soils seemed to capture the attention of the party who had been spending much of their time in the open deserts and grasslands below the plateau. Almon Harris Thompson wrote that in Nail Canyon there were "Many huge pine trees….One that has fallen was at least 200 feet high and 5 feet through, another 150 feet high and 5 feet through" and that Big Springs formed a small pond at the base of the 200 foot waterfall, and then flowed for about one-quarter mile before sinking into the ground (Thompson, 1939: p. 69). And Walter Clement Powell, peering up from Stewarts homestead said that

> "Rounded peaks, heavily wooded, covered with snow, rise above us. Giant pines and cedars hem round the little valley. Straight, symmetrical, these royal trees, clad in ermine and emerald, rise to a height of 200 feet, and often 250 feet" (Powell, 1872: p. 398).

Clarence Dutton said of the canyon that "…around us is the sylvan scenery and a rolling country traversed by many valleys and ravines" (in Powell, 1882). Importantly, and in my opinion largely ignored in contemporary historical reviews, he went on to provide a context for such early descriptions that should not be overlooked by researchers who attempt to interpret pioneer impressions into management visions: "True, they [the sylvan scenes] are not the finest types, *but when we recall the desert we have just left, this place looks like a paradise*" (in Powell, 1882, my emphasis added).

Coming from the east, the approach to the plateau was similar to the western ascent, and perhaps more scenic with the Vermilion Cliffs immediately to the travelers' right. In 1872, J.H. Beadle came from this direction when he crossed the Arizona Strip during a five year tour of the undeveloped west. After departing Jacob's Pool where he spent the night with Rachel Lee (one of John D. Lee's eleven wives who complained to Beadle about the injustice of polygamy) he wrote "A few miles from the spring I commenced the ascent of the 'Buckskin,' a low range of partially wooded hills, putting out across the plateau nearly to the Colorado. All over this I found good blue grass [*Bouteloua gracilis*?], which is very rare elsewhere in the Rocky Mountains" (Beadle, 1873: p. 656). Hurrying on past Jacob's Lake to find the next water source which he mistakenly thought was Navajo Wells, he neglected to take note of the conditions in the forest proper.

Nearly forty years would pass before further accounts of the forest would be published or recorded, and it was in this period that intense overgrazing by huge herds of livestock would change the condition and trajectory of the plateau's forests and parks. In 1909, at the height of

this wholesale abuse of the range, the Forest Service allotted permits for 14,000 cattle and 7,500 sheep (Goldman & Locke, 1923) but due to the inability of the young agency to enforce regulations, the number of trespass stock could have equaled permitted head (Mitchell & Freeman, 1993). The Arizona Strip supported approximately 50,000 head of cattle and 200,000 sheep most of the year (McOmie et al., 1913), and when conditions in the surrounding areas were too dry, cattlemen and shepherds would just move on up to higher country without thinking twice (See chapter 3 for a more detailed discussion of grazing).

Figure 4.1 *Two hunters enjoying the bounty on the Kaibab Plateau in 1900*

Sharlot Hall, Arizona's Territorial Historian, made a trip through the strip during the summer of 1911, during the most intense period of livestock grazing, and spent a week in the high forest escaping the heat and intolerable sun of the Navajo Desert through which she had just passed. She and her companion crossed the plateau on the established road that cut up from near today's Two-Mile Ranch headquarters (Larsen, 2000) and wrote that "…we are in the gray sage country and the air is pungent with is bitter scent; it drowns the pinon balsam and the quinine bush [*Purshia* sp.; cliffrose] that is in full blossom. It must be the chief food for the cattle for *there is no grass*" (Hall, 1975: p. 60, my emphasis added). The blue grass all round that J.H. Beadle saw just forty years earlier had been trampled out or eaten up by the cattle and sheep, but that wasn't all that had changed. She wrote a few days later that "Nail Canyon is a deep, narrow canyon with a…scattering of pines growing thicker and taller as we went, till we came to a…*field of alfalfa and oats a mile or two long and a hundred yards wide*" (Hall, 1975: p. 67, my emphasis

added). The deep soils that 200 foot tall trees had sunk their roots into were now the domain of attempts at large scale agriculture. Nail Canyon wasn't the only place where Mormon settlers tried cultivating crops. In 1879, David K. Udall, Lawrence Mariger, and William T. Stewart planted fifty to seventy-five acres of wheat in DeMotte Park, and potatoes were planted in Tater Canyon, but all attempts failed shortly after their inception and farming never dug its roots any deeper on the Kaibab Plateau (USDA Forest Service, 1998).

Hall continued south through Nail Canyon as it slowly climbed past Dry Park and the upper limit of the ponderosa forest. She walked ahead of the wagon into the mixed conifer forest where "the spruce trees and fir thickened as we came on up a long narrow canyon….There are several kinds of spruce trees, or perhaps some of them are fir, and the largest quakenasp trees I ever saw anywhere" (Hall, 1975: pp. 72-73). Arriving at DeMotte Park she noticed the "…low hills, thickly forested with spruce…" (Hall, 1975: p. 73) and on the trail to Cape Royal she rode "…through a forest where never a tree has felt the axe. The canyon sides were hidden in masses of spruce and fir[,] and yellow pine more thinly covered the level" (Hall, 1975: p. 75). Two days later, on August 24th, Hall and her companion "took a pack outfit of two horses with food for several days and started for [Point Imperial, where]….The forest…was tall and unbroken except for little natural glades and shallow canyons with grassy bottoms…" (Hall, 1975: p. 76). Nearing the end of her Kaibab tour, she approached Jacob's Lake and wrote that "The forest all along has been fine, big yellow pine for the most part" (Hall, 1975: p. 84). She then carried on towards the Mormon towns and cities to the west, and left in her passing a poetic description of the Kaibab of nearly one hundred years ago.

Several years later, in 1916, a wealthy easterner named George C. Fraser toured the Kaibab as part of a two year stint of western adventure. His descriptions of the forest mirror those of his predecessors:

> "The whole 25-mile ride today [from Jacob's Lake to DeMotte Park] was…through a succession of vales, glades or parks in the valley bottoms, with intervening forests on the slopes and divides. Except for vistas along these glades, there was not a distant view. In no place was there any underbrush, and except for thick groves of quaking aspen, one could ride at a gallop through the forest anywhere. The parks are carpeted with rich grass and a great variety of wildflowers, yellow tints predominating….The pines grow far apart, with their lowest branches usually over 15 feet above the ground. Beneath them the ground is covered with needles and a sparse growth of grass" (Fraser, 2005: p. 39).

It is important to note that his entire days ride was in valley bottoms where the forest structure was, and still is, generally open. Most accounts of the early Kaibab probably were made in the valley bottoms, not on flatlands or ridges where the forest may have been denser. Fraser's observations also recorded that in the parks there was abundant ground cover, but beneath the trees little grass grew. This can be interpreted in different ways: did Fraser observe the natural order in ponderosa pine forests, that beneath the trees there is a sparse understory owing to ecological dominance by the tree and its accumulations of litter and duff? Or was what he observed a result of overgrazing and fire suppression, where fine fuels accumulated and suppressed the growth of understory plants that had suffered greatly from huge herds of livestock? Qualitative observations from the early 1900's reflect a landscape that had been altered rapidly and beyond the range of normal utilization. Because of this, these travelers' impressions should be carefully interpreted.

Plateau predators

The grizzly bear (*Ursus arctos*) was once native to most of western North America, but in the last century its range has been reduced to the northern Rockies and San Juan Mountains in Colorado. Woodbury (1944) briefly mentions that grizzly bears were still on the Markagunt Plateau in southern Utah as late as 1908, and Larsen (2000) tells of a grizzly that killed a cow on the Kolob Plateau near Zion National Park in 1871 which was around the last time any records for the Kaibab Plateau tell of them. Bailey (1935) reported that a grizzly was killed by an Indian boy in South Canyon around 1870, and later in the 1880's one was seen by Charles D. Walcott in Nankoweap Valley. Besides these stories, no other sightings exist. Black bears (*Ursus americanus*), however, are probably still residents of the Kaibab, although they may be very rare. Tracks are occasionally seen on the North Rim (Lamb, 1994), and records show their presence in the early 20th century (Collins, 1994). Also, Grand Canyon National Park lists black bears as resident fauna in the Kaibab Plateau's highest elevations (GCNP, 2005).

Wolves were once common but now a memory on the Kaibab Plateau. Early settlers and explorers had no room in their hearts for these beasts, as evidenced in this story told by Loretta Ellsworth in 1885 as she made her way across the desert west of the Kaibab: "…way out on the desert...we found ourselves completely surrounded by wolves….The boys killed wolves as long as their ammunition lasted. It was an amazing sight to see about fifty large wolves lined up like

soldiers" (Ricketts, 2001: p. 76). Sharlot Hall wrote in her journal in 1911: "The Kaibab Plateau was so full of lions and wolves when the Old Hunter [Jim Owens] came seven years ago that the stockmen had given up trying to raise horses and even lost grown stock as well as colts and calves" (Hall, 1975: p. 80). In a letter to Gifford Pinchot, Forest Ranger William Mace wrote that occasionally he ran across the trail of a wolf when he worked on the Kaibab Plateau between 1909 and 1911, but coyotes were more plentiful, probably because by that time most of the wolves had been killed (Mace, 1990). Wolf killing was a pastime for all who ventured into the area in the early days, even John Wesley Powell's surveyors would regularly chase wolves from House Rock Valley into the forest where they would shoot them for their skins (Powell, 1871). Between 1906 and 1922 government hunter Jim Owens killed around 30 wolves on the plateau and surrounding areas, as well as many owls, hawks, eagles, bobcats, mountain lions, and coyotes (Easton & Brown, 1961; Hughes, 1991).

Rasmussen (1941) says that the last wolf in the area was taken in 1926, but two stories of the last wolf put the date even earlier. According to the late Roland Rider, a legendary local cowboy, around 1910 there was a lone timber wolf that roamed a great circuit around the Kaibab Plateau and scared many a cowboy and traveler. The wolf would kill about a cow a day but not eat them and ended up getting chased over to the Paria Plateau by angry stockmen. A posse rounded up to kill it and they pushed him up to the northern edge, where they were sure they'd shoot him as he was pushed to the edge of Paria Canyon. After searching the area for the wolf, the posse found a sixteen foot juniper bridge across a constriction in the canyon where the wolf had crossed into Utah. Evidently, the Robbers Roost gang built the bridge to escape the law, and the wolf used it to his advantage too. Soon after, there were stories of cattle being killed up in the country north of the Paria River by a lone timber wolf (Rider & Paulsen, 1985). But according to Leonard Heaton, in 1912 two wolves came off the plateau to the west and started giving ranchers trouble. One was caught right away but the other survived for twelve years on calves and pregnant cows, eating the calf inside. Finally it was trapped by T. Gilby and shot in the trap by an Indian passing through. The skinned hide was just under ten feet long from tail to nose. Heaton said that was the last report of a wolf in the area (Larsen, 2000: pp. 68-70). Regardless of when the last wolf was killed, it marked an end to the "unearthly howls" that were heard by the Powell surveyors and many others for centuries before (Powell, 1871: p. 366).

Part II. Early forest inventories and ecological studies

The Lang and Stewart survey

The first substantial forest inventory on the Kaibab Plateau was completed in 1910 by a US Forest Service crew sent there to assess timbering possibilities. On January 13, 1910 the reconnaissance party, consisting of D.M. Lang, S.S. Stewart, N.B. Eckbo, and J.E. Ingram, R.W. Taylor, Lincoln Cromwell, William Mace, and A.L. Griffen left Ogden, Utah and made it to Kanab by the 20th. After provisions arrived they made it to the forest on February 2nd. The snow being too deep to continue with ease by team, the party had to haul all the equipment by sled to Jacob's Lake. By February 15th they were ready to begin the work. From then until September 15th the party, which at times consisted of different men, mapped and estimated 412,000 acres of timberland, surveyed 35 miles of transit line, and surveyed 195 miles of compass line; all for the cost of $9,163.30, or, $.022 per acre! Their methods entailed surveying strips that were as near as possible to represent average stands. All trees were measured down to 6 inches diameter at breast height, and sometimes seedlings and saplings were counted. In actuality, only 5% of the plateau was sampled (Lang & Stewart, 1910).

The reconnaissance party found that

> "The Forest as a whole is practically an unbroken body of mature timber occupying the top of the Kaibab Plateau and merging gradually into the mahogany and sage brush as the elevation decreases. The main body of merchantable timber, in detail, is frequently intercepted by irregular areas entirely free of tree growth, --parks, broad canyon bottoms, dry southern exposures, and in many cases ridges, the latter especially near the exterior limits of the forest. This unequal occurrence of the forest cover is due to a number of agencies, chiefly fire and lack of moisture" (Lang & Stewart, 1910: p. 7).

That depiction echoes some impressions of earlier explorers but is less poetic and slightly more descriptive, especially since it points out that there was a distinction between the main body of timber and the open park areas. What was most different about the report of this survey was the interest in gaining control of the mechanisms that created and maintained the plateau's forest:

> "The forest under consideration in this report presents a variety of conditions; is so irregular in density, age classes, and quality of timber represented that the usual objects of management must be sidestepped and all efforts directed to securing some sort of silvicultural order" (Lang & Stewart, 1910: p. 18).

In the ponderosa pine, the surveyors witnessed "patchy, uneven aged reproduction" (p. 18) "in scattered clumps…varying in age and density" (p. 26) which was not consistent with silvicultural goals of the era. The researchers encountered a highly spatially variable forest where

> "Generally the stand is very open…[and] broad flat ridges occur where the old trees are isolated, the mineral soil very much exposed…[with] practically no reproduction….Other situations occur where the stand is moderately dense with little or no undergrowth or reproduction [with] A fair soil cover of needles and humus…making an ideal seed bed for yellow pine reproduction" (Lang & Stewart, 1910: p. 24).

Of significant value are the photographs included in the 1910 report, which go beyond personal impressions of the forest and show the variability and diversity of the forest landscape.

Figure 4.2 *Best quality of mature yellow pine*

Figure 4.2 shows a stand that was described as the "best quality of mature yellow pine with understory of saplings and poles" (Lang & Stewart, 1910: p. 9). Visibility is no more than 100 yards, and indeed the forest at center appears fairly dense. Also, very few understory plants can be seen in this image; whether this is a result of overgrazing by livestock or deer the authors do not specify. Trees of a wide range of ages are growing, and in the lower left side, behind the mature tree, one can see a spindly and bent-over pine, a common site in modern doghair thickets.

Similarly, Figure 4.3 shows a wide range of age classes and densities, especially the dark and very dense stand immediately behind the tent at left. The density of the patches cannot adequately be described in terms of trees per acre, as open areas bring down the total value and skew the data to represent less dense conditions. This is exemplified in Figure 4.4 where a surveyor is standing in front of another dense stand of uneven aged trees with an "open park"

Figure 4.3 *Camp scene in early March*

in the foreground. The authors wrote that "The pine occurs mostly in open stands park-like or even isolated in character" (p. 9), which begs us to confront our perceptions of what is meant by "open" and "park-like."

Figure 4.4 *Illustrating the characteristic grouping habit of western yellow pine*

However, Figure 4.5, titled "Open or park like yellow pine stand found near exterior limit of yellow pine type, West side of Little Mt" (Lang & Stewart, 1910: p. 25), does fit our notions of 'open, park like stands.'

Figure 4.5 *Open or park like yellow pine*

Figure 4.6 also appears to be an open and park-like stand. Although not included in the original report, this photo, which was added to the 2002 digitized version, is of the

reconnaissance party moving camp and “showing cutover lands in the vicinity of Jacob's Lake” (Lang & Stewart, 1910: p. 16). In this author’s opinion, the appearance of the cutover lands beyond the sled team is what many people imagine to be historic open park-like stands.

Figure 4.6 *Cutover lands in the vicinity of Jacob’s Lake*

Interestingly, another photograph from the report taken near Jacob’s Lake (Figure 4.7) shows a fairly dense stand, especially to the left of the snowshoers.

Figure 4.7 *Near Jacob’s Lake*

Looking at the data that was collected by this earliest survey team is another way to recreate the historic Kaibab, and it yields a surprisingly high total number of trees per acre for ponderosa pine forests (Table 4.1). Most trees are in the smallest size class (<6” DBH [diameter

at breast height]) which would be expected as fire had been suppressed in some manner for as long as thirty years when data was collected. Very few mature white fir trees were found but they were abundant in the youngest age class indicating that the lack of fire had indeed allowed them to invade previously open stands. Importantly the data shows that the majority of ponderosa pines were smaller sizes, a fact that has been supported by more recent research into historic conditions (Fule et al., 2002).

Trees per acre in ponderosa pine, 1910

	Ponderosa pine	Douglas fir	White fir	Spruce	**TOTAL**
<6" DBH	51	6	40	10	107
6-12" DBH	19	<1	2	<1	~21
13-18" DBH	12	<1	<1	<1	12-14
20-42" DBH	9	<1	<1	<1	9-11
TOTAL	91	6-8	~42	10-12	**~150**

Table 4.1 *Average trees per acre, rounded to nearest whole number, for 500 acres of ponderosa pine forest in 1910 (Lang & Stewart, 1910).*

The reconnaissance team surveyed a cumulative 128 acres of mixed conifer forest in addition to ponderosa pine. Like in the ponderosa pine, large amounts of both white and subalpine fir and spruce had established themselves in the smallest size class (Table 4.2). The mixed forests they encountered were dominated by ponderosa pine in fairly even distribution from 6 to 18" DBH.

Trees per acre in mixed conifer, 1910

	Ponderosa pine	Douglas fir	White/subalpine fir	Spruce	**TOTAL**
<6" DBH	25	10	81	22	158
6-12" DBH	10	4	8	5	27
13-18" DBH	11	<1	1	<1	~12
TOTAL	46	~15	90	~27	**~190**

Table 4.2 *Average trees per acre, rounded to the nearest whole number, for 128 acres of mixed-type forest in 1910 (Lang & Stewart, 1910)*

Figure 4.8 *A typical stand of mixed conifers encountered by Lang & Stewart, 1910*

The report did not account for aspen which is a significant component of the stand in Figure 4.8 which they called a typical mixed stand along the main ridge of Big Park, so actual density was even higher than their measurements can account for. The variability illustrated by the Lang & Stewart (1910) report and photographs has implications for our understanding of historical forest structure on the Kaibab Plateau. The survey reported density in trees-per-acre (Tables 4.1 & 4.2), as many forestry reports do, but this is an oversimplified expression of a highly heterogeneous landscape that becomes clearer by examining the photographs.

Lang and Stewarts survey convinced the government that the Kaibab was in need of management and in 1913 the Forest Service completed another reconnaissance with the goal of "removal of the mature yellow pine, the insect infested timber and the less desirable species (blue spruce and white fir) and in this way bring about a more uniform stand and better silvicultural order" (Graves, 1913: p. 4). Forester Henry Graves described the variety of conditions on the Kaibab Plateau as "ranging from dense stands to isolated trees and accompanied by patchy uneven ages reproduction" (Graves, 1913: p. 4). The photographs included in Graves (1913)

Figure 4.9 *Open stand of Bull pine encountered by Graves, 1913*

report, like those of Lang and Stewarts (1910), suggest that the forest was well stocked and comprised of all ages of trees, not just old-growth widely spaced and divided by avenues of rich undergrowth (Figures 4.9 & 4.10).

Figure 4.10 *Typical stand encountered by Graves, 1913*

Insect disturbance

Lang and Stewart (1910) briefly mention an insect outbreak of 80 to 100 acres on the Walhalla Plateau, as well as "large patches where practically the whole stand littered the ground" (Lang & Stewart, 1910: p. 20). They reported that "The old fallen trunks, existing in all stages of decay, argue that this pest has been working for many decades, probably hundreds of years" (Lang & Stewart, 1910: p. 20).

Their assumption was right. F.C. Craighead spent considerable time documenting the Black Hills beetle (*Dendroctonus ponderosae*) infestation and experimenting with control treatments for it. His 1924 article in the journal *Forest Worker*, which was the first publication that described the epidemic, responsibly provided an important historical context for the beetle activity:

> "…a preliminary survey of the forest has brought out a much more significant fact, namely, that this beetle has been present in this forest, killing enormous quantities of timber, probably since the forest has been in existence, although absolute records can only be dated back 400 years…" (Craighead, 1924: p. 74).

Indeed, the record of the Black Hills beetle on the Kaibab did show frequent killings of great quantities of trees. Miller (1924: p. 50) observed that "Stumps cut during control work show where the beetles have attacked the trees hundreds of years ago, with many periodic attempts since that time." M.W. Blackman spent 1925 and 1926 on the plateau studying the outbreak that began around 1917 (Blackman, 1931). He found evidence for epidemics on the Kaibab in 1837 to 1846, 1853 to 1864, 1878 to 1882, 1886 to 1892, 1906 to 1910, and 1916 to 1926 (Blackman, 1931). The infestation that began in 1917 killed around twelve percent of the ponderosa pine, blue, and Engelmann spruce on the plateau with most mortality above 8,000 feet and very little killing evident below 7,500 feet. Mortality was scattered all over the plateau but concentrated in two or three areas (Craighead, 1924) with extensive mortality on Moquitch and Castle Ridges (Blackman, 1931). The outbreak was the second largest killing documented in the United States at that time (Miller, 1924; Blackman, 1931).

J.M. Miller described the outbreak as an "infestation [that] occurs in great centers composing thousands of infested trees…on the Kaibab National Forest where the entire stand has been killed over a considerable acreage" (Miller, 1924: p. 50). The beetles, in less than a decade, reduced the stand density and basal area dramatically; in 1923 alone Miller (1924) reported that 81,890 trees contained twenty-five million board feet of timber were killed. This killing and those that preceded it resulted in huge amounts of fuel on the ground: "The forest floor is strewn with decaying trunks showing the markings of the beetles" (Figure 4.11)(Miller, 1924: p. 50) and "Over the entire Buckskin Mountain old killings are in evidence, the trunks prostrate on the ground. Many of these are as large as the present killing…" (Craighead, 1925: p. 352). The densely stocked and immature ponderosa pine forest described by Craighead (1924, 1925) was, according to his estimates, a result of past beetle activity.

Could the widespread, young stand have been a result of fire suppression? Fires were indirectly suppressed as early as the 1880's when grazing reduced fine fuels that would carry fires, but active suppression didn't start until 1910 (Buckley, 2004), and even then the ability

Figure 4.11 *Fifteen year old beetle kill on the Walhalla Plateau, 1925*

to put out fires was constrained by a lack of manpower and equipment (See chapter 5 for more discussion on fire suppression and fire history). Perhaps, then, young, dense stands were naturally allowed to mature, and only then did beetles thin the stands, create open areas, and ground fires would eliminate the evidence of the once dense stocking. F.C. Craighead adequately explains this hypothesis:

> "This [cycle of beetle epidemics] has resulted in a rather unusual condition for a virgin yellow pine stand. Generally speaking, the forest consists of a densely stocked immature stand. Stands of old mature timber are very limited in extent….These beetles have in reality been putting into effect a form of management-cutting by a group system the annual increment of the forest for hundreds of years in the past and providing at the same time good conditions for reproduction" (Craighead, 1924: p. 74).

And later he wrote that

> "The history of the Kaibab forest is essentially that of the Black Hills beetle, supplemented by local fires. Thus, in this forest the killing has been more or less continuous although probably with cycles of greater severity. In other words,

> this densely stocked, immature, yellow pine forest has been produced by these beetles…(Craighead, 1925: p. 352).

In addition, some explanations for the plateau's remarkable stands of aspen were offered by these early researchers:

> Fires burning through green mature timber have scorched trees and killed reproduction, but where they have burned through old 'bug killings,' complete destruction has occurred and pine has been temporarily replaced by aspen" (Miller, 1924: p. 50).

> "Fires have also played a small part as local sorts of affairs. Usually starting from lightning, they burn up small areas of the bug killed timber, at the same time killing the reproduction. With the seed trees gone and the reproduction that was previously established killed, poplar rapidly comes in and converts such burns into a poplar type. There is an excellent lesson here for foresters and one that should receive thorough investigation" (Craighead, 1924: p. 74).

> Past fires in bug-killed centers with much inflammable debris on the ground have been more severe, killing the reproduction and changing the pine to an aspen type….The Wylie Point Plateau once contained an excellent stand of pine, as evidenced by the dead trees now on the ground and a small remaining block of standing green timber, but this is now largely an aspen forest beneath a scattering of scrubby pines" (Craighead, 1925: p. 352).

