APPENDIX D:

STOCK USE AND MEADOW MONITORING AND MANAGEMENT STRATEGY

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FIGURES

TABLES

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STOCK USE AND MEADOW MONITORING AND MANAGEMENT STRATEGY

This appendix describes the strategy for monitoring and managing stock use that would be implemented by the NPS under the preferred alternative as described by this Wilderness Stewardship Plan and Final Environmental Impact Statement (WSP/FEIS). The introductory sections describe the objectives for managing stock use in the wilderness of the parks, provide an overview of the parks' meadow resources, and review the history of stock use, associated impacts, and its management in the parks. This is followed by sections that describe the adaptive management program, including approaches for monitoring and managing stock use in such a way as to minimize and mitigate impacts while providing continued access to wilderness for visitors travelling with stock.

INTRODUCTION

Pack and saddle stock have been used in the southern Sierra Nevada since the mid-nineteenth century, first for exploration and then in conjunction with sheep and cattle grazing and mining. In the late nineteenth century, and progressively into the twentieth century, stock were used for access to the mountains of the region for recreational purposes. The numbers of stock used for recreational trips increased and peaked in the 1930s, dropped in the 1940s, increased again in the 1950s, and have since declined. Pack stock have been used to support the development and administration of the remotest areas of the two parks—e.g., for trail building and maintenance and ranger patrols—since their establishment. The use of stock for administrative and recreational purposes is still recognized as a traditional, historically and culturally significant, and legitimate activity that will continue in the wilderness of Sequoia and Kings Canyon National Parks (NPS GMP 2007).

The Act that created the National Park Service states that its "purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for future generations" NPS Organic Act (16 USC 1). National Park Service policy and the legislation that created these parks require that ecosystems in wilderness be protected and preserved while allowing for their use and enjoyment. NPS *Management Policies 2006*, Section 8.2.2.8 states that:

> "Equine species such as horses, mules, donkeys and burros, and other types of animals (including llamas, alpacas, goats, oxen, dogs and reindeer) may be employed when it is an appropriate use to support backcountry transport of people and materials and will not result in unacceptable impacts. Planning for recreational stock use should be conducted in the context of visitor use planning to address social, biological, and physical carrying capacity considerations, and to make allocation decisions that minimize potential conflicts between and among user groups. The plan should (1) establish routes, trails, and areas of travel; and (2) identify the need for supporting infrastructure such as designated horse camps, hitch rails, corrals, and appropriate trailhead facilities designed for vehicles towing horse trailers. The plan should also identify sensitive natural and cultural resource areas and develop management strategies to protect these resources."

Grazing that is incidental to the recreational use of stock is regulated by the horse and pack stock regulations (36 CFR 2.16). Where grazing is permitted, NPS policy directs the use of best management practices, with particular attention being given to protecting wetland and riparian areas, sensitive species and their habitats. Grazing is managed so that ecosystem dynamics and the composition, condition, and distribution of native plants and animal communities are not significantly altered (NPS *Management Policies 2006*, Section 8.6.8.2).

Many kinds of disturbance occur naturally in meadow ecosystems; this strategy addresses those associated with human activities and stock use. Some disruption of natural ecosystems and processes by stock is expected and considered acceptable as the consequence of a form of primitive wilderness use that is appropriate in Sequoia and Kings Canyon National Parks. The monitoring and assessment protocols proposed in this strategy are designed to provide insight into the integrity of meadow ecosystems, to provide early warnings of stock related changes, and to inform a management program that anticipates potential impacts. The proposed management standards and thresholds are set at levels that will ensure the protection of wilderness character by triggering timely and effective corrective action.

The environmental impacts associated with stock use are discussed in detail under the impacts topics addressed in chapters 3 and 4 of this WSP/FEIS.

OBJECTIVES OF THE STOCK USE AND MEADOW MONITORING AND MANAGEMENT STRATEGY

A goal of wilderness management in Sequoia and Kings Canyon National Parks is to provide for recreational and administrative saddle and pack stock use in a manner that will protect the parks' natural and cultural resources and values, the processes that shape them, and the quality of visitor experience distinctive to them.

Chapter 1 of this WSP/FEIS further articulates the desired conditions which guide protection of the natural quality of wilderness as follows:

- The natural quality of wilderness would be preserved by mitigating the impacts of modern civilization on ecosystem structure, function, and processes.
  - The NPS aspires to minimize or localize adverse impacts caused by visitor use and administrative activities. In the wilderness, natural processes would dominate:
    - ecosystem structure and function
    - native biodiversity
    - water quality and quantity
    - decomposition, nutrient cycling and soil forming processes
    - meadow and wetland productivity
    - fire regimes
    - soundscapes, dark skies and viewsheds

Some or all of these desired conditions may not be fully attainable due to factors (such as climate change and air pollution) that are unrelated to visitor use or park administrative activities. The ability of the parks to achieve desired conditions that are either tangentially or unrelated to visitor use and administrative activities is being systematically evaluated through a "climate-smart" lens in the parks Resources Stewardship Strategy (RSS).

The following objectives for stock use and meadow monitoring and management provide a more specific interpretation of how the NPS will meet these goals:

- Limit stock induced changes to plant composition, density, cover, productivity and/or vigor

- Prevent adverse effects to soils and associated sod that may lead to accelerated erosion, prevent changes to springs, seeps and water courses that could alter hydrologic processes
- Promote recovery from past overuse where necessary.
- Minimize the effects of stock on trails and camps
- Minimize the effects of stock on hydrology and water quality
- Ensure that a series of meadows (or definable parts of meadows), including representatives of all major types within these parks, be preserved in an ungrazed condition so that they are perpetuated as—or allowed to become—natural functioning ecosystems to the greatest extent possible. Ungrazed meadows will provide an opportunity for visitors to experience naturally functioning meadows, and will facilitate study of the relative effects of climate, plant succession, and grazing.
- Design and implement a monitoring strategy to provide information about the effects of stock on the resources of the parks that enables adaptive management given uncertain future conditions and ensures that objectives are met.

BACKGROUND INFORMATION

DESCRIPTION OF THE MEADOW RESOURCE

Meadows and uplands, including woodland meadows, forest grasslands, and alpine vegetation, are among the most attractive and important natural resources within Sequoia and Kings Canyon National Parks. Meadows are the principal destinations of many wilderness travelers. Meadows and their environs are important to those visitors who ride and/or pack into the backcountry, both for camping nearby and traditionally as places to graze their stock.

Meadows and associated uplands serve as important sources of food, birthing sites, nesting areas, and hunting grounds for many species of wildlife. Meadow areas also provide an opportunity for scientific research and observation. Natural (or near natural) vegetation may serve as a baseline to which the professional resource manager can refer to evaluate the effects of use on areas used by stock. The value of such baseline conditions contributed to earning these parks International Biosphere Reserve status in 1976 (NPS 2012).

Meadows are complex ecosystems, varying widely in character and composition (Benedict and Major 1982, Ratliff 1982). The plant associations and physical conditions of a meadow determine its tolerance to the effects of grazing and trampling. Because meadow vegetation exhibits a high degree of spatial and temporal heterogeneity, only a very broad, relatively insensitive, classification system can be employed at the meadow level. Since it is often of limited value to generalize about the vegetation of meadows as a whole, it is important to understand the characteristics and tolerances of the plant associations that combine to form meadows. Traditionally, meadow classifications have been based primarily on vegetation and soil characteristics (Klikoff 1965, Benedict and Major 1982, Ratliff 1982, Ratliff 1985). Recognizing the importance of the environmental factors underlying and shaping these assemblages, Weixelman et al. (2011) have developed a classification system for Sierra Nevada meadows that incorporates both hydrology and geomorphology. This classification, which represents a more functional approach to the characterization of these complex systems, has been widely adopted by ecologists and public land managers in the Sierra Nevada.

Stock use is not confined to open meadow environments. Forests and woodlands include extensive areas of species palatable to stock including grasses, sedges, rushes, and other herbaceous plants found within aspen or conifer stands along streams, in seeps, or as an extension of the forest meadow transition. Upland forbs and grasses may provide abundant and nutritious forage, especially when bunch grasses are present (Sumner 1941). Horses and mules spend a considerable amount of time in forested areas where they are protected from wind and mosquitoes and are able to keep their hoofs dry. Alpine vegetation may also provide forage for stock, but in general these areas are lightly used by stock parties (Frenzel and Haultain 2013), in part due to the limited availability of forage and cover for animals and the challenges faced in constraining stock in treeless terrain, and in part due to restrictions on campfires, which are preferred by many recreational stock users.

Ecologists have begun to investigate the importance of peat-accumulating wetlands (fens) in the Sierra Nevada over the past decade. Fens are peat-forming wetlands, supported by nearly constant groundwater inflow (Bedford and Godwin 2003). This state of permanent saturation leads to the development of oxygen-deprived soils characterized by very low rates of decomposition, allowing for the accumulation of organic matter produced by wetland plants. Fens develop and are maintained only under hydrologic conditions that create perennial soil saturation on the time scale of millennia (Wood 1975, Sikes et al. 2013). As is true for most of the Sierra Nevada, most fens in Sequoia and Kings Canyon National Parks occur in meadow complexes consisting of areas of wet meadow (usually saturated for 1-2 months; Benedict 1983) intermixed with peat accumulating areas that stay saturated for most or all of the year.

Concern over the conservation of these relatively rare and distinctive wetlands has grown, as it is thought that activities leading to the disturbance of the hydrologic regime or soil temperature of a fen, causing drying or warming, may threaten its functioning (Sikes et al. 2013). Alternatively, fens may be more resistant to change than wet meadows due to more stable hydrologic regimes associated with springs and other hydrogeomorphic features (Gage et al. 2014). Because peatlands are thought to play an important role in global carbon storage, research interest in fen dynamics has grown significantly in recent years. Despite this attention, the knowledge of fens does not yet allow for accurate predictions of what the impact of climate change will be on these systems (Rydin and Jeglum 2013).

HISTORY OF STOCK USE AND ASSOCIATED IMPACTS

Sheep and cattlemen of the gold rush era found the meadows and plateaus of the High Sierra unaffected by early Spanish immigrants (Strong 1964). Large numbers of domestic sheep and cattle were first herded into the southern Sierra Nevada during the great drought years of 1862-1864 (Burcham 1957).The next forty years can be characterized as a period of heavy, unregulated use. Tens (and perhaps hundreds) of thousands of sheep were driven into the High Sierra annually. Use was locally heavy (Muir 1877; Reports of the Acting Superintendent of Sequoia and General Grant National Parks, 1892, 1894; Dudley 1896, 1898, 1899; King 1902), and it is assumed that virtually all of the areas now included within the parks that were accessible to sheep were grazed. Cattle were also common in the area but were generally confined to the more easily accessible plateaus and drainages.

Sequoia National Park and Kings Canyon National Park were established in stages spanning the years 1890-1940 (Strong, 1968), and thus different areas have different grazing histories. Sequoia National Park was established in 1890 but was not expanded to include the Kern Canyon and Sierra Crest regions until 1926. Kings Canyon National Park was established in 1940. Prior to this time, that area was administered by the U. S. Forest Service. With establishment of Sequoia and Kings Canyon National Parks, grazing by sheep and cattle was virtually eliminated. Exceptions included a considerable amount of trespass grazing from 1890 to 1905, special wartime grazing permits during and immediately following World War I, and lifetime grazing permits extended as a condition of establishing Kings Canyon National Park. Although the Forest Service regulated grazing by permit on its lands after 1905, grazing pressure was heavy with maximum herd sizes on allotments peaking in the 1920s and 1930s (Harper, 1974). Thus, many meadows in Kings Canyon National Park were degraded at the time of its establishment (Sumner 1941). Detailed accounts of the use of the Sierra Nevada by domestic 1ivestock during pre-park and early park periods are presented by Burcham (1957), Otter (1963), Loughman (1967), Vankat (1970), Harper (1974), Holmes and Dobson (1976), DeBenedetti (1977), Vankat and Major (1978), and DeBenedetti and Parsons (1979), and summarized by Neuman (1990).

Recreational use of pack and saddle stock on land now included within these parks predates their establishment. Large stock-assisted Sierra Club outings began visiting this area in the early 1900s. Loughman (1967) reported that the use of stock for recreational purposes increased steadily after World War I and peaked in the 1930s. Following a decline in the 1940s, use again increased in the early 1950s, only to decline again through the early 1960s (Briggle et al. 1961). Use levels ranged between 8,800 and 11,500 stock nights during the seven years from 1977-84 (National Park Service Annual Stock Use Reports 1977-84). This level of use as measured by the number of stock nights spent in the wilderness was about one-third of the level of the early 1950s and may have been as little as one-sixth of the peak levels of the 1930s. Use levels have continued to decline since the 1980s, with an average of 7,594 annual stock nights reported for the period 1993-2002, followed by an average of 6,775 annual stock nights reported for the years 2003 to 2012 (ranging from a low of 5,434 nights in 2012 to a high of 8,218 nights in 2003) (Hopkinson et al. 2013).

Wilderness meadows in Sequoia and Kings Canyon National Parks have been the object of much study, with early work being mostly qualitative in nature. Beginning with Sumner (1941), these reports were the result of observations that many meadows seemed to be in a deteriorated condition; the cause of this deterioration was believed to be overgrazing by pack stock, cattle, and/or sheep. There has been much controversy over both the definition and the magnitude of the effects of historic grazing. The Sumner series of observations (1940, 47, 48, 68), in conjunction with Sharsmith (1959), suggested that many meadows in the 1930s and 1940s were undamaged even with heavy use. Other areas, at the same time, were assessed as seriously deteriorated. None of the authors, however, proposed that areas they examined were unaltered compared to what would have been their condition without grazing by livestock. For example, Ratcliff (1956) noted during a survey of the Rock Creek areas that the Rock Creek, Crabtree, and Wright Creek areas were in good condition considering the past and then current levels of use. Near Timberline Lake, however, he reported damage due to trampling. He noted that his report should not be extrapolated to represent conditions in Kings Canyon. Sharsmith (1959) also found Crabtree meadows in good shape. Damage reported by Sumner, Sharsmith, and Ratcliff was, in general, proportional to use the area received. Strand (1972) observed that, "many strategically located meadows along popular trails had been severely damaged by pack stock, and their recovery from earlier abuse either prohibited or delayed."

The need to objectively define what constituted "damage" resulted in a shift from qualitative to quantitative assessment (e.g., Bennett 1965 and Strand 1972). Bennett selected ten meadows and determined their condition, trend, and causes of such trends, and made recommendations for their future management. Strand revisited Bennett's transects in search of detectable trends in condition. Strand found some meadows in slightly deteriorating or slightly improving condition; others showed no trend. In general "those meadows which received the greatest amount of grazing were also those determined to be in a state of deterioration or which showed the least amount of recovery from a previously deteriorated state. This was determined by changes in the relative densities of forage species, low value species, and "invasion species" (Strand 1972). Mazzu (1987) reread transects in four of the original meadows sampled by Bennett and Strand, and found that the meadows closed to grazing showed increased species diversity relative to those that had continued to be grazed.

Grazing had been restricted on the meadows assessed by Strand and Bennett after the earlier Sharsmith and Sumner reports. The 1960 Backcountry Management Plan (Briggle et al. 1961) was the first attempt to formally implement the recommendations of Sharsmith and Sumner:

> Ecological studies in these Parks clearly indicate that overgrazing, not drought cycles and floods, has been the primary cause of meadow deterioration despite the beliefs of a few stockmen to the contrary (Briggle et al. 1961).

Both the 1960 and the 1986 plans agreed that the history of scientific study indicated that (1) prior to the use of restrictions, locally significant damage (i.e., deteriorating vegetation and soils) existed in the parks; (2) the result of restrictions had been a general slowdown in deterioration and, in many areas, improvement; (3) there is finite level of use beyond which unacceptable impacts result, and past use patterns give some idea of what this level may be.

Widespread turn of the century grazing by sheep and cattle in the Sierra Nevada destabilized meadow wetlands by weakening sods, which allowed erosion channels to form, resulting in lower water tables and loss of meadow sediments. From the 1930s to 1980, managers in Sequoia and Kings Canyon National Parks attempted to conserve soil and restore moisture in meadows by constructing check dams and fences, logging invading trees, rerouting trails, and altering grazing management. These efforts are documented in the parks' file reports describing the activities of the dedicated Soil and Moisture Crews and were summarized for named meadows by Neuman (1990).

Popular and strategically located meadows and forage areas, many of which were reported to be in deteriorated condition during surveys conducted as late as 1959 (Sumner, 1941; Sharsmith, 1959) have been the continued focus of monitoring and management. Modern recreational and administrative stock use remains more localized than historic use, with use concentrated along the primary trail corridors, on the Hockett Plateau, in the Roaring River area, and in the Kern Canyon. Of the total meadow area in the parks, approximately half is currently open to grazing. During the period following implementation of the 1986 Stock Use and Meadow Management Plan (SUMMP), some level of use has been documented in approximately half of the meadows open to stock, or a quarter of the total meadow area of the parks (Frenzel and Haultain 2013).

Stock grazing has declined in volume since the 1960s, with a trend towards more concentrated use in the past two decades (Hopkinson et al. 2013). In an analysis of use levels between 1985 and 2009, Hopkinson et al. found that grazing levels were relatively light in the majority of meadows, with almost half of the grazed meadows having less than one animal unit night (AUN)/acre per year reported. The number of meadows with at least one season of grazing over 90 AUN/acre decreased from 17 meadows between the years 1985-1997 to only 7 meadows in the period 1998-2009. Stock use on individual meadows was highly variable, with some meadows having significant use in one year and none in the next. Detailed discussions of recent use patterns can be found in the meadow sections of the Natural Resource Condition Assessment (Hopkinson et al. 2013), and in the annual summaries of stock use and grazing (e.g., Frenzel and Haultain 2013; 2014).

The Natural Resource Condition Assessment (NPS 2013a) also assessed the condition of grazed meadows in the two parks through analysis of several decades of monitoring data. In an analysis of monitoring data collected from 25 grazed meadows between 2001 and 2009, Hopkinson et al. (2013) found a trend of increasing residual biomass, or the amount of vegetation left on a meadow at the end of the growing season, while that from comparable ungrazed meadows showed no statistically significant trend. It is likely that this reflects improved meadow condition due to an increased emphasis on residual biomass to inform stock management, with use levels managed to maintain acceptable levels of residual biomass in grazed meadows.

To evaluate stock grazing effects on plant species composition, data have been collected on a set of five paired grazed-ungrazed meadows over the past twenty-five years. Supporting earlier analyses of these data by McClaran and Neuman (1989) and Abbott et al. (2003), Hopkinson et al. (2013) found very little evidence for grazing-related compositional differences in the five paired meadows. They also reported that percent cover of bare ground was never statistically significantly different for any of the five meadow pairs' grazed and ungrazed meadows, and that temporal trends in bare ground were generally in tandem for paired grazed and ungrazed meadows. Based on these results, the authors found no strong evidence that current management of stock use has resulted in vegetation change in the five meadow pairs sampled. They were careful to note, however, that based on a five year grazing experiment in mountain meadows in Yosemite National Park, Cole et al. (2004) concluded that when grazing impact is light, species composition change is a less sensitive indicator of meadow condition than changes in productivity and ground cover; thus, the lack of strong differences in species composition between grazed and ungrazed meadow pairs may not definitively demonstrate that stock grazing has had no effect on the meadows.

The past decade has seen a marked increase in research interest in the meadow and wetland systems of the Sierra Nevada. In addition to studies of meadow hydrology, productivity, and biodiversity, there have been a number of investigations into the environmental effects of stock use and grazing. Ostoja et al. (2014) reviewed existing literature to provide a summary of potential effects of pack stock on broad response categories relevant to Sierra Nevada meadows, including water quality, soils, plants, and wildlife. Specific relevant results on these topics have been integrated into chapter 3 of the WSP/FEIS.

A number of recent mapping efforts have addressed the value of spatially explicit information on the distribution of meadows in the two parks, both in support of grazing management and to establish a broader ecological knowledge base. Early maps of the meadows used by stock were based on black and white aerial photographs and delineated on 15 minute topographic maps (Neuman 1990). National Wetland Inventory maps based on remotely sensed imagery were created for the parks in 1996 (USFWS 1996); these included many of the wet meadow types, but by definition did not delineate upland types. In 2007 the first comprehensive association-level map of the vegetation of the two parks was completed (NPS 2007b). Based on 1:15840 color infrared photography and traditional photo-interpretation methods, this map incorporated the information captured by the earlier wetland and meadow mapping efforts. In 2013, park ecologists completed the first map distinguishing peat accumulating wetlands and wet meadow complexes within the parks' meadows (Pyrooz et al. 2014 in review), providing a level of detail that had not been discernible from the parks' 2007 vegetation map and insights into the distribution of peat accumulation across the landscape.

In addition to these mapping efforts, the hydrogeomorphic classification system developed by Weixelman et al. (2011) has recently been applied to a majority of the parks' meadows used by stock. Taken together, these studies and mapping efforts have made significant contributions to the understanding of the distribution, use and condition of park meadows.

PACK AND SADDLE STOCK MANAGEMENT HISTORY

Prior to the implementation of the 1986 SUMMP, grazing management in these Parks was not systematic. Heavily grazed meadows were identified sporadically and specific restrictions established to lessen effects. Due to evidence of grazing effects, a framework for a systematic approach to meadow management was proposed in the early 1940s (Sumner 1941; Armstrong 1942). Flexible opening dates for specific forage areas based upon site conditions, limits on herbage removal, and long-term trend monitoring were to be the foundation of the system. All meadows then would receive protection based upon ecological factors and site-specific characteristics. Although the Armstrong-Sumner system was not implemented at the time, in many ways this approach was similar to that described and implemented by the 1986 SUMMP.

Concern about the condition of many wilderness meadows led to NPS support of an inventory of meadow conditions in 1959 (Sharsmith 1959). Sharsmith visited many Kings Canyon meadows previously surveyed by Sumner (1941) as well as meadows in Sequoia National Park. He qualitatively described trends in specific meadows through comparative photography and narratives. He concluded that many popular and strategically located meadows were in worse condition than at the time of Sumner's survey and were continuing to deteriorate. As a result of these studies, several meadows were added to the 1ists of those meadows closed to all grazing or subject to restricted grazing (NPS 1937, 1949, 1960-1964; Briggle et al. 1961). Use limits were established, including: head limits for specific forage areas (NPS 1949); closure of certain meadows to grazing and opening dates for meadows (NPS 1960-1964; Briggle et al. 1961); and a limit of 20 head per stock party in 1966. At the same time, the NPS expanded management tools to include opening dates for meadows. A program to reroute trails out of meadows was initiated; lodgepole pine and other woody species thought to have encroached into meadows as a result of historic grazing were removed in several places. No cohesive set of criteria defining acceptable or allowable impact accompanied these actions, however.

In 1985, an effort to compile available information on the meadows and forage areas in the two parks was initiated (McClaran and Neuman 1989). Park ecologists expanded this work and in 1990 *Past and Present Conditions of Backcountry Meadows in Sequoia and Kings Canyon National Parks, 2nd Edition* (Neuman 1990) was completed. Building on an early inventory and classification of the parks' meadows developed by DeBenedetti (1984), the resulting narrative recognized 333 forage areas and brought together site-specific information on vegetation associations, use levels, management history and regulatory status, and condition from a wide variety of sources. The report also included maps of the meadows and forage areas derived from black and white aerial photographs (1964, 1:16000). This work provided a detailed history of the meadows in the parks and established the context for implementation of the 1986 SUMMP. The full document is currently being converted to digital database format in order to link the information to spatial data layers, increase accessibility to site-specific management history, and to facilitate continued updates.

The 1986 SUMMP established the first formal system for the management of stock use in the parks. The plan identified which meadows would be open to grazing, and established a network of meadows to be permanently closed to grazing for the purposes of long-term protection and study. It identified areas open to off-trail travel, and specified tools for managing stock use, including night and party size limits and the use of opening dates for controlling the onset of grazing. The plan also established minimum impact restrictions and guidelines for the use of drift fences.

Recognizing that long-term information is necessary to document changes in conditions and to provide information on the effectiveness of the management program, the 1986 SUMMP also established a monitoring program. The objectives of this program were to track use levels, measure changes in plant species composition and bare ground over time, and using a system of photographic records, document coarse changes in meadow condition. In the late 1980s, a temporary range conservationist was hired by the wilderness management program to develop and implement the monitoring protocols. In 1995, a permanent plant ecologist position was created within the Division of Resource Management and Science to oversee the monitoring program. This marked the beginning of the collaborative monitoring and management program currently in place. This program relies heavily on wilderness ranger staff for much of the field data collection and on the ground management, with plant ecology staff overseeing protocol development, data collection, management and summarization. The wilderness coordinator and plant ecologist work together closely to facilitate the integration of monitoring results into adaptive management.

ADAPTIVE MANAGEMENT

Adaptive management is a structured, iterative process by which system monitoring is incorporated into management practices to achieve desired results. Adaptive ecosystem management requires continuing monitoring and investigations to advance the understanding of stressors impacting native species and wilderness resources so that managers remain informed about which stressors are most serious, which stressors are manageable, and the ways stressors, such as grazing, can be managed. Scientific research allows for expansion of management tools available today and provides information that can be incorporated into future management activities.

Adaptive management is a system of management practices based on clearly identified desired conditions and monitoring to determine whether management actions are achieving objectives and, if not, facilitating management changes that would best ensure that desired conditions are met or re-evaluated (Walters and Holling 1990; Williams et al. 2007). Adaptive management is a technique employed for charting a decision-making course to obtain a desirable condition. An effective monitoring program is required to provide the navigational framework needed for successfully meeting the challenges of adaptive management.

Adaptive management recognizes that knowledge about natural resource systems is sometimes uncertain (43 CFR 46.30; Moir and Block 2001; Ruhl 2005). Adaptive management considers management actions and policy in a context analogous to experimental treatments. Thus, it embraces possible unknown elements by defining a set of quantitative responses that are consistent with management experience for each desired condition (hypothesized outcome). This is often accomplished through the use of various conceptual or quantitative models. The evidence for achieving the conditions/outcomes is considered in a well-designed monitoring framework.

Adaptive management integrates science and management (Lee 1993). From a science perspective, management objectives become the primary response of interest and the source of questions being posed. From a management perspective, the management objectives remain the primary concern, but learning becomes an additional, explicit objective. Thus, management takes on a part of science (i.e., learning), and science takes on a part of management (i.e., the objectives). More detailed information about the use and implementation of adaptive management is given in *Adaptive Management: The U.S. Department of the Interior Technical Guide* (Williams et al. 2007).

Compliance with NEPA is a statutory and regulatory requirement for federal activities affecting the environment, whereas adaptive management is a discretionary, learning-based approach to structured decision-making that may be used in conjunction with the NEPA process. It is a management tool that is consistent with NEPA's goal of informed decision-making (DOI 2010). Adaptive management and NEPA are complementary in that both emphasize collaboration, working with partners or stakeholders, and learning as part of the management process.

Adaptive management is an integral feature of the management of stock use under each of the alternatives evaluated in this WSP/FEIS. The adaptive management approach would include long-term monitoring to evaluate effectiveness of grazing management actions. Stakeholders, such as commercial outfitters, diverse user groups, and other land managers would continue to be fully engaged.

The proposed strategy for managing stock use is designed to prevent unacceptable impacts to meadows through implementation of multiple complementary field protocols and a suite of adaptive management tools. Taken together, the complementary elements of the management program at the parks—monitoring, which includes residual biomass and bare ground, stock use, species composition, repeat photography, and regularly scheduled site visits; an opening date system based on moisture, soil, and vegetation conditions; management tools including the ability to rest meadows when needed, as well as adjust use levels through controls on party size and length of stay; and ongoing research into meadow function and the effects of grazing on meadow ecology—are designed to protect meadows by preventing, minimizing, and/or mitigating impacts.

MONITORING STRATEGY AND THRESHOLDS FOR MANAGEMENT ACTION

Long-term information on the condition of meadows, and on stock use levels and patterns, is necessary to provide information on the effectiveness of the management program, document changes in conditions, and to inform the management of stock and the meadow systems they use. In their review of pack stock monitoring and management in wilderness, McClaran and Cole (1993) recognized the strengths of the program established by the 1986 SUMMP. However, they also called attention to two weaknesses: the application of a single uniform grazing standard to all park meadows, and the absence of defoliation standards. The monitoring protocols and management system described below address those deficiencies, through 1) the development of site-specific grazing capacities that can be modified to take into account different management objectives at the meadow scale, and 2) the continued implementation of residual biomass monitoring in frequently grazed meadows. The strategy for monitoring stock use and meadow condition includes protocols for:

- monitoring stock use, which provides a direct measurement of the timing, frequency, and duration of grazing as well as the holding and feeding of animals
- conducting site visits, for the purpose of surveillance and early detection of stock impacts (including sensitive areas such as springs, seeps, and streambanks)
- monitoring residual biomass, which provides a quantitative estimate of the amount of plant material remaining on a meadow at the end of the growing season and conversely, of the amount of vegetation consumed by grazing animals
- monitoring bare soil, which is an early indicator of the potential for increased erosion in meadow systems
- monitoring streambank alteration by stock, which is an early indicator for the potential for changes to soil erosion and meadow hydrology
- monitoring species composition, which serves to detect changes in the plant species composing meadow vegetation as a result of grazing
- photographic documentation of conditions and trends

Within each forage area, the primary meadows would be routinely evaluated to assess the status of soils, streambanks, and vegetation. Forage areas are defined as the primary meadows and their associated forested or upland grasslands, which are commonly used by stock for grazing. The forage areas open to grazing under each alternative are illustrated on the stock use and grazing alternatives maps provided in chapter 2 of this WSP/FEIS. The condition of the most heavily used portions of the forage area would be used to indicate the status of surrounding and associated areas grazed by stock. This approach rests on the assumption that if conditions in the most heavily used areas remain within established standards, the rest of the forage area will meet standards as well. If the species composition, density, and soil condition in the primary meadows remain comparable to similar but ungrazed meadows, it is assumed that the associated meadows will remain in good health. Because stock may graze areas outside of the primary named meadows, these areas would also be assessed during site visits but would not necessarily be the subject of the formal monitoring protocols.

The proposed strategy for monitoring and managing stock use relies on the measurement of proxy variables and implementation of preventive management strategies to maintain desired wilderness conditions. In the event that standards are not achieved, the management strategy prescribes adaptive management actions that will provide for recovery. The proposed management tools—such as grazing limits, opening dates, length of stay and party size limits—are site specific, and could be revised as additional information becomes available to address meadow-specific vulnerability to impacts. Thresholds for management action are designed to provide managers with a range of tools that are triggered by either use levels and/or conditions, and the thresholds are set at a point before which unacceptable impacts occur. The following sections describe each of the formal monitoring protocols, establish thresholds for management action, and identify which actions may be triggered under different scenarios.

STOCK USE AND GRAZING LEVELS

In this WSP/FEIS, stock users are divided into three classes: administrative, commercial, and private. Administrative users are those that are employed by the NPS and who use pack stock in order to carry out their official duties. Commercial providers are entities that provide saddle and or pack stock as a paid service. Companies or individuals of this class are required to hold a NPS issued Commercial Use Authorization (CUA) or be a licensed in-park concession; clients of these commercial providers are also required to obtain a wilderness permit. Private use is packing and riding done by an individual with friends or family; only a wilderness permit is required for this class of use. At times commercial packers are employed to provide support for administrative activities. This use would continue to be attributed as commercial for tracking purposes but classified as serving an administrative function, and thus not count towards commercial service allocations. The WSP/FEIS sometimes refers to commercial and private stock use collectively as “recreational stock use,” to distinguish stock use by visitors from stock use by NPS.

Because grazing would continue to be both self-reported and documented by field staff at regular intervals, managers would be able to track the timing, duration, and intensity of use throughout the summer season. As part of the annual work planning process, administrative packers would continue to share their grazing plans with wilderness managers early in the season; commercial outfitters would continue to be required to submit trip itineraries to the parks two weeks in advance of entering the wilderness. All stock parties would continue to be required to report their itineraries after completing their trips. Monthly reports of commercial stock use would be due to the Concessions Management Office according to the requirements established by the relevant Commercial Use Authorization or concessions contract. Commercial service providers would continue to be required to report day use in wilderness, including trail rides, resupply, and spot and dunnage trips whether or not any grazing occurred. Administrative use would continue to be reported monthly, while private users would be requested to submit their reports at the end of the summer season.

The location of each overnight camp, the number of people and stock present, the type of animals, the corresponding dates, and the number of stock fed or grazed would be reported. Stock use reporting forms would be provided to commercial pack stations, NPS and USFS trailheads and administrative packers. Private stock parties would be given reporting cards when obtaining wilderness permits, or when encountered by wilderness rangers in the field. Wilderness rangers would be given a supply of cards each spring for distribution to users, and would also be charged with documenting all observed use within their patrol area. The self-reported use data, along with the wilderness ranger observations, would continue to be compiled and compared against records from the wilderness permit database. This combined information would continue to be evaluated for reporting errors and inconsistencies, summarized, and reported annually. Data would be presented in tabular and graph form, and comparison with past years use presented. Where possible, trends and patterns would be identified and the potential causes discussed. Stock use data would continue to provide information that helps show what levels of stock use resulted in present conditions and would be used to inform the annual discussion of wilderness conditions and any proposed changes to management or restrictions.

Thresholds for Management Action: Use levels serve as a primary proxy for potential impacts to meadow systems, and as such, are used to trigger monitoring activity as well as management responses where necessary. Wilderness rangers would continue to track use in the field and notify the wilderness office when the estimated capacity of a meadow is approached. Self-reported commercial and administrative use would be similarly reviewed by plant ecology staff as reports become available. Meadows in which use reaches the estimated capacity (see attachment 1) would be evaluated for impacts. If conditions warrant, a grazing closure or other appropriate management action would be taken. Such actions would be recommended to the appropriate district ranger by field personnel during the grazing season for immediate implementation, or proposed to the Superintendent following the annual review of monitoring results for implementation during the following summer season. Increased use may be allowed where information from the monitoring program and observed conditions indicate.