Why would the Kaibab Plateau have shouldered such attacks while the rest of the southwest was spared? Wilson and Tkacz (1993) suggest that outbreaks on the Kaibab are likely due to the late onset of logging activities, whereas many other forests in the southwest were heavily logged as early as fifty years prior to the Kaibab outbreak, thus suppressing the beetles by limiting their habitat. Since the early 20th century the cycle has continued with outbreaks from 1935 to 1938, a minor one in 1950, and another from 1973 to 1977 (Parker & Stephens, 1979), though these outbreaks were localized and low level (Parker, 1980). Parker (1980) suggests that the smaller outbreaks of the late 20th century were a result of increased logging after World War II that reduced basal area across much of the forest to around 100ft/acre^2, therefore diminishing the quality of the beetles required habitat.

Disturbance at great scales may be a critical part of the history of the Kaibab Forest. In 1916, G.C. Fraser witnessed a windthrow event on the Walhalla Plateau that may have been exacerbated by the beetle killings of the previous decade. He wrote that

> "…the forest had suffered severely this year [1916] from heavy wind occurring after the thaw when the ground was soft. The resulting was the uprooting of quantities of trees, large and small. [Y]ellow pines, close to 100 feet tall, [were] down with their roots torn loose, making big holes in the plateau surface. Other trees of considerable size had been broken off three to six feet from the ground" (Fraser, 2005: pp. 136-137).

Figure 4.12 *Scattered limby yellow pine in canyon bottom of Indian Hollow (Lang & Stewart, 1910)*

The soils of the Kaibab Plateau are shallow and coarse textured which makes for a less stable rooting substrate than basalt or sandstone soils, and windthrow has commonly been recorded at reference sites along the North Rim (Fule et al., 2002) suggesting that Frasers observation was not out of the ordinary.

Other insects infestation that have thinned the forest from time to time include Western Spruce Budworm (*Choristoneura occidentalis*) and Pandora moth (*Coloradia pandora pandora*) defoliations. A spruce budworm epidemic in 1958 was controlled with DDT, and an outbreak from 1975 to 1979 that peaked in 1977 with over 70,000 acres defoliated was controlled with Sevin-4 (USDA Forest Service, 1979). Pandora moth outbreaks in 1979 and 1981 defoliated 5,000 and 17,000 acres each (Wagner & Mathiasen, 1985). Pandora moth outbreaks may act to reduce dwarf mistletoe (*Arceuthobuim vaginatum*) on ponderosa pine. Wagner and Mathiasen (1985) reported that data indicated that mortality from the moth tended to occur on trees that were heavily infested with dwarf mistletoe, though the moth did not prefer these trees. Furthermore, trees weakened by mistletoe did not survive long after moth defoliation. They wrote that

> "in forest areas not under intensive forest management, defoliation by the Pandora moth may actually have a beneficial effect. Since mortality preferentially occurs on the more heavily infested trees, defoliation may have the affect of reducing stand mistletoe infection levels" (Wagner & Mathiasen, 1985: p. 425).

The Kaibab Plateau is the southernmost forest where large outbreaks of the Pandora moth have occurred (Fule et al., 2002). Miller (1983) studied the effects of fire on the moth and found that the highest amounts of pupae are found in open areas with little litter and duff. Prescribed fire had little effect on the moth because it doesn't get hot enough to kill the pupae in those areas with fewer fuels where the moth pupates. Also, he observed that defoliation didn't reduce growth and vigor in most trees (Miller, 1983), suggesting that the Kaibab Plateau forest ecosystem just might have adapted to this "pest" long before forest management came along.

Early ecological descriptions

Pauline Mead spent a summer on the Kaibab Plateau in the 1920's to conduct field work for her dissertation at the University of Chicago (Mead, 1930). Her study was the first to describe plants other than merchantable timber in any detail. A complication with her data however, is that it was collected just after the climax of the Kaibab deer irruption (see chapter 3) which makes interpretation of the following statement difficult: "except in the clearings the forest floor is completely clean with little underbrush and only a few herbs" (Mead, 1930: p. 115). In addition, fire suppression had at that point disrupted the natural plant communities and affected the ability of some plants to propagate, therefore her descriptions and all those that followed her should not be treated as 'relict' data but rather as 'reference' data to compare changes over the last eighty years.

Meadow grasses reported by Mead (1930)
Stipa colunbiana
Stipa Comata
Phleum alpinum
Blepharoneuron tricholepis
Koeleria cristata
Bouteloua gracilis
Boutelous eriopoda
Scleropogon brevifolius
Poa pratensis
Poa fendleriana
Festuca octoflora
Festuca ovina
Bromus ciliatus
Bromus porteri
Bromus frondosus
Elymus lanceolatus
Agropyron smithii

Table 4.3 *Meadow grasses reported by Mead, 1930*

She observed that grasses were the prominent plants in the meadows (Table 4.3), *Lupinus barbiger* was the most common plant in the ponderosa pine forest, and *Hymenoxys richardsonii* was the most widely distributed plant over the entire plateau. Other common plants in the pine forests were *Erigeron divergens, Solidago velutina, Viguera multiflora, Geranium fureatum, Asclepediodora decumbens, and Draba asprella* (Mead, 1930). In rocky places up to 8,500 feet *Castilleja linariaefolia, Orthocarpus purpureoalbus and Angora coronopifolia* were common plants. A complete plant list for the plateau was compiled and can be found in Appendix 1. Included in the list are many comments on certain plants such as their abundance or where they could be found, especially for meadow and park plants.

Mead (1930) was the first researcher to comment on tree encroachment into meadows which has been a management concern for some time (see chapter 3). She wrote:

> "In a great many cases seedlings of *Picea pungens* occur along the edge of the meadow in the open. This apparently does not signify encroachment since usually no trees of intermediate sizes are found between the seedlings and the mature trees. These seedlings are stunted and short for their ages. Some that are ten years old are only a foot and a half tall. Natives report that such seedlings have appeared along the edge of the meadow for fifty years. Perhaps they germinate in a favorable year, live until conditions are hard, when they are killed off, and the process is repeated. Sometimes, however, they are successful and grow to maturity in the open meadow. In a good many cases it appears that [aspen grows] into the open meadows [around the spruce] seedlings. These seedlings are apparently more healthy and in some cases grow to maturity" (Mead, 1930: pp. 128-129).

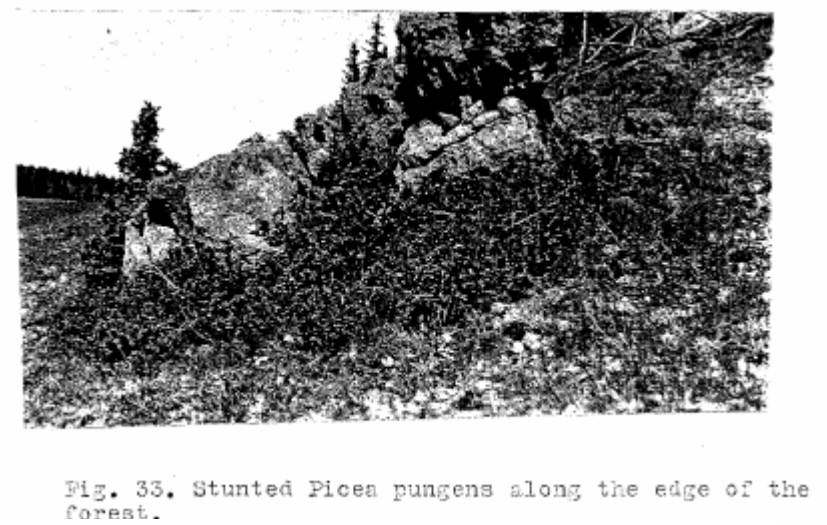


Fig. 33. Stunted Picea pungens along the edge of the forest.

Figure 4.13 *Stunted spruce growing along a meadow edge, from Mead (1930)*

An additional component of her study was determining why the meadows were such harsh places for the seedlings to grow. Her conclusion was that cold air masses that sink to the low elevation canyon bottoms maintained cooler soil temperatures that were not conducive to tree growth (Mead, 1930).

Rasmussen spent 1929 through 1931 on the plateau describing biotic communities and the Kaibab deer herd. Regarding the ponderosa pine forest he wrote:

> "The forest here is decidedly open. The trees are unusually large and mature, growing in groups or widely spaced so that the sunlight reaches the ground in almost all parts of the forest. The understory is usually free from shrubs or smaller trees and little fallen timber is present throughout the forest" (Rasmussen, 1941: p. 253).

It is interesting that he reports little fallen timber, yet just before his visits the the plateau beetle kills leveled thousands of acres. His forest inventories are similar to Lang and Stewarts (1910) in that he found that on sample plots in the mature forest there were forty to fifty-five trees per acres over six inches DBH. However, what had changed significantly was that he reported 200 to 400 trees per acre less than six inches DBH (Rasmussen, 1941), whereas Lang and Stewart (1910) reported around 100 trees per acre for that size class. Obviously, an additional two decades of fire suppression had allowed tremendous numbers of trees to germinate that would otherwise have been thinned by frequent fires.

In the higher elevation forests he reported that the deer herd had severely diminished scrub willows which may have been an important component of the forest at one time:

> "There are a number of old dead willow, *Salix* sp., showing evidence of having been killed by deer browsing. It is doubtful that more than a few individuals of this species are now alive at the summit of the plateau, and a few years of current usage will completely destroy the evidence of its former occurrence" (Rasmussen, 1941: pp. 262-263).

Indeed, a few more years of usage occurred and the willow is now just a memory. His descriptions of the meadows and parks at the crest of the plateau are similar to those of Mead (1930), and he even reports that grasses made up fifty percent of the total ground cover. According to his report, other important plants in the meadows were *Orthocarpus purpureoalbus, O. luteus, Pseudocymopterus montanus, Phlox caespitosa,* and species of *Erigeron, Eriogonum, Antennaria* and *Potentilla* (Rasmussen, 1941), suggesting that contemporary meadows have changed very little since that time.

Merkle (1954) studied the highest elevation forests on the Kaibab Plateau within Grand Canyon National Park. He established fifty half-meter quadrats in forests from 8,700 feet to 9,200 feet elevation. The most important herbs were *Poa fendleriana, Bromus ciliatus, Carex siccata, Erigeron formosissima, Frageria virginiana,* and *Packera multilobata* (see Appendix 2

for data tables). One point of significant value in his report is that: "There is a general belief among local foresters that the Kaibab forest suffered a terrific fire [at] some indefinite time in the last two centuries" (Merkle, 1954: p. 318). Given the extent of historic beetle kills many large fires probably burnt as a result of huge quantities of fallen timber that followed the infestations (see chapter 5 for more on large fires).

Conclusion

The descriptions of the Kaibab forest compiled here provide important insights into past forest structure and ecological processes. The earliest written descriptions were brief but paint a picture of a forest that was open in some places and denser in others. Nail Canyon was perhaps a pinnacle of beauty, described by several early surveyors to be an open forest with incredibly tall trees. Unfortunately the Kaibab was severely overused by livestock before adequate descriptions of ground flora could be made, a fact lamented by more than one historical ecologist (Buckley, 2004). The vast majority of anecdotal descriptions highlight the open and park like aspects of the forest, but those are loaded words that reflect the personal perceptions of openness that is inherently different for every person. Travelers from the eastern states would find even moderately thin stands to be very open compared to eastern deciduous forests, so relying on such historical descriptions can be misleading.

The most valuable and impressive descriptions of the Kaibab Plateau's forests came from the earliest timber surveyors and forest workers, who, although their intent was to control the forests' natural processes, recorded a rare glimpse into the scale and extent of natural disturbance in a relatively wild southwestern forest. Lang and Stewarts (1910) and Graves (1913) inventories are useful reference points, and while they may not be rigorous and statistically defensible by modern standards, they serve as functional guides for modern forest restoration and ecosystem management. Importantly, the photographs included in those two reports show the range of very dense to very open forests that characterized the Kaibab Plateau in days past. Ecological studies from the early part of this century reflect ecosystems that had already departed from their natural trajectory, but are useful benchmarks to weigh improvements and further degradation in the forest since grazing was brought under control by the government.

Combined, the descriptions and reports reviewed in this chapter should be considered the most thorough evaluation of historic conditions yet compiled regarding the Kaibab Plateau, and should serve to influence management in such a way as to permit the natural range of disturbances and structural attributes that defined the plateau for millennia.

Literature Cited

Azar, J.S. 2005. Buckskin Mountain. Pages 53-56 In Anderson, Michael F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Bailey, V. 1935. Mammals of the Grand Canyon region. Natural history bulletin no. 1. Grand Canyon Natural History Association.

Baker, R.D, R.S. Maxwell, V.H. Treat, and H.C. Dethloff. 1988. Timeless heritage: a history of the Forest Service in the southwest. US Department of Agriculture Forest Service, FS-409, College Station, TX.

Beadle, J.H. 1873. The undeveloped west. National Publishing Company, Philadelphia, PA.

Blackman, M.W. 1931. The Black Hills beetle (Dendroctonus ponderosae Hopk.). Bulletin of the New York State College of Forestry IV(4).

Booth, P.M. 2005a. Blue denim university: The Civilian Conservation Corps' retooling of Arizona youth. Pages 91-98 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Booth, P.M. 2005b. The Civilian Conservation Corps' role in tourism: The CCC's retooling of Arizona's natural resources. Pages 73-80 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Briggs, W. 1976. Without noise of arms: The 1776 Dominguez-Escalante search for a route from Santa Fe to Monterey. Northland Press, Flagstaff, AZ.

Brooks, J. 1944. Journal of Thales H. Haskell. Utah Historical Quarterly Vol. XII. Pp.69-98.

Burnett, H. 1991. Green island in the sky. American Forests 97: 44-47, 62.

Collins, G.L. 1994. Bare facts about bear tracks. Pages 142-143 in (Ed.) S. Lamb. The best of Grand Canyon Nature Notes. Grand Canyon Natural History Association: Grand Canyon, AZ.

Craighead, F.C. 1924. The black hills beetle practicing forestry on the Kaibab. Forest Worker, November, 1924: 74.

Craighead, F.C. 1925. The *Dendroctonus* problem. Journal of Forestry 23: 340-354.

Dutton, C.E. 1887. Physical geology of the Grand Canyon district. Second annual report of the United States Geological Survey, pp. 49-166. Government Printing Office, Washington, D.C.

Easton, R. and M. Brown. 1961. Lord of the beasts-the saga of Buffalo Jones. University of Arizona Press, Tucson. 287 pages.

Fraser, G.C. 2005. Journeys in the canyonlands of Utah and Arizona, 1914-1916. Edited by F.H. Swanson. University of Arizona: Tucson, Arizona.

Fule, P.Z., W.W. Covington, M.M. Moore, T.A. Heinlein, and A.E.M. Waltz. 2002. Natural variability in forests of the Grand Canyon, USA. Journal of Biogeography 29: 31-47.

GCNP. 2005. Grand Canyon mammals. Available online at http://www.nps.gov/grca/pphtml/subanimals6.html. Last accessed March 6, 2006

Goldman, E.A. and S.B. Locke. 1923. The mountain of twenty thousand deer. American Forestry 29: 649-653.

Graves, H.C. 1913. Timber reconnaissance: Kaibab National Forest, Arizona. USDA Forest Service, District 4 Office of Silviculture.

Hall, S.M. 1975. Sharlot Hall on the Arizona Strip: A diary of a journey through northern Arizona in 1911. Compiled by C.G. Campton. Northland Press, Flagstaff, AZ.

Hayfen, L. 1947. Armijo's journal. Huntington Library Quarterly 11: 87-101.

Hughes, J. Donald. 1991. In the house of stone and light: a human history of the Grand Canyon. Grand Canyon Natural History Association, University of Denver, CO.

Jones, S.V. 1872. In Gregory, H.E. (ed.) 1948-1949. Journal of Stephen Vandiver Jones. Utah Historical Quarterly 16-17: 19-174.

Lamb, S. 1994. (ed.) The best of Grand Canyon Nature Notes. Grand Canyon Natural History Association: Grand Canyon, AZ.

Lang, D.M. and S.S. Stewart. 1910. Reconnaissance of the Kaibab National Forest. Available on-line at www.nau.edu/library/speccoll/manuscript/kaibab_recon.

Larsen, W. 2000. Arizona strip stories as told in their own words. Draft manuscript on file at Dixie State College, Special Collections, St. George, UT.

Mace, W. M. 1990. Will Mace memoirs: a letter to Gifford Pinchot dated February 9, 1940. Pages 65-73 in People and Places of the Old Kaibab. USDA Forest Service Cultural Resources Management Report No. 10. Southwestern Region.

McHenry, D.E. 1994. Quaking aspen-its future in the park. Pages 75-76 in (Ed.) S. Lamb. The best of Grand Canyon Nature Notes. Grand Canyon Natural History Association: Grand Canyon, Arizona.

McOmie, A.M., C.C. Jacobs, and O.C. Bartlett. 1913. The Arizona Strip: report of reconnoissance [sic] of the country north of the Grand Canyon. Arizona Board of Control.

Mead, P. 1930. An ecological description of the Kaibab Plateau, Arizona. M.S. Dissertation, University of Illinois, Chicago, IL.

Merkle, J. 1954. An analysis of the spruce-fir community on the Kaibab Plateau, Arizona. Ecology 35: 316-322.

Miller, J.M. 1924. The Black Hills beetle on the Kaibab forest. Timberman 26(2): 50.

Miller, K.K. 1983. The ecology and impact of the Pandora moth, *Coloradia pandora pandora* Blake, in northern Arizona. M.S. thesis, Northern Arizona University, Flagstaff, AZ.

Mitchell, J.E. and D.R. Freeman. 1993. Wildlife-livestock-fire interactions on the North Kaibab: a historical review. Gen. Tech. Rep. RM-222. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Parker, D.L. 1980. Mountain pine beetle, *Dendroctonus ponderosae* Hopkins, in ponderosa pine, Kaibab Plateau, Arizona. USDA Forest Service Integrated pest management guide, R-3 80-8.

Parker, D.L. and R.E. Stephens. 1979. Mountain Pine beetle infestation characteristics in ponderosa pine, Kaibab Plateau, Arizona, 1975-1977. USDA Forest Service, Research Note RM-367. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Powell, J.W. 1882. Second annual report of the United States Geological Survey. Government Printing Office, Washington, D.C.

Powell, W.C. 1871/1872. In Kelly, C. (ed.) 1948-1949. Journal of W.C. Powell. Utah Historical Quarterly 16-17: 257-478.

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecological Monographs 11(3): 229-275.

Ricketts, N.B. 2001. Arizona's honeymoon trail and Morman wagon roads. Cox Printing: Mesa, AZ.

Rider, R.W., as told to D.M. Paulsen. 1985. The roll away saloon: cowboy tales of the Arizona strip. Utah State University Press, Logan, UT.

Schlegel, P.A. 1992. A history of the cattle industry in northern Arizona, 1863-1912. MA Thesis, Northern Arizona University, Flagstaff, AZ.

Thompson, A.H. 1939. Diary of Almon Harris Thompson. Compiled by J. Cecil Alter. Utah State Historical Quarterly 7: 2-138.

USDA Forest Service. 1979. Draft Environmental Impact Statement, western spruce budworm management, Kaibab National Forest and Grand Canyon National Park. USDA Forest Servive, Albuquerque, NM.

USDA Forest Service. 1998. Kaibab National Forest, North Kaibab Ranger District History. Informational paper describing the history of the North Kaibab Ranger District, available at Kaibab National Forest, North Kaibab Ranger District, Fredonia, AZ.

Wagner, M.R., and R.L. Mathiasen. 1985. Dwarf mistletoe-pandora moth interaction and its contribution to ponderosa pine mortality in Arizona. Great Basin Naturalist 45(3): 423-426.

Wilson, J.L., and B.M. Tkacz. 1993. Status of insects and diseases in the southwest: implications for forest health. Pages 196-203 in Covington, W.W. and L.F. DeBano, technical coordinators. Sustainable ecological systems: implementing an ecological approach to land management. USDA Forest Service General Technical Report RM-247. Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO.

Woodbury, A.M. 1944. A history of southern Utah and its National Parks. Utah State Historical Quarterly Vol. XII. Pp. 111-209.

Chapter 5.

Kaibab Plateau fire history studies: a review

Introduction

The natural history of fire has been well documented on the North Rim of the Grand Canyon. This paper reviews fire history studies and related information regarding the North Rim and Kaibab Plateau to provide reference information for fire management and to inform discussions on the natural range of variability of fire and fire-adapted plant communities for the Kaibab Plateau's forests and woodlands. No fire related studies have been published that exclusively focus on the forest outside of Grand Canyon National Park (GCNP), though informal studies by the US Forest Service may exist, although none were located for this research. Despite possible climatic differences between inland plateau forests and forests on the North Rim, considerable similarity exists to warrant the use of North Rim forests as the best reference areas available for inferring the natural role of fire in plateau ecosystems. In addition to GCNP studies, a study from southern Utah's Paunsaugunt Plateau is included for additional regional comparison.

Stephens and Fule (2005) argue that the GCNP sites should be considered 'quasi-reference' areas because they have experienced periods of intense human use that may have affected natural disturbance regimes and ecological processes. However, given the short duration of intense use and the close proximity to the rest of the Kaibab Plateau's forests these areas are highly suitable sources of reference information. Goebel et al. (2005) suggest that

> "Generally, reference ecosystem conditions should reflect the compositional and structural attributes that have developed after natural disturbances, and the most useful reference conditions are often those that represent the range of 'natural' variability associated with the ecosystem" (p. 351).

Because of the protection afforded by the designation of Grand Canyon National Park in 1919 the sites discussed here meet those criteria. Indeed, Stephens & Fule argue that "these reference sites [at GCNP] are incredibly valuable and should be protected in the future. At the same time it is important to recognize the limitation of relict areas for making broader inferences" (Stephens & Fule, 2005: p. 361). In this paper I will first discuss the history of post-settlement

human use of these reference sites to provide a context for their use. I then review thirteen published studies of fire regime patterns and ecological processes associated with fire adapted ecosystems on the Kaibab Plateau. Finally I suggest management actions that can allow these forests to persist with their range of natural variability.

Euro-American disturbance of natural ecosystem processes at GCNP reference areas

The points and plateaus of the southern limits of the Kaibab Plateau that reach into the Grand Canyon have been less affected by anthropogenic change than almost anywhere else in the American southwest because of the late onset of development activities, specifically logging, grazing, and fire suppression, which are often cited as the principal agents of disruption to natural fire regimes in the southwest. The North Rim study sites referenced in this paper (Figure 5.1) have never been commercially logged, though localized tree removal has occurred for construction of corrals, cabins, or other limited infrastructure. Livestock grazing was limited in duration, though it may have been intense at times. At the climax of unrestricted grazing on the Kaibab Plateau, around 1900 to 1920, the parks and forests were heavily used by cattle, sheep, and horses, although the majority of use was more to the north. The mixed conifer and spruce-fir forests "which, in places, formed a more or less dense jungle of mixed species such as Yellow pine, Douglas fir, Balsam, Spruce, and Quaking Aspen" (Mace, 1990: p. 68) may have served to protect the rim area from the heaviest grazing pressure that originated at grazing headquarters in Nail Canyon, DeMotte Park, and House Rock Valley. However, the rim was grazed for a period of thirty to forty years. Two areas within GCNP that have been used as 'reference areas' experienced heavy grazing by horses. The Powell Plateau was used by Game Warden Jim Owens as a horse pasture, probably only for the first two decades of the 1900's (Fraser, 2005) but perhaps until 1938 when a fence was erected to keep livestock out of GCNP (Hughes, 1991). Owens left the Kaibab in 1922 (Easton & Brown, 1961) and after that point there is no evidence for continued use of the Powell Plateau by other stockmen, though use was certainly possible until 1938. The Walhalla Plateau was used a horse pasture by local stockmen by the 1890's when a fence was erected to contain the horses (Buckley, 2004), and use of the Walhalla would have ceased by 1938 if not 1924 when the Grand Canyon Cattle Company left the area (Menninghaus & Jensen, 1967).