As a guideline, areas receiving high levels of use (80% or greater of the estimated capacity) would be evaluated annually, those receiving moderate use (50-79% of the estimated capacity) would be evaluated biannually (or annually if resources are available), and those areas that are lightly used (less than 50% of the estimated capacity) would be evaluated at least every 5 years.

SITE VISITS AND CONDITION ASSESSMENTS

Site visits to grazed meadows would continue to be made with the goal of surveying for stock impacts and describing and documenting these impacts. A typical site visit would include a survey of stock camps, preferred forage areas, maintained and informal trails, stream banks, seeps, and springs, and any other sensitive features in the meadow area. In the course of each site visit, staff would describe stock impacts and other factors influencing meadow vegetation and hydrology. Stock impacts which will be evaluated would include the extent and severity of deep hoof prints, trampled vegetation, closely cropped vegetation, stream bank shearing, erosion, and extent of the area subject to preferential grazing.

Documentation would consist of categorical assessments, narrative, and photographs. The date and extent of each survey would be documented. Observations would be linked to the timing and amount of stock use which has occurred at the time of the survey. The efficacy of existing management (opening dates, capacities, head and night limits, education and outreach) for meeting goals would be evaluated. The need for additional monitoring (residual biomass, bare ground, repeat photography, streambank alteration) would be assessed. Parameters used to estimate grazing capacity would be verified. When non-native species, rare species, or other sensitive resource features are encountered, staff would document and distribute this information to appropriate specialists.

Meadow monitoring staff would continue to train others working in wilderness (wilderness rangers, other technicians, packers) in data collection protocols and collate and summarize field reports.

Because grazing would be both self-reported and documented by field staff at regular intervals, managers would remain able to track the timing, duration, and intensity of use throughout the summer season. Meadow condition would be evaluated during and at the close of the grazing season by both field rangers and professional ecologists. The frequency of site visits would be determined by documented use levels and patterns, which are largely well established and predictable, as well as through regular communication with commercial outfitters and administrative packers. As part of the annual work planning process, administrative packers would continue to share their grazing plans with wilderness managers early in the season; and commercial outfitters would continue to be required to submit trip itineraries to the parks two weeks in advance of entering the wilderness. These requirements would facilitate the focusing of monitoring efforts on popular locations as the need arises.

Thresholds for Management Action: Site visits would provide for early detection of impacts and would identify where management action or additional monitoring may be needed. Although site visits would be triggered by use levels, site visits could trigger management actions or implementation of additional formal monitoring protocols independent of stock use data.

VEGETATION AND SOILS

The primary emphasis of the vegetation and soils components of the monitoring program is to measure changes in productivity, species composition and bare soil over time. Implementation of these protocols also provides for the early detection of impacts to sensitive features (such as streambanks, seeps and springs) and the introduction of nonnative plant species. Four protocols (residual biomass, species composition, bare soil, and repeat photography) developed to address these topics are described below. Each of these protocols would be implemented in a subset of targeted meadows, which will likely fluctuate in response to use levels, availability of staff time, and expertise. Site visits by wilderness patrol and meadow monitoring staff would continue to be made to meadows not included in one of these formal sampling efforts with the goal of monitoring conditions in all meadows used by stock. Site visits would serve to document conditions in meadows used by stock using a standardized rapid assessment protocol (in development) and would include written descriptions of soil and vegetation conditions, presence of nonnative species, impacts of concern, use patterns, and any additional relevant observations.

RESIDUAL BIOMASS

Residual biomass refers to the amount of above ground plant material present in a meadow after grazing. In systems dominated by herbaceous plants, adequate residue serves to protect soil surfaces and plants, to replenish the soil mulch and organic layers, and to trap and hold moisture. Ungrazed vegetation also provides shelter and forage for animals that depend on meadows for all or part of their life cycles. As such, residual biomass is both an important contributor to meadow function and an indicator of grazing impacts that can provide a quantifiable and repeatable measure to guide management. In remote areas where the timing and duration of grazing is unpredictable and the collection of data on plant growth to generate precise estimates of plant productivity is prohibitively costly, monitoring residual biomass on ungrazed sites provides an efficient proxy measure of productivity.

The comparative yield method of estimating residual biomass (Haydock and Shaw 1975) was modified and adopted for use in the wilderness meadows of Sequoia and Kings Canyon National Parks in 1993 (Neuman 1993). In this method, reference quadrats are selected in the field to represent a linear scale of biomass within a designated plot. These quadrats then serve as standards against which the yields of 150-200 systematically selected quadrats are estimated by eye. The ocular estimates are calibrated using the dry matter yields of the original standards and two additional sets of standards that are clipped following the sampling. This procedure is applied to both a core (grazed) and reference (ungrazed) plot within each meadow. The protocol was specifically designed to be used by non-specialists (such as wilderness rangers and packers) and to avoid the installation of permanent markers in wilderness. Each year wilderness rangers at Sequoia and Kings Canyon would continue to undergo training in residual biomass monitoring, with field oversight and assistance provided by the plant ecology program to ensure data consistency and quality.

The locations of the core and reference plots would continue to be documented using photographs and distance and direction to recognizable features. Although the plots would not be permanently marked, this allows for sampling to take place in the same area year after year. As animals tend to graze close to established camps and in favored areas, the location of the plots generally coincides with the area of concentrated use and impact.

The amount of biomass remaining at the end of the growing season would continue to be estimated using this method in meadows that are regularly grazed by stock at levels approaching the estimated capacity, and/or which show signs of heavy use. Core plots would continue to be located subjectively within the area of greatest grazing pressure. If a suitable location is available, an ungrazed reference plot would be located in an area that is both biotically and abiotically comparable to the core plot, with similar soil and hydrologic regime. Optimally the reference plot would also be located within the same meadow; where this is not possible due to the presence of grazing impacts throughout the meadow; a similar site in an adjacent meadow area may be selected. Both core and reference plots may vary in size depending on the size of the meadow being monitored.

This monitoring would continue to use subjectively chosen core plots where grazing impacts are greatest; if the impacts there are considered acceptable, then the rest of the meadow will likely also fall within management standards. This design would prioritize detailed information about the greatest impacted areas of each sampled meadow rather than conditions across the entire meadow or across all meadows in the parks.

Residual biomass monitoring data would continue to be summarized and reported annually. As with the stock use data, these data would continue to be presented in tabular and graph form, and comparison with past years presented. Where possible, trends and patterns would be identified and the potential causes discussed. Residual biomass data could also be used to characterize productivity in ungrazed portions of individual meadows. This information would continue to be coupled with the stock use data and used to inform the annual discussion of wilderness conditions and any proposed changes to management or restrictions. Residual biomass guidelines would be periodically reevaluated to reflect improved knowledge about the relationship between utilization and impacts.

Thresholds for Management Action: Residual biomass monitoring provides meadow production and utilization data that can be used for informing strategies for meadow management. By quantifying the amount of plant material remaining on a meadow at the end of the growing season (and conversely, of the amount of vegetation consumed by grazing animals), the protocol allows managers to assess the validity of assumptions regarding consumption levels used in capacity estimates. When residual biomass monitoring results indicate that utilization has exceeded the established standard (utilization standards, expressed as the proportion of meadow vegetation available for grazing, are provided in attachment 1), management actions would be taken to adjust use levels to bring residual biomass into standard. The specific management actions taken would be based on a consideration of all available monitoring data.

BARE SOIL

The amount and distribution of bare soil is considered an important indicator of meadow integrity as it directly relates to site stability and susceptibility to erosion (Smith and Wischmeier 1962, Morgan 1986, Benkobi et al. 1993; Blackburn and Pierson 1994; Gutierrez and Hernandez 1996; Cerda 1999). Grazing has been linked to increases in bare soil as well as decreased plant cover, decreased primary productivity, and shifts in species composition (Miller and Donart 1981; Trimble and Mendel 1995; Olson-Rutz et al. 1996; Fahnestock and Detling 2000; Cole et al. 2004). Trampling, by either humans or stock, can produce similar results (Cole 1995; Liddle 1975, 1991) with the added impact of soil compaction that compromises root growth and water infiltration (Gilman et al. 1987; Unger and Kaspar 1994; Pietola et al. 2005).

Bare soil is considered a more sensitive indicator of meadow condition than species composition (Cole et al. 2004), as it increases at lower levels of disturbance compared with shifts in species composition in a variety of montane vegetation types of North America (including alpine meadows) (Cole 1993). Plant productivity may be more sensitive to grazing pressure than bare soil (Cole et al. 2004), but is more time consuming and costly to monitor in wilderness settings and is also subject to high interannual variability in response to climatic factors (Moore et al. 2013), such as the timing and amount of precipitation (Walker et al. 1994), snowpack, or snowmelt (Walker et al. 1995). Because bare soil measured from point data is efficient, objective, easily obtained, and repeatable across time and observers, it has been used to assess meadow condition in Sierra Nevada meadows by the USFS (Weixelman and Zamudio 2001) and has recently been adopted as an indicator of meadow condition in Yosemite National Park (NPS 2014a and 2014b).

Weixelman and Zamudio (2001) classified bare soil cover values into low, moderate and high ecological condition classes based on monitoring data from a comprehensive multi-year study in U.S. Forest Service meadows in the Sierra Nevada (table D-1). These condition classes for bare soil values are based on point-intercept data collected from 363 meadows across a broad disturbance gradient (Weixelman and Zamudio 2001). The values for bare soil cover that define the ecological condition classes presented by Weixelman and Zamudio (2001) vary according to moisture regime and elevation. For example, to be in a high condition class, a moist (mesic) meadow would not have bare soil exceeding 6% of its surface area, and a wet (hydric) montane meadow (6,000-8,000 feet) would not have bare soil exceeding 4%. These values have recently been used as a starting point to inform condition class development in Yosemite National Park (NPS 2014a and 2014b) and are provided below as an example of how they may be applied in Sequoia and Kings Canyon National Parks. Note that the meadows included in the sample described by Weixelman and Zamudio occur at lower elevations than many park meadows, reflecting both latitudinal effects and the preference of the use of montane meadows for livestock grazing in the National Forests.

Table D-1: Provisional Bare Soil Cover Values for Ecological Condition Classes among Sierra Nevada Meadow Types

Meadow Type	High Condition	Moderate Condition	Low Condition
Montane			
Hydric meadow	0-4%	5-9%	>9%
Mesic meadow	0-6%	7-13%	>13%
Xeric meadow	0-8%	9-13%	>13%
Subalpine			
Hydric meadow	0-4%	5-8%	>8%
Mesic meadow	0-6%	7-13%	>13%
Xeric meadow	TBD	TBD	TBD

NOTES: The montane zone is about 6,000 to 9,000 feet in elevation and the subalpine zone is 9,000 to 10,000 feet in elevation in the southern Sierra. Values are from Weixelman et al. 2001 as presented in NPS 2014a.

These values are provisional and will be subject to revision following further study in park meadows.

Estimates of bare soil (and other groundcover categories—e.g., litter and duff) would continue to be collected during residual biomass monitoring (using the step-point method) and species composition monitoring (as cover data associated with each frequency quadrat). These measures have been used in concert with residual biomass data to inform assessments of meadow condition and the need for use level adjustments (Haultain and Frenzel 2013).

It is important to note that estimates of bare soil collected from the residual biomass monitoring plots reflect conditions in a relatively small proportion of the total meadow area, which by design represents the area of highest use; if the impacts there are considered acceptable, the rest of the meadow will likely also fall within management standards. This design would prioritize collection of detailed information about the greatest impacted areas of each sampled meadow rather than conditions across the entire meadow or across all meadows in the parks.

Thresholds for Management Action: The provisional values for bare soil condition classes would be revised based on values obtained through analysis of existing data and additional data collection in order to ensure applicability to the meadows of Sequoia and Kings Canyon. NPS and USFS ecologists would gather information on bare soils in park meadows using methodology comparable to that used by the USFS and in Yosemite National Park. Data would be collected from both grazed and ungrazed meadows representing a range of use levels, elevations, and vegetation types. Results from these efforts would be used to assess the applicability of the condition classes developed by Weixelman and Zamudio (2001) to park meadows and would inform the further development of thresholds for management action (table D-2).

Table D-2: Provisional Thresholds for Management Action and Rationale Based on Bare Soil Values

Threshold(s) for Management Action	Management Actions	Rationale
Threshold 1: Monitoring indicates “low ecological condition” bare soil cover value at any grazed meadow.	Apply a secondary assessment method for a qualitative evaluation of meadow condition.	Secondary assessments are diagnostic tools that provide standardized, rapid, field-based assessments of the overall condition or functional capacity of meadows. Assessing meadow condition would aid in identifying key stressors that may be affecting meadow condition. Assessment results would assist with interpretation of monitoring results.
Threshold 2: Monitoring indicates “low ecological condition” bare soil cover value at any monitored site for two successive monitoring periods AND secondary assessment indicates stock use is a contributing stressor for both monitoring periods	Increase education about minimum impact and best management practices in meadows for Wilderness visitors, and the parks’ staff and partners.	Education in maintaining meadow condition would help prevent further increases in bare soil associated with human or stock use.
	Adjust total grazing levels or timing of use if needed to minimize impacts. Rest the meadow if necessary. Temporarily discontinue grazing until conditions improve based on secondary assessment results.	Grazing capacities constitute use levels that can be sustained in a meadow based on available forage cover, productivity and site condition, which can guide in setting an appropriate level of use. Allowing a period of meadow “rest” facilitates meadow recovery. Effects of trampling and grazing that are expected to decline with reduced use or avoidance of early-season use include soil compaction, bare ground exposure, and plant disturbance.
	Monitor annually for 3-5 years or until meadow reaches moderate or high condition based on bare soil values.	Frequent monitoring would facilitate rapid detection of, and management response to, changes in ecological condition as well as inform the evaluation of the effectiveness of changes in the intensity and/or timing of use on meadow condition.

Table D-2: Provisional Thresholds for Management Action and Rationale Based on Bare Soil Values (continued)

Threshold(s) for Management Action	Management Action	Rationale
Threshold 3: Bare soil is double the value of "low ecological condition" class at a meadow OR previous management actions (such as reduction in use) have been ineffective OR assessments for 3-5 years have not shown improvement in ecological condition.	Discontinue grazing until conditions improve based on bare soil monitoring.	Allowing a period of meadow "rest" facilitates meadow recovery. Effects of trampling and grazing that are expected to decline with reduced use or avoidance of early-season use include soil compaction, bare ground exposure, and plant disturbance.

STREAMBANK ALTERATION

One of the effects of grazing animals on wetland habitats is the alteration of hydrologic regimes through impacts on streambanks and channels (Kauffman and Krueger 1984, Trimble and Mendel 1995). Streambank vegetation plays a critical role in the stability of channels and banks (Gordon et al. 2004). Impacts to streambank vegetation from grazing animals have the potential to interact with climate change to alter hydrologic conditions in wetlands (Viers et al. 2013).

Stream channel and stream bank stability is a function of many complex, interacting factors such as basin size, surficial geology and sediment supply, climate, land use, and history (Gordon et al. 2004). Depending on these factors, stream channels can be relatively static (stable) or dynamic (unstable) in the absence of stock impacts. Alteration is a measure of actual stock impacts to streambank soils and vegetation; it can occur from shearing, trampling, and trailing (table D-3). All else being equal, stability decreases with alteration. Alteration is sensitive to management and actions to reduce alteration can result in more natural channel morphology over time (Bengeyfield 2006).

There are no consensus approaches to setting streambank alteration standards (Cowley 2002). Guidelines for alteration where anadromous fish populations or other sensitive resources are a concern are generally 10%. Alteration standards of 10% on portions of the Inyo National Forest have been part of a management strategy to allow riparian recovery (Frietas et al. 2014).

Table D-3: Definition of Streambank Alteration Impact Types*

Alteration Type	Definition
Shearing	Removal of a portion of the streambank by ungulate hooves leaving a smooth vertical surface and an indentation of a hoofprint at the bottom or along the sides.
Trampling	Indentation of a hoofprint and exposed roots or soil, resulting in a depression at least 13 mm deep or soil displacement at least 13 mm upwards.
Trailing	Linear features compacted and denuded by repeated traffic. Trailing is counted where there are signs of current-year use even if hoofprints do not result in 13-mm displacement of soil because of the impacts of compaction.

* adapted from Heitke et al. 2008 and Burton et al. 2011

Site visits would be used to identify areas where streambank alteration is a concern. Monitoring would be established to quantify the extent of current year alteration and would provide information about trends related to management actions in a specific forage area. Streambank alteration would be monitored along both banks of affected channels through the forage area. The extent of the survey would be documented by recording the upstream and downstream extents of the monitored reach. Alteration would be measured along a step-transect located along the first line of continuous perennial vegetation (the "greenline," Winward 2000), with decision rules about locating transects adapted from the Multiple Indicator Monitoring protocols (Burton et al. 2011). Alteration would be measured on a 92-centimeter (cm) line perpendicular to and centered on the greenline. Alteration could be recorded as either presence/absence along the 92 cm line or the amount of the 92 cm line that is altered ("GL" or "GLP" method, respectively, Heitke et al. 2008). Current year impacts would be identified based on the absence of weathering effects of freeze and thaw cycles, rain events, and erosion by stream flow or vegetative regrowth. Data would be summarized as percent alteration, calculated as the number of sample points altered divided by the total number of sample points (for presence/absence) or the total length of altered bank divided by the total length evaluated (precise method).

Thresholds for Management Action: In the absence of applicable standards for alteration, monitoring data would be used to identify trends in streambank alteration relative to use patterns and management actions and to provide context to evaluations by subject matter experts. If streambank alteration is associated with accelerated erosion or instability, management action would be taken to limit further alteration and facilitate recovery.

SPECIES COMPOSITION

To evaluate grazing effects on plant species composition, data have been collected from five pairs of grazed and ungrazed meadows over the past twenty-five years. Data were collected on the first meadow pair in 1985 and since then sampling has been conducted on four other meadow pairs, resampling every pair on an approximately 5-year rotation. Meadow pairs selected for monitoring are located at East Lake and on the Monarch Divide in Kings Canyon National Park, and on the Hockett Plateau and in the Upper and Lower Rock Creek drainage in Sequoia National Park. The meadow pairs represent several different meadow types, including fine sedge (*Eleocharis pauciflora*), medium sedge (*Carex scopulorum* var. *bracteosa*)-grass-herb, tall grass (*Deschampsia cespitosa*) and sedge-herb, fine grass (*Calamagrostis breweri*) and sedge-herb, and wide sedge (*Carex utriculata*)-fine grass (*Calamagrostis breweri*)-herb (as described by DeBenedetti 1984).

The sampling protocol implemented in Sequoia and Kings Canyon National Parks was developed by McClaran and Neuman (1989) specifically for use in wilderness and is described in detail in Frenzel and Haultain (2012) and McClaran and Neuman (1989). Briefly, a single large plot (approximately 500 to 3,000 m^2) has been established in the grazed and ungrazed meadows of each meadow pair. Although not permanently marked, plots are relocated using photographs and distance and compass direction from recognizable features. Each plot is divided into 10–15 equal subareas; within these 10–15 subareas, 10–20 25 x 25 cm quadrats are haphazardly located (to avoid bias) during the sampling event, for a total of 100 to 200 quadrats per meadow. The number of quadrats is determined by the vegetation type and is the same for all sampling years for a given meadow. All species rooted within the quadrat are recorded as present, as are moss and hoof prints greater than 2.5 cm deep; percentage of bare ground within the quadrat is also recorded. The same data are collected for a 10 x 10 cm quadrat nested within the 25 x 25 cm quadrat. Abundance is reported as a species' frequency of occurrence in the 100-200 quadrats of each large plot.

Early detection of nonnative plants is also a concern directly related to monitoring changes in species composition. Field staff survey for nonnative plants as part of implementation of each of the stock use and meadow monitoring protocols described here. Both active and passive surveillance protocols for detecting nonnative species introductions, as well as appropriate management responses, are described in "Appendix N: Strategy for Reducing Nonnative Plants in Wilderness".

Thresholds for Management Action: In comparing native and naturalized species composition of the paired grazed and ungrazed areas beginning with the base year of the monitoring program, modifications to grazing use levels and patterns would be necessary when the grazed area shows: 1) more than 15% change in the dominant species as recorded by the frequency plots, or 2) more than a 15% change in the proportion of bare ground and with observed erosion.

Although these results would apply only to these specific meadow pairs, changes detected as part of this monitoring protocol would also serve as an indicator of the need for additional monitoring in similar meadows.

New occurrences of nonnative plants detected during species composition or other monitoring activities would be documented (including the collection of voucher specimens) and reported to the invasive plant program manager as soon as possible. When identification has been confirmed by a subject matter expert, immediate manual control efforts would be taken as feasible.

REPEAT PHOTOGRAPHY

The 1986 SUMMP introduced a system of using repeat photography to document gross changes in meadow vegetation over time. This system was designed to detect general changes in vegetation (e.g., a shift in dominance from grasses to sedges or sedges and grasses to forbs, enlargement or shrinking of the boundaries of vegetation types, changes in soil conditions and erosional effects and proportion of bare ground). The long-term meadow vegetation repeat photography collection was built on early work by park employees Clay Peters and Terry Gustafson (summarized in a file report prepared by T. Gustafson dated January 15, 1965), and expanded and formalized by Range Conservationist M. Neuman in the late 1980s and early 1990s. Historic scenes of park meadows were obtained, archived, and documented in a tracking database. Binders of printed photographs and associated label information were created for each wilderness patrol area, with the intention that the rangers would re-take the black and white photographs each year and return them at the end of the season for processing.

The long-term meadow repeat photography collection represents a valuable source of information on gross changes in meadow vegetation and morphology. The collection consists of 320 scenes, dating from 1929 through 1992, that have been formally documented in a database. At least 202 of these have one contemporary shot documented in the database; 34 have been re-taken three times and documented, and seven have been photographed four times. Black and white prints of each original scene and subsequent revisit have been made and reside in park files. Subsets of the photographs have been re-taken as time and resources allowed. These images provide a tool with which to document the establishment of lodgepole pine (*Pinus contorta*) saplings into meadows, a dynamic that has been the subject of much research and discussion. Recovery from past heavy grazing by cattle and sheep, and the efficacy of the efforts of the Soil and Moisture Crews (1948-1980) to halt erosion and restore proper hydrologic functioning through the installation of check dams could also be assessed using this resource. The Soil and Moisture Crews also removed 'invasions' of *Pinus contorta* and *Veratrum californicum* from within selected meadows. These restoration efforts were well documented in reports and photographs that remain in park files, and thus there are potentially useful ancillary data on management actions to correlate with any changes in condition captured by the photographic record.

Photographic documentation would continue to be included in each component of the monitoring program, although images would be acquired using contemporary high-resolution color digital photography as opposed to film. Photographs would be taken during site visits made by field staff, during assessment of opening date conditions, as part of species composition and residual biomass monitoring, and whenever concerns or questions arise regarding meadow, camp, or trail conditions. Digital images would continue to be processed and archived on the park network for access by managers and subject matter experts.

Thresholds for Management Action: There are no specific standards in place for the types of changes that may be detected through repeat photography. Photographic documentation of such changes or of impacts associated with stock use would remain an important source of information when considering management actions. In addition to monitoring photographs taken by wilderness rangers or plant ecology staff, photographs submitted by other staff from the parks, partners, or wilderness visitors can be used to trigger subsequent site visits and inform decisions regarding monitoring or management actions.

THE MANAGEMENT SYSTEM

The goals of managing recreational grazing in a National Park wilderness differ from those in areas devoted to the production of livestock; within the park, the protection of naturally functioning meadow ecosystems is given greater weight than the provisioning of forage for stock. Grazing by recreational stock is inherently less predictable than that of production oriented livestock systems, as different numbers and types of animals, led by different handlers, arrive at varying times throughout the season. A successful management system must have the flexibility to address the variable nature of the timing and intensity of grazing by recreational stock, site-specific responses to grazing, and the inherent variability in productivity of meadow systems in response to changing weather and climate.

Under the preferred alternative, management of stock use in the wilderness of Sequoia and Kings Canyon would continue to use the grazing management tools described in the 1986 SUMMP, which are based in part on traditional range management techniques and adapted for use in the wilderness setting. Stock permitted within Sequoia and Kings Canyon National Parks would continue to include only horses, mules, burros, and llamas. Goats would remain specifically prohibited as they can carry diseases that threaten native bighorn sheep. Management actions would continue to be applied at the scale of the forage area. Forage areas are defined as the primary meadows and their associated forested or upland grasslands, which are commonly used by stock for grazing. Other areas within accessible proximity of the trails and travel zones open to use, although not designated as forage areas and not having an established use level, may also be used for grazing by stock. The 1986 SUMMP recognized that the primary meadow within each of the forage areas was likely the most sensitive to the influence of grazing and would reflect early change. The primary meadow would continue to be the focus of monitoring and used as a barometer to guide decisions on future adjustments in timing and level of grazing use.

The following sections describe the specific components of the management system and how information derived from monitoring would inform management actions.

NETWORK OF MEADOWS CLOSED TO GRAZING

A series of meadows would continue to be closed to grazing to provide opportunities to compare ungrazed meadows with grazed meadows as part of the monitoring program, to provide opportunity for scientific study of meadows that are not affected by stock grazing, and to provide opportunities for park visitors to observe a representative sample of meadows, in proximity to general travel routes, that are not affected by grazing.

For scientific study purposes, a major value of Sequoia and Kings Canyon (an International Biosphere Reserve) is that it contains ecosystems that are as undisturbed by human activities as is reasonably possible. Meadows that are representative of each significant type (by physiography, origin, plant associations, and unique features) would continue to be protected from grazing by stock. Basin, slope, and streamside stringer meadows; meadows of pre-glacial and post-glacial origins; and meadows representative of the area's common meadow plant associations were identified by the SUMMP and would continue to be included in this category. A selection of meadows closed to grazing would be accessible by trail so that they can easily be observed by the public and accessed efficiently for scientific study.

Table D-4: Network of Meadows Closed to Grazing for Scientific and Social Value

Meadows Designated in 1986 SUMMP	Proposed Additions (Under NPS Preferred Alternative)
Big Pete Meadow (forested portion)	Bighorn Plateau
Crabtree Ranger Station Meadow	Meadow 0.6 mi south of Bighorn Plateau
Dragon Lake Meadow	Chagoopa Plateau #3 Meadow
Ellis Meadow	Darwin Meadow Proper
Goddard Creek Meadows	Grouse Meadow
Guyot Creek Meadows (west of trail)	Guyot Creek Meadows (east of trail)
Lake South America Col Meadow	Lower Crabtree Meadow
Mitchell Meadow	Taboose Pass Meadow (12 acre wet meadow at 10,920 feet)
Rock Creek Ranger Station Meadow	
Rock Creek #2 Meadow	
Wallace Creek Closed Meadow	
Woods Lake Shoreline Meadow	
Wright Creek Closed Meadow	

Meadows that would be closed to grazing under the NPS preferred alternative are listed in chapter 2 of this WSP/FEIS.

STOCK USE AND GRAZING MANAGEMENT TOOLS AND TECHNIQUES

Opening Dates

Opening dates are established for all of the park forage areas. These dates are designed to prevent mechanical disturbance to surface soil and vegetation that results in the breakage of the root-soil complex to the point that vigor of individual plants (or networks of plants) deteriorates as evidenced by deeply incised hoof prints, change in species density, or composition, or both. Such breakage increases soil erosion over what would be natural without grazing. Opening dates also allow for adequate plant development to replenish carbohydrate stores expended in spring and allow plants to reproduce. Meadow vegetation provides an important source of floral and seed forage for native fauna (Frase and Armitage 1989; Hatfield and Lebuhn 2007; Hoffman Black et al. 2011; Holmquist et al. 2011; Smith and Weston 1990). Delaying grazing in meadows thus may allow for many species of wildlife, such as birds, small mammals, invertebrates, and amphibians, to complete critical portions of their life cycles prior to the onset of grazing.

Specific opening date estimates for the parks' major forage areas are based on quantitative data gathered from individual meadows between 1977 and 1984. Moisture conditions and associated physical impacts by stock were tracked in specific plant associations throughout the season in several dozen meadows over the course of the entire study period. A number of other meadows were evaluated less frequently. In meadows where specific data did not exist for all types of hydrological years, or where only one data point was available, extrapolations were made based on similar vegetation, location, and comparable meadow physiography.

In the initial five-year (1977-81) effort to monitor moisture conditions in individual plant associations in specific forage areas, it was found that moisture was retained at or near the surface for two to four times longer than the norm for that site when the water content of the April 1 or May 1 snowpack exceeded 150 percent of the long-term average. The actual time beyond the norm required for meadow vegetation to dry to a point where trampling damage does not occur depends primarily upon the type of plant associations present in the meadow. Late spring and early summer weather conditions, the topographic position of the meadow, and the size of the watershed it resides in may also cause some variation in this date. Correspondingly, meadows were found to retain moisture for a period of one to three weeks less than the norm during the years where the April 1 or May 1 snowpack was below 50 percent of the long-term average. While these relationships certainly occur along a gradient, the 50 percent and 150 percent level breaking points were found to correlate well with obvious wet (i.e., 1969, 1973, 1978, 1980) and dry (i.e., 1972, 1976, 1977) years.

Based on these results, opening dates for wet, dry, and normal years have been prescribed for the major forage areas based on the water content of the May 1 snowpack. Years in which the May 1 snowpack represents 50% to 150% of the long-term average are characterized as ‘normal’; those ranging from 50% or less of the long-term average are characterized as ‘dry’; and those 150% or more of the long-term average are considered ‘wet’.

Opening dates are keyed to sensitive vegetation and soil within the forage area. Sensitive vegetation and soils are defined as the plant associations and soil surfaces that are most susceptible to trampling damage and would be expected to be trod upon by free-roaming animals when present; or that are especially sensitive to herbage removal. The key plant association may not necessarily comprise a majority of the specific meadow. In nearly all cases, the key association accounts for at least 15 percent of the total meadow area.

Opening dates vary considerably depending on both climatic and topographic factors, as described above. The general range is from mid-July to mid-August for normal years, with some locations earlier or later depending on their characteristics. Opening dates in wet years are later and dry years earlier. Opening dates are established so that, generally, once a given drainage basin is open to use, the entire basin is open. Necessary protection of the resource is provided and the system is simplified for both the stock user and park management. Actual opening dates are seldom the specific dates predicted by the May 1 snowpack because field conditions vary from year to year. For example, on a year classified as normal it may be found that the actual conditions for a specific meadow or basin trend toward dry, so the actual opening date would be set somewhere between the normal and dry season date. Similarly, late lying snows in what would otherwise be characterized as a normal year can lead to delays in opening until soils are sufficiently dry. Opening dates remain flexible according to actual field conditions and staff in the field would continue to be able to make adjustments as needed to respond to observed conditions.

Tentative opening dates would continue to be made available following the April l snow survey. Opening dates for specific forage areas would continue to be established immediately following receipt of the results of the May l snow survey each year. Established opening dates would continue to be compared with on-site conditions in specific forage areas, as reflected from field data, and adjustments to the normal dates in the plan made when necessary. Actual opening dates would be documented each year and summarized as part of the annual report on stock use monitoring. Studies of the effects of early season use and its relationship to climatic conditions would continue as time and resources allow. As more information and experience are gained, the large range of moisture content included in the definition of a normal year may be narrowed, or adjusted for specific forage areas. Specific opening dates are listed in table D-5.