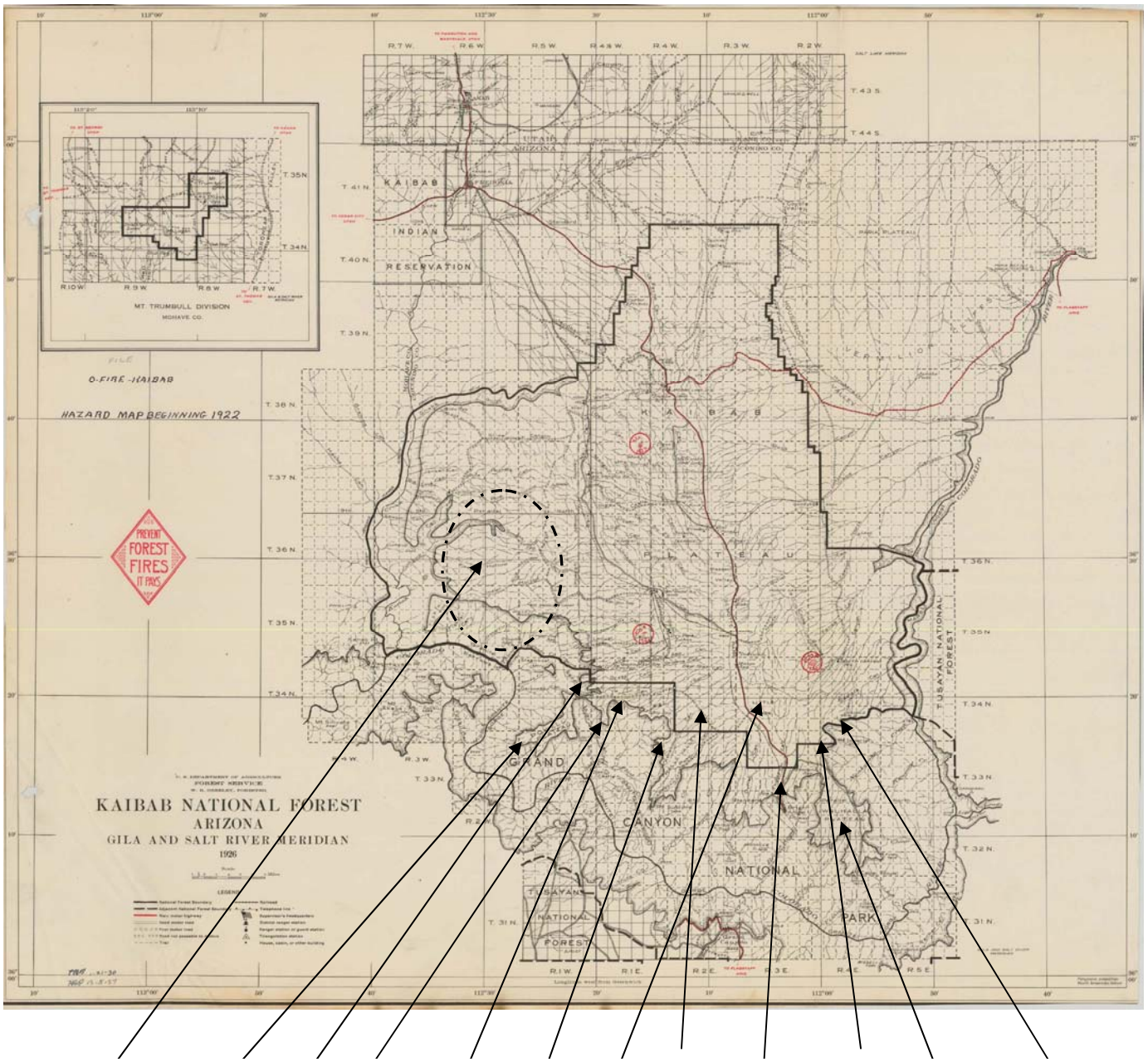


Figure 5.1 *Locations of reference area studies and important fires mentioned in this chapter overlaid on the North Kaibab Ranger District Fire Hazard Map, 1926-1930*

Fire exclusion began as early as the late 1800's when livestock removed fine fuels that would have carried fire, and this date is cited as the onset of suppression by numerous studies (see for example Fule et al., 2002; Stephens & Fule, 2005), but active suppression probably only began in the 1920's when the first GCNP buildings and infrastructure were installed and roads permitted access into previously remote areas.

Figure 5.2 *Fredonia resident Orson Pratt helps writer Dane Coolidge up the rough eastern side of the Kaibab Plateau on the old Kaibab or Bar-Z Road, prior to 1920*

Roads can significantly alter fire regimes and a brief history on the North Kaibab is worth mentioning. Starting in the late 1800's and continuing until the early 1920's tourists could take the Union Pacific train to Cedar City, Utah, and from there go by coach to the North Rim (Richmond, 2005). Travel by automobile was difficult until the 1920's even though the forests were fairly open (Figure 5.2). The first car to the North Rim was driven by Edwin Wooley, his wife, and his brother-in-law who took three days from Kanab in 1909. They carried with them tools for constructing and clearing a route, and relied on pre-dropped cans of gas every 30 miles (Woodbury, 1944). Soon thereafter, in 1913, the US Forest Service began construction of an official road with a budget of $2,750 (Woodbury, 1944). By 1919 the North Rim could be reached by dirt road from Kanab (Figure 5.3), the road was paved in 1932, and by 1938 the entire route from Flagstaff had been paved (Hughes, 1991).

Figure 5.3 *The "Grand Canyon Highway" in 1916*

Figure 5.4 *An example of a lookout tree*

A lookout tower was built two miles south of Jacob's Lake by 1916 (Fraser, 2005), and modern steel towers at Jacob's Lake and Big Springs were finished in 1934 (USDA Forest Service, 1998). Lookout trees were built in the late teens and early 1920's (Cleeland, 1990), and the Civilian Conservation Corps put out twenty to twenty-five fires a year on the Kaibab Plateau in the early 1930's, marking the real beginning of active fire suppression (Buckley, 2004). In 1925 a ranger's cabin, barn, warehouse and machinery shed were built at Bright Angel Point (Hughes, 1991) but manpower was so limited that total suppression would have been difficult. By 1959 as many as thirty-three lookout trees (Figure 5.4 and Appendix 6) were present on the plateau when their use was starting to decrease (Cleland, 1990). In 1933, the Civilian Conservation Corps established CCC Camp NP-1-A at Neil Springs (Booth, 2005b) on the North Rim. Throughout the Corps' nine year tenure in Arizona they stationed at least 4,000 men at GCNP at six camps, two of which were on the North Rim (Booth, 2005a). The Corps cut the

amount of acreage burned in northern Arizona in half over the acreage burned in the 1920's (Booth, 2005b) suggesting that the Corps was a significant player in fire suppression efforts on the Kaibab Plateau which at that point was still a remote forest. Total suppression continued until the 1970's and 1980's when GCNP initiated fire-use protocols that have since allowed for natural-ignition fires to burn under acceptable conditions (Stephens & Fule, 2005).

Fire history studies

There is considerable variability in fire occurrence and behavior across the Kaibab Plateau because of numerous steep east-west trending drainages as well as elevational gradients rising from pinyon-juniper woodlands to spruce-fir forests. Even within small areas variability exists since north facing slopes may experience fire infrequently while south facing slopes burn

Study sites mentioned in this chapter and important variables

Site	Author	Forest type	Fire Return Intervals (in years)			Years of widespread fire
			Mean/range	10% scarred	25% scarred	
Paunsaugunt Plateau	Stein, 1988	MC[1]	15.2-18.4			
Walhalla Plateau	Wolf & Mast, 1998	PP[2]	4.84-10.3			1736, 1748, 1785, 1805, 1832, 1863
The Basin	Wolf & Mast, 1998	MC	4.84-10.3			↓
Thompson Canyon	White & Vankat, 1993	MC	2-27			
Thompson Canyon	White & Vankat, 1993	SF[3]	70-250			
Little Park	Fule et al., 2003	MC	2.6	8	31	1735, 1748, 1773, 1785, 1879
Galahad Point	Fule et al., 2003	PP	4	4	6.8	↓
Fire Point	Laughlin et al., 2004	PP	3-8.9			↓
Powell Plateau	Laughlin et al., 2004	PP	3-8.9			↓
Rainbow Ridge/ Plateau	Laughlin et al., 2004	PP	3-8.9			↓

[1] Mixed conifer: ponderosa pine, white fir, Douglas fir, spruce, fir, and aspen
[2] Ponderosa pine
[3] Spruce-fir

Table 5.1 *Fire return intervals and years of widespread fire at selected study sites*

often. Fule et al. (2003b) suggest that fires were most common on islands of ponderosa pine formed by points and plateaus, such as the several North Rim study sites that have received attention from numerous researchers in recent years.

Origin of fire regimes

Fire has been an important factor in landscape scale ecological processes for approximately 10,000 years on the Kaibab Plateau. During the late glacial period (13,500 to 10,995 years before present) the vicinity of Fracas Lake was sparsely vegetated by spruce with an understory of dwarf juniper (*Juniperis communis*), sage (*Artemesia*), and grasses. Bear Lake, at a slightly higher elevation, was entirely treeless until 12,900 years ago when the area was invaded by spruce and fir. Charcoal deposits in Fracas and Bear Lakes become abundant after 10,600 years ago indicating that fire appears to have not been common on the Kaibab Plateau until then. Climatic change during that period allowed ponderosa pine to move into the region from the south, arriving at Fracas Lake around 11,000 years ago and Bear Lake 9,725 years ago. Over the next several thousand years as monsoonal weather patterns became established that included frequent lightning strikes, ponderosa pine forests and frequent fire came to dominate the plateau (Weng & Jackson, 1999). That pattern had changed very little over the last several thousand years, until the advent of fire suppression.

Trees mentioned in this chapter

Common name used in text	Scientific name
Ponderosa pine	*Pinus ponderosa*
Aspen	*Populus tremuloides*
Douglas fir	*Pseudotsuga menziesii*
White fir	*Abies concolor*
Spruce	*Picea engelmanii & P. pungens*
Fir	*Abies lasiocarpa*

Table 5.2 *Tree species mentioned in this chapter*

Extent of fires in the past

Several studies support a fire regime where lightning-started fires along North Rim points in ponderosa pine forests would burn up in elevation into more dense stands, and if conditions

were suitably dry then large fires would intensify and carry into the crowns of mixed conifer and spruce-fir forests (Wolf & Mast, 1998; Fule et al., 2000, 2002b, 2003a, 2003b). Fire scars taken from Little Park, Galahad Point, Fire Point, and the Powell and Rainbow Plateaus record twenty years of fire activity across at least three sites (Fule et al., 2003a). Several major fire years appear to have burned at least 12,000 acres, and in 1785 fire scars record what could have been a fire of nearly 60,000 acres (Fule et al., 2003a). Fule et al. (2002b) suggest that some fires may have exceeded 120,000 acres.

Wolf and Mast (1998) conducted a fire scar study at the Walhalla Plateau (2,200 to 2,500m) and The Basin (2,600 to 2,830m) to determine fire return intervals along an elevational gradient in different forest types. They found most trees were scarred in July and August and fire activity ceased in 1919. Interestingly they found that fires were slightly more frequent during the settlement period (1879 to 1919) than before 1979 which they attributed to increased human ignition. Most importantly they documented five years of widespread fire activity (Table 5.1) which may suggest that large fires burned over the landscape, perhaps originating in lower forests and moving up in elevation. At least two years from this study were confirmed as large fire years by Fule et al. (2002b, 2003a, 2003b). Furthermore, two large fire years align with insect epidemics documented by Blackman (1931) which are normal on the Kaibab Plateau (Covington and Moore, 1994b). Such fires may have been responsible for the extensive aspen forests encountered by early foresters that have since been in decline (Craighead, 1924; Miller, 1924) (see chapter 4).

Patterns in ponderosa pine forests

Table 5.1 shows that study sites in ponderosa pine had short fire return intervals, ranging from 3 to 10.3 years. Lightning ignitions are very frequent along the rim. From 1936 to 1990 forty such fires were recorded at Galahad Point, but all were suppressed and the largest grew to just under 30 acres before being put out (Fule et al., 2003a). In 1988 alone lightning ignited 125 fires along the North Rim (Fule et al., 2003b). Additionally, more fires have burned than fire scars studies reveal. For instance, a 20 acre fire on the Rainbow Plateau in 1987 is on record but didn't show up on any scars and a 1931 fire on Fire Point burnt 160 acres but only scarred one tree (Fule et al., 2000). Throughout much of the southwest an irruption of trees occurred in 1919 following ideal climatic conditions and extended fire suppression, but this burst of germination is

not evident on the Kaibab Plateau, perhaps because the climate of the plateau was not conducive to such an event (Fule et al., 2002).

Patterns in high elevation mixed conifer and spruce-fir forests

Moving up in elevation into mixed conifer forests, fires regimes were of mixed severity and variable frequency, resulting in a "patchwork of stand densities" (Fule et al., 2003a: p. 483) where climatic conditions were important in determining the severity and intensity of fires. Studies at Little Park (Fule et al., 2002b, 2003a) show an overall pattern of numerous small fires that scar a small portion of the sample trees and occasional large fires that initiate new stands. Fifty-eight percent of all plots in high elevation forests at Little Park were initiated by stand replacing fire between 1782 and 1879. Twenty percent of mixed conifer stands were established this way. Fire initiated stands were highly mixed across the landscape and could only be detected by fire scar studies; satellite imagery or aerial photos could not delineate such stands (Fule et al., 2003a).

The mixed severity regime in high elevation forests appears unstable over temporal and spatial scales, and "quite possibly, no stable distribution of severe burning events ever existed" (Fule et al., 2002b: p. 16). White and Vankat (1993) found that mixed conifer stands in Thompson Canyon were complex mosaics of ages and densities with frequent fires while spruce fir stands were more homogenous with long fire return intervals (Table 5.2). From 1933 to 1996 seventy-one lightning ignited fires were recorded at Little Park, but until 1981 all were extinguished and none exceeded 12 acres. Aspect is important in determining fire regime. In Little Park, Fule et al. (2003a) found that 53% of scarred trees were on south facing slopes, 23% were on west facing slopes, 19% were on east facing slopes, and only 5% were on north facing slopes.

Forest structure

Covington and Moore (1994a) located plots on locations compatible with Lang and Stewarts (1910) original Kaibab Plateau forest inventory and simulated change through time using ECOSIM multiresource forest growth and yield simulation. They found density had increased from 55.9 trees per acre in pre-settlement times to 276.3 trees per acre in modern times, and their model predicted that basal area was 45ft^2/acre in 1881. Their model suggested

that the 1881 tree density was two times higher than at Beaver Creek Experimental Watershed but old-growth trees were relatively few and far between (Covington & Moore, 1994a). Fule et al. (2002) found that trees on the North Rim are generally younger than trees elsewhere in the southwest which may be due to the shallow, coarse textured limestone soils which are less productive than fine textured basalt soils that occur throughout much of the region. A common occurrence at North Rim study sites are windthrown trees (Fule et al., 2002). Such events were recorded by Fraser (2005) who witnessed the aftermath of a great windthrow on the Walhalla Plateau in 1916 that uprooted great quantities of trees. Another event occurred in 1958 when over 900 acres of spruce, fir, and aspen blew down in one storm (Hungerford, 1970).

Reconstruction of forest structure at Little Park in 1880 shows past forests were significantly less dense than current forests with around 62 to 140 trees per acre. Basal area values for ponderosa pine, aspen, and Douglas fir did not change much from 1880 to 2000, but spruce, fir, and white fir were sparse in 1880, in contrast to their current dominance (Fule et al., 2003a). The 1880 forest may have been more open with many young trees that have now grown to be the dominant spruce-fir type. Fule et al. (2004b) found that only 6% of North Rim forests were vulnerable to stand replacing fire in 1880 whereas 33% was in 2000. At sites above 2,500m the greatest increase was in mesic species, a pattern observed in similar forest types on the Paunsaugunt Plateau by Stein (1988) where individual old ponderosa pines are surrounded by dense spruce-fir.

Figure 5.5 *A wildfire on the Powell Plateau in 2002*

An escaped prescribed fire in 1993 provided an opportunity to look at forest structural change and fire interactions. On September 20, 1993, a 1,185 acre prescribed fire unit called Northwest III was ignited in a mixed conifer forest at Swamp Ridge in GCNP. Unexpectedly, winds gusted to nearly 80 miles per hour and the fire escaped, resulting in high mortality. Within the burn perimeter there was 67% mortality of all trees, and as much as 90% of old-growth aspen was killed (Fule et al., 2004a; Huisinga et al., 2005). Post-burn basal area was the same as the 1879 reconstruction (28.5m^2/ha) and post-burn density of 137 trees per acre was

within 1.2 standard deviations of the reconstructed 102 trees per acre (Fule et al., 2004a). The burn was spatially variable with patches of high mortality and patches of no mortality. The highest mortality was concentrated in fire susceptible species like aspen and white fir, restoring dominance to ponderosa pine (Fule et al., 2004a).

Wildfire effects on flora

Laughlin et al. (2004) compared ground flora characteristics from Powell Plateau (Figure 5.5) and Rainbow Ridge to Fire Point after nearly 380 acres burned from September 2 to December 12, 1999. All plots were measured in 1998 and 2001. Powell Plateau and Rainbow Ridge were considered reference sites to compare against Fire Point because they had burnt several times throughout the 20th century whereas Fire Point had only burned once, in 1923 (Laughlin et al., 2004). Plant communities at Fire Point moved toward reference site composition after the burn. Species richness was higher at the reference sites in both 1998 and 2001 though change was greatest at Fire Point (Table 5.3). Annual forbs such as *Chenopodium, Gayophytum diffusum,* and *Polygonum douglasii* were more abundant at Fire Point post-fire and the reference sites than at Fire Point pre-fire which is consistent with Huisinga et al.'s (2005) finding that after the Northwest III fire-escape native annuals increased.

Plant community characteristics

Community characteristic	Ref site 1998	Refs 2001	Fire PRE	Fire POST
Richness	31.3 (6.5)	34.9 (3.8)	20.9 (6)	26.5 (7.9)
Plant cover %	34 (2)	22(2)	15 (3)	16 (4)
Shannons H	2.1 (0.2)	2 (0.4)	1.8 (0.5)	1.6 (0.6)
Percent native spp. 0.1ha^{-1}	94.1 (0.9)	94.6 (0.3)	93 (0.1)	93.6 (0.3)

Table 5.3 *Plant community characteristics, mean (SD), in cm*
(Table 2 from Laughlin et al., 2004)

The burn reduced duff depths and increased litter depths and analysis showed that the duff to litter ratio was negatively correlated with species richness, consistent with Huisinga et al. (2005) who observed the same effect after the Northwest III fire-escape (Laughlin et al., 2004) (Table 5.4).

Forest floor characteristics

Forest floor fuels	Ref sites 1998	Fire 1998	Fire 2001
Litter	0.89 (0.8)	0.58 (0.2)	1.32 (0.4)
Duff	2 (0.9)	3.67 (1.6)	1.24 (0.5)
Total fuel depth	2.89 (1.3)	4.25 (1.7)	2.55 (0.8)
D:L	3.41 (2.1)	6.7 (2.6)	1.01 (0.5)

Table 5.4 *Forest floor characteristics, mean (SD), in cm*
(Table 4 from Laughlin et al., 2004)

Both Huisinga et al. (2005) and Laughlin et al. (2004) observed that plant cover and species richness increased shortly after fire, and Gildar et al. (2004) found that Galahad Point, which has not burnt regularly since settlement, had lower richness and diversity measures than plots on Powell Plateau and Rainbow Ridge that have burned several times. They also found that at all three locations richness and diversity increased from 2000 to 2001 because of increased rainfall, and annual forbs were the most common plant to appear in the wet year (Gildar et al., 2004). An important finding from that study was "high variability between closely matched sites" (Gildar et al., 2004: p. 109) for measures of richness, diversity, understory composition, tree seedling composition, and forest floor depths, which could have been a result of too few replicates or an extremely heterogeneous landscape.

Recent fire history and management responses

Fires have continued to ignite and burn on the Kaibab Plateau despite suppression efforts. Figure 5.6 shows fire events on the North Kaibab Ranger District from 1936 to 1940. About 100 fires are shown, including 8-10 started by humans. The fires on the Kaibab Plateau are fairly evenly distributed throughout the ponderosa pine belt. Only two are found in the pinyon-juniper; in Slide Canyon to the west and near the cockscombs to the east. Several are found close to the transition zone between the pinyon-juniper and the ponderosa pine, and several are in the mixed conifer and spruce fir forests on the ridges bordering DeMotte Park. In 1960, 9,000 acres burned near the Park/Forest boundary at the east edge of the plateau. This fire does not seem unprecedented given the discussion above. The burned area was immediately reseeded with a variety of mostly non-native forage species including *Melilotus alba, Sanguisorba minor,*

Lotus wrightii, Dactylis glomerata, Koeleria cristata, Bromus inermis, Phleum pratense, Agropyron cristatum & Agropyron intermedium (Hungerford, 1970).

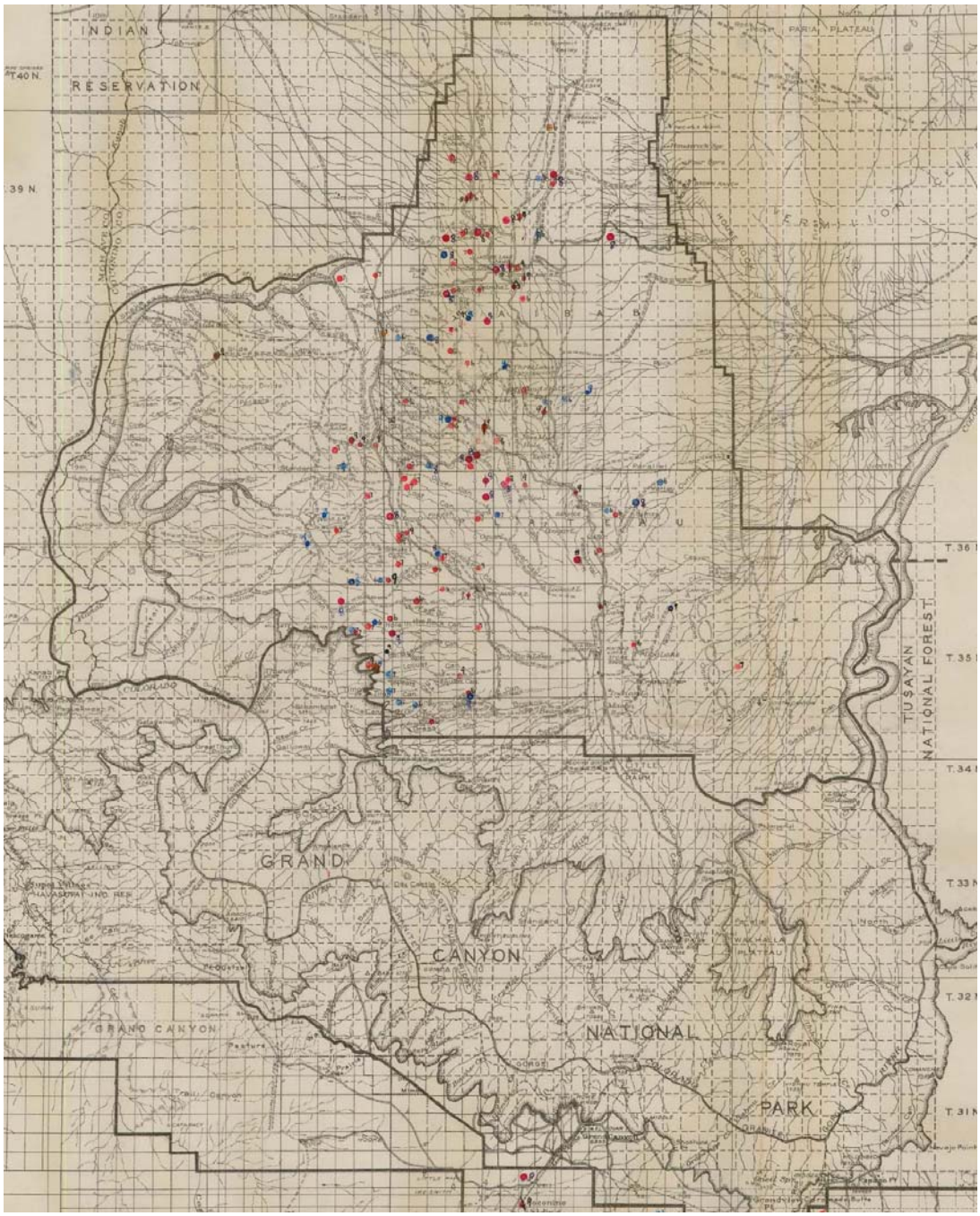


Figure 5.6 *Fire occurrence map for 1936 through 1940. The original includes the Tusayan District and the South Rim of the Grand Canyon which had many more fires caused by humans. Red dots indicate fires that were suppressed at less than 0.25 acres, blue dots represent fires that grew up to 10 acres, and orange dots represent fires that grew up to 100 acres. Vertical lines through dots represent fires that were set by humans*

The largest fire in recorded history on the Kaibab Plateau was the 1996 Bridger Knolls Complex (Figure 5.1). It burned 51,516 acres through mostly pinyon-juniper, but also carried into the ponderosa pine. Over half of the fire was classified as moderate to high severity (Steffensen et al., 1997), but such behavior may not be atypical for pinyon-juniper woodlands (see chapter 6 for more discussion) The North Kaibab Ranger District began keeping accurate fire records in 1970 (Steffensen et al., 1997) and prior to then almost all records of anything pertaining to the management of the forest were thrown out after five years (Dennis Lund, Ecological Restoration Institute, personal communication, 2/9/06). Between 1970 and 1996, 151 ignitions occurred. Of that, 108 were suppressed and never exceeded 0.25 acres, 37 spread up to 10 acres, 11 grew to 100 acres, and 3 grew to 300 acres. Beyond those, two fires exceeded 5,000 acres; one of which was Bridger Knolls (Steffensen, 1997). An additional close to 1,000 acres in the pinyon-juniper woodlands on the west side of the plateau were prescribed fire in the 70's and 80's (Steffensen, 1997). Numerous other fires have occurred but no or limited records exist.