Table D-5: Anticipated Opening Dates by Travel Zone and Moisture Year

Travel Zone	Forage Area Number	Name of Travel Zone or Forage Area	Dry Year <50% of average snowpack	Normal Year 50%-150% of average snowpack	Wet Year >150% of average snowpack
28	all	Goddard Canyon	1-Jul	15-Jul	1-Aug
33	1	Evolution	15-Jun	1-Jul	15-Aug
33	2-4	McClure, Colby and Darwin	7-Jul	1-Aug	31-Aug
34	all	Evolution Basin	15-Jul	1-Aug	15-Aug
38	all	Blue Canyon	1-Jul	15-Jul	1-Aug
39	all	LeConte	1-Jul	15-Jul	15-Aug
42	all	Dusy Creek	1-Jul	15-Jul	15-Aug
45	all	Upper Palisade Creek	1-Jul	15-Jul	15-Aug
46	1, 3-6	Upper S. Fork Kings River/Above JMT Jct	15-Jul	1-Aug	15-Aug
46	2	Upper S. Fork Kings River/Below JMT Jct	1-Jul	15-Jul	15-Aug
51	all	Simpson and Tehipite	1-Jul	15-Jul	1-Aug
52	all	Kennedy Canyon	1-Jul	15-Jul	1-Aug
53	1-6, 8	Dougherty Creek	15-Jul	1-Aug	15-Aug
53	7	Shorty's Meadow	1-Aug	15-Aug	31-Aug
54	all	Granite Basin	20-Jun	7-Jul	1-Aug
56	all	Twin Lakes	1-Jul	15-Jul	1-Aug
57	all	Woods Lake Basin	15-Jul	1-Aug	15-Aug
58	1	Castle Domes	1-Jul	15-Jul	1-Aug
58	2-3	Woods Creek Crossing	7-Jul	21-Jul	1-Aug
63	all	Charlotte Creek	1-Jul	15-Jul	1-Aug
65	all	Upper Bubbs Creek	1-Jul	15-Jul	1-Aug
66	all	Lower Bubbs Creek	15-Jun	1-Jul	20-Jul
67	all	East Lake	1-Jul	10-Jul	20-Jul
68	all	Sphinx Creek	15-Jun	1-Jul	20-Jul
69	all	Roaring River	10-Jun	25-Jun	20-Jul
70	all	Cloud Canyon	10-Jun	1-Jul	20-Jul
71	all	Deadman Canyon	15-Jun	1-Jul	20-Jul
72	1-13.1	Sugarloaf	15-Jun	1-Jul	15-Jul
72	13.2-22	Ferguson	15-Jun	1-Jul	20-Jul
73	all	Ball Dome Area	15-Jun	1-Jul	20-Jul
74	all	Clover and Silliman Creeks	15-Jun	1-Jul	20-Jul
75	all	Lone Pine Creek	1-Jul	15-Jul	1-Aug
77	1-4, 6-7	Bearpaw Meadow and Cliff Creek	15-Jun	1-Jul	1-Aug
77	5	Redwood Meadow	1-Jun	15-Jun	1-Aug
79	all	Kern-Kaweah	1-Jul	15-Jul	1-Aug

Table D-5: Anticipated Opening Dates by Travel Zone and Moisture Year (continued)

Travel Zone	Forage Area Number	Name of Travel Zone or Forage Area	Dry Year <50% of average snowpack	Normal Year 50%-150% of average snowpack	Wet Year >150% of average snowpack
80	all	Tyndall Creek	20-Jun	1-Jul	25-Jul
81	1-2.2, 2.4	Wright and Wallace Creeks	20-Jun	1-Jul	25-Jul
81	2.3	Wallace Creek Waterfall	1-Jul	15-Jul	10-Aug
82	all	Upper Kern Canyon (Junction Mdw to Hot Springs)	25-Jun	5-Jul	25-Jul
83	1-3, 5-8	Lower Crabtree	20-Jun	1-Jul	1-Aug
83	4	Upper Crabtree	5-Jul	15-Jul	20-Aug
84	all	Lower Rock Creek	20-Jun	1-Jul	1-Aug
85	all	Upper Rock Creek	1-Jul	15-Jul	15-Aug
86	all	Lower Kern Canyon (Hot Springs to Kern Ranger Station)	1-Jun	15-Jun	1-Jul
87	all	Chagoopa Plateau and Big Arroyo	20-Jun	10-Jul	10-Aug
88	1-2	Little Five Lakes	1-Jul	15-Jul	10-Aug
88	3-5	Big Five Lakes	15-Jul	25-Jul	15-Aug
89	1-4, 10	Lost, Soda, Lower Rattlesnake, Laurel, Crytes, Coyote	15-Jun	1-Jul	1-Aug
89	5-9	Upper Rattlesnake (>9,000 feet)	1-Jul	15-Jul	15-Aug
90	all	Hockett	10-Jun	20-Jun	20-Jul
91	all	South Fork Kaweah River	1-Mar	15-Mar	1-Apr
95	all	North Fork Kaweah River	1-Mar	15-Mar	1-Apr

Grazing Levels

The total amount of grazing in each of the meadows and related forage areas open to grazing would be guided by the estimated grazing capacities described in attachment 1. Depending on the meadow characteristics, any impact could be a limiting factor for the amount of grazing that can take place. For example, stream bank shearing could reach unacceptable levels—and trigger management action—before the amount of trampling, social conflicts, species composition changes, or defoliation reaches an unacceptable level.

Due to the inherent delays in use reporting and the variability in the timing and intensity of recreational grazing, actual use of individual areas may be somewhat higher than the estimated capacity in some years and lower in others. For this reason administrative use of specific forage areas which are also used by the public would be kept below the estimated capacity and work would be planned to minimize competition for grazing.

Traditional methods of adjusting grazing levels and patterns would be employed when necessary, including:

- adjusting the number of nights a given party may graze an area
- adjusting the number of stock per party that may graze in a specific area
- allocation of grazing to specific users (administrative, commercial, or private)

- adjusting opening dates
- adjusting the total amount of grazing that occurs within a growing season
- closing an area to grazing (or a portion of it, if feasible) temporarily

Forage areas may be temporarily closed to grazing due to stock impacts and when recovery has been sufficient those areas would be reopened. Such closures would be recommended to the appropriate district ranger by field personnel during the grazing season for immediate implementation, or proposed to the Superintendent following the annual review of monitoring results for implementation during the following season. Procedures for implementing mid-season management actions are described in Management Directive No. 9: Wilderness Stock Use and Group Size Management (NPS 2013b). All use levels would be subject to change as conditions and monitoring data indicate. Changes would be announced by March 1st of each year, with opportunity for comment by interested parties. In order to ensure that the estimated capacities reflect the most current knowledge of meadow response to grazing, capacities would undergo a comprehensive reevaluation every five years, with annual modifications as needed to ensure resource protection. Changes to capacities would be made available for public comment by March 1st of each year along with other public use limits.

Drift Fences, Hitch Rails, and Temporary Means for Holding Stock

Preventing stock from leaving a preferred grazing area and entering areas where grazing is prohibited can be challenging. In areas of higher use that are adjacent to sensitive or at risk resources, drift fences can be a tool to prevent stock from traveling away from the preferred grazing area into closed areas. Besides drift fences, users would have a wide variety of tools at their disposal which could be used to manage their stock. These tools would include electric fences, hobbles, high lines, hand grazing and in limited circumstances, pickets. These tools, often used in combination with natural features, can be effective in containing stock.

In some instances users may be able to use a temporary barrier at a pinch point to contain stock. These temporary barriers can be a very effective and low impact tool to contain stock. Temporary barriers which have been successfully used at pinch points include logs and ropes. When users are considering using a temporary barrier at a pinch point, great consideration must be given to doing so without hampering the travel of other users. Temporary barriers may only be used when stock is actually roaming free in permitted grazing areas and they must be removed when the stock is gathered. Damaging natural resources when constructing temporary barriers is prohibited.

Drift fences and hitch rails would be provided by the NPS in specific locations for visitor safety, resource protection, and visitor or administrative convenience. Fences maintained primarily for convenience would also protect resources and visitor experience, through dispersal of stock use and protection of sensitive areas. Fences and hitch rails that become unnecessary would be removed. An inventory of such installations in wilderness would be maintained by the trails program with input from wilderness field staff, and maintenance conducted under the direction of the trail maintenance program. The establishment of any new fence or hitch rail, temporary or permanent, would require separate planning and compliance, which would be conducted prior to construction. Detailed justification including a minimum requirements analysis and a description of the fence route and dimensions would be required for consideration.

The treatment of specific hitch rails and drift fences varies by alternative in this WSP/FEIS; see table 51b in chapter 2 for a list of those retained under the preferred alternative.

Minimum Impact Stock Use Practices

The following restrictions and recommended practices would minimize the impact of stock to camps and trails and to allow for the restoration of impacted areas:

1) Stock would be tethered to trees for no more than enough time to unpack the animals. Animals pawing the soil away at the base of individual trees cause soil disturbance, root damage, and debarking of trees. Deep depressions and exposed roots are visible evidence of the types of impacts this regulation is designed to prevent.
2) Stock held for periods longer than for unpacking (such as for overnight), would be tethered to a line tied between two trees or rocks. The line must be located on a hardened (flat, sparsely vegetated) site to limit impacts to tree roots and plants.
3) Picketing would be allowed for short periods of time provided that animals are moved frequently to prevent resource impacts.
4) The use of temporary electric fences is allowed for holding lead animals when stock are turned out to graze; as with picketing, such enclosures must be moved frequently to prevent resource impacts.
5) When camping, animals would not be confined within 100 feet of lakes, streams, trails or campsites except while loading or unloading. Manure deposited within or at the perimeter of camps while loading or unloading would be dispersed and scattered to points at least 100 feet from camps, water, or trails. This distance protects water quality, lessens impact on the campsite, and helps reduce insect problems.
6) Stock present in forage areas prior to opening dates or areas closed to grazing would be confined as per (2) and (3), and fed.
7) Shortcutting trails and switchbacks would be prohibited.
8) Loose herding—when riderless animals are not being led by ropes—would be prohibited except as necessary for safety where the exposure is great and there is danger of animals falling off the trail.
9) Stock manure handling best practices—The following best management practices can reduce the impacts of stock manure and urine on the natural environment and protect aesthetic aspects of wilderness character. Scattering (kicking) manure piles increases decomposition rates, reduces odors and fly concentrations, and reduces the potential for manure to enter water bodies.

   Required:

   - Remove manure from within 100 feet of core camping and tie-up areas and scatter manure on dry terrain. The core camp is defined as that area within 100 feet of the fire ring or cooking area.

   Recommended:

   - Carry a shovel and rake, and keep them readily accessible, for use in cleaning up and naturalizing areas.
   - Scatter manure whenever encountered, paying particular attention to manure piles in or near water. Remove manure piles from water whenever possible. Scatter manure that accumulates at riding break areas.

- After stock have grazed or have been held in an area, inspect the area and scatter manure piles.
- Take measures that give stock an opportunity to urinate and defecate away from water (e.g., stop to let them urinate before leading them into water to drink).
- At parking areas and trailheads, pick up and remove all manure from the parks.

In addition to the above restrictions and recommended practices, guidelines for minimum impact travel with stock would continue to be provided to all users online, at permit issuing stations, during seasonal orientation sessions, and through directed mailings to commercial service providers and interested members of the public.

TRAIL USE AND OFF-TRAIL/CROSS-COUNTRY STOCK TRAVEL

The majority of wilderness stock use occurs on the primary trail system in the parks. Current regulations (36 CFR Sec. 2.16 (b and d)) require that the superintendent designate areas and trails that are open to stock travel. The areas and trails proposed open to stock travel under the preferred alternative are described in chapter 2 of this WSP/FEIS (refer to figures 8a and 8b [alternative 1], figures 14a and 14b [alternative 2], 17a and 17b [alternative 3], 19a and 19b [alternative 4], and 22a and 22b [alternative 5] in chapter 2 for stock access and grazing restrictions).

Maintained Trails

Under the preferred alternative, visitors traveling with stock would continue to have access to most maintained trails in the parks (650 of 691 miles). Stock parties would be allowed to travel up to one-half mile from trails in areas where they are allowed to camp. In areas open to day-use only, stock parties would be allowed to travel up to 100 yards from trails. Approximately 530 miles of maintained trails would be open to overnight stock travel. Some trails would be open to stock parties for day use only, some would be open to overnight use for walking parties with burros and llamas (as they cannot travel as far in a day) but limited to day use for parties with horses or mules, and some would be closed to stock travel entirely for reasons including visitor safety, natural and cultural resource protection, and/or popular day use by hikers. Trails with restricted stock access under the preferred alternative are listed in chapter 2 of this WSP/FEIS.

Off-Trail Travel

Stock parties would continue to be allowed to travel up to one-half mile from trails to reach camps. Travel more than one-half mile from maintained trails would continue to be allowed in four areas of the parks: on the Hockett Plateau, on the Monarch Divide, in the Roaring River drainage, and along the western side of the Kern River watershed south from the Chagoopa Plateau.

Trails and areas open to use may be changed from time to time in order to provide for visitor safety or resource protection. Areas or trails that have been closed may be reopened where there is evidence that no resources of the parks or other values would be compromised. Unless in response to emergency conditions, the public would be notified of proposed modifications of areas and trails open to stock through press release and posting on the parks website; comments may be sought before a decision is made.

INTEGRATION OF MONITORING RESULTS INTO MANAGEMENT ACTIONS

Successful adaptive management relies on the formal integration of monitoring results into appropriate management action. The monitoring program described here is designed to detect and characterize impacts, and to provide information to adjust stock use when impacts exceed established standards. Standards are set to ensure that impacts are limited to levels that protect the long-term integrity of meadow habitats and that resource impairment is prevented through timely management action.

Should observations made during site visits indicate a need for immediate management action, field staff would continue to follow the procedures described in Management Directive No. 9: Wilderness Stock Use and Group Size Management (NPS 2013b). This directive describes the procedures for adjusting seasonal opening dates, and defines how case-by-case temporary meadow closures, variances for group sizes (both people and stock), and variances in grazing night limits and limits on the total amount of grazing in a meadow are made. It also establishes who is authorized to adjust opening dates and make closures and how that information is communicated to the public and park staff.

Monitoring data would continue to be summarized annually and provided to the Stock Use and Meadow Management Committee. This committee would continue to meet once each year mid-winter to discuss issues pertaining to stock use and meadow management in the wilderness of the two parks. The interdisciplinary committee would continue to be composed of representatives from most divisions of the park, including wilderness managers, trails staff, and resource specialists. The annual meeting would serve two purposes: to share results from the stock use and meadow monitoring program, and to provide a forum for the discussion of stock use management issues. Results from the previous years' monitoring program would be presented, and where conditions indicate a need for action, alternatives proposed and discussed. If a need for imposing or lifting formal restrictions on stock use should arise, recommendations would be made to the superintendent for final approval. A notice of temporary restrictions for the upcoming season would be distributed to users by March 1, and submitted to the law enforcement specialist for inclusion in the Superintendents Compendium at the same time. Area specific management actions that do not require formal restrictions—such as encouraging use of one meadow over another, or modifying administrative grazing plans—would continue to be discussed at subsequent district-level operations meetings held each spring, and communicated to field staff during early season training and orientation sessions.

Public Notification of Temporary Use Restrictions and Wilderness Conditions

Public notification of temporary restrictions on wilderness travel for the upcoming year would be provided via bulletin and posted online each year in early March. Grazing regulations, restrictions, and trip planning information, including detailed maps and descriptions of forage areas, would be posted online each year at the beginning of the grazing season, sent via mail to all commercial users, and provided to private users on request. Opening date bulletins, which include anticipated opening dates for grazing, would be sent out and posted following the early April and May snow surveys. Information regarding meadow status throughout the season—changes to opening dates at the beginning of the season, and closures as grazing capacities are reached—would be posted online, communicated via phone to commercial operators, and provided to all users who contact the wilderness office or a permitting station by phone or in person as it becomes available from the field. All users must recognize, however, that such information may not always be available and incorporate flexibility in their trip planning accordingly. Wilderness travel by its nature involves a degree of uncertainty and this is reflected and celebrated in the lack of designated campsites or allocated grazing nights in the wilderness areas managed by Sequoia and Kings Canyon National Parks.

Table D-6 provides a summary of monitoring measures and activities and proposed thresholds for triggering management actions. An explicit goal of stock use management is to select actions that are appropriate to the extent and severity of the observed impacts, and to acknowledge the variability of ecosystems and the statistical uncertainty associated with sampling those systems. Therefore, this strategy enumerates several actions for each monitoring program and threshold. More aggressive actions would be taken where impacts are more significant and certainty is high, while less aggressive actions would be taken where impacts are less significant or certainty is low. This would provide managers with the flexibility to meet the overall goals and objectives of the plan.

Table D-6: Meadow Monitoring Data, Measures, Thresholds for Action, and Actions

Monitoring Data, Measure	Threshold	Actions
Stock use, percentage of estimated grazing capacity	Current year's use is greater than 100% of estimated capacity.	Site visit during current year (if possible) or following year Consider establishing residual biomass or bare ground monitoring. Temporary reduction in the following year's capacity if conditions indicate.
	Previous five years' average use is 80-100% of estimated capacity.	Annual site visits to determine the need for management changes. Consider establishing RB or bare ground monitoring.
	Previous five years' average use is 50-80% of estimated capacity.	Site visits at least every 2 years to determine the need for management changes.
	Previous five years' average use is less than 50% of estimated capacity.	Site visits at least every 5 years to determine the need for management changes.
Site visits, qualitative evaluations	Stock impacts to vegetation cover or soil stability in springs, seeps, or stream banks observed.	Consider a temporary grazing closure to prevent further impacts. Document and establish monitoring (follow up site visits, repeat photographs, or streambank alteration as appropriate). Reevaluate opening date. Reevaluate grazing capacity.
	Stock impacts to vegetation cover or soil stability in springs, seeps, or stream banks result in accelerated erosion or instability.	Consider a temporary grazing closure until vegetation and soils have stabilized. Consider active restoration of disturbed soils and vegetation Document and establish monitoring (follow-up site visits, repeat photographs, or streambank alteration as appropriate). Reduce stock impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate opening date. Reevaluate grazing capacity.

Table D-6: Meadow Monitoring Data, Measures, Thresholds for Action, and Actions (continued)

Monitoring Data, Measure	Threshold	Actions
Site visits, qualitative evaluations (continued)	Deep hoof prints observed in a sensitive area (spring, seep, steep area, rare plant population, amphibian habitat, etc.) or over a majority of the meadow area.	Consider a temporary grazing closure. Reduce stock impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate opening date. Reevaluate grazing capacity.
	Closely cropped or trampled vegetation observed in a sensitive area (spring, seep, steep area, rare plant population, amphibian habitat, etc.) or over a majority of the meadow area.	Consider a temporary grazing closure. Reduce stock impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate grazing capacity.
	Introduced species with the potential for spread detected.	Document extent and abundance. Provide to vegetation management program. Control immediately if feasible. Refer to vegetation management program if not feasible. Modify stock use to prevent spread, if appropriate.
Residual biomass, percentage of annual production	Less than 55% in -moist lower montane meadows with high logistical value.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
	Less than 65% in - dry or wet lower montane meadows with high logistical value - moist lower montane meadows with low logistical value - upper montane and subalpine meadows with high logistical value.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
	Less than 75% in -dry or wet lower montane meadows with low logistical value -upper montane and subalpine meadows with low logistical value.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
Bare ground, percentage of soil surface	Bare soil cover value within range for low ecological condition (values to be determined).	Site visit to assess meadow condition and contributing factors.
	Bare soil cover value within range for low ecological condition (values to be determined) for two successive monitoring periods and site visit indicates stock use is a contributing stressor for both monitoring periods.	Reduce impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate opening date. Reevaluate grazing capacity. Consider temporary grazing closure until bare soil cover value improves. Monitor annually for 3-5 years or until bare soil cover value falls within range for moderate or high ecological condition (values to be determined).
	Bare soil cover value double the value for low ecological condition (values to be determined), or previous management actions have been ineffective, or monitoring for 3-5 years has not shown improvement in bare ground.	Discontinue grazing until bare soil cover value falls within range for moderate or high ecological condition (values to be determined).

Table D-6: Meadow Monitoring Data, Measures, Thresholds for Action, and Actions (continued)

Monitoring Data, Measure	Threshold	Actions
Streambank alteration	Streambank alteration is associated with accelerated erosion or instability.	Consider a temporary grazing closure until vegetation and soils have stabilized. Consider active restoration of disturbed soils and vegetation. Reduce stock impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate opening date. Reevaluate grazing capacity.
Species composition, percent change	Greater than 15 percent change in the dominant species as recorded by the frequency plots.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
	Greater than 15 percent increase in the proportion of bare ground and with observed erosion.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.

RELATIONSHIP TO OTHER MONITORING PROGRAMS

In addition to the specific monitoring protocols described here, there are a number of other programs in place that will provide information relevant to the management of stock use and grazing in wilderness meadows. These include, but are not limited to, the following:

- The Sierra Nevada Network Inventory and Monitoring Program has implemented a long-term Wetland Ecological Integrity monitoring protocol in Kings Canyon, Sequoia, and Yosemite National Parks (Gage et al. 2014). This protocol is designed to characterize the status of and detect changes in wetland water dynamics, plant community composition, and macroinvertebrates in wet meadows and fens. The integration of multiple vital signs in this protocol will improve the ability to understand and interpret change in ungrazed wetland systems, providing important comparison for similar systems that are subject to grazing by pack stock. The inclusion of a bare soil measurement in the permanently marked plots would contribute to a better understanding of the range of variability in this measure in ungrazed wet meadows and fens. There is also tremendous potential for collaboration between this program and the stock use and meadow management program, as both require similar skill sets and deploy field biologists to park meadows.
- The USFS monitors meadow ecosystems subject to livestock grazing in the national forests adjacent to Sequoia and Kings Canyon National Parks, and this information has been used to develop preliminary standards for bare soil for park meadows (Weixelman and Zamudio 2001) as well as provided insights into meadow ecosystem dynamics and response to grazing (Freitas et al. 2014). Sampling by USFS ecologists using this protocol in ungrazed Sequoia and Kings Canyon meadows is scheduled to begin in 2015, which would further contribute to characterization of the range of variability in bare soil and vegetation parameters in park meadows.
- As part of planning efforts focused on the Merced and Tuolumne River corridors in Yosemite National Park, the NPS has identified indicators of meadow condition and developed monitoring protocols which will also help increase the understanding of the natural range of variability in these systems (NPS 2014a, 2014b). Implementation of these protocols would also allow for the continued collaborative development of monitoring and management strategies in the Sierra Nevada parks.

RESOURCE REHABILITATION AND RESTORATION

In areas where past use has caused detrimental effects to vegetation, soils or other resources, the NPS would evaluate the effects and may undertake rehabilitation or restoration. This could include actions such as filling eroded trail beds or hitching areas and revegetating the areas. It could also include re-routing of trail segments to avoid sensitive resources, relocating camps, or the removal of nonnative plant species. Such trail management activities would be guided by the trails management plan described in appendix K of this plan, while the control of non-native plants would be guided by appendix N of this plan, the Resource Stewardship Strategy (in development) and/or a future Invasive Plant Management Plan.

RESEARCH NEEDS

Continued learning through scientific investigation and evaluation of new information is a critical component of the adaptive management process. Although the past decade has seen a marked increase in research interest in the meadow and wetland systems of the Sierra Nevada, additional research in the coming years will lead to a better understanding of wetland ecosystem dynamics. In particular, information is needed on environmental effects across ranges of use levels (e.g., frequency, duration, or intensity gradients) would enhance our understanding of effect thresholds and further inform the management of stock in wilderness (Ostoja et al. 2014). The following sections describe a limited selection of ongoing, planned and potential research topics that would be expected to improve the knowledge of ecosystem dynamics and further inform decisions regarding stock use and grazing management.

DETERMINING VULNERABILITY OF SIERRA NEVADA MEADOWS TO CLIMATE CHANGE

Sierra Nevada land managers have come to recognize that threats posed by climate change may now exceed those posed by anthropogenic activities. Although local land managers can do little to influence global climate trends, it is critically important that they understand how resources may be affected by the simultaneous effects of climate change and land use stressors. Understanding how climate change affects meadow ecosystems, which are centers of biological diversity and productivity, will be a central component of any climate change adaptation strategy for the Sierra Nevada. Although recent studies provide detailed descriptions of hydrologic processes within a few individual meadows, to date there has not been an attempt to characterize the key hydrologic attributes of large groups of meadows over broad landscapes in the Sierra Nevada. This information is needed to classify meadows for their relative vulnerability to climate change versus land use factors. Through this project, research scientists at the USGS Yosemite Field Station are creating a hydrologic vulnerability to climate change assessment for the more than 9,000 meadows located within the national parks of the central and southern Sierra Nevada.

REFINING MEASUREMENTS OF PRODUCTIVITY AND BARE GROUND IN PARK MEADOWS

In order to protect the natural quality of wilderness character while continuing to allow stock use to occur, the proposed monitoring and management strategy described in this WSP/FEIS specifically seeks to limit stock-induced changes in bare ground and plant productivity. The plan proposes preliminary grazing capacities based on modeled estimates of productivity, and preliminary standards for bare ground in grazed meadows that are based on work done primarily on USFS meadows. As the current and proposed monitoring program is primarily dedicated to assessing conditions in grazed meadows, limited direct information is available to judge whether observed bare ground and productivity on a given meadow site in these parks are altered due to visitor activity. Additional research focused on characterizing the range of bare ground and productivity values in ungrazed reference meadows in the parks' wilderness would allow the parks to revise the preliminary standards proposed by the WSP/FEIS for these two attributes. A study design that employed randomized site selection stratified across the primary environmental gradients of importance (e.g., elevation, moisture, and species composition) would allow for broad applicability of reference data for comparison with sites used by stock.

ASSESSING POTENTIAL EFFECTS OF STOCK USE ON WILDLIFE

Although much work has been done to investigate the effects of cattle on wildlife, the applicability of these studies to pack stock effects is limited, especially in the parks where livestock grazing is prohibited (Ostoja et al. 2014). Studies specific to the effects of pack stock on meadow-dependent vertebrates, such as small mammals are thus a high priority for additional research.

DETECTING CHANGES IN SPECIES COMPOSITION IN GRAZED MEADOWS

The WSP/FEIS proposes to continue monitoring species composition in five pairs of grazed/ungrazed meadows as part of an ongoing long-term monitoring protocol. Although this dataset provides detailed information in these specific meadow pairs, and can serve as a trigger for additional monitoring in other meadows, due to constraints in the study design these results cannot be extrapolated to other meadows in the parks without caution. Through the Wetland Ecological Integrity protocol described above, changes in species composition in ungrazed meadows—in response to factors other than grazing—may be detected and be used to inform management actions where appropriate. Expanding the network of species composition study sites in grazed meadows would increase the likelihood of detecting changes occurring as a result of stock use while improving the understanding of the interaction of external stressors, such as climate change, and stock use. Revisiting the transects established by Bennett in 1965, which were subsequently re-read by Strand (1972) and Mazzu (1987), could be encouraged as a potential masters level research project. Abbott et al. (2003) also suggested that species composition could be characterized as part of the residual biomass monitoring protocol. Although assessing species composition requires specific technical expertise, such an approach may be worth exploring should such staffing be available in the future.

TEMPORARY VARIANCES AND MODIFICATIONS TO THE STRATEGY

TEMPORARY VARIANCES

Climatic conditions, accessibility to portions of the wilderness, needs and interests of wilderness stock parties, and other factors change from year to year, making it possible to consider temporary variances in site-specific guidelines.

Variances could be made in opening dates, numbers of stock per trip, number of nights per area, number of stock per area, etc. Such variances would normally be granted on a case-by-case basis to accommodate special visitor needs where the effects on wilderness character, the parks' resources and other visitors would be within acceptable limits. Short-term or one-time-only variances proposed by visitors would be considered on a case-by case basis by the Superintendent, and if approved would likely be subject to special conditions. Requests for variances should be made in writing at least four weeks in advance to provide adequate time for consideration.

MODIFICATIONS TO THE STRATEGY

As knowledge of meadow systems, technology, and field techniques evolve, the methods used to monitor stock use and resource conditions will be subject to change and improvement. The process by which grazing levels would be evaluated is described in attachment 1. Significant changes to monitoring protocols would be subject to the appropriate level of peer review and provided to the public for comment.

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ATTACHMENT 1:

GRAZING CAPACITIES FOR RECREATIONAL PACK AND SADDLE STOCK – BACKGROUND AND USE IN SEQUOIA AND KINGS CANYON NATIONAL PARKS

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Grazing Capacities for Recreational Pack and Saddle Stock – Background and Use in Sequoia and Kings Canyon National Parks

LIMITING IMPACTS FROM STOCK GRAZING

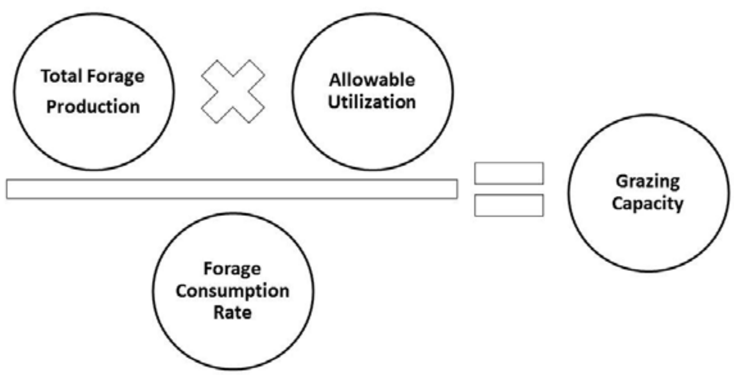
There are several ways that grazing stock can impact natural resources and other wilderness users. Setting a limit on the total amount of grazing allowed within one growing season is one management tool that the NPS can use to keep impacts within standards in the parks.

Depending on the meadow characteristics, any one kind of impact could be a limiting factor for the amount of grazing that can take place. For example, stream bank shearing could reach unacceptable levels before the amount of trampling, social conflicts, species composition changes, or defoliation reaches an unacceptable level. Because defoliation has the closest relationship to grazing (defoliation being a necessary impact for grazing to occur rather than an undesirable side effect which can be mitigated) it is the starting place for developing capacities. The methodology used to estimate capacities for grazing in the parks' meadows is described below.

GRAZING CAPACITY MODEL

Ratliff et al. (1987) present a grazing capacity model based on the ability of Sierra Nevada meadows to produce foliage palatable to stock while leaving enough plant biomass for maintenance or improvement of meadow condition and for meeting other management goals, such as wildlife habitat protection. This model was first applied to the parks' meadows grazed by pack stock in 1992 (Neuman 1994). With modification for wilderness management, this basic model provides a framework for defining and establishing annual grazing capacity.

The model includes total forage production, allowable utilization (the proportion of forage production which can be grazed), and a forage consumption rate by pack and saddle stock.



FORAGE PRODUCTION

Net primary productivity (hereafter, "productivity") is the amount of solar energy captured by plants minus the amount of energy used by the plant for respiration; it is expressed per unit area. Measurements of aboveground biomass (the dry weight of plant material per unit area present at one point in time) at the end of the growing season are commonly used to estimate productivity for herbaceous species in temperate environments. Productivity varies across the landscape due to many abiotic and biotic factors (Barbour et al. 1998). In the Sierra Nevada, the factors that are most relevant are elevation, moisture availability, and condition; in the absence of site-specific data, these are the factors used to predict productivity. The total amount of forage produced will be a product of the area and productivity.

Productivity

Measuring productivity at a specific site over a period of several years (to account for climate variation) is the most precise way of estimating forage production. In the absence of productivity data collected from a particular site, regression relationships developed from existing data can be used to estimate the amount of productivity. The regression models provided in Ratliff et al. (1987) take into account elevation, broad moisture regimes, and condition.

Elevation: All else being equal, meadow productivity decreases as elevation increases (Ratliff 1985; Ratliff et al. 1987). The model assumes a linear decline with elevation.

Moisture: Moisture availability influences both species composition and productivity (Ratliff 1985; Ratliff et al. 1987). The productivity model assumes that meadows can be assigned to one of three moisture classes (Ratliff et al. 1987). Moist meadows with shorthair grass (*Calamagrostis muiriana*), tufted hairgrass (*Deschampsia cespitosa*), or Nebraska sedge (*Carex nebrascensis*) as dominant species are the most productive. Wet meadows with beaked sedge (*Carex utriculata*, C*. vesicaria*) or spikerush (*Eleocharis acicularis*, *E. pauciflora*) as dominant species are intermediate in productivity. Dry sites with shorthair sedge (*Carex filifolia*) as the dominant species are the least productive. In comparing published information, different authors may assign a given species to different moisture categories.

Within any given meadow, a range of moisture conditions and several dominant species will exist. Because horses and mules are selective grazers and do not graze evenly across the meadow, the moisture category (wet, moist, or dry) of the vegetation favored by stock in a given forage area is used to estimate productivity.

Condition: Productivity may vary with species composition and plant vigor, and how intact litter and soils are. Taken together these factors can be considered as "range condition" and included as a factor in the productivity model. Ratliff et al. (1987) assume a decline in the productivity of forage species related to condition based on data presented in Crane (1950).

The decline in productivity is assumed to be the same at all elevations and moisture types (Ratliff et al. 1987). Meadows in excellent condition are assumed to have the maximum productivity. Productivity for other condition levels is given in reference to maximum productivity: good condition produces 65%, fair condition 44%, and poor condition 25%. No reduction was presented for very poor condition meadows.

The missing litter and humus, broken sods, and erosion that characterize fair, poor, and very poor condition meadows are rare in the parks' meadows, and where they occur, are limited to very small portions of the meadow (although before effective grazing controls were implemented, these impacts were more widespread; see Sumner 1941, Sharsmith 1959, and others). The meadows classified as "excellent" condition by Crane (1950) were largely cultivated and irrigated pastures, while natural meadows generally fit the criteria for "good" condition. Ratliff (1985) applied contemporary condition class concepts (USFS 1969) to 90 non-randomly selected Sierra Nevada meadows and found 27% to be in excellent condition and 26% in good condition. Therefore, it is assumed that 65% of maximum productivity is a conservative, reasonable value to use in estimating the forage productivity of the parks' meadows.

Productivity model: Given these assumptions, the productivity of dry, moist, and wet meadows can be estimated by the following equations where productivity is in units of pounds per acre, and elevation is in units of feet.

- Dry: Productivity = 2275 - 0.175 * Elevation
- Moist: Productivity = 4725 - 0.325 * Elevation
- Wet: Productivity = 4705 - 0.36 * Elevation

Productivity for other condition classes can be calculated using the coefficients in table D-15. Predicted forage productivity values calculated from data in Ratliff et al. (1987) are illustrated in figure D-1.