Conclusion/Management implications

Recent fires such as the 1996 Bridger Complex that burned over 50,000 acres and the 2000 Outlet fire that burned almost 13,000 acres are not unprecedented when historic fire patterns are taken into consideration. The results of the Outlet Fire are similar to the structure of Little Park in 1880 (Fule et al., 2003a) and the conditions in which both the Bridger and Outlet Fires burned were similar to historic large fire years; a dry year following a wet year. In fact these types of fires are very much within the natural range of variability because "it is in precisely such years that large presettlement fires occurred" (Fule et al., 2000). The years of widespread fire activity (Table 5.1) were dry years following wet years (Fule et al., 2003a) and this pattern will likely continue into the future. Management has the ability to allow fire to function within its natural range but fire-use is unlikely to be permitted during extremely dry years therefore the timing and size of fires will remain outside of its range of natural variability (Fule et al., 2000).

Fire suppression has had little effect on spruce-fir forests (White & Vankat, 1993), but the effects have been significant on mixed conifer and ponderosa pine forests. Overall, white fir throughout much of the forest may be of an abnormally young age class and its abundance is a result of fire suppression (White & Vankat, 1993). Also, fire suppression, as well as climatic

Figure 5.7 *A View of the effects of the 2000 Outlet Fire which burned close to 13,000 acres on the North Rim*

oscillations and increased atmospheric carbon have favored the establishment of dense stands of young trees (Stein, 1988; Covington & Moore, 1994b). Fires like the Northwest III escaped prescribed fire are not inconsistent with restoration goals (Fule et al., 2004a; Huisinga et al., 2005) and should be considered as effective ways of managing within a range of natural variability. Crown fires in high elevation forests should be managed as natural disturbances rather than treated as catastrophes, and reductions of canopy biomass up to 50% could still maintain historic conditions if older trees survived (Fule et al., 2004b). However, fires in dense ponderosa pine forests can easily exceed those of pre-settlement times (Fule et al., 2002b) so careful and informed management should define what areas are at greatest risk and what areas fire-use plans are appropriate. It is my hope that this analysis of the best reference sites available can inform those decisions.

Literature Cited

Booth, P.M. 2005a. Blue denim university: The Civilian Conservation Corps' retooling of Arizona youth. Pages 91-98 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Booth, P.M. 2005b. The Civilian Conservation Corps' role in tourism: The CCC's retooling of Arizona's natural resources. Pages 73-80 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Buckley, S. 2004. Mountain lying down: restoration, bioregionalism, and the indigenous Kaibab Plateau. Master of Liberal Studies Thesis, Northern Arizona University, Flagstaff, AZ.

Covington, W.W. and Moore, M.M. 1994a. Postsettlement changes in natural fires regime and forest structure: ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry 2: 153-181.

Covington, W.W. and M.M. Moore. 1994b. Southwestern ponderosa forest structure: changes since Euro-American settlement. Journal of Forestry 92(1): 39-47.

Craighead, F.C. 1924. The black hills beetle practicing forestry on the Kaibab. Forest Worker, November, 1924: 74.

Easton, R. and M. Brown. 1961. Lord of the beasts-the saga of Buffalo Jones. University of Arizona Press, Tucson, AZ.

Fraser, G.C. 2005. Journeys in the canyonlands of Utah and Arizona, 1914-1916. Edited by F.H. Swanson. University of Arizona: Tucson, Arizona.

Fule, P.Z., T.A. Heinlein, W.W. Covington, and M.M. Moore. 2000. Continuing fire regimes in remote forests of Grand Canyon National Park. In: Cole, D.N. and S.F. McCool (eds) Proceedings: Wilderness Science in a Time of Change. Proc. RMRS-P-15. USA Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA, pp. 242-248.

Fule, P.Z., W.W. Covington, M.M. Moore, T.A. Heinlein, and A.E.M. Waltz. 2002a. Natural variability in forests of the Grand Canyon, USA. Journal of Biogeography 29: 31-47.

Fule, P.Z., J.E. Crouse, M. Daniels, J. Springer, T.A. Heinlein, M.M. Moore, W.W. Covington, and G. Verkamp. 2002b. Mixed-severity fire regime in a high-elevation forest: Grand Canyon, Arizona. Final Report to the Joint Fire Science Program, CA-1200-00-009-NAU 04 (Part 1).

Fule, P.Z., J.E. Crouse, T.A. Heinlein, M.M. Moore, W.W. Covington, and G. Verkamp. 2003a. Mixed-severity fire regime in a high-elevation forest of Grand Canyon, Arizona, USA. Landscape Ecology 18: 465-486.

Fule, P.Z., T.A. Heinlein, W.W. Covington, and M.M. Moore. 2003b. Assessing fire regimes on Grand Canyon landscapes with fire-scar and fire-record data. International Journal of Wildland Fire 12: 129-145.

Fule, P.Z., A.E. Cocke, T.A. Heinlein, and W.W. Covington. 2004a. Effects of an intense prescribed fire: is it ecological restoration? Restoration Ecology 12(2): 220-230.

Fule, P.Z., J.E. Crouse, A.E. Cocke, M.M. Moore, and W.W. Covington. 2004b. Changes in canopy fuels and potential fire behavior 1880-2040: Grand Canyon, Arizona. Ecological Modelling 175: 231-248.

Gildar, C.N., P.Z. Fule, and W.W. Covington. 2004. Plant community variability in ponderosa pine forest has implications for reference conditions. Natural Areas Journal 24: 101-111.

Goebel, P.C., T.C. Wyse, and R.G. Corace, III. 2005. Determining reference ecosystem conditions for disturbed landscapes within the context of contemporary resource management issues. Journal of Forestry 103(7): 351-356.

Hughes, J.D. 1991. In the house of stone and light: a human history of the Grand Canyon. Grand Canyon Natural History Association, University of Denver, CO.

Huisinga, K.D., D.C. Laughlin, P.Z. Fule, J.D. Springer, and C.G. McGlone. 2005. Effects of an intense prescribed fire on understory vegetation in a mixed conifer forest. Journal of the Torrey Botanical Society 32(4): 590-601.

Hungerford, C.R. 1970. Response of Kaibab mule deer to management of summer range. Journal of Wildlife Management 34(4): 852-862.

Lang, D.M. and S.S. Stewart. 1910. Reconnaissance of the Kaibab National Forest. Available on-line at www.nau.edu/library/speccoll/manuscript/kaibab_recon.

Laughlin, D.C., J.D. Bakker, M.T. Stoddard, M.L. Daniels, J.D. Springer, C.N. Gildar, A.M. Green, and W.W. Covington. 2004. Toward reference conditions: wildfire effects on flora in an old-growth ponderosa pine forest. Forest Ecology and Management 199: 137-152.

Mace, W. M. 1990. Will Mace memoirs: a letter to Gifford Pinchot dated February 9, 1940. Pages 65-73 in People and Places of the Old Kaibab. USDA Forest Service Cultural Resources Management Report No. 10. Southwestern Region.

Menninghaus, F.F. and D.B. Jensen. 1967. Central Summer, Central Winter and Sowats Allotment Management Plan. Unpublished report dated October 16, 1967 on file at Kaibab National Forest, North Kaibab Ranger District, Fredonia, AZ.

Miller, J.M. 1924. The Black Hills beetle on the Kaibab forest. Timberman 26(2): 50.

Richmond, A. 2005. Rails at both rims. Pages 15-18 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Steffensen, D. 1997. Current conditions and trends of vegetation on Central Winter: focusing on the pinyon-juniper woodlands. Unpublished USDA Forest Service report on file at Grand Canyon Trust.

Stein, S.J. 1988. Explanations of the imbalanced age structure and scattered distribution of ponderosa pine within a high-elevation mixed coniferous forest. Forest Ecology and Management 25: 139-153.

Stephens, S.L. and P.Z. Fule. 2005. Western pine forests with continuing frequent fire regimes: possible reference sites for management. Journal of Forestry 103(7): 357-362.

USDA Forest Service. 1998. Kaibab National Forest, North Kaibab Ranger District History. Informational paper describing the history of the North Kaibab Ranger District, available at Kaibab National Forest, North Kaibab Ranger District, Fredonia, Arizona.

White, M.A. and J. L. Vankat. 1993. Middle and high elevation coniferous forest communities of the North Rim region of Grand Canyon National Park, Arizona. Vegatatio 109: 161-174.

Wolf, J.J. and J.N. Mast. 1998. Fire history of mixed-conifer forests on the North Rim, Grand Canyon National Park, Arizona. Physical Geography 19(1): 1-14.

Chapter 6.

Characterizing a range of natural variability in pinyon-juniper woodlands: a review of relict area studies, historical accounts, and other information

Introduction

A considerable range of variation within pinyon-juniper ecosystems can be expected due to their distribution across a variety of soils, latitudes, and sources of anthropogenic disturbance. Approximately one-third of the Kane and Two-Mile Ranches are classified as pinyon-juniper, but within that there really exists two physiographically distinct ecotypes. The east, north, and west flanks of the Kaibab Plateau differ from the Paria Plateau primarily in parent materials and soils, but they have experienced a different recent history of human use as well. The sandy soils and impassible cliffs on three sides of the Paria Plateau differ markedly from the rocky limestone soils and gradual transitions to lower elevations found over much of the Kaibab Plateau where pinyon and juniper fade into desert grasslands, such as in House Rock Valley. A lack of water sources on the Paria Plateau also delayed the onset of large-scale ranching on most of the plateau by half a century (see chapter 3). Despite these differences, some similarities in vegetational composition, disturbance regimes, and ecosystem processes should exist. The information presented in this chapter should be critically reviewed by future resource managers to determine to what extent it reflects each ecotype and how it should be appropriately used in each.

The scope of this paper is to provide guidance for ecosystem management and restoration in these woodlands through two means. First, a compilation of historical accounts of pinyon-juniper woodlands in the eastern Arizona Strip sheds light onto the conditions encountered by early travelers and explorers, though such accounts are not abundant. Second, a review of studies in 'relict sites' within the region documents trends or patterns in vegetation, soils, and disturbance and provides a benchmark to weigh current range and overstory conditions against. In addition to 'pure' pinyon-juniper relict sites I have included three studies in desert grasslands and blackbrush (*Coleogyne ramosissimum*) associations because often these ecosystems can be found within the pinyon-juniper type and they are of significant importance on the Kane and Two Mile Ranches. Neither approach should be assumed to embody actual pre-settlement ecosystem attributes or processes, however, such an attempt to define a natural range of

variability by evaluating the aforementioned sources can advance our perception of local pinyon-juniper woodlands as geographically unique ecosystems. An informed discussion of a natural range of variability is important to ensure sustainable management of this widespread resource.

Historical accounts

Prior to the early 1900's little attention was paid to pinyon-juniper woodlands by Euro-American's besides as an abundant source of fuelwood and fenceposts (Graves, 1913; Knack, 1993). Several members of John Wesley Powell's 1871 survey of the area ventured to the edge of the Paria Plateau above Two Mile Spring, but their interest was to gain a vista of the Kaibab Plateau and the lack of water prevented them from continuing deeper into the unknown (Thompson, 1939). In 1872 J.H. Beadle crossed the Kaibab and noted that good blue grass was all around which was rare elsewhere in the Rocky Mountains (Beadle, 1873). As he descended the west slope towards the next water source he wrote that "west of the Buckskin was a singular floodplain some six miles wide, with rich soil but no moisture, and nearly destitute of grass" (Beadle, 1873: p. 656). Unfortunately we cannot be certain of exactly what he was describing, but it is very likely Johnson Wash which is the first major drainage west of the Kaibab Plateau where he crossed.

A survey of the Kaibab Plateau's forest resources in 1910 by the U.S. Forest Service gave little consideration to the woodlands because "The junipers and pinon were not considered important enough to deserve any attention" (Lang & Stewart, 1910: p. 11). Of their thirty page report, the woodlands received the following description:

> "The woodland type covers all the foothills, low ridges, mesas, dry slopes and the semiarid tract between Little Mountain and Kanab Creek Canyon comprising approximately 50% of the total area. The forest is very irregular, patchy and consists principally of clumps of pinon pines (*Pinus edulis*) and juniper (*Juniperus utahensis* and *Juniperus scopulorum*). Mature trees are brushy, crooked and have little commercial value" (Lang & Stewart, 1910: p. 8)…."The soil is loose and considerably exposed….The ground cover and undergrowth are usually so slight as to eliminate the necessity of fire lines" (Lang & Stewart, 1910: p. 24) (Figure 6.1).

Figure 6.1 *A photograph from Lang & Stewart (1910) titled* ***"****Southwest edge of timber. Showing Juniper, Pinon, Mt. Mahogany and Yellow Pine". The small shrubs in the foreground may be* Artemesia *sp., and beyond them the scene appears dominated by more small shrubs. The ridge in the background appears heavily wooded on its summit yet the side facing the photographer is open with sparse trees. This pattern of strips of wooded and open areas is similar to the pattern left by the 1996 Bridger Knoll Complex Fire that burnt over 50,000 acres in the vicinity of this photo.*

Sharlot Hall, Arizona's Territorial Historian in the early part of the 20th century, commented on the Paria Plateau behind her as she summited the Kaibab in 1911, saying that it was "a semi-mesa covered in wildest confusion with cones and saw-toothed peaks of rich-tinted sandstone and overgrown with cedar and pinon trees" (Hall, 1975: p. 60). As she crossed over the Kaibab she wrote "…we are in the gray sage country and the air is pungent with is bitter scent; it drowns the pinon balsam and the quinine bush (cliffrose, *Purshia* sp.) that is in full blossom. It must be the chief food for the cattle for there is no grass" (Hall, 1975: p. 60). She then spent a few days in the vicinity of Kanab resting and getting to know the locals. Near Fredonia, Arizona she wrote that

> "The grass has been trampled out years ago by big flocks of sheep brought in from Utah and by cattle that overstocked the range, but the summer rains start a good growth of rains and keep the sage brush growing….Near Kanab, the spider plant (*Cleome lutea*), common to all of Arizona, was higher than the top of our wagon and was growing in sand a foot or two deep" (Hall, 1975: p. 65).

Further on the road to the Kaibab Plateau where she would spend a week in the forest she echoed that remark, writing that "There is little grass. Like other parts of Arizona this region has been "sheeped to death" years ago and the grass roots trampled out, but there is a great deal of the sage, both black and white…" (Hall, 1975: p. 66). As she closed in on the plateau her last

comment on the surrounding woodlands and grasslands was that "…the mountain and hills have enough cedar and pinon for fuel for many years" (Hall, 1975: p. 67).

Figure 6.2 *Looking down upper North Canyon in the Saddle Mountain Wilderness, 1928*

In 1913, former president Theodore Roosevelt came off the Kaibab Plateau through the "scattered, sprawling pinyon and cedars of the side slopes" (Roosevelt, 1913: p. 309), but it was a passage without further description. The pinyon-juniper woodlands have been regarded as almost worthless by many, like the 1913 Arizona Board of Control assessment team who wrote that "The Paria Plateau northwest of the Vermillion Cliffs is rough and of no value except for grazing for sheep and goats" (McOmie et al., 1913: pp. 4-5) and that "…according to information gathered from cattlemen, [the Paria Plateau] is of little value except for grazing, and the scarcity of water even prevents extensive flocks from subsisting there" (McOmie et al., 1913: p. 22). In a 1913 timber report, Forester Henry C. Graves described the pinyon-juniper woodlands as "very irregular and made up of short-bodied limby trees….The cedar occupying the lower sandstone flats, and the pinon the higher benches along the edge of the yellow pine

type. All age classes are represented but the majority of the stand is made up of old, mature trees" (Graves, 1913: no page number). Rasmussen (1941) spent 1929 through 1931 on the Kaibab Plateau studying interactions between deer and vegetation. His observed that

> "in this woodland, or "pygmy forest" the trees do not ordinarily form solid stands, but are scattered with intervening spaces of grass, sage, or other shrubs….Only in the bottom of draws and toward the upper limit of the association do the trees grow closely enough together to cast a continuous shade….Blue grama grass…is the most abundant and widespread of the plants, forming in many places the only other abundant plant besides the dominant trees" (Rasmussen, 1941: pp. 243-244).

He also echoed the remarks of Hall (1975) and Mead (1930), reporting that at the northern portions of the plateau the most dominant plant was sagebrush (Rasmussen, 1941).

Early descriptions of pinyon-juniper woodlands

Year	Location	Description	Source
1872	Northern Kaibab Plateau	Good blue grass all around	Beadle, 1873
1872	West of Kaibab Plateau	Nearly destitute of grass	Beadle, 1873
1910	Central Winter range	Irregular, patchy, clumpy forest	Lang & Stewart, 1910
1910	Central Winter range	Soil is loose and considerably exposed	Lang & Stewart, 1910
1910	Central Winter range	Ground cover slight	Lang & Stewart, 1910
1911	Paria Plateau	Overgrown with cedar and pinon	Hall, 1975
1911	Northern Kaibab Plateau	Abundant sagebrush, no grass	Hall, 1975
1911	West of Kaibab Plateau	Little grass, great deal of sage	Hall, 1975
1913	Eastern Kaibab Plateau	Scattered, sprawling pinyon and cedars	Roosevelt, 1913
1913	Paria Plateau	Rough terrain, scarcity of water	McOmie, 1913
1913	Kaibab Plateau	Irregular forest of mostly old, mature trees	Graves, 1913
1929-1931	Kaibab Plateau	Trees scattered with intervening spaces of grass, sage or shrubs	Rasmussen, 1941
1929-1931	Kaibab Plateau	Blue grama most abundant plant besides trees	Rasmussen, 1941

Table 6.1 *Selected early descriptions of pinyon-juniper woodlands on the Kaibab and Paria Plateaus*

These historical descriptions offer little guidance for those who ask what the pinyon-juniper woodland was like one hundred years ago. It would be easy to take such brief descriptions of single passages through the area by disparate parties and extrapolate them to the whole area, but to do so would be irresponsible. Furthermore, many of these descriptions came

from people who hadn't seen the area prior to the introduction of livestock. Hall (1975) remarks on the abundance of sagebrush and associates it with heavy grazing, but Vale (1975), who reviewed twenty-nine journals from 1811 to 1859 of travelers through Colorado, Nevada, Wyoming, northern Utah, and eastern Oregon and Washington found that the early writings describing the northern Intermountain West suggest a pristine vegetation visually dominated by shrubs, most often sagebrush. Determining the extent to which sagebrush increased in the forty years preceding Hall's visit in 1911 is close to impossible given the scarcity of historical descriptions to compare it to. Interpretations of her observations must consider that sagebrush was a common, if not dominant, plant in the area prior to livestock grazing. Conversely, Hall's observation that there was no grass on the summit of the Kaibab seems to imply that something happened to it since J.H. Beadle observed blue grass all around in 1872.

Relict areas studies

Vegetation and soils

Numerous isolated mesas and plateaus exist throughout the southern Colorado Plateau that can provide useful information about vegetation and soil characteristics in the absence of grazing and fire suppression (Figure 6.3 and Table 6.2). Fishtail Mesa in Grand Canyon National Park has been recognized as a relict area since 1934 when Odell Julander and colleagues conducted a brief reconnaissance and found that broom snakeweed (*Gutierrezia sarothrae*) was present but not common (Jameson et al., 1962). In 1954, J.H. Cravens and C.P. Pase visited the mesa and noted that much of the big sagebrush (*Artemesia tridentata*) grew in what appeared to be old burns. They also noted that *Poa longiligula (P. fendleriana)* was the most common grass (Jameson et al., 1962). The first substantial study on Fishtail Mesa, in 1958, categorized the mesas vegetation into two plant communities, a pinyon-juniper type that covered 74% of the mesa, and a shrub type dominated by big sagebrush and Bigelow's sagebrush (*A. bigelovii*). Five soil types were determined, but there was no relationship between soil and vegetation types. Within pinyon-juniper stands sagebrush was the dominant understory plant, and in fact herbaceous plants made up only 0.5% of ground cover in both types (Jameson et al., 1962).

Rowlands and Brian (2001) returned to Fishtail Mesa in 1996 to remeasure Jameson et al.'s plots and concluded that species cover and composition had not changed appreciably over

38 years and that sagebrush was the primary plant species. Although most results were not statistically significant the following changes were noted: within the shrub type sagebrush declined and *Poa fendleriana* increased; tree cover increased in the shrub type; and *Ephedra torryana*, *Opuntia polyacantha* and *Gutierrezia sarothrae* declined (Rowlands & Brian, 2001).