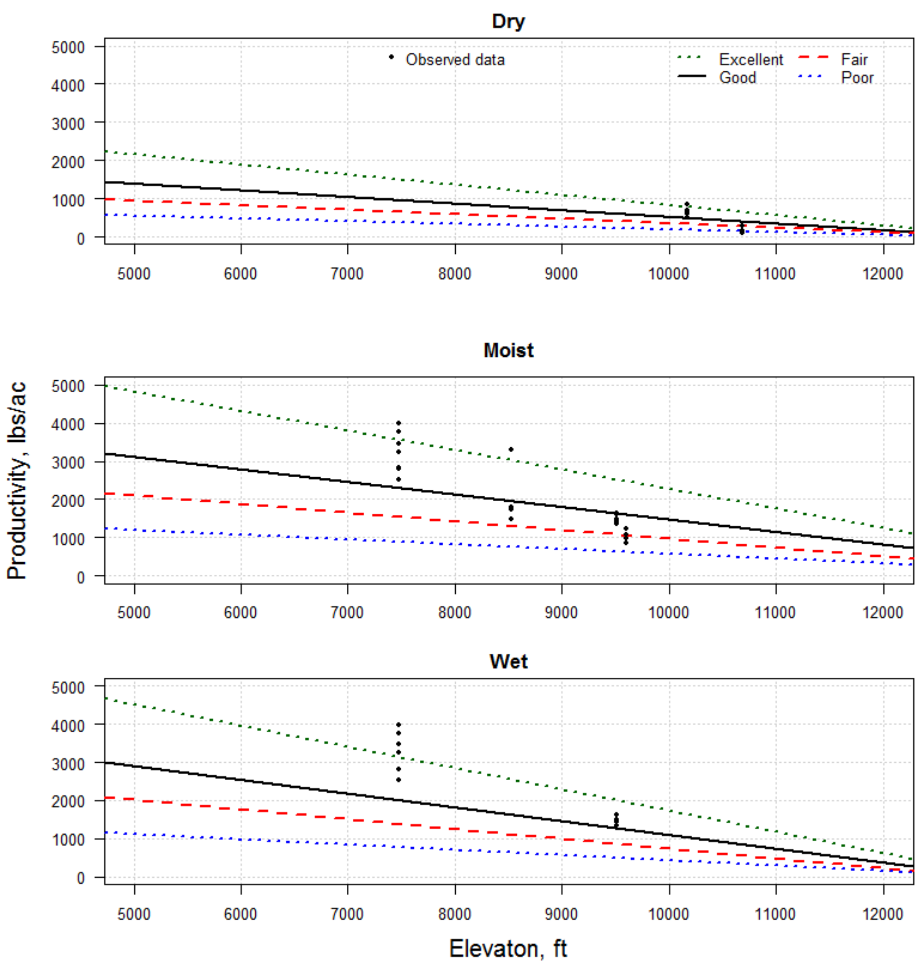


Figure D-1: Predicted productivity (pounds/acre) by elevation (feet) for three moisture classes (dry, moist, wet), and four condition classes (excellent, good, fair, poor)

While Ratliff et al. (1987) does not provide information about model fit, data reported from other locations in the Sierra Nevada can provide some estimate of the uncertainty of productivity estimates.

Productivity values from locations in the Rock Creek drainage of Sequoia National Park were measured over 5 years (Stohlgren et al. 1989). They reported productivity for three vegetation types as the mean across seven sites. Observed mean productivity was significantly lower (41 – 117% of predicted) than that predicted by the model (table D-7). The poorest agreement was for the dry site, while the best fit was for the wet-moist site.

Table D-7: Comparison of Model Productivity Values to Measured Productivity from Three Vegetation Types in Sequoia National Park

Site and Characteristics	Year	pounds/acre	% of Predicted	
Rock Creek and Miter Basin, Dry, 10400 - 11600 feet Dominant species: *Carex filifolia* Predicted productivity: 405 pounds/acre (at the weighted mean elevation of 10685 feet)	1977	297	73%	
	1978	171	42%	
	1979	120	30%	
	1980	145	36%	
	1981	101	25%	
	Mean	**167**	**41%**	
Rock Creek Ranger Station, Moist, 9600 feet Dominant species: *Eleocharis pauciflora - Calamagrostis breweri* Predicted productivity: 1607 pounds/acre	1977	986	61%	
	1978	981	61%	
	1979	869	54%	
	1980	1078	67%	
	1981	1217	76%	
	Mean	**1026**	**64%**	
Lower Rock Creek, Moist-Wet, 9400 – 9600 feet Dominant species: *Deschampsia caespitosa* Predicted productivity: 285 pounds/acre if “wet” (at the mean elevation of 9514 feet) Predicted productivity: 1637 pounds/acre if "moist" (at the mean elevation of 9514 feet)	1977	1635	127%	100%
	1978	1486	116%	91%
	1979	1353	105%	83%
	1980	1433	112%	88%
	1981	1617	126%	99%
	Mean	**1505**	**117%**	**92%**

Source: Stohlgren et al. 1989

Data from three locations in Yosemite National Park over 7 years of study (Moore et al. 2013) indicates that the measured productivity values were much higher than predicted at the high elevation xeric site and the low elevation hydric site, but were slightly lower than predicted at the middle elevation mesic site (table D-8).

Table D-8: Comparison of Model Productivity Values to Measured Productivity from Three Sites in Yosemite National Park

Site and characteristics	Year	pounds/acre	% of Predicted	
Gaylor Lakes, Dry, 10170 feet Dominant species: *Carex filifolia* Predicted productivity: 495 pounds/acre	1994	688	139%	
	1995	518	105%	
	1996	645	130%	
	1997	594	120%	
	1998	693	140%	
	1999	851	172%	
	2000	863	174%	
	Mean	**693**	**140%**	
Tuolumne Meadows, Moist 8530 feet Dominant species: *Calamagrostis breweri* Predicted productivity: 1952 pounds/acre	1994	3296	169%	
	1995	1472	75%	
	1996	1730	89%	
	1997	1782	91%	
	1998	1480	76%	
	1999	1769	91%	
	2000	1806	92%	
	Mean	**1906**	**98%**	
Harden Lake, Moist-Wet, 7480 feet Dominant species: *Deschampsia cespitosa* Predicted productivity: 2012 pounds/acre if “wet” Predicted productivity: 2294 pounds/acre if "moist"	1994	3983	198%	174%
	1995	2522	125%	110%
	1996	3468	172%	151%
	1997	3754	187%	164%
	1998	2799	139%	122%
	1999	2824	140%	123%
	2000	3249	161%	142%
	Mean	**3229**	**160%**	**141%**

Source: Moore et al. 2013

These comparisons of model predictions to observed data indicate that productivity values from the model may be inaccurate for any given site or vegetation type. Furthermore, there is considerable interannual variability which may make model predictions a better or worse fit depending on the year.

Area

Calculating capacities for management units of interest requires determining how much grazing area is available. Forage areas are defined as the primary meadows and their associated forested or upland grasslands, which are commonly used by stock for grazing. Therefore, the forage area is the scale at which grazing capacities are calculated.

Total area: The total amount of meadow area in each forage area was calculated from vegetation maps (NPS 2007).

Preferred Proportion: Because horses and mules are selective grazers and overall grazing pressure is light, grazing impacts are generally concentrated in one vegetation type ("patch grazing," McClaran and Cole 1993). For each forage area in the parks, a preferred proportion (1-100%) has been assigned. This is an estimate of the proportion of the entire forage area occupied by vegetation types favored for grazing by horses and mules.

Initial estimates of the preferred meadow vegetation proportion were assigned to the parks' forage areas by Neuman (1994) who described preferred forage as "grasses (both small, fine-leaved species and taller species) and medium sedges, occupying sites that are neither particularly dry nor wet." These estimates are periodically revised as new information is obtained about stock grazing patterns. This information is most reliably obtained by observing actual stock grazing patterns at the end of the grazing season and noting the species which have been grazed by stock and their extent. Where this information is not available, the extent of preferred vegetation can also be estimated by extrapolating observed stock grazing patterns from similar forage areas.

The preferred proportion for all forage areas in the parks was reviewed between 2012 and 2014. Where site knowledge or other information provided more precise estimates of the amount of meadow vegetation favored by stock, the preferred proportion was revised. The review also ensured that the preferred proportion did not include any peat accumulating area within the forage area.

Upland Forage: In some areas, graminoids in non-meadow upland areas may provide some or all of the preferred forage. The extent of upland forage has been described narratively for some areas, but reliable productivity values are not available. If quantitative data for the extent, productivity, and appropriate utilization rate become available, this data can be used to estimate capacity in upland areas using the same basic model as for meadow vegetation. Until quantitative data on the extent, productivity, and appropriate utilization rates for these areas become available, narrative descriptions may be used to identify management areas where total forage is grossly underestimated, and to adjust capacities upwards based on past use patterns and observed impacts (see the "Evaluation and Revision of Capacities" section).

ALLOWABLE UTILIZATION

The amount of biomass that should be left ungrazed for the purposes of maintaining a litter and humus layer on the soil, for wildlife habitat, for maintaining the health of vegetation, and for other purposes will vary with the management goals for individual meadows. In perennial grasslands such as mountain meadows, the amount of biomass to leave at the end of the growing season has generally been defined as a percentage of total biomass production. The proportion of total biomass production which can be grazed while meeting management goals is "allowable utilization." The amount of vegetation remaining ungrazed at the end of the season is referred to as "residual biomass."

Existing utilization guidelines

Guidelines for appropriate utilization rates for Sierra Nevada meadows have evolved over time.

Consistent with range standards at the time, Crane (1950) suggested that utilization guidelines of 60-70% were appropriate for Sierra Nevada meadows used for livestock production.

Ratliff (1976, 1980) measured decomposition rates of filter paper and natural herbage *in situ* to estimate how much biomass decomposed annually; these were proposed this as the minimum that should be retained as residual to maintain a meadow at a given condition, and that more could be retained to increase the condition of meadows in degraded condition (Ratliff et al. 1987, table D-9). Ratliff found that decomposition rates were highest at intermediate moisture levels, and suggested that utilization guidelines of 20-45% would be appropriate to either maintain or improve condition of Sierra Nevada meadows (Ratliff 1985).

Neuman (1994) proposed reducing the utilization limits in Ratliff (1985, 1987) by 10 percentage points to reflect more conservative grazing levels in a National Park wilderness area.

Table D-9: Utilization Recommendations by Moisture and Condition

Moisture	Condition	Allowable utilization, Ratliff et al. (1987)
Moist	Excellent	45
	Good	40
	Fair	35
	Poor	30
Dry or Wet	Excellent	35
	Good	30
	Fair	25
	Poor	20

Source: Ratliff et al. 1987

The USFS (2001) adopted utilization limits of 30-40% for montane and subalpine meadows and 10-20% for alpine meadows in the Ansel Adams, John Muir and Dinkey Lakes Wildernesses (table D-10). The higher number is for meadows in high-seral ecological condition and the lower is for meadows in mid- to low-seral ecological condition. High-seral status would roughly correspond to Crane's (1950) excellent condition, and mid to low-seral state would roughly correspond to good or lower conditions although the two condition classifications differ.

Table D-10: Utilization Standards for Herbaceous Perennial Vegetation in Wilderness Meadows of the Sierra and Inyo National Forests

Landscape Zone	Seral Ecological State	Allowable use
Montane and Subalpine	High	40
	Mid to Low	30
Alpine	High	20
	Mid to Low	10

Source: USFS 2001

Yosemite National Park used utilization values of 25% to estimate grazing capacities in the upper montane and subalpine meadows of Upper Lyell Canyon (Ballenger 2013).

A study which evaluated the impacts of a range of utilization rates on three upper montane and subalpine meadow vegetation types in Yosemite National Park described the relationship between utilization rates and impacts to meadow attributes (Cole et al. 2004). The authors fit linear models for the relationships between utilization and productivity, basal vegetation cover, and relative graminoid cover, with variation by vegetation type and number of years of grazing. In dry *Carex filifolia* vegetation, statistically significant relationships for productivity and basal vegetation cover were reported. In mesic *Calamagrostis muiriana* vegetation, statistically significant relationships for productivity, basal vegetation cover, and relative graminoid cover were reported; the relationship with bare ground was statistically significant, but had poor predictive ability. In mesic to hydric *Deschampsia cespitosa* vegetation, only the relationship for productivity was statistically significant.

Cole et al. (2004) suggested that managers could set utilization values by deciding the amount of change in meadow vegetation that would be accepted. This is accomplished by specifying an average level of change for an attribute (e.g., -10%) and then solving for the corresponding utilization value using the regression relationships presented for each attribute and vegetation type (table D-11). The reported coefficient of determination (r^2) value provides a sense of how well utilization predicts the response of interest. Where more than one vegetation type is present in upper montane and subalpine forage areas, one of the combinations of attribute and vegetation type will be the limiting factor, where the level of acceptable change would be reached first.

Table D-11: Utilization Values for Different Levels of Acceptable Change in Attributes for Three Upper Montane and Subalpine Meadow Vegetation Types

Attribute	Vegetation type	r^2	Acceptable change in attribute				
			0%	-5%	-10%	-15%	-20%
Productivity (from peak standing crop)	*Carex filifolia*	0.41	27%	31%	35%	39%	43%
	Calamagrostis muiriana	0.17 – 0.34	5%	15%	24%	34%	43%
	Deschampsia cespitosa	0.37	10%	17%	24%	31%	38%
Basal vegetation cover	*Carex filifolia*	0.38	28%	30%	32%	34%	37%
	Calamagrostis muiriana	0.52 – 0.68	39%	41%	43%	45%	47%
Relative graminoid cover	*Calamagrostis muiriana*	0.01 – 0.39	12%	22%	31%	41%	50%

Values were calculated from regression equations presented in Cole et al. (2004). Values for *Calamagrostis muiriana* are averages across treatment years

Proposed Utilization Rates for Action Alternatives Allowing Grazing

The proposed utilization rates would be used as a starting point for setting grazing capacities at levels that limit stock induced changes to plant composition, density, cover and/or vigor, and productivity. These capacities would be one tool to prevent adverse effects to soils and associated sod that may lead to accelerated erosion, prevent changes to springs, seeps, and water courses that could alter hydrologic processes, and could promote recovery from past overuse where necessary. Allowable utilization rates would vary by vegetation zones and the logistical value of the forage area.

Vegetation zones: Each forage area is classified as either “lower montane/woodland” or “upper montane/subalpine.” The upper montane/subalpine/ forage areas are generally located at higher elevations, but overlap in elevation range with lower montane/woodland forage areas.

Lower montane/woodland zones are below approximately 8,500 feet in elevation. Research results from Ratliff (1976, 1980) were used to guide utilization rate selection for these forage areas.

Upper montane/subalpine zones are above approximately 7,500 feet in elevation. The research results from Cole et al. (2004) were used to guide utilization rate selection in these forage areas.

Logistical value: Some forage areas have high logistical value to groups travelling with stock. The characteristics used to designate forage areas as having high logistical value are:

- resource concerns other than defoliation do not limit grazing capacity
- closest forage area to a high pass
- first forage area beyond round-trip distance from trailhead
- fires allowed at forage area but not in nearby forage areas
- lack of other forage areas open to grazing nearby
- traditional stock camp
- strategic location for administrative use

Proposed Utilization Rates: Using the approach suggested in Cole et al. (2004), utilization rates were arrived at by choosing a level of change in meadow characteristics and determining what utilization value would limit changes to that level. In doing so, the parks' managers considered the value of grazing to opportunities for primitive and unconfined recreation, as well as the cost of grazing to the natural quality of wilderness.

Lower utilization rates are proposed in forage areas with low logistical value; this provides a greater level of conservation without unduly reducing recreational opportunities for stock travelers. Forage areas would not be designated as high logistical value if recent grazing demands could be met by these lower utilization rates. Fifty-five forage areas met these criteria: 14 in the lower montane and woodland zones and 40 in the upper montane and subalpine zones. A list of the named forage areas assigned a high logistical value is provided in table D-16.

Using this process, the proposed utilization standards which would be used to estimate grazing capacities under the preferred alternative range from 25% to 45% (table D-12).

Table D-12: Utilization Rates Proposed as Standards and Used to Estimate Grazing Capacities

<table>
<tr><th>Vegetation Zone</th><th>Moisture Class</th><th>Logistical Value</th><th>Utilization Limit</th></tr>
<tr><td rowspan="4">Lower Montane / Woodland</td><td rowspan="2">Moist</td><td>High</td><td>45%</td></tr>
<tr><td>Low</td><td>35%</td></tr>
<tr><td rowspan="2">Dry or Wet</td><td>High</td><td>35%</td></tr>
<tr><td>Low</td><td>25%</td></tr>
<tr><td rowspan="2">Subalpine / Upper Montane</td><td rowspan="2">All</td><td>High</td><td>35%</td></tr>
<tr><td>Low</td><td>25%</td></tr>
</table>

These utilization rates would, on average, result in changes to the most heavily grazed portions of meadows relative to comparable ungrazed vegetation (tables D-13 and D-14). In lower montane meadows, maximum utilization would be equal to or less than the amount needed to leave residual biomass equal to that which decomposed annually. In upper montane and subalpine meadows, maximum utilization rates would be set to limit decreases in productivity, basal vegetation cover, and relative graminoid cover to 18% or less.

Table D-13: Predicted Response of Meadow Attributes for Lower Montane and Woodland Vegetation Types to 25%, 35%, and 45% Utilization*

Attribute	Utilization Moist <35% Dry or Wet <25%	Utilization Moist 35-45% Dry or Wet 25-35%
Residual biomass	greater than annual decomposition	greater than or equal to annual decomposition
Productivity	similar to comparable ungrazed meadow vegetation	similar to comparable ungrazed meadow vegetation

* Based on Ratliff (1976, 1980, 1985); responses for productivity would be expected to occur after more than one growing season

In lower montane forage areas with higher logistical value, utilization would be limited to no more than 45% in moist meadows and 35% in dry or wet meadows. The amount of foliage left ungrazed at these levels would be approximately equal to the amount of herbage which would be expected to decompose annually; if grazed to capacity regularly, productivity would be expected to remain near current levels.