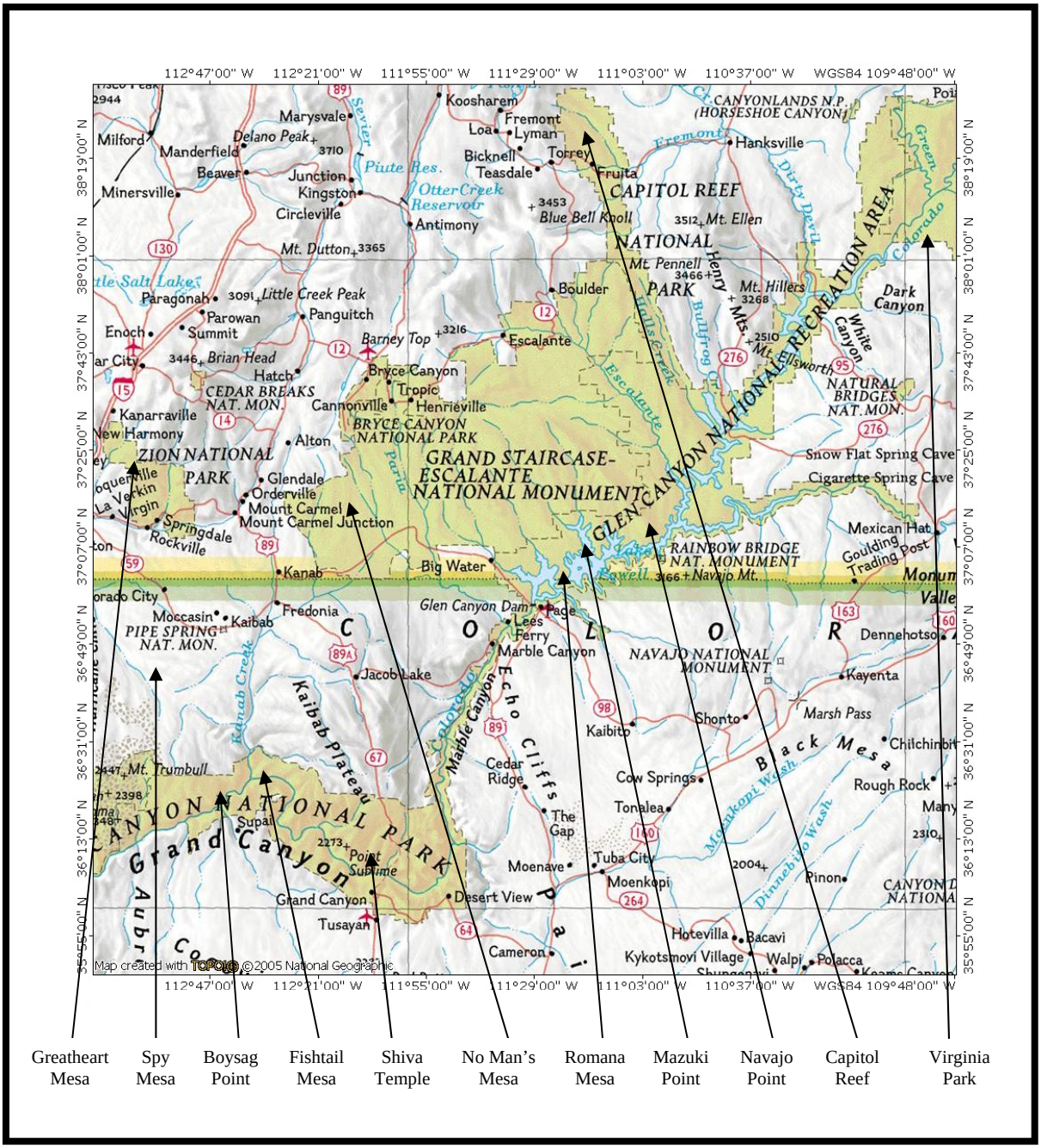


Figure 6.3 *Locations of relict sites and study areas discussed in this chapter. Map created with National Geographic TOPO!*

Comparison of variables at 9 relict sites

	▶		Pinyon-juniper		◀ ▶		Grassland, blackbrush	◀
	Boysag Point	**Spy Mesa**	**No Man's Mesa**	**Greatheart Mesa**	**Fishtail Mesa 1996**	**Mazuki Point & 5831 Mesa**	**Romana Mesa**	**Virginia Park**
Author	Schmutz et al., 1967	Thatcher & Hart, 1974	Mason et al., 1967	Madany & West, 1984	Rowlands & Brian, 2001	Fisher, 2005	Jeffries & Klopatek, 1987	Kleiner & Harper, 1977
Location	43 miles southwest of Fredonia, AZ	15 miles south of Colorado City, AZ	30 miles northeast of Kanab, UT	10 miles northwest of Zion Lodge	Confluence of Kanab Creek and the Colorado River	Glen Canyon National Recreation Area	10 miles northeast of Glen Canyon Dam	Canyonlands National Park
Elevation	5540-5587 ft	5000 ft	6600-7222 ft	7092-7410 ft	6,000-6,200 ft	~6,000 ft	4,700 ft	~6000 ft
Precipitation	12 in/yr	13 in/yr	14-16 in/yr	Not mentioned	14 in/yr	5-10 in/yr	5-10 in/yr	10 in/yr
Size	70 acres	40 acres	1788 acres	210 acres	1420 acres	Not mentioned	Not mentioned	235 acres
Geology	Kaibab limestone	Not mentioned	Carmel formation (Sandstones and shales)	Carmel & Temple Cap formations (Sandstones and shales)	Kaibab Limestone	Kayenta, Navajo, Carmel, and Entrada Sandstones	Not mentioned	Cedar Mesa Sandstone
Soil Type	Winona, Shanub, and Boysag series	No attempt to identify to series, type, or phase	Preston-like loamy fine sand and Menefee-like fine sandy loam	Paunsaugunt series	Mostly lithic ustochrepts	Not mentioned	Not mentioned	Not identified
Soil description	Shallow calcareous	Silty and sandy loams and clay-loams	Loamy fine sand and fine sandy loam	Gravelly silt-loams and sandy loams	Shallow and poorly developed	Not mentioned	Not mentioned	Deep single grain sandy
Livestock grazing history	Small amounts from 1920-1943; 1000 for 2 or 3 weeks at one time in the 1920's	None	800 to 1500 goats for short periods in 1927 & 1928	None	None	None, but compared to nearby grazed sites	None, but compared to nearby grazed sites	None, but compared to a nearby grazed site
Native grazers or browsers	Essentially ungrazed	Deer, porcupine, rabbit, ground squirrel	Few chipmunks, porcupine & rabbits	Deer	Deer	Deer and rabbit	None	None mentioned but deer are common in the Park
Fire	None on point, but evidence of a pre-1889 fire on adjacent mainland	Abundant evidence of relatively recent fires; burnt stumps; lightening killed trees	Not mentioned	Probably none for more than 100 years	Juniper snags in 60% of sagebrush type probably killed in fire	Not mentioned	Not mentioned	Not mentioned
Biological soil crusts	Not mentioned	Not mentioned	0-7% cover	Not mentioned	Only traces were detected; included with litter	Not mentioned	High to low cover on a continuum of grazed to relict sites	38% cover vs. 5% cover in grazed site

Table 6.2 *Comparison of variables at relict pinyon-juniper, grassland, and blackbrush sites discussed in chapter 6*

Repeat photography confirmed that trees were reoccupying the shrub type since 1958. Species richness was around 40-45 plants which is not different than the species list compiled by Jameson et al. (1962) of 44 plants.

Thatcher and Hart (1974) surveyed 40 acre Spy Mesa in 1973 and found 27 species present on six soil types. Three soil types produced significant amounts of grass and all had granular sandy loam surfaces. The other three soil types had vesicular, massive, or platy surfaces and produced primarily pinyon, juniper, and shrubs but supported very little grass. Soil qualities proved to be the most significant factor in determining plant community composition (Thatcher & Hart, 1974). Unlike Fishtail Mesa, sagebrush was not a dominant plant; in fact it wasn't even one of the fifteen plants that contributed significantly to vegetative production. Snakeweed (*G. lucida*) and rabbitbrush (*Chrysothamnus viscidiflorus*) were found in greatest abundance around dead juniper and skunkbush (*Rhus trilobata*), and blue and sideoats gramas (*Bouteloua gracilis, B. curtipendula*) were only present in trace amounts (Thatcher & Hart, 1974).

Ground flora characteristics for selected pinyon-juniper relict sites

Ground flora variables	Fishtail Mesa	Spy Mesa	No Man's land Mesa	Boysag Point
Richness (size of mesa)	40-45 species (1,400 ac)	27 species (40 ac)	32+ species (1,788 ac)	88 species (70 ac)
Snakeweed	Rare	Rare	None	Low production
Sagebrush	Most abundant plant	Not Mentioned	Highest production	Most abundant plant
Forbs	Average 0.5% cover	Minimal importance	Only *Cryptantha* sp., *Lappula redowskii,* and *Arabis pendulina* contribute as much as 1% production	24 species but less than 4% cover
Most important grasses (Production, abundance, or cover)	*Poa fendleriana, Bouteloua gracilis*	*Stipa speciosa, Hilaria jamesii*	*Poa fendleriana*	*Stipa* sp., *Poa* sp., *Bouteloua eriopoda, H. jamesii*
Least important grasses (Production, abundance, or cover)	*Stipa speciosa, S. comata*	*Bouteloua gracilis, B. curtipendula*	*Koeleria cristata, Stipa speciosa, Agropyron smithii*	*B. gracilis, Elymus elymoides*

Table 6.3 *Characteristics of important components of pinyon-juniper understory plant communities for the four closest relict sites to the Kane and Two Mile Ranches*

Soil characteristics were also found to be important in determining plant distribution and abundance on No Man's Land Mesa (Mason et al., 1967). The mesa was categorized into two soil types: a deep sand type and a shallow breaks type that was warmer and held less moisture.

Sagebrush, Gambel oak (*Quercus gambelii*), snowberry (*Symphoricarpos oreophilus*), and manzanita (*Arctostaphylos pungens*) were important components on the deep sandy soils but absent on the shallow soils. Converesly, desert needlegrass and dryland sedge (*Carex* sp.) were only found on the shallow breaks (Mason et al., 1967). Production was higher overall on the sandy soils.

Schmutz et al. (1967) recorded 88 species on Boysag Point but only 38 on the adjacent mainland that had been subjected to heavy grazing for nearly 100 years. Perennial grasses made up 36% of the cover and trees and shrubs made up 60% whereas on the mainland trees and shrubs made up 90% of the cover and grasses were only 6%. Forbs and annual grasses were relatively unimportant and made up lass than 4% on both sites. Sagebrush and snakeweed were less important on the point than the mainland, but sagebrush was still the dominant plant at both sites.

Grazing impact studies with relict sites as references

Kleiner and Harper (1977) compared a grazed grassland/juniper savanna to an ungrazed one nearby and found that *Hilaria jamesii* was more abundant in the ungrazed park, but *Stipa comata, Oryzopsis hymenoides,* and *Sporobolus cryptandrus* were more abundant in the grazed site, opposite of Jeffries and Klopatek's (1987) finding that *O. hymenoides* was dominant in a relict site and *H. jamesii* was dominant in a grazed area. Kleiner and Harpers (1977) findings are further refuted by what Fisher (2005) found in Glen Canyon National Recreation Area. She found that *Poa fendleriana, Erioneuron pulchellum, Sporobolus cryptandrus, Poa secunda, Aristida purpurea, Hilaria jamesii, Stipa speciosa* and *Panicum* species were present at ungrazed relict sites or in late Holocene packrat middens but absent at grazed sites (Fisher, 2005).

Analysis of 27 packrat middens from the last 995 years and comparison to modern middens from ungrazed relict areas (including Mazuki Point and 5831 Mesa, see Figure 6.3) showed that native grasses as well as skunkbush, cliffrose (*Purshia mexicana*), and wooly plantain (*Plantago patigonica*) have decreased in grazed areas in time and space, and modern plant communities were more homogeneous than relict sites or pre-settlement packrat middens (Fraser, 2005). Analysis of 9 packrat middens from modern to 5,400 years before present in pinyon-juniper woodlands at Capitol Reef National Park showed that snakeweed pollen and remains only become common in the last two centuries (Cole et al., 1997) and in Glen Canyon

snakeweed species were absent in all middens that dated to before settlement (Fisher, 2005). Winterfat (*Eurotia lanata*) and buffaloberry (*Shepherdia rotundifolia*) remains were found in middens from Capitol Reef but not at the site in modern times (Cole et al., 1997). Additionally, those species were more common in middens from relict areas in Glen Canyon than from grazed areas (Fisher, 2005), suggesting that ground flora and shrub composition in pinyon-juniper woodlands have been altered by livestock grazing.

A study of five sites along a continuum of grazing at Grand Canyon National Park found that *Poa fendleriana* cover was 19.1% on Shiva Temple, the relict site (see Figure 6.3), and 6.6% at the most intensively grazed site (Beymer & Klopatek, 1992). Despite its reduced cover, *P. fendleriana* was the dominant plant on grazed sites along with squirreltail (*Elymus elymoides*) which was not present at the relict site. Cliffrose was not present on grazed sites but was on the relict site and *Lesquerella intermedia, Gutierrezia sarothrae, and Hymenoxys acaulis* were more abundant on grazed sites than on Shiva Temple (Beymer & Klopatek, 1992).

Fire

Native Americans may have burned over large areas of pinyon-juniper woodlands prior to Mormon colonization of the Arizona Strip (see chapter 1 for discussion), but no definitive evidence exists to determine the frequency, intensity, and results of Indian burning. A few studies have documented fire in regional pinyon-juniper ecosystems, typically infrequent fires with variable severities, though existing data cannot reliably determine exact fire regimes. Despite the unavailability of solid evidence, assumptions of semi-frequent fire regimes are typical (see for example USDI Bureau of Land Management, 2004). An important finding from Fishtail Mesa was that about 20% of the original tree type had been converted to shrubs by fire, and trees would have dominated 90% of the mesa if not for past burns (Jameson et al., 1962). Rowlands and Brian (2001) did not dispute the suggestion of fire initiated sagebrush stands when they remeasured the mesa in 1996. They reported that no additional fires appeared to have burned on Fishtail Mesa since the sagebrush-initiating event, suggesting that the fire return interval there was at least 80 to 100 years, and likely longer (Rowlands & Brian, 2001).

Recent research at Navajo Point on the Kaiparowits Plateau in Glen Canyon National Recreation Area by Floyd et al. (2005) has important implications for our understanding of fire in pinyon-juniper woodlands. Navajo Point should not technically be considered a relict site

because it has been grazed for about a century, but its remoteness and proximity to the Kane and Two Mile Ranches make it an ideal reference/comparison site (Figure 6.4). Additionally, the 5,600 acre study site is similar to the Paria Plateau in elevation, soils, and plant communities. Floyd et al. (2005) examined 18 sites for fire history, current spatial patterns in tree density, and current fuel loadings. They found no evidence for low-intensity creeping ground fires, but instead they found abundant evidence of stand-replacing fires such as charred juniper snags, both standing and fallen. They calculated that approximately 50% of the Kaiparowits Plateau has burned in the last 300 years, and that it would take 400 to 600 years to burn the entire Navajo Point study area. Because of unique topographic and vegetational features some areas would burn more than once during that rotation while others may never burn at all. Six of the

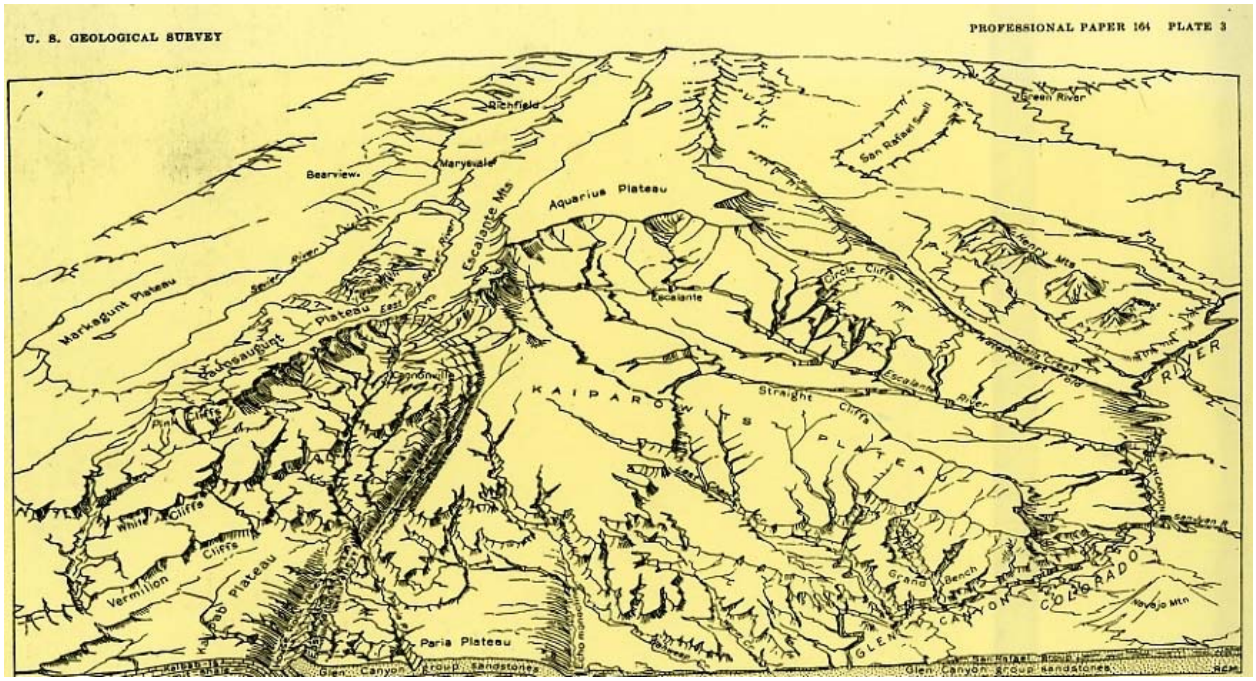


Figure 6.4 *The Kaiparowits region, adjacent to the northern extent of the Paria Plateau in Utah. Map from Gregory and Moore (1931).*

Kaiparowits stands that were sampled appear to be around 150 years old, and may have originated after fires in 1842, 1847, or 1851, some of which were years of large fires detected in studies on the Kaibab Plateau in coniferous forests (see chapter 5). They concluded that

> "the historical fire regime of Navajo Point has been dominated by 1) high-severity fires that occurred either as relatively frequent small fires (a few hectares at most), or as relatively infrequent but large fires that burned within an extensive, anastomosing perimeter, but were extremely patchy within that

> perimeter, or 2) infrequent larger fires that consume the entire area within the perimeter. Notably, our data suggest that surface fire clearly was *not* an important component of the historical fire regime" (Floyd et al., 2005: p. 12).

On Spy Mesa some fire had occurred in small patches or single trees because of discontinuous fuels and those sites produced twice as much desert needlegrass (*Stipa speciosa*) as unburned sites on the same soil (Thatcher & Hart, 1974). On Greatheart Mesa in Zion National Park, Madany and West (1984) found that fire had probably not burnt in that pinyon woodland for at least a century or more. They did observe that on nearby Church Mesa that a number of mature pinyons were killed in a 1964 fire on a variety of sites (Madany & West, 1984).

Biological soil crusts

Several studies have examined biological soil crusts (BSC) in relict areas. Beymer and Klopatek (1992) examined five sites along a continuum of grazing use near the Grand Canyon. Shiva Temple, off of the North Rim, was used as a relict site since it has never been grazed. They found that plots on Shiva Temple had 23.3% BSC cover, and percent values and biomass levels steadily declined along the continuum to the most grazed plots in the adjacent Kaibab National Forest with only 5.2% cover (Beymer & Klopatek, 1992). A similar study by Jeffries and Klopatek (1987) looked a continuum of four sites in the Glen Canyon area. The relict site in that study, Romana Mesa, had nearly twice as much cover as a lightly grazed site, and over forty times higher cover than a heavily grazed site. Furthermore, after ten years without grazing on one site there was still no recovery (Jeffries & Klopatek, 1987). Kleiner and Harper (1977) found similar results comparing two sites in Canyonlands National Park. Virginia Park is a virgin grassland and had 38% BSC cover whereas Chesler Park, which had been grazed until 1962, only had 5% cover of BSC. They attributed the decline in cover and diversity to light winter grazing, even though it had terminated 15 years prior (Kleiner & Harper, 1977). Not all relict sites have high BSC cover values though. Mason et al. (1967) found that BSC cover on No Man's Land Mesa ranged from 0 to 7% on soils with fairly similar sandy and loamy surfaces, and BSC's were so rare on Fishtail Mesa that they were included with litter in ground cover estimates (Rowlands & Brian, 2001).

Conclusion

The information presented in this chapter allows us to answer, at least partially, some important questions regarding the range of natural variability in pinyon-juniper woodlands, specifically related to overstory structure, fire frequency and severity, shrub components, and ground flora characteristics. Historical observations of these woodlands consistently allude to a patchy and irregular distribution of clumps of trees across the landscape (Lang & Stewart, 1910; Roosevelt, 1913; Graves, 1913; Rasmussen, 1941). Steffensen (1997) reported that since the 1940's open savannas have closed considerably and formed contiguous blocks at the highest elevations of the woodlands in the Central Winter range. However, he also suggests that there may be more grassland at the lower elevations today than in the past (Steffensen, 1997) which could reflect natural shifts in distribution across landscapes. Whatever filling-in of open areas is occurring may be more a response to climate than anthropogenic impacts. Rowlands and Brian's (2001) remeasurement of Fishtail Mesa concluded that there, where there has been no grazing or fire suppression, sagebrush steppes were being invaded by pinyon.

Ultimately, fire was probably a hugely important factor in creating the overstory pattern of patchiness that we ascribe to pre-settlement times. Fire is probably the agent which led to much of the sagebrush steppe on Fishtail Mesa (Rowlands & Brian, 2001), it created openings on Spy Mesa (Thatcher & Hart, 1974), and Floyd et al. (2005) documented fire of 'catastrophic' proportions as the norm on the Kaiparowits Plateau. With that in mind, the 1996 Bridger Knolls Fire that burned over 50,000 acres may be normal fire behavior for this area (see chapter 5 for a thorough discussion). The range of fire size is from single trees (Thatcher & Hart, 1974) to hundreds if not thousands of acres (Floyd et al., 2005). Further complicating the issue of fire is its use by Paiute Indians prior to the 1860's (see chapter 1) which may have affected the composition and structure of the woodlands significantly, and their exclusion may be contributing to contemporary filling-in of savannas (Steffensen, 1997). Future inquiries into the history of fire in the lower elevations on the Kane and Two Mile Ranches should note blackbrush stands, as they are extremely intolerant of fire and do not recover from it even after long periods (Callison et al., 1985). Typically, if a blackbrush stand burns it will convert to a non-shrub system (Bowns & West, 1976), so their distribution can provide insights into the fire history of those places where it occurs.

Typically, sagebrush stands are assumed to be a result of past overgrazing. Hall (1975) noted the density of the sagebrush on the northern portions of the Kaibab Plateau and attributed it to the overstocking of sheep. While sagebrush can and does expand its range in overgrazed areas, it is also a naturally occurring dominant on relict sites that have never experienced livestock. In addition to its ecological dominance on Fishtail Mesa, Boysag Point, and No Man's Land Mesa, its dominance was confirmed in early journals (Vale, 1975), and Fisher (2005) found that at Glen Canyon, along with rabbitbrush, it did not increase under the influence of grazing but rather decreased or stayed the same in distribution. Snakeweed, however, appears to be a true increaser since its presence at relict sites is minimal (Table 6.3) and packrat middens studies from Glen Canyon (Fisher, 2005), Capitol Reef (Cole et al., 1997), and Grand Canyon (Coates, 1997) show that snakeweed is common at study sites today but middens don't reflect it until the last two centuries.

Surveys of relict sites strongly suggest that forbs are not an important component of pinyon-juniper woodland understory production and abundance (Jameson et al., 1962; Mason et al., 1967; Schmutz et al., 1967; Thatcher & Hart, 1974; Rowlands & Brian, 2001). Beymer and Klopatek (1992) found that forb cover was highest on the most grazed site along a continuum of grazing pressure, dominated by weedy annuals. Overall plant species richness didn't change from the relict site, Shiva Temple, because of the increase in weedy annuals (Beymer & Klopatek, 1992). Despite the potentially depauparate nature of forbs in woodlands, Schmutz et al. (1967) recorded 24 species on Boysag Point, suggesting that even though their presence is limited, their diversity is significant, therefore making it important to recognize areas of diverse forb assemblages.

Relict sites showed diverse and abundant grass components that contradict each other in their most and least important species (Table 6.3). The earliest account of pinyon-juniper woodlands described what is probably *Bouteloua gracilis* (Beadle, 1873) which was also the most common grass in the late 1920's (Rasmussen, 1941) after years of excessive grazing. Grama grass is the most and least important grass at several relict sites (Table 6.3) as well as *Stipa* species. The only certain conclusion that can be drawn from Table 6.3 regarding relict dominance is that of *Poa fendleriana* which was also found to decrease under grazing pressure at Glen Canyon (Fisher, 2005). Similarly, biological soil crusts are irregularly represented at relict

sites (Table 6.2) yet their sensitivity to livestock trampling has been documented (Kleiner & Harper, 1977; Beymer & Klopatek, 1992).

The pattern that emerges after considering the available data on soils, vegetation, and ecosystem processes is that there is a tremendous range of variability inherent in pinyon-juniper woodlands. Soil characteristics have profound effects of vegetative composition at some relict sites but not at others. Fires may have been set at frequent intervals by Paiute Indians at some locations (see chapter 1) and they may not burn for centuries at others. Sagebrush may or may not be the naturally occurring dominant plant, grass distribution is variable, and soil crusts may or may not even be able to colonize different sites. If the key to ecosystem health is diversity, then these woodlands have got it.

Literature Cited

Beadle, J.H. 1873. The undeveloped west. National Publishing Company, Philadelphia, PA.

Beymer, R.J. and J.M. Klopaptek. 1992. Effects of grazing on cryptogamic crusts in pinyon-juniper woodlands in Grand Canyon National Park. American Midland Naturalist 127: 139-148.

Bowns, J.E. and N.E. West. 1976. Blackbrush on southwestern Utah rangelands. Utah Agricultural Experiment Station Research Report 27. Utah State University, Logan UT.

Callison, J., J.D. Brotherson, and J.E. Bowns. 1985. The effects of fire on the blackbrush (*Coleogyne romosissima*) community of southwestern Utah. Journal of Range Management 38(6): 535-538.

Coates, L. L. 1997. Middle to late Wisconsinan vegetation change at Little Nankoweap, Grand Canyon National Park, Arizona. Thesis, NAU, Flagstaff, AZ

Cole, K.L., N. Henderson, and D.S. Shafer. 1997. Holocene vegetation and historic grazing impacts at Capitol Reef National Park reconstructed using packrat middens. Great Basin Naturalist 57(4): 315-326.

Fisher, J.F. 2005. Using packrat middens to assess how grazing influences vegetation change in Glen Canyon National Recreation Area, Utah. MS Thesis, Northern Arizona University, Flagstaff, AZ.

Floyd, M.L., W.H. Romme, D.H. Hanna, M. Winterowd, and D. Hanna. 2005. Fire History of the Piñon-juniper Woodlands, Navajo Point, Glen Canyon National Recreation Area. Unpublished Final Report GLCA-00347. Not for General Distribution.

Fraser, G.C. 2005. Journeys in the canyonlands of Utah and Arizona, 1914-1916. Edited by F.H. Swanson. University of Arizona: Tucson, AZ.

Graves, H.C. 1913. Timber reconnaissance: Kaibab National Forest, Arizona. USDA Forest Service, District 4 Office of Silviculture.

Gregory, H.E., and R.C. Moore. 1931. The Kaiparowits region: a geographic and geologic reconnaissance of parts of Utah and Arizona. USDI Geologic Survey Professional Paper 164. US Government Printing Office, Washington, DC.

Hall, S.M. 1975. Sharlot Hall on the Arizona Strip; a diary of a journey through northern Arizona in 1911. Compiled by C.G. Campton. Northland Press, Flagstaff, AZ.

Jamesen, D.A., J.A. Williams, and E.W. Wilton. 1962. Vegetation and soils of Fishtail Mesa, Arizona. Ecology 43(3): 403-410.

Jeffries, D.L. and Klopatek, J.M. 1987. Effects of grazing on the vegetation of the blackbrush association. Journal of Range Management 40(5): 390-393.

Kleiner, E.F. and K.T. Harper. 1977. Soil properties in relation to cryptogamic groundcover in Canyonlands National Park. Journal of Range Management 30: 202-205.

Knack, M.C. 1993. Interethnic competition at Kaibab during the early twentieth century. Ethnohistory 40(2): 212-245.

Lang, D.M. and S.S. Stewart. 1910. Reconnaissance of the Kaibab National Forest. Available on-line at www.nau.edu/library/speccoll/manuscript/kaibab_recon.

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

Mason, L.R., H.M. Andrews, J.A. Carley, and E.D. Haacke. 1967. Vegetation and soils of No Man's Land Mesa relict area, Utah. Journal of Range Management 20: 45-49.

McOmie, A.M., C.C. Jacobs, and O.C. Bartlett. 1913. The Arizona Strip: Report of reconnoissance [sic] of the country north of the Grand Canyon. Arizona Board of Control.

Mead, P. 1930. An ecological description of the Kaibab Plateau, Arizona. M.S. Dissertation, University of Illinois, Chicago, IL.

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecological Monographs 11(3): 229-275.

Roosevelt, T. 1913. Across the Navajo desert. The Outlook 105(11): 309-317.

Rowlands, P.G. and N.J. Brian. 2001. Fishtail Mesa: A vegetation resurvey of a relict area in Grand Canyon National Park, Arizona. Western North American Naturalist 61(2): 159-181.

Schmutz, E.M., C.C. Michaels, and B.I. Judd. 1967. Boysag Point: A relict area on the north rim of Grand Canyon in Arizona. Journal of Range Management 20: 363-369.

Steffensen, D. 1997. Current conditions and trends of vegetation on Central Winter: focusing on the pinyon-juniper woodlands. Unpublished USDA Forest Service report on file at Grand Canyon Trust, Flagstaff, AZ.

Thatcher, A.P. and V.L. Hart. 1974. Spy mesa yields better understanding of pinyon-juniper in range ecosystem. Journal of Range Management 27(5): 354-357.

Thompson, A.H. 1939. Diary of Almon Harris Thompson. Compiled by J. Cecil Alter. Utah State Historical Quarterly 7: 2-138.

USDI Bureau of Land Management. 2004. Landscape assessment for the Buckskin Mountain area. Grand Staircase-Escalante National Monument. Bureau of Land Management, Kanab, UT.

Vale, T.R. 1975. Presettlement vegetation in the sagebrush-grass areas of the intermountain west. Journal of Range Management 28(1): 32-36

Chapter 7.

Arroyo cutting events in the late 19th century: causes and effects

A period of rapid downcutting in the late 1800's and early 1900's alarmed those who witnessed it and left in its wake a trademark of southwestern scenes: the arroyo. Gulches and ditches formed in almost every wash and creek soon after the arrival of domestic livestock, but were livestock to blame? This chapter discusses the historical perceptions of arroyo cutting and our intellectual evolution that has left us facing an inevitable fact: erosion is cyclical, and it will continue as long as it's downhill to the sea.

Many of what are now gulches used to be something entirely different. When the first settlers arrived at Marsh Pass in Tsegi Canyon near Kayenta there was no Laguna Creek as there is today. "The valley and canyon floors were a vast plain, dotted with lakes and swamps….Hunting parties frequented the region to kill ducks in the swamps and marshes" (Reagan, 1924: p. 284). Such marshy areas may have been the norm, not the exception. "As late as 1890 upper Kitchen Canyon [in the Paria basin] was a region of swamps, ponds and grassy meadows, famous for its choice forage….Likewise for many years the floor of Park Wash was an undissected surface of alluvium coated by grass and palatable herbage" (Gregory, 1948: pp. 246-247). In the 1870's Kanab Creek flowed in shallow, braided channels (Webb et al., 1991), forage was abundant, and Mormon settlers were attracted to the lush pastures. In the 1860's and 1870's groundwater could be found just three feet under the surface in Kanab and Johnson Washes, and as late as 1876 Clarence Dutton reported that Kanab Creek was actually aggrading (Webb et al., 1991). Soon, tens of thousands of domestic sheep, cattle, and horses were trampling the range, and then it all changed.

"About 1895 the shallow, narrow streamway [of Park Wash] began to deepen and since that time has continued to cut downward and sideways into alluvium 10 to 30 feet thick, destroying grazing land and farm land in the main wash, and stripping the branch washes of their soil" (Gregory, 1948: pp. 246-247). In just a few years, the floodplain meadows that had attracted so many settlers to towns like Kanab, Paria, Fredonia, and others gave way and incised deeper than many could have thought possible. Flat, tillable riparian areas on the Navajo Reservation were suddenly, after 1880, arroyos up to one hundred feet deep (Bryan, 1925). After a series of floods that started on July 29, 1883 (Bryan, 1925) Kanab Creek incised 60 feet

deep and 75 feet wide for 13 miles (Webb et al., 1991). After the Mormons colonized Tuba City in 1870, Moenkopi Wash entrenched up to 40 feet deep in places (Bryan, 1925). The destruction wrought by the floods and the loss of pasture led to the abandonment of townships like House Rock, Adairville, and Johnson City (Gregory, 1948). The village of Paria fell apart and was abandoned too after floods converted their agricultural fields to a narrow channel (Gregory & Moore, 1931). It wasn't just in the desert either. The Rio de Flag, winding through stately ponderosa pines, was once a slow moving perennial stream, but just as the first settlers arrived it entrenched 20 to 30 feet (Bryan, 1925). Between 1871 and 1911 more than 10 dams were built on Kanab Creek that were subsequently washed out by more floods (Webb et al., 1991).

Early explanations for the erosion events suggested that livestock and roads had weakened the soil and tore the plants from the ground, and then the ground just let go (Reagan, 1924). As early as 1912 though, Frederick C. Dellenbaugh argued that it wasn't just grazing that had caused the arroyos (Dellenbaugh, 1912). He reported that he had been to places where no cattle had ever been and there were deep arroyos there too. He suggested that it is simply a matter of erosion, no matter how much or what kind of vegetation is or isn't there, it's just the southwest, and that's the way it is (Dellenbaugh, 1912). Indeed, after nearly a century of research into the issue of arroyo cutting, we can safely say that Dellenbaugh was right: "Arroyo entrenchment has been an important characteristic of alluvial channels throughout the Holocene" (Webb et al., 1991: p. 6).

Leopold (1976) argued that previous erosion cycles happened that pre-date the coming of livestock and had nothing to do with human intervention. So what exactly happened? Hereford (2002) examined the causes and processes of deposition that allowed the washes to become lush pastures loaded with alluvium. According to him, deposition was a recent geologic phenomenon that occurred from 1400 to around 1880, and prior to that an equally destructive erosion period lasted from 1200 to 1400 (Hereford, 2002) (Figure 7.1). Three previous arroyo cutting events have been documented for the Kanab Creek Basin over the last 5,200 years (Webb et al., 1991). The transition from the Little Ice Age, the last period of aggradation, to the era of global warming was characterized by some of the largest runoff events of the preceding 400 to 500 years in the Virgin, Upper Colorado, Kanab and Escalante River basins (Hereford, 2002). The erosion events of the late 1800's were a reaction to increased runoff from highly intense frequent rainfalls (Hereford, 1986). The winter of 1861-1862 it rained for 40 to 45 days straight over

much of the Colorado Plateau (Hereford, 2002) which could have been the trigger for what Kirk Bryan named an "erosion epicycle" (Bryan, 1925).

Grazing was another trigger at local scales in heavily grazed areas, but it can't be considered more influential than climate (Webb et al., 1991; Hereford, 2002). It was purely coincidence that settlement occurred at the brink of major climate change and grazing should be considered a secondary factor (Hereford, 1986). Since the alluvial layers under question are mappable at regional scales, such as from the Colorado Plateau all the way to southern Arizona, that implies a widespread climatic function rather than a local influence as the causal agent of erosion and deposition (Hereford, 2002). Hereford (1986) studied tree rings at four sites in the Paria River basin and found that in 1882 significant precipitation increases began. Webb et al. (1991) and Hereford (2002) suggest that long term changes in flood frequency and intensity may be directly related to El Nino Southern Oscillation patterns (Figure 7.2)

We are in a period of deposition today that began around 1940 (Hereford, 1986) which may reflect additional climate change, but not enough evidence exists to support that as fact (Leopold, 1976). Geomorphic and stratigraphic evidence suggests that the primary source of modern alluvial fill is weathered bedrock from hillslopes (Hereford, 2002). Considerable refilling has occurred and one of the most striking changes evident after comparing historic and modern photographs is the dramatic increase in woody vegetation (see Webb et al., 1991 for historic paired photographs). Much growth is Tamarisk, which was planted at Paria in 1875 (Gregory & Moore, 1931), but there is also sage, willows, saltbush, and other shrubs that contribute to sediment retention. Periods of significantly dry weather with decreased frequency of intense rainfall cause refilling to occur, but historic ones may have been even drier than the current drought. Cole et al. (1997) reported that severe droughts, those that had less than 165mm/year of precipitation occurred 9 times in the 1600's, 4 times in the 1700's, and 7 times in the 1900's. Such events can contribute to further aggradation of incised streams on the Colorado Plateau, but that doesn't mean we won't experience massive floods for another century or more. In 1996, 14 inches of rain fell over the southern Kaibab Plateau over 3 days, causing tremendous floods to scour many washes and creeks (Cooley et al., 1977). North Canyon Wash through House Rock Valley was deepened and widened by a foot and a debris slide in the spruce fir forest covered a section of the Point Sublime trail. Thompson Canyon and other drainages in the park showed several feet of arroyo cutting in this event, but most parks and canyons in the

Kaibab National Forest were spared, though they showed evidence of older events (Cooley et al., 1977).

That grazing and other 19th century anthropogenic impacts had little to do with the arroyo cutting of the late 1800's is reassuring, but the recovery of the regions waterways may be hindered by the continued use of the range by domestic livestock. Though no documentation of arroyo cutting in smaller tributary streams exists, similar effects are probable (Hereford, 1986). All waterways should be considered affected by the erosion events of the late 1800's, and as evidenced in 1966 on the North Rim, the possibility of continuing events exists.

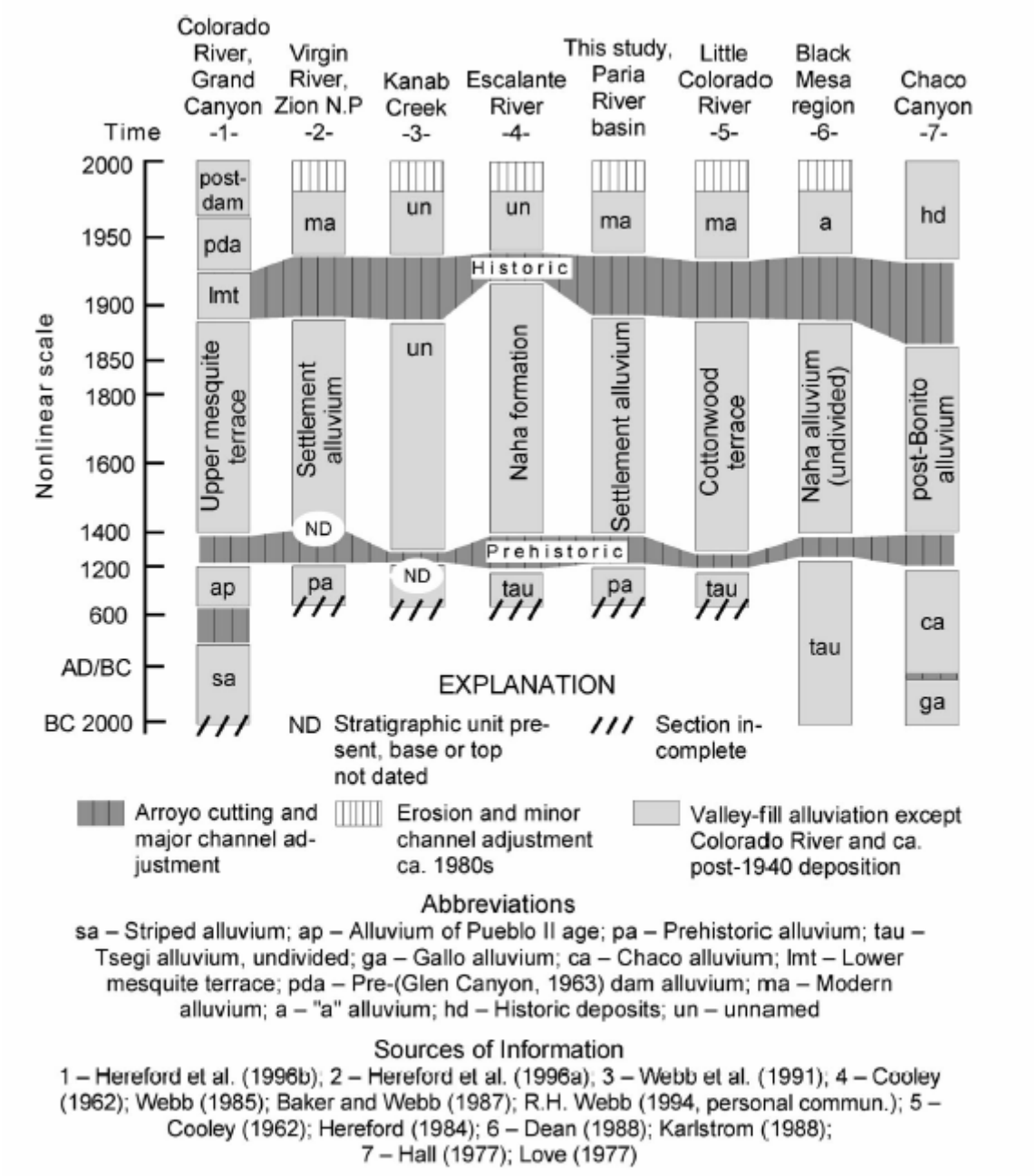


Figure 8. Chronostratigraphic correlation of late Holocene valley-fill alluvium emphasizing the post-1200 period at seven well-studied rivers, creeks, basins, or regions in the southern Colorado Plateau (for location, see inset map in Fig. 1).

Figure 7.1 *Figure from Hereford, 2002 showing past erosion events throughout the Colorado Plateau*

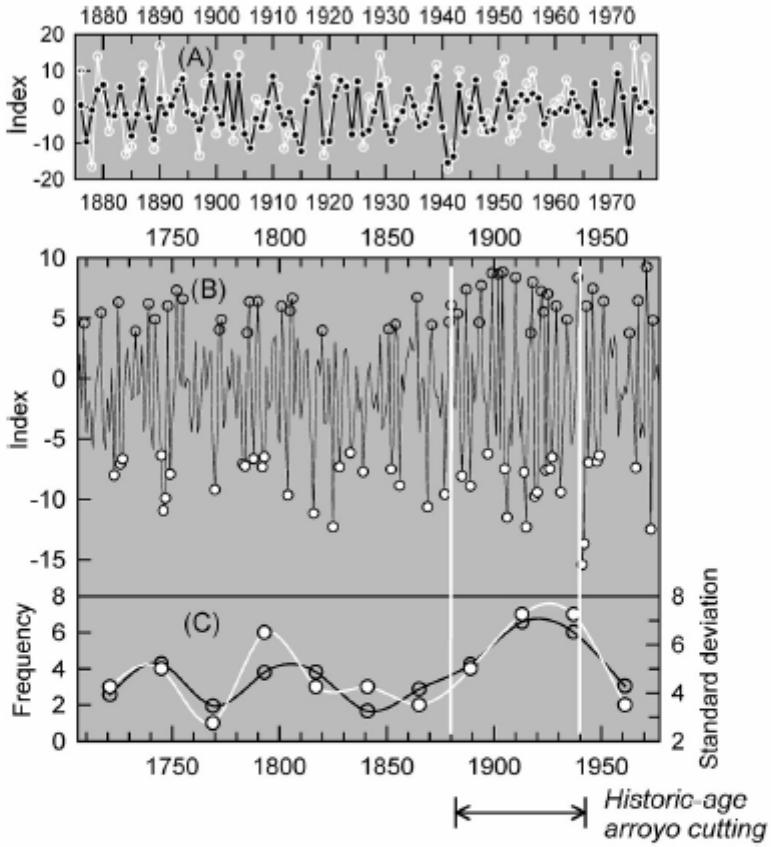


Figure 9. (A) Instrumental (white line with open symbol) and reconstructed SOI (Southern Oscillation Index; black line and symbol) during the calibration period, 1876–1977. The latter is in phase with and explains 53% of the variability of the measured SOI. (B) Dendroclimatological reconstruction of the winter SOI, 1706–1977 (December through February; data from Stahle et al., 1998, Table A1). Solid circles are estimated El Niño (potentially wet) conditions, and open circles are La Niña (generally dry) conditions defined as ±1 standard deviation from the long-term average of the reconstructed index. (C) Estimated frequency of wet El Niño events (white line and symbol) and standard deviation or intensity of SOI (black line with open symbol) in 11 nonoverlapping 24-yr intervals, plotted at center of the interval and smoothed with a spline function. Historic arroyo cutting was contemporaneous with the increased frequency and intensity of ENSO that peaked in the early 1900s.

Figure 7.2 *Figure from Hereford (2002) relating ENSO activity and erosion epicycles*

Literature Cited

Bryan, K. 1925. Date of channel trenching (arroyo cutting) in the arid southwest. Science 62: 338-344.

Cole, K.L., N. Henderson, and D.S. Shafer. 1997. Holocene vegetation and historic grazing impacts at Capitol Reef National Park reconstructed using packrat middens. Great Basin Naturalist 57(4): 315-326.

Cooley, M.E., B.N. Aldridge, and R.C. Euler. 1977. Effects of the catastrophic flood of December, 1966, North Rim area, eastern Grand Canyon, Arizona. USGS Professional Paper 980. US Government Printing Office, Washington, DC.

Dellenbaugh, F.S. 1912. Cross cutting and retrograding of stream beds. Science 35: 656-658.

Gregory, H.E., and R.C. Moore. 1931. The Kaiparowits region: a geographic and geologic reconnaissance of parts of Utah and Arizona. USDI Geologic Survey Professional Paper 164. US Government Printing Office, Washington, DC.

Gregory, H.E. 1948. Geology and geography of central Kane County, Utah. Bulletin of the Geologic Society of America 59: 211-248.

Hereford, R. 1986. Modren alluvial history of the Paria River drainage basin, southern Utah. Quaternary Research 25: 293-311.

Hereford, R. 2002. Valley-fill alluviation during the Little Ice Age (ca. A.D. 1400-1880), Paria River basin and southern Colorado Plateau, United States. Geological Society of America Bulletin 114(12): 1550-1563.

Leopold, L.B. 1976. Reversal of erosion cycle and climate change. Quaternary Research 6: 557-562.

Reagan, A.B. 1924. Recent changes in the Plateau region. Science 60: 283-285

Webb, R.H., S.S. Smith, and V.A.S. McCord. 1991. Historic channel change of Kanab Creek, southern Utah and northern Arizona. Grand Canyon Natural History Association, Monograph No. 9.

Bibliography

Akers, J. P. 1960. The Chinle formation of the Paria Plateau, Arizona and Utah. MS Thesis, University of Arizona, Tucson, Arizona.

Alder, D.D. and K.F. Brooks. 1996. A history of Washington County. Utah State Historical Society, Salt Lake City, UT.

Altschul & Fairley. 1989. Man, models, and management: an overview of archaeology on the Arizona Strip and management of its cultural resources. Report prepared for USDA Forest Service and USDI Bureau of Land Management. Prepared by Statistical Research, Plateau Archaeology, and Dames & Moore, Inc.

Azar, J.S. 2005. Buckskin Mountain. Pages 53-56 In Anderson, Michael F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Bailey, V. 1935. Mammals of the Grand Canyon region. Natural history bulletin no. 1. Grand Canyon Natural History Association.

Baker, R.D, R.S. Maxwell, V.H. Treat, and H.C. Dethloff. 1988. Timeless heritage: a history of the Forest Service in the southwest. US Department of Agriculture Forest Service, FS-409, College Station, TX.

Barnes, W.C. 1935. Arizona place names. University of Arizona Bulletin 6(1). General Bulletin No. 2. University of Arizona, Tucson, AZ.

Beadle, J.H. 1873. The undeveloped west. National Publishing Company, Philadelphia, PA.

Beymer, R.J. and J.M. Klopaptek. 1992. Effects of grazing on cryptogamic crusts in pinyon-juniper woodlands in Grand Canyon National Park. American Midland Naturalist 127: 139-148.

Blackman, M.W. 1931. The Black Hills beetle (Dendroctonus ponderosae Hopk.). Bulletin of the New York State College of Forestry IV(4).

Bolton, H.E. 1950. Pageant in the Wilderness: The story of the Escalante expedition to the interior basin, 1776. Utah State Historical Society, Salt Lake City, UT.

Booth, P.M. 2005. Blue denim university: The Civilian Conservation Corps' retooling of Arizona youth. Pages 91-98 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Booth, P.M. 2005. The Civilian Conservation Corps' role in tourism: The CCC's retooling of Arizona's natural resources. Pages 73-80 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Bowns, J.E. and N.E. West. 1976. Blackbrush on southwestern Utah rangelands. Utah Agricultural Experiment Station Research Report 27. Utah State University, Logan UT.

Briggs, W. 1976. Without noise of arms: The 1776 Dominguez-Escalante search for a route from Santa Fe to Monterey. Northland Press, Flagstaff, AZ.

Brooks, J. 1944. Journal of Thales H. Haskell. Utah Historical Quarterly 12: 69-98.

Bryan, K. 1925. Date of channel trenching (arroyo cutting) in the arid southwest. Science 62: 338-344.

Buckley, S. 2004. Mountain lying down: Restoration, bioregionalism, and the indigenous Kaibab Plateau. Master of Liberal Studies Thesis, Northern Arizona University, Flagstaff, AZ.

Bureau of Land Management a. File of Bert Leach, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management b. File of A.D. Findlay with supplementary files, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management c. File of Trevor K. Leach, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management d. File of Vermilion Cliff Cattle Company, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management e. File of Arnold L. Hawkins, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management f. File of Royal B. Woolley Estate, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management g. File of C.H. Vaughn, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management h. File of Alvin C. Tso, on file at USDI Bureau of Land Management, Arizona Strip Field Office, St. George, UT.

Bureau of Land Management i. Compiled grazing use summaries on file at Grand Canyon Trust, Flagstaff, AZ.

Burnett, H. 1991. Green island in the sky. American Forests 97: 44-47, 62.

Callison, J., J.D. Brotherson, and J.E. Bowns. 1985. The effects of fire on the blackbrush (*Coleogyne romosissima*) community of southwestern Utah. Journal of Range Management 38(6): 535-538.

Chiquone, L. 2005. Ecosystem descriptions. Unpublished report on file at Grand Canyon Trust, Flagstaff, Arizona.

Cleeland, T.A. 1990. Lag bolts and ladders. Pages 74-80 in People and Places of the Old Kaibab. USDA Forest Service Cultural Resources Management Report No. 10. Southwestern Region.

Cleland, R.G., and J. Brooks. 1983. A Mormon chronicle: The diaries of John D. Lee. Vol 2. University of Utah Press, Salt Lake City, UT.

Coates, L. L. 1997. Middle to late Wisconsinan vegetation change at Little Nankoweap, Grand Canyon National Park, Arizona. MS Thesis, Northern Arizona University, Flagstaff, AZ.

Coker, E. 1978. Historical resources of the Kaibab National Forest. USDA Forest Service, Kaibab National Forest, Williams, Arizona.

Cole, K. 1985. Past rates of change, species richness, and a model of vegetative inertia in the Grand Canyon, Arizona. The American Naturalist 125(2): 289-302.

Cole, K.L., N. Henderson, and D.S. Shafer. 1997. Holocene vegetation and historic grazing impacts at Capitol Reef National Park reconstructed using packrat middens. Great Basin Naturalist 57(4): 315-326.

Collins, G.L. 1994. Bare facts about bear tracks. Pages 142-143 in (Ed.) S. Lamb. The best of Grand Canyon Nature Notes. Grand Canyon Natural History Association: Grand Canyon, Arizona.

Cooley, M.E., B.N. Aldridge, and R.C. Euler. 1977. Effects of the catastrophic flood of December, 1966, North Rim area, eastern Grand Canyon, Arizona. USGS Professional Paper 980. US Government Printing Office, Washington, DC.

Coues, E. 1900. On the trail of a Spanish pioneer: The diary of Francisco Garcés. Frances P. Harper Company, New York, NY. Two volumes.

Covington, W.W. and Moore, M.M. 1994. Postsettlement changes in natural fires regime and forest structure: ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry 2: 153-181.

Covington, W.W. and M.M. Moore. 1994. Southwestern ponderosa forest structure: changes since Euro-American settlement. Journal of Forestry 92(1): 39-47.

Craighead, F.C. 1924. The black hills beetle practicing forestry on the Kaibab. Forest Worker, November, 1924: 74.

Craighead, F.C. 1925. The *Dendroctonus* problem. Journal of Forestry 23: 340-354.

Crampton, C.G. 1972. Land of the living rock: The Grand Canyon and the high plateaus: Arizona, Utah, Nevada. Alfred A. Knopf Company, New York, NY.

Creer, L.H. 1958. The activities of Jacob Hamblin in the region of the Colorado. University of Utah Anthropological Paper #33.

Dellenbaugh, F.S. 1912. Cross cutting and retrograding of stream beds. Science 35: 656-658.

Dellenbaugh, F.S. 1965. The Romance of the Colorado River. Rio Grand Press, Chicago, IL.

DeMotte, H. 1872. Six days on the Kaibab. Alumni Journal of Illinois Wesleyan University 2(10): 233-239.

Dutton, C.E. 1887. Physical geology of the Grand Canyon district. USGS. 2nd Annual Report: 49-166.

Dutton, C.E. 2001. Tertiary history of the Grand Canyon district. University of Arizona Press, Tucson, AZ. (reprint)

Easton, R. and M. Brown. 1961. Lord of the beasts-the saga of Buffalo Jones. University of Arizona Press, Tucson, AZ.

Ellsworth, S.G. 1987. Samuel Claridge: Pioneering the outposts of Zion. Self-published, Logan, UT.

Fisher, J.F. 2005. Using packrat middens to assess how grazing influences vegetation change in Glen Canyon National Recreation Area, Utah. MS Thesis, Northern Arizona University, Flagstaff, AZ.

Floyd, M.L., W.H. Romme, D.H. Hanna, M. Winterowd, and D. Hanna. 2005. Fire History of the Piñon-juniper Woodlands, Navajo Point, Glen Canyon National Recreation Area. Unpublished Final Report GLCA-00347. Not for General Distribution.

Fraser, G.C. 2005. Journeys in the canyonlands of Utah and Arizona, 1914-1916. Edited by F.H. Swanson. University of Arizona: Tucson, Arizona.

Fule, P.Z., T.A. Heinlein, W.W. Covington, and M.M. Moore. 2000. Continuing fire regimes in remote forests of Grand Canyon National Park. In: Cole, D.N. and S.F. McCool (eds) Proceedings: Wilderness Science in a Time of Change. Proc. RMRS-P-15. USA Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA, pp. 242-248.

Fule, P.Z., W.W. Covington, M.M. Moore, T.A. Heinlein, and A.E.M. Waltz. 2002. Natural variability in forests of the Grand Canyon, USA. Journal of Biogeography 29: 31-47.

Fule, P.Z., J.E. Crouse, M. Daniels, J. Springer, T.A. Heinlein, M.M. Moore, W.W. Covington, and G. Verkamp. 2002. Mixed-severity fire regime in a high-elevation forest: Grand Canyon, Arizona. Final Report to the Joint Fire Science Program, CA-1200-00-009-NAU 04 (Part 1).

Fule, P.Z., J.E. Crouse, T.A. Heinlein, M.M. Moore, W.W. Covington, and G. Verkamp. 2003. Mixed-severity fire regime in a high-elevation forest of Grand Canyon, Arizona, USA. Landscape Ecology 18: 465-486.

Fule, P.Z., T.A. Heinlein, W.W. Covington, and M.M. Moore. 2003. Assessing fire regimes on Grand Canyon landscapes with fire-scar and fire-record data. International Journal of Wildland Fire 12: 129-145.

Fule, P.Z., A.E. Cocke, T.A. Heinlein, and W.W. Covington. 2004. Effects of an intense prescribed fire: is it ecological restoration? Restoration Ecology 12(2): 220-230.

Fule, P.Z., J.E. Crouse, A.E. Cocke, M.M. Moore, and W.W. Covington. 2004. Changes in canopy fuels and potential fire behavior 1880-2040: Grand Canyon, Arizona. Ecological Modelling 175: 231-248.

GCNP. 2005. Grand Canyon mammals. Available online at http://www.nps.gov/grca/pphtml/subanimals6.html. Last accessed March 6, 2006

Gildar, C.N., P.Z. Fule, and W.W. Covington. 2004. Plant community variability in ponderosa pine forest has implications for reference conditions. Natural Areas Journal 24: 101-111.

Goebel, P.C., T.C. Wyse, and R.G. Corace, III. 2005. Determining reference ecosystem conditions for disturbed landscapes within the context of contemporary resource management issues. Journal of Forestry 103(7): 351-356.

Goldman, E.A. and S.B. Locke. 1923. The mountain of twenty thousand deer. American Forestry 29: 649-653.

Graves, H.C. 1913. Timber reconnaissance: Kaibab National Forest, Arizona. USDA Forest Service, District 4 Office of Silviculture.

Gregory, H.E. and R.C. Moore. 1931. The Kaiparowits region: A geographic and geologic reconnaissance of parts of Utah and Arizona. United States Geologic Survey Professional Paper 164. US Government Printing Office, Washington, DC.

Gregory, H.E. 1948. Geology and geography of central Kane County, Utah. Bulletin of the Geologic Society of America 59: 211-248.

Hall, S.M. 1975. Sharlot Hall on the Arizona Strip: A diary of a journey through northern Arizona in 1911. Compiled by C.G. Campton. Northland Press, Flagstaff, AZ.

Hayfen, L. 1947. Armijo's journal. Huntington Library Quarterly 11: 87-101.

Hereford, R. 1986. Modren alluvial history of the Paria River drainage basin, southern Utah. Quaternary Research 25: 293-311.

Hereford, R. 2002. Valley-fill alluviation during the Little Ice Age (ca. A.D. 1400-1880), Paria River basin and southern Colorado Plateau, United States. Geological Society of America Bulletin 114(12): 1550-1563.

Hughes, J.D. 1991. In the house of stone and light: A human history of the Grand Canyon. Grand Canyon Natural History Association, University of Denver Press, Denver, CO.

Huisinga, K.D., D.C. Laughlin, P.Z. Fule, J.D. Springer, and C.G. McGlone. 2005. Effects of an intense prescribed fire on understory vegetation in a mixed conifer forest. Journal of the Torrey Botanical Society 32(4): 590-601.

Hungerford, C.R. 1970. Response of Kaibab mule deer to management of summer range. Journal of Wildlife Management 34(4): 852-862.

Iverson, V. no date. Oral History of Vernon and Nora Iverson, on file at Sharlot Hall Museum, Prescott, AZ.

Jackson, S.T., and S.J. Smith. 1994. Pollen dispersal and representation on an isolated forested plateau. New Phytologist 128: 181-193.

Jamesen, D.A., J.A. Williams, and E.W. Wilton. 1962. Vegetation and soils of Fishtail Mesa, Arizona. Ecology 43(3): 403-410.

Jeffries, D.L. and Klopatek, J.M. 1987. Effects of grazing on the vegetation of the blackbrush association. Journal of Range Management 40(5): 390-393.

Jones, S.V. 1872. In Gregory, H.E. (ed.) 1948-1949. Journal of Stephen Vandiver Jones. Utah Historical Quarterly 16-17: 19-174.

Kelsey, M. 1987. Hiking and exploring the Paria River. Kelsey Publishing, Provo, UT.

Kleiner, E.F. and K.T. Harper. 1977. Soil properties in relation to cryptogamic groundcover in Canyonlands National Park. Journal of Range Management 30: 202-205.

Knack, M.C. 1993. Interethnic competition at Kaibab during the early twentieth century. Ethnohistory 40(2): 212-245.

Lamb, S. 1994. (ed.) The best of Grand Canyon Nature Notes. Grand Canyon Natural History Association: Grand Canyon, AZ.

Larsen, W. 2000. Arizona strip stories as told in their own words. Draft manuscript on file at Dixie State College, Special Collections, St. George, UT.

Laughlin, D.C., J.D. Bakker, M.T. Stoddard, M.L. Daniels, J.D. Springer, C.N. Gildar, A.M. Green, and W.W. Covington. 2004. Toward reference conditions: Wildfire effects on flora in an old-growth ponderosa pine forest. Forest Ecology and Management 199: 137-152.

Lang, D.M. and S.S. Stewart. 1910. Reconnaissance of the Kaibab National Forest. Available on-line at www.nau.edu/library/speccoll/manuscript/kaibab_recon.

Leopold, L.B. 1976. Reversal of erosion cycle and climate change. Quaternary Research 6: 557-562.

Mace, W. M. 1990. Will Mace memoirs: A letter to Gifford Pinchot dated February 9, 1940. Pages 65-73 in People and Places of the Old Kaibab. USDA Forest Service Cultural Resources Management Report No. 10. Southwestern Region.

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

Mann, W.G. and S.B. Locke. 1931. The Kaibab deer-a brief history and recent developments. Unpublished report on file at North Kaibab Ranger District, Kaibab National Forest, Fredonia, AZ.

Mason, L.R., H.M. Andrews, J.A. Carley, and E.D. Haacke. 1967. Vegetation and soils of No Man's Land Mesa relict area, Utah. Journal of Range Management 20: 45-49.

McClintock, J.H. 1921. Mormon settlement in Arizona. University of Arizona, Tucson, AZ.

McCulloch, C.Y. 1986. A history of predator control and deer productivity in northern Arizona. The Southwestern Naturalist 31(2): 215-220.

McHenry, D.E. 1994. Quaking aspen-its future in the park. Pages 75-76 in S. Lamb. (ed.) The best of Grand Canyon Nature Notes. Grand Canyon Natural History Association, Grand Canyon, AZ.

McOmie, A.M., C.C. Jacobs, and O.C. Bartlett. 1913. The Arizona Strip: Report of reconnoissance [sic] of the country north of the Grand Canyon. Arizona Board of Control.

Mead, E. 1903. Report of irrigation investigations in Utah. USDA Office of Experiment Stations, Bulletin No. 124. Government Printing Office, Washington, D.C.

Mead, J.I. and A.M. Phillips. 1981. The late Pleistocene and Holocene fauna and flora of Vulture Cave, Grand Canyon, Arizona. Southwestern Naturalist 26: 257-288.

Mead, J., S.E. Sharpe, and L.D. Agenbroad. 1991. Holocene bison from Arches National Park, southeastern Utah. Great Basin Naturalist 51(4): 336-342.

Mead, J. 2002. Bison of the Grand Canyon Region: An overview assessment. A report to the Grand Canyon National Park, Arizona. Unpublished and not for general distribution.

Mead, P. 1930. An ecological description of the Kaibab Plateau, Arizona. M.S. Dissertation, University of Illinois, Chicago.

Menninghaus, F.F. and D.B. Jensen. 1967. Central Summer, Central Winter and Sowats Allotment Management Plan. Unpublished report dated October 16, 1967 on file at Kaibab National Forest, North Kaibab Ranger District, Fredonia, AZ.

Merkle, J. 1954. An analysis of the spruce-fir community on the Kaibab Plateau, Arizona. Ecology 35: 316-322.

Miller, J.M. 1924. The Black Hills beetle on the Kaibab forest. Timberman 26(2): 50.

Miller, K.K. 1983. The ecology and impact of the Pandora moth, *Coloradia pandora pandora* Blake, in northern Arizona. M.S. thesis, Northern Arizona University, Flagstaff, AZ.

Mitchell, J.E. and D.R. Freeman. 1993. Wildlife-livestock-fire interactions on the North Kaibab: a historical review. Gen. Tech. Rep. RM-222. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Niehuis, C.C. 1983. Strip characters, strip cronies. Arizona Highways, August 1983.

Olsen, R.W. 1965. Pipe Springs, Arizona, and thereabouts. The Journal of Arizona History 6(1): 11-20.

Onstott, T.A. 1970. Man and the northern Kaibab Plateau. MA Thesis, New Mexico State University, Las Cruces, NM.

Parker, D.L. 1980. Mountain pine beetle, *Dendroctonus ponderosae* Hopkins, in ponderosa pine, Kaibab Plateau, Arizona. USDA Forest Service Integrated pest management guide, R-3 80-8.

Parker, D.L., and R.E. Stephens. 1979. Mountain Pine beetle infestation characteristics in ponderosa pine, Kaibab Plateau, Arizona, 1975-1977. USDA Forest Service, Research Note RM-367. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Powell, J.W. 1882. Second annual report of the United States Geological Survey. Government Printing Office, Washington, D.C.

Powell, J.W. 1961. The exploration of the Colorado River and its canyons. Dover Publications, New York, NY. (reprint)

Powell, W.C. 1871/1872. In Kelly, C. (ed.) 1948-1949. Journal of W.C. Powell. Utah Historical Quarterly 16-17: 257-478.

Pyne, S.J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton University Press, Princeton, NJ.

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecological Monographs 11(3): 229-275.

Reagan, A.B. 1924. Recent changes in the Plateau region. Science 60: 283-285

Reiner, R.J., and P.J. Urness. 1982. Effect of grazing horses managed as manipulators of big game winter range. Journal of Range Management 35(5): 567-572.

Reilly, P.T. 1999. Lee's Ferry: From Mormon crossing to National Park. Utah State University Press, Logan, UT.

Richmond, A. 2005. Rails at both rims. Pages 15-18 In Anderson, M.F. (ed). A gathering of Grand Canyon historians: Ideas, arguments, and first-person accounts. Proceedings of the inaugural Grand Canyon History Symposium, January 2002. Grand Canyon Association, Grand Canyon, AZ.

Ricketts, N.B. 2001. Arizona's honeymoon trail and Mormon wagon roads. Cox Printing, Mesa, AZ.

Rider, R.W., as told to D.M. Paulsen. 1985. The roll away saloon: cowboy tales of the Arizona strip. Utah State University Press, Logan, UT.

Roosevelt, T. 1913. Across the Navajo desert. The Outlook 105(11): 309-317.

Rowlands, P.G. and N.J. Brian. 2001. Fishtail Mesa: A vegetation resurvey of a relict area in Grand Canyon National Park, Arizona. Western North American Naturalist 61(2): 159-181.

Russo, J.P. 1964. The Kaibab North deer herd-its history, problems and management. State of Arizona Department of Game and Fish. Wildlife Bulletin #7.

Savage, L.M. 1936. Journal of Levi Mathers Savage 1876-1935. Compiled by Juanita Brooks and others as a Works Progress Administration project. Mimeographed by Brigham Young University Extension Division, Provo, Utah. On file at Dixie State College, Special Collections, St. George, Utah.

Schlegel, P.A. 1992. A history of the cattle industry in northern Arizona, 1863-1912. MA Thesis, Northern Arizona University, Flagstaff, AZ.

Schmutz, E.M., C.C. Michaels, and B.I. Judd. 1967. Boysag Point: A relict area on the north rim of Grand Canyon in Arizona. Journal of Range Management 20: 363-369.

Sesnie, S.E. 2001. Environmental histories: a foundation for adaptive forest management on the Kaibab Plateau in northern Arizona. MS Thesis, Northern Arizona University, Flagstaff, AZ.

Steffensen, D. 1997. Current conditions and trends of vegetation on Central Winter: focusing on the pinyon-juniper woodlands. Unpublished USDA Forest Service report on file at Grand Canyon Trust.

Stein, S.J. 1988. Explanations of the imbalanced age structure and scattered distribution of ponderosa pine within a high-elevation mixed coniferous forest. Forest Ecology and Management 25: 139-153.

Stephens, S.L. and P.Z. Fule. 2005. Western pine forests with continuing frequent fire regimes: possible reference sites for management. Journal of Forestry 103(7): 357-362.

Stewart, G. 1941. Historic records bearing on agricultural and grazing ecology in Utah. Journal of Forestry 39: 363-375.

Stoffle, R.W. and M.J. Evans. 1976. Resource competition and population change: A Kaibab Paiute ethnohistorical case. Ethnohistory 23(2): 173-197.

Swetnam, T.W., C.D. Allen, and J.L. Betancourt. 1999. Applied historical ecology: using the past to manage for the future. Ecological Applications 9(4): 1189-1206.

Thatcher, A.P. and V.L. Hart. 1974. Spy mesa yields better understanding of pinyon-juniper in range ecosystem. Journal of Range Management 27(5): 354-357.

Thomas, R.L. 1974. Couples made trek over romantic trail. Arizona Republic, 10-5-74.

Thompson, A.H. 1939. Diary of Almon Harris Thompson. Compiled by J. Cecil Alter. Utah State Historical Quarterly 7: 2-138.

Turkowski, F.L. and H.G. Reynolds. 1970. Response of some rodent populations to pinyon-juniper reduction on the Kaibab Plateau, Arizona. The Southwestern Naturalist 15(1): 23-27.

USDA Forest Service. 1979. Draft Environmental Impact Statement, western spruce budworm management, Kaibab National Forest and Grand Canyon National Park. USDA Forest Servive, Albuquerque, NM.

USDA Forest Service. 1980. Environmental analysis report. Central Summer Allotment Management Plan. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

USDA Forest Service. 1997. Current Condition Report. Central Winter Allotment. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

USDA Forest Service. 1998. Kaibab National Forest, North Kaibab Ranger District History. Informational paper describing the history of the North Kaibab Ranger District, available at Kaibab National Forest, North Kaibab Ranger District, Fredonia, Arizona.

USDA Forest Service. 2004. Burro Allotment Annual Operating Instructions for 2004. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

USDA Forest Service. 2004. Central Summer, Central Winter, Kane, and C & H Allotments Annual Operating Instructions for 2004. North Kaibab Ranger District, Kaibab National Forest. On file at Grand Canyon Trust, Flagstaff, AZ.

USDI Bureau of Land Management. 2004. Landscape assessment for the Buckskin Mountain area. Grand Staircase-Escalante National Monument. Bureau of Land Management, Kanab, UT.

Vale, T.R. 1975. Presettlement vegetation in the sagebrush-grass areas of the intermountain west. Journal of Range Management 28(1): 32-36

Van Devender, T.R. and J.I. Mead. 1976. Late Pleistocene and modern plant communities of Shinumo Creek and Peach Springs Wash, Lower Grand Canyon, Arizona. Journal of the Arizona Academy of Science 1:16-22.

Wagner, M.R. and R.L. Mathiasen. 1985. Dwarf mistletoe-pandora moth interaction and its contribution to ponderosa pine mortality in Arizona. Great Basin Naturalist 45(3): 423-426.

Webb, R.H., S.S. Smith, and V.A.S. McCord. 1991. Historic channel change of Kanab Creek, southern Utah and northern Arizona. Grand Canyon Natural History Association, Monograph No. 9.

Weng, C. and S.T. Jackson. 1999. Late Glacial and Holocene vegetation history and paleoclimate of the Kaibab Plateau, Arizona. Paleogeography, Paleoclimatology, Paleoecology 153: 179-201.

White, M.A. and J. L. Vankat. 1993. Middle and high elevation coniferous forest communities of the North Rim region of Grand Canyon National Park, Arizona. Vegatatio 109: 161-174.

Wilson, A.K. 1941. History of the Arizona strip to 1913. MA thesis, Arizona State Teachers College, Flagstaff, AZ.

Wilson, J.L. and B.M. Tkacz. 1993. Status of insects and diseases in the southwest: implications for forest health. Pages 196-203 in Covington, W.W. and L.F. DeBano, technical coordinators. Sustainable ecological systems: implementing an ecological approach to land management. USDA Forest Service General Technical Report RM-247. Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO.

Wolf, J.J. and J.N. Mast. 1998. Fire history of mixed-conifer forests on the North Rim, Grand Canyon National Park, Arizona. Physical Geography 19(1): 1-14.

Woodbury, A.M. 1944. A history of southern Utah and its National Parks. Utah State Historical Quarterly 12: 111-209.

Young, C.C. 2002. In the absence of predators: conservation and controversy on the Kaibab Plateau. University of Nebraska Press, Lincoln, Nebraska.

Younghans, G. and K. Rodgers. 2003. A short history of Kane Ranch. Unpublished report on file at Grand Canyon Trust, Flagstaff, AZ.

Annotated Bibliography

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecological Monographs 11(3): 229-275.

Rasmussen's dissertation work, completed in the years 1929-1931 has been hailed as the original ecological description of the Kaibab Plateau, although the thesis of Pauline Mead was submitted to the University of Chicago in 1930. Rasmussen's work is of a broad scope. Included are inventories of birds, mammals, predators, plants, amphibians, reptiles, and invertebrates. There is a specific focus on the Kaibab deer irruption. While there is little potential for using his published work as a comparison for quantitative data, it at least provides a benchmark for the variety of flora and fauna that was present immediately following the climax of the Kaibab deer irruption. Included in the publication are appendices of species encountered in the three years of survey which can be useful for reference.

Garrett, L.D., J.R. Ellenwood, and M.H. Soulen. n.d. Changing forest ecosystems in the southwest: "The North Kaibab".

This unpublished report is included on Supplemental CD 1 and along with the section from Sesnie (2002) should be used as the definitive history of lumbering on the Kaibab Plateau. Because of the succinct and detailed nature of these two works I did not reinvent the wheel and write a chapter on logging on the Kaibab. This paper starts at the earliest inventories and works through the history of forest management on the Kaibab Plateau to support the thesis that there are many more trees on the plateau today than in past times. It also described issues related to wildlife and other forest management objectives.

Buckley, S. 2004. Mountain lying down: restoration, bioregionalism, and the indigenous Kaibab Plateau. Master of Liberal Studies Thesis, Northern Arizona University, Flagstaff, Arizona.

This thesis is a series of beautifully written creative essays examining bioregionalism and indigenous environmental history of the Kaibab Plateau within the context of contemporary ecological restoration. The essays examine the deep-time and cross-cultural bioregional history of the Kaibab Plateau since the end of the Pleistocene, and the examine bioregionalism and its indigenous ancestry as a potential political framework for the implementation of ecological restoration. In the style of Aldo Leopold or Craig Childs, Buckley spins together a story rich in data and personal experience.

Onstott, T.A. 1970. Man and the northern Kaibab Plateau. MA Thesis, New Mexico State University, Las Cruces, New Mexico.

This thesis examines the human history on the Kaibab Plateau; the effect of man on the environment and the effect of the environment on man. It is a chronological examination of archaic peoples, Paiute inhabitants, Mormon colonization, and federal management. The author suggests that the history of the Kaibab Plateau is an excellent example of the effect of topography on human development and use of an area.

Sesnie, S.E. 2001. Environmental histories: a foundation for adaptive forest management on the Kaibab Plateau in northern Arizona. MS Thesis, Northern Arizona University, Flagstaff, Arizona.

This thesis is an investigation of the management history of ponderosa pine forests on the Kiabab Plateau. It describes land use histories, historic documents, photos, insect surveys, wildlife and forest ecology research, inventory data, data conversion programs, and other pertinent records. The second part of the thesis is an applied collaborative effort to define old-growth forest conditions on the Kaibab. Finally, the author used a Forest Vegetation Simulator model to estimate current and future pine forest development stages. The model results were compared to actual data to determine the efficacy of model output in forest planning. This is the definitive source for a detailed account of timbering activities on the Kaibab and the evolution of management goals and techniques.

Young, C.C. 2002. In the absence of predators: conservation and controversy on the Kaibab Plateau. University of Nebraska Press, Lincoln, Nebraska.

Christian Young provides by far the most comprehensive account of the 1920's Kaibab deer irruption available. By reviewing a wealth of documents, ranging from letters between Forest officials to published studies, he offers an insightful look back at the evolving understanding of predators in natural and managed communities. Hundreds of studies, oftentimes contradicting each other, on the Kaibab Plateau by scientists and resource managers spanning the early 20th century bring to light the uncertainty and misunderstandings inherent in the evolving fields of ecology and wildlife management. This should be regarded as the ultimate source for any inquiries into the controversy of predator control and game management on the Kaibab.

Fule, P.Z., J.E. Crouse, T.A. Heinlein, M.M. Moore, W.W. Covington, G. Verkamp. 2003. Mixed-severity fire regime in a high-elevation forest of Grand Canyon, Arizona, USA. Landscape Ecology 18: 465-486.

A comprehensive fire scar and forest reconstruction study at four sites along an elevational gradient on the North Rim of GCNP.

Mitchell, J.E., and D.R. Freeman. 1993. Wildlife-livestock-fire interactions on the North Kaibab: a historical review. Gen. Tech. Rep. RM-222. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p.

Provides a critical review of the various accounts of the 1924 Kaibab deer herd irruption. This should be a primary source for any future inquiries into the management history of the Kaibab Deer herd

Altschul & Fairley. 1989. Man, models, and management: an overview of archaeology on the Arizona Strip and management of its cultural resources. Report prepared for USDA Forest Service and USDI Bureau of Land Management. Prepared by Statistical Research, Plateau Archaeology, and Dames & Moore, Inc.

By far the most comprehensive compilation of Arizona Strip prehistory ever. This should be referenced if any questions regarding land settlement patterns, prehistoric sites, or other archaeological topics arise. Also, if any Native American sites are located this could be a useful reference to determine what era of occupation the site belongs to.

Hereford, R. 2002. Valley-fill alluviation during the Little Ice Age (ca. A.D. 1400-1880), Paria River basin and southern Colorado Plateau, United States. Geological Society of America Bulletin 114(12): 1550-1563.

The most detailed review of arroyo cutting events on the Colorado Plateau. Provides explanation for historic patterns and ties them to weather cycles.

Appendices

Appendix 1
Mead (1930) plant list: see supplemental CD 1

Appendix 2
Spruce-fir forest understory data from Merkle (1954)
50 0.5m quadrats in GCNP between 8,700 and 9,200 feet

Species	Frequency	Cover %
Juniperus communis	22	2
Berberis repens	8	0
Poa fendleriana	32	1.3
Bromus ciliatus	16	0.3
Pedicularis centranthera	12	0.1
Carex species	12	0.1
Erigern formosissimus	10	0.1
Packera multilobata	8	0
Hieracium fendleri	8	0
Frageria virginiana	6	0
Goodyera oblongifolia	4	0
Antennaria parvifolia	4	0
Elymus elymoides	4	0
Arenaria fendleri	4	0
Silene scouleri	4	0
Erigeron ursinus	2	0
Antennaria marginata	2	0
Geranium richardsonii	2	0
Castilleja miniata	2	0
Agrostis scabra	2	0
Aster adscendens	2	0
Pseudocymopterus montanus	2	0
Pteridium aquilinum	2	0
Epilobium angustifolium	2	0
Polygonum douglasii	2	0

0% cover means that there was less than 0.1% of a 0.5m quadrat

Other species encountered but not in plots were
Pyrola virens
Pyrola picta
Chimaphila umbellata
Corallorhiza maculata
Orthilia secunda
Draba asprella
Pterospora andromedea
Aquilegia coerulea
Ranunculus flammula
Blepharoneuron tricholepis

Appendix 3

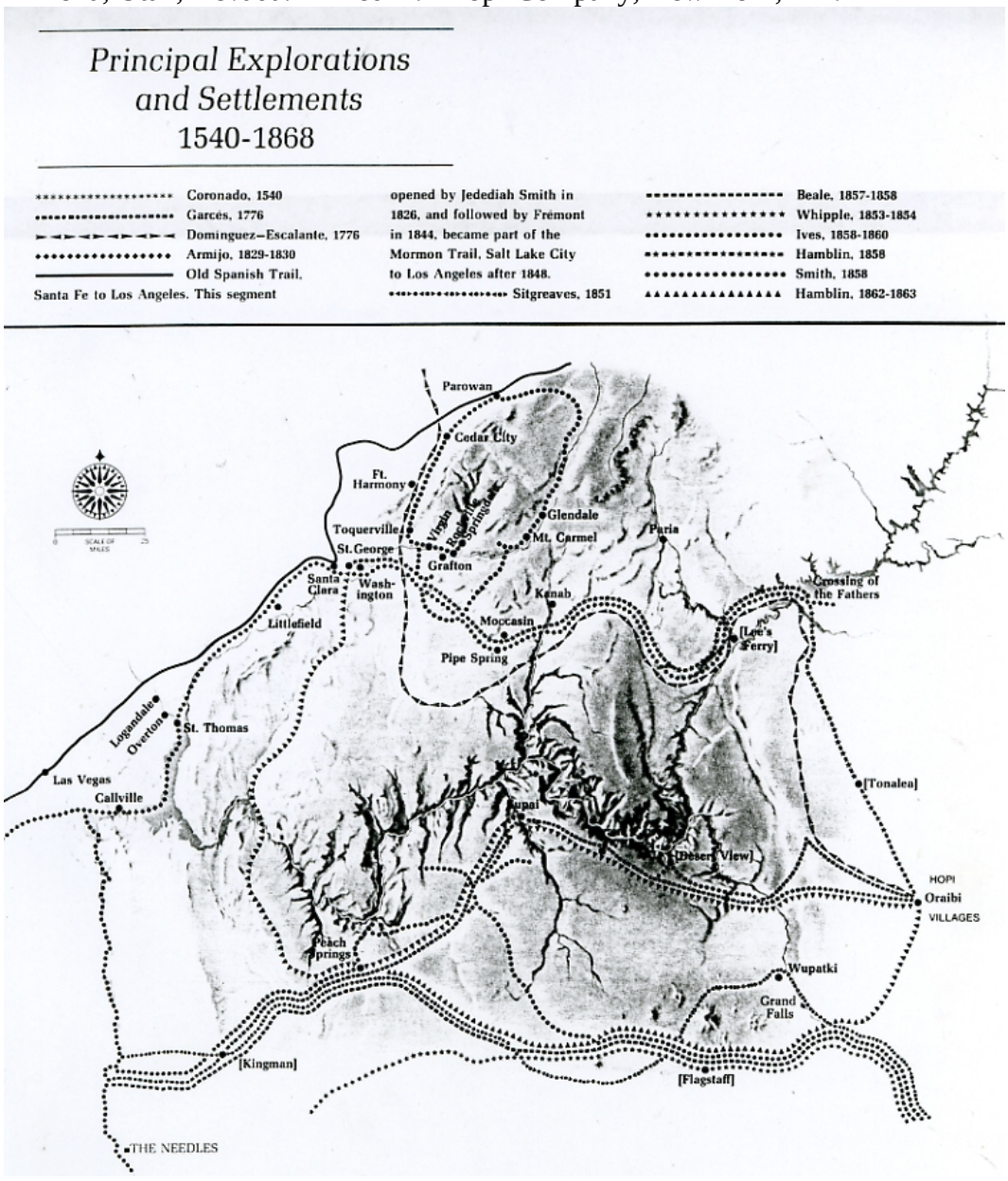
Spruce-fir overstory data from Merkle, 1954

Species	Freq. %	0-2 ft tall	2-10 ft tall	10-25 ft tall	25+ ft tall	Total stems	% of total	Basal Area	% of BA	Cover %
Populus tremuloides	*100*	621 (96)	30 (18)	2 (2)	102 (23)	755 (139)	43 (75)	41 (6)	17	9
Picea engelmannii	90	60	57 (2)	30 (4)	54 (6)	201 (12)	12 (6)	44 (4)	18	9
Abies lasiocarpa	80	162	199 (3)	63 (7)	90 (12)	415 (22)	23 (12)	40 (5)	17	13
Abies concolor	74	110	86	46	30 (8)	272 (8)	16 (4)	26 (3)	11	6
Psuedotsuga menziesii	64	9	8	11 (2)	39 (2)	67 (4)	3 (2)	50 (<1)	21	8
Pinus ponderosa	32	7	3	1	18 (1)	29 (1)	2 (0.5)	33 (<1)	14	3
Picea pungens	18	1	5	1	5 (1)	12 (1)	1 (0.5)	6 (<1)	3	1
TOTAL						**1751 (187)**		**240**		**49**

Appendix 4

Routes of early expeditions mentioned in this report, including Dominguez-Escalante, Hamblin, Armijo, and Garces.

From:
Crampton, C.G. 1972. Land of the living rock: The Grand Canyon and the high plateaus: Arizona, Utah, Nevada. Alfred A. Knopf Company, New York, NY.

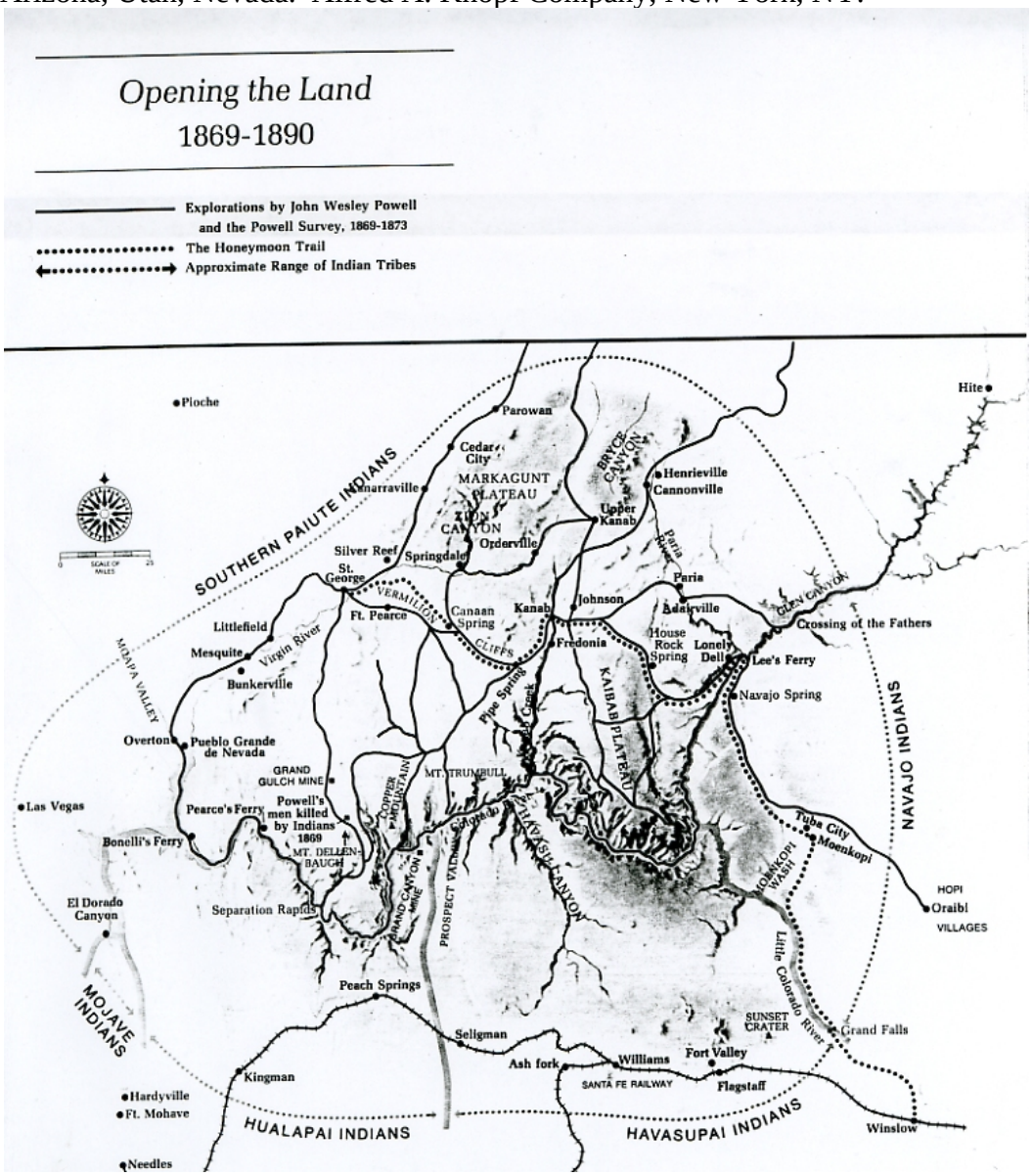


Appendix 5

The Honeymoon Trail and JW Powell's routes through the Grand Canyon region in the late 1800's.

From:

Crampton, C.G. 1972. Land of the living rock: The Grand Canyon and the high plateaus: Arizona, Utah, Nevada. Alfred A. Knopf Company, New York, NY.

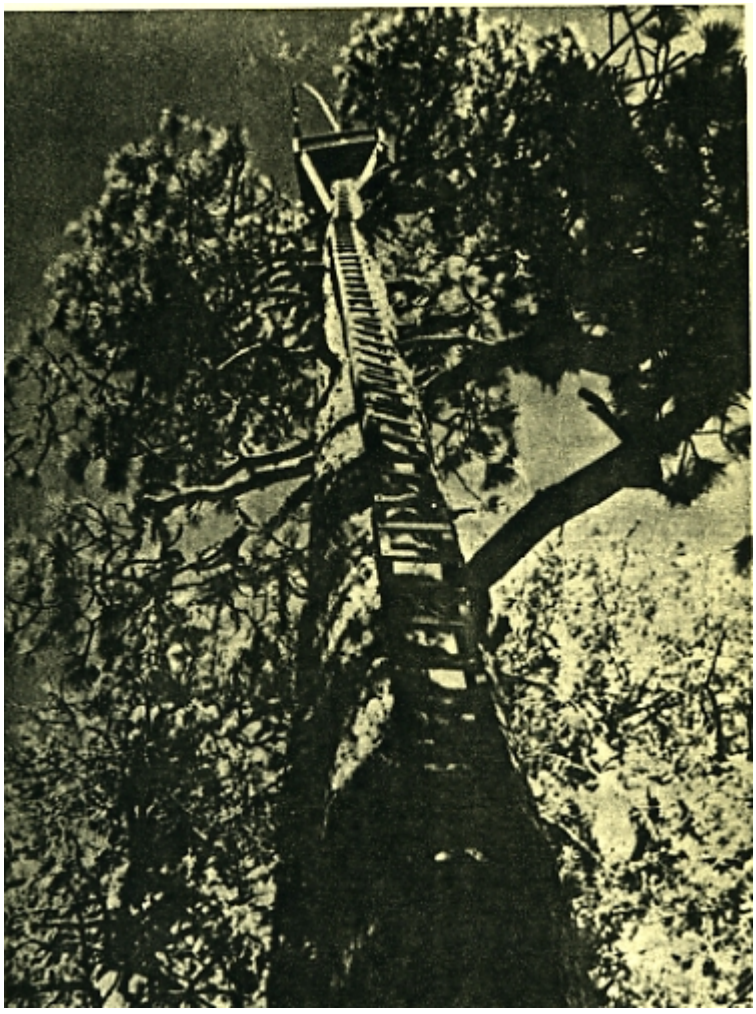


Appendix 6

A lookout tree on the Kaibab Plateau photographed by Charles Cunningham in 1937

From:

Cleeland, T.A. 1990. Lag bolts and ladders. Pages 74-80 in People and Places of the Old Kaibab. USDA Forest Service Cultural Resources Management Report No. 10. Southwestern Region.



Appendix 7

List of printed literature included in Supplemental Folder

Beymer, R.J. and J.M. Klopaptek. 1992. Effects of grazing on cryptogamic crusts in pinyon-juniper woodlands in Grand Canyon National Park. American Midland Naturalist 127: 139-148.

Cole, K. 1985. Past rates of change, species richness, and a model of vegetative inertia in the Grand Canyon, Arizona. The American Naturalist 125(2): 289-302.

Cole, K.L., N. Henderson, and D.S. Shafer. 1997. Holocene vegetation and historic grazing impacts at Capitol Reef National Park reconstructed using packrat middens. Great Basin Naturalist 57(4): 315-326.

Covington, W.W. and Moore, M.M. 1994. Southwestern ponderosa forest structure: changes since Euro-American settlement. Journal of Forestry 92(1): 39-47.

Fule, P.Z., J.E. Crouse, A.E. Cocke, M.M. Moore, and W.W. Covington. 2004. Changes in canopy fuels and potential fire behavior 1880-2040: Grand Canyon, Arizona. Ecological Modelling 175: 231-248.

Fule, P.Z., J.E. Crouse, M. Daniels, J. Springer, T.A. Heinlein, M.M. Moore, W.W. Covington, and G. Verkamp. 2002. Mixed-severity fire regime in a high-elevation forest: Grand Canyon, Arizona. Final Report to the Joint Fire Science Program, CA-1200-00-009-NAU 04 (Part 1).

Fule, P.Z., T.A. Heinlein, W.W. Covington, and M.M. Moore. 2000. Continuing fire regimes in remote forests of Grand Canyon National Park. In: Cole, D.N. and S.F. McCool (eds) Proceedings: Wilderness Science in a Time of Change. Proc. RMRS-P-15. USA Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA, pp. 242-248.

Fule, P.Z., T.A. Heinlein, W.W. Covington, and M.M. Moore. 2003. Assessing fire regimes on Grand Canyon landscapes with fire-scar and fire-record data. International Journal of Wildland Fire 12: 129-145.

Galatowitsch, S.M. 1990. Using the original land survey notes to reconstruct presettlement landscapes in the American west. Great Basin Naturalist 50(2): 181-191.

Hereford, R. 1986. Modren alluvial history of the Paria River drainage basin, southern Utah. Quaternary Research 25: 293-311.

Jamesen, D.A., J.A. Williams, and E.W. Wilton. 1962. Vegetation and soils of Fishtail Mesa, Arizona. Ecology 43(3): 403-410.

Johansen, J.R., St.Clair, L.L., Webb, B.L., and Nebeker, G.T. 1984. Recovery patterns of cryptogamic soil crusts in desert rangelands following fire disturbance. The Bryologist 87(3): 238-243.

Knack, M.C. 1993. Interethnic competition at Kaibab during the early twentieth century. Ethnohistory 40(2): 212-245.

Larsen, W. 2000. Arizona Strip Stories: In their own words. Manuscript donated courtesy of Dixie State College Special Collections and Archives.

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

Mason, L.R., H.M. Andrews, J.A. Carley, and E.D. Haacke. 1967. Vegetation and soils of No Man's Land Mesa relict area, Utah. Journal of Range Management 20: 45-49.

Mead, J.I., S.E. Sharpe, and L.D. Agenbroad. 1991. Holocene bison from Arches National Park. Great Basin Naturalist 51(4): 336-342.

Menninghaus, F.F., and D.B. Jensen. 1967. Central Summer, Central Winter and Sowats Allotment Management Plan. Unpublished report dated October 16, 1967 on file at Kaibab National Forest, North Kaibab Ranger District, Fredonia, Arizona.

Turkowski, F.L., and H.G. Reynolds. 1970. Response of some rodent populations to pinyon-juniper reduction on the Kaibab Plateau, Arizona. The Southwestern Naturalist 15(1): 23-27.

Rowlands, P.G. and N.J. Brian. 2001. Fishtail Mesa: A vegetation resurvey of a relict area in Grand Canyon National Park, Arizona. Western North American Naturalist 61(2): 159-181.

Schmutz, E.M, C.C. Michaels, and B.I. Judd. 1967. Boysag Point: A relict area on the North Rim of Grand Canyon in Arizona. Journal of Range Management 20: 363-369.

Pages 22-30 (history of timbering on the Kaibab Plateau) in:
Sesnie, S.E. 2001. Environmental histories: a foundation for adaptive forest management on the Kaibab Plateau in northern Arizona. MS Thesis, Northern Arizona University, Flagstaff, AZ.

Spear, S., S. Martinet, G. Oakleaf, and D. Lund. 1997. North Kaibab district recreation strategy. Report prepared for J. Leonard, District Ranger, North Kaibab Ranger District, Kaibab National Forest, Fredonia, Arizona.

Stoffle, R.W. and M.J. Evans. 1976. Resource competition and population change: a Kaibab Paiute ethnohistorical case. Ethnohistory 23(2): 173-197.

Swetnam, T.W. and J.L. Betancourt. 1998. Mesoscale disturbance and ecological response to decadal climatic variability in the American southwest. Journal of Climate 11: 3128-3147.

Thatcher, A.P. and V.L. Hart. 1974. Spy Mesa yields better understanding of pinyon-juniper in range ecosystem. Journal of Range Management 27(5): 354-357.

USDA Forest Service. 1998. Kaibab National Forest, North Kaibab Ranger District History. Informational paper describing the history of the North Kaibab Ranger District, available at Kaibab National Forest, North Kaibab Ranger District, Fredonia, Arizona.

Van Devender, T.R., and J.I. Mead. 1976. Late Pleistocene and modern plant communities of Shinumo Creek and Peach Springs Wash, Lower Grand Canyon, Arizona. Journal of the Arizona Academy of Science 1:16-22.

Wagner, M.R. and R.L. Mathiasen. 1985. Dwarf mistletoe-pandora moth interaction and its contribution to ponderosa pine mortality in Arizona. Great Basin Naturalist 45(3): 423-426.

Appendix 8

Literature on supplemental CD 1

Appendix 1: Mead (1930) plant list
Anderson et al., 1982: Recovery of cryptobiotic soils from grazing on Utah winter ranges
Barlow & McCulloch, 1984: Mortality in the Kaibab deer herd
Beier & Drennen, 1997: Forest structure and prey abundance in goshawk foraging areas
Bureau of Land Management i: Paria Plateau actual grazing use 1986-2003
Callison et al., 1985: Effects of fire on blackbrush
Craighead, 1924: The black hills beetle practicing forestry on the Kaibab
Freeman, 1983: The north Kaibab revisited
Fule et al., 2002: Variability in forests of the Grand Canyon region
Fule et al., 2003: Assessing fire regimes on the North Rim with fire scar data
Fule et al., 2004: Changes in North Rim canopy fuels
Garrett et al., 1993: Changing forest ecosystems of the southwest, The North Kaibab
Graves, 1913 : Kaibab Plateau Timber reconnaisance
Hayfen, 1947: Armijo's journal
Heinlein et al., 2000 : Development of ecological restoration experiments at GCNP
Hereford, 2002: Paria River alleviation, 1400-1800
Huisinga et al., 2005: Effects of an intense prescribed fire on ground flora
Jeffries & Klopatek, 1987: Effects of grazing on vegetation of the blackbrush association
Kelsey, 1987: History of the sand hills area
Kleiner & Harper, 1977: Soil properties of cryptogamic soils in Canyonlands Park
Landres et al., 1999: Overview of the use of natural variability concepts
Lang & Stewart, 1910: Kaibab forest recon
Madanay & West, 1984: Vegetation of two relict areas in Zion Park
Mason & West, 1970: Timber Top Mesa, a Zion relict area
Mason et al., 1967: Vegetation and soils of No Man's Mesa relict area
McCulloch, 1986: A history of predator control and deer productivity in northern Arizona
Mead, 1930: Kaibab Plateau ecological assessment
Merkle, 1953: Ecological analysis of Kaibab meadows
Miller & Wigand, 1994: Holocene changes in pinyon juniper
Miller, 1924: Black hills beetle on the Kaibab forest
Mitchell & Freeman, 1993: Wildlife-fire-livestock interactions on the Kaibab
Patton et al., 1994: Effects of timber harvesting on the Kaibab squirrel
Provenza et al., 1983: Manipulation of blackbrush by goat browsing
Rasmussen, 1941: Biotic communities of Kaibab Plateau, Arizona
Seegmiller, 1999: Existing resource conditions for Soap Creek and Badger Creek AMP's
Steele, 1926: In Roosevelt's cougar trail
Steffensen, 1997: Central Winter current conditions and vegetation trends
USDA Forest Service, 1980: Central summer EA
USDA Forest Service, 1997: Central winter current condition
USDA Forest Service, 2004: Annual operating instructions for central summer, winter and Kane
USDA Forest Service, 2004: Burro allotment annual operating plan
USDI BLM, 2004: Buckskin landscape assessment
USDI BLM, 1997: Badger creek allotment summaries
Vale, 1975: Presettlement vegetation of the intermountain west
Weng & Jackson, 1999: Holocene vegetation of the Kaibab
White & Vankat, 1993: Vegetation communities of North Rim middle and high elevation forests
Yorks et al., 1994: Changes in PJ in Utah's Pine Valley from 1933-1990