In lower montane forage areas with lower logistical value, utilization would be limited to no more than 35% in moist meadows and 25% in dry or wet meadows. The amount of foliage left ungrazed at these levels would be more than the amount of herbage which would be expected to decompose annually; if grazed to capacity regularly, productivity would be expected to trend towards or be similar to comparable ungrazed meadow vegetation.

Table D-14: Predicted Mean Response of Meadow Attributes for Three Upper Montane and Subalpine Vegetation Types to 25% and 35% Utilization*

Attribute	Vegetation type	25% utilization, percentage change relative to ungrazed conditions	35% utilization, percentage change relative to ungrazed conditions
Productivity	*Carex filifolia*	+2%	-10%
	Deschampsia cespitosa	-11%	-18%
	Calamagrostis muiriana	-10%	-16%
Basal vegetation cover	*Carex filifolia*	+7%	-16%
	Calamagrostis muiriana	+41%	+14%
Relative graminoid cover	*Calamagrostis muiriana*	-6%	-12%

* Based on Cole et al. (2004); predicted response for *Calamagrostis muiriana* is average across treatment years as reported for two, three and four years of grazing in the original study.

In subalpine and upper montane forage areas having higher logistical value, utilization rates would be limited to 35%. If grazed to capacity regularly, this level of utilization in dry *Carex filifolia* vegetation would, on average, reduce productivity by 10% and reduce basal vegetation cover by 16% relative to ungrazed vegetation. In moist to wet *Deschampsia cespitosa* vegetation, this level of utilization would, on average, reduce productivity by 18% relative to ungrazed vegetation. This level of utilization in moist *Calamagrostis muiriana* vegetation would, on average, reduce productivity by 16%, increase basal vegetation cover by 14%, and decrease relative graminoid cover by 12% relative to ungrazed vegetation. Due to the inherent variability in meadow systems, considerable variation in observed changes would be expected. The magnitude of this variation is reflected in the coefficients of determination reported for the relationship between utilization and meadow response which range from 0.01 – 0.68 (table D-11).

In subalpine and upper montane forage areas having lower logistical value, utilization would be limited to no more than 25%. If grazed to capacity regularly, this level of utilization in dry *Carex filifolia* vegetation would, on average, increase productivity by 2% and increase basal vegetation cover by 7% relative to ungrazed vegetation. In moist to wet *Deschampsia cespitosa* vegetation, this level of utilization would, on average, decrease productivity by 11% relative to ungrazed vegetation. This level of utilization in moist *Calamagrostis muiriana* vegetation would, on average, reduce productivity by 10%, increase basal vegetation cover by 41%, and decrease relative graminoid cover by 6% relative to ungrazed vegetation. Due to the inherent variability in meadow systems, considerable variation in observed changes would be expected. The magnitude of this variation is reflected in the coefficients of determination reported for the relationship between utilization and meadow response which range from 0.01 – 0.68 (table D-11).

BIOMASS CONSUMPTION RATES

Rates of biomass consumption are expressed as an amount of biomass grazed over a given period of time. As most grazing occurs during overnight stays (saddle and pack animals generally work during the day) the time period of interest is one night.

The amount of biomass grazed by a pack or saddle animal is related to the size of the animal. Ninety-four percent of all overnight stock use in the parks' is by horses and mules (Frenzel and Haultain 2013). Horses, mules, burros, and donkeys consume about 3% of their body weight each day (Holechek 1988). Among horses and mules, there is considerable variability in the size of animals that graze in the parks, with larger animals often used as saddle stock and smaller animals used as pack stock. Approximately 45% of all overnight stock use is by NPS-owned animals. The average size of horses and mules in the parks' herd is approximately 900-1000 pounds (NPS 2014). This gives an average nightly forage requirement of 27-30 pounds for horses and mules in the parks' herd. Making the assumption that the parks' herd may be slightly smaller than the other animals in the parks, a conservative nightly forage consumption of 32 pounds is assumed for horses and mules. Burros and llamas are smaller, and consume approximately 10 pounds and 7 pounds per night, respectively (Ratliff et al. 1987).

Capacities provided to stock users and managers are based on a nightly forage consumption of 32 pounds and are expressed in units of "stock nights" which is defined as an overnight stay by any horse, mule, burro, or llama. Capacities reported as stock nights (as opposed to the animal unit nights used in range management) are simple for stock users and managers to understand, track, and report. Information about animal type is included in stock use reports and is available to inform management decisions in the few places where burros and llamas make up a significant portion of the total grazing; therefore, more stock nights can be sustained in areas grazed by burros and llamas.

CAPACITY CALCULATION

Grazing capacities for the parks' forage areas are calculated as:

$$\frac{\text{area} * \text{preferred proportion} * \text{productivity} * \text{allowable utilization}}{\text{nightly forage consumption}} = \text{capacity in stock nights}$$

Model capacities are provided in table D-17 along with the model parameters.

EVALUATION AND REVISION OF CAPACITIES

Given the multiple complex goals and objectives for grazing management, the great variability in natural systems across space and time, and the difficulty in predicting the response of such systems to perturbation, it is expected that the model capacities provide only coarse estimates of the true grazing capacity in any given year. Therefore, evaluating grazing capacities against field observations and revising them upward or downward to better fulfill management goals and objectives will be an essential part of the adaptive management of pack and saddle stock grazing.

The evaluation process will include two complementary aspects: evaluation and revision of model parameters and evaluation of model capacities against observed conditions. All evaluations of model capacities or model parameters will be documented to provide a record of the information used, analysis performed, and the conclusions reached. This information will be reported as part of the annual monitoring report prepared by the plant ecology program each year.

EVALUATING AND REVISING MODEL PARAMETERS

The grazing capacities presented in table D-17 are based on the most up-to-date model parameters available. Qualitative and quantitative data collected in the field can be used to evaluate the model parameters area, preferred proportion, preferred vegetation type, moisture regime, productivity, and utilization.

AREA AND PREFERRED PROPORTION

Site visits can be used to document the extent of the meadow forage and the extent of preferred forage by observing actual stock grazing patterns at the end of the grazing season and noting the extent of area that has been preferentially grazed by stock. These model parameters can be revised as needed.

Where past grazing above modeled capacities has resulted in acceptable meadow condition, upland vegetation (such as the understory of forests and woodlands) is often an important source of additional forage for stock. Therefore, the model may underestimate grazing capacity in these forage areas. The extent of upland forage has been described narratively for some areas. Until quantitative data on the extent, productivity, and appropriate utilization rates for these areas become available, narrative descriptions may be used to identify management areas where total forage is grossly underestimated, and to adjust capacities upwards based on past use patterns and observed impacts. If quantitative data for the extent, productivity, and appropriate utilization rate become available, this data can be used to estimate capacity in upland areas using the same basic model as for meadow vegetation.

PREFERRED VEGETATION TYPE AND MOISTURE REGIME

Site visits can be used to document which species provide the preferred forage by observing actual stock grazing patterns at the end of the grazing season and noting the species which have been preferentially grazed by stock. The moisture category from Ratliff et al. (1987) can be reassigned as indicated by evaluation.

PRODUCTIVITY

The meadow productivity data provided in Ratliff et al. (1987) was based on relatively sparse data and may under- or over-predict forage productivity for any given forage area. Therefore, field measurements of productivity provide an opportunity to input more accurate data into the capacity model.

Residual biomass data measured on ungrazed reference sites provides an estimate of productivity. However, this data is measured in a relatively small area, so caution should be used in using these values to calculate capacity. At minimum, the reference sites may identify forage areas that consistently produce more or less forage biomass than predicted by the model (Abbott et al. 2003), which could result in inaccurate capacities.

Productivity estimates are averages. Annual weather fluctuations are not explicitly included in the model, although they are known to influence productivity. In high snowfall years, productivity can be reduced by cold wet soils and shorter growing seasons (Moore et al. 2013). In very low snowfall years, lack of soil moisture may limit productivity.

Comparison of model values to observed values illustrates the importance of interannual variability on productivity. Residual biomass data collected from ungrazed reference sites in the parks can be used to estimate the magnitude of interannual variation. Twenty-seven meadows had at least three years of reference residual biomass data. The coefficient of variation (ratio of the sample standard deviation to sample mean with small-sample correction [Sokal and Rohlf 1995]), for these meadows averaged 0.36. Data from three sites in Yosemite National Park had coefficients of variation ranging from 0.17 – 0.34 (Moore et al. 2013), while coefficients of variation of three vegetation types in Sequoia National Park ranged from 0.08 – 0.48 (Stohlgren et al. 1989). This variability highlights the need for multiple years of data collection to characterize productivity for use in the capacity model; 3 to 5 years should be considered the minimum needed (USDA 2014).

In years where very high or very low precipitation is an important factor, public information provided to stock users is used to warn them of reduced capacities. Monitoring of conditions throughout the season can indicate when a mid-season grazing closure is appropriate due to reduced productivity

Utilization

Utilization values have been selected which limit grazing induced changes in vegetation, soils, and hydrology. If these values fail to set capacities at a level which meets the goals and objectives of the WSP/FEIS, they could be revised accordingly.

Studies of the relationship between utilization and ecosystem properties conducted in comparable habitats (such as Cole et al. [2004] and Norton et al. [2013]) provide one source to revise utilization values. Residual biomass data provides coarse estimates of utilization. If observed conditions in a forage area with residual biomass monitoring are not meeting goals and objectives, utilization levels from the monitoring data could inform any changes to utilization levels.

The assumption has been made in setting utilization rates that utilization by wildlife, especially by large ungulates such as mule deer and bighorn sheep, is generally low. Horses and mules are characterized as patch grazers, as they tend to graze some areas very closely and leave other areas almost untouched. In most meadows, this use pattern results in areas of meadow vegetation remaining available for wildlife consumption and to meet habitat needs. In meadows monitored for residual biomass, field observations of end-of-season standing crop also account for wildlife utilization. If wildlife utilization is found to be an important consideration in a given meadow, utilization values could be revised to meet the goals and objectives of the plan.

EVALUATING AND REVISING ESTIMATED CAPACITIES

In the adaptive management context, each year becomes a data point for a given forage area. The primary tool for evaluating capacities is to compare observed grazing regimes (total amount of grazing, timing) to observed impacts. The model capacities presented in table D-17 have been evaluated with the information available. Where that information indicates that the model capacity should be revised, an “evaluated capacity” has been assigned using the methods described below. In order to ensure that the estimated capacities reflect the most current knowledge of meadow response to grazing, capacities would undergo a comprehensive reevaluation every five years, with annual modifications as needed to ensure resource protection. Changes to capacities would be made available for public comment by March 1 of each year along with other public use limits.

Comparison of Use Levels to Monitoring Data and Standards

Monitoring data (i.e., site visits, residual biomass, bare ground, streambank alteration) can be associated with grazing timing and intensity levels from stock use data.

If management goals and objectives are being met at an observed use level, then that use level is more likely to be less than or equal to the true capacity. If goals and objectives are not being met, then the observed use level is more likely to be greater than the true capacity. Over time, this should provide a more nuanced understanding of the relationship between total grazing levels and impacts and allow for refinement of grazing capacities.

In making comparisons between use levels and monitoring data, capacity will be evaluated at appropriate spatial (forage area) and temporal (multiple year) scales. In addition to foliage removal by grazing stock, poor agreement between model capacity and observed conditions may be attributable to factors other than defoliation. Climate anomalies should also be considered during evaluation of monitoring data against capacities to ensure that changes to capacities do not reflect atypical responses to grazing.

Impacts Other Than Defoliation

Where grazing at model capacities results in impacts outside of standards, impacts other than defoliation can be the factor limiting grazing capacity. In these areas, previous use levels can be compared to observed impacts to adjust capacity values. Use levels will be evaluated for their impacts in the following areas:

- Trampling
- Impacts to soils and hydrology
- Water quality
- Plant species composition
- Social conflicts

For example, concerns over mechanical impacts such as shearing, trampling in peat accumulating meadows and fens have been partially addressed by ensuring that these areas are not included in the preferred acreage of a meadow. Limiting capacity to the amount of forage available outside of fen areas may reduce the likelihood that stock will seek forage within the fen.

Grazing capacities will be evaluated and refined by continuing to document the grazing level at which impacts other than grazing occur. This will be done in a context which includes other aspects of the grazing regime such as timing or stock handling practices. Some impacts may be more effectively mitigated through management tools other than grazing capacities, such as grazing opening dates or education of visitors and staff traveling with stock.

Timing and Intensity of Use

Managing grazing by livestock in the traditional sense differs from the management of recreational grazing in wilderness in that in the latter, the timing and intensity of grazing in any given location can be highly variable and is often unpredictable. The arrival and departure of animals at a given site can result in periods of rest for the meadow, during which vegetative growth may occur and thus result in increased capacity. Conversely, periods of intense grazing without recovery periods may lead to depletion of the allowable biomass before the estimated capacity is reached. On site monitoring allows for mid-season adjustments in use levels that reflect these conditions.

Table D-15: Regression Coefficients for Each Combination of Moisture Level and Condition*

Moisture	Condition	B_0	B_E
D	Excellent	3470	-0.265
D	Good	2275	-0.175
D	Fair	1520	-0.115
D	Poor	878	-0.0675
M	Excellent	7355	-0.51
M	Good	4725	-0.325
M	Fair	3225	-0.225
M	Poor	1825	-0.125
W	Excellent	7297	-0.5575
W	Good	4705	-0.36
W	Fair	3297	-0.2575
W	Poor	1780	-0.135

* Productivity for a given moisture and condition is given by $B_0 + B_E$*Elevation.

Table D-16: Forage Areas Designated as Having High Logistical Value

Kings Canyon National Park	Sequoia National Park
28-3 Cony Camp 28-4 Franklin-Montgomery 33-1 Evolution 39-2 Big Pete 39-4 Ladder Camp 39-8 Deer 46-2 South Fork Kings River 51-1 Simpson 53-4.2 Glacier Valley 53-5 Fallen Moon 53-7 Shorty's 58-1 Castle Domes 58-2 Woods Creek Crossing 58-3 Baxter Creek Drift Fence 63-1 Charlotte Creek 65-3 Upper Vidette 65-4 Upper Bubbs Creek 66-3 Junction (Bubbs Creek) 67-1 East Lake 69-2.2 Upper West Side Roaring River 69-3 JR Past; Allen Camp 69-4 Lackey Pasture 69-5.1 Scaffold Tourist Pasture 69-5.2 Grasshopper 70-4 Cement Table 70-5 Big Wet 70-6 Grand Palace Hotel 71-1 Austin Camp 71-2 Grave 71-3 Ranger	77-7 Pinto Lake 79-1 Cold Springs Camp Area 79-5 Gallats Lake 80-3 Tyndall Cr 81-2.1 Wallace Cr/JMT Junction 83-4 Upper Crabtree 83-7 Lower Whitney Creek 83-8 Sandy 84-2 Lower Rock Creek Crossing 85-4 Penned-up 85-10 Nathan's 86-1 Kern Bridge Camp 86-2 Upper Funston 86-5 Lower Funston 86-7 Lewis Camp Large Pasture 87-3 Big Arroyo Patrol Cabin 89-3 Lower Lost Canyon 89-9 Middle Rattlesnake Canyon 89-10 Cow Camp (Rattlesnake Creek) 90-5.1 Hockett 90-5.2 Hockett Pasture 90-9 Lower South Fork 90-10 South Fork Meadow 90-11 South Fork Pasture 90-13 Slim's

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
28-1	Piute Cr	8050	D	U	L	0.8	100%	866	25%	5		5	0
28-2	Aspen	8200	M	L	L	0.5	100%	2060	35%	11		11	3.2
28-3	Cony Cmp	8420	M	L	H	1.8	100%	1989	45%	50		50	8.4
28-4	Franklin-Montgomery	8720	W	U	H	7.7	50%	1566	35%	66		66	19
28-5	Pig Chute	9160	M	U	L	0.8	100%	1748	25%	11		11	0
28-6	Hell-For-Sure Jct Area	10000	M	U	L	32.8	50%	1475	25%	189		189	5.8
33-1	Evolution	9230	M	U	H	13.4	80%	1725	35%	202		202	89
33-2	McClure	9630	W	U	L	21.3	50%	1238	25%	103		103	57.2
33-3	Colby	9700	W	U	L	9.6	75%	1213	25%	68		68	21.4
33-4.1	Upr Colby (Upr Colby #1)	9850	W	U	L	3.6	30%	1159	25%	10		10	0
33-4.2	Darwin Pockets (Upr Colby #2)	9850	W	U	L	4.5	30%	1159	25%	12		12	18.2
34-1	Evolution Lk	10860	W	U	L	60.4	25%	795	25%	94		94	0.2
34-2	Sapphire Lk	10970	W	U	L	36.8	35%	756	25%	76		76	0
34-3	Huxley Lk	11300	D	U	L	34.2	35%	298	25%	28		28	0
34-4	Wanda Lk	11400	D	U	L	100.9	15%	280	25%	33		33	0
38-2	Blue Cyn	8410	W	U	L	28.9	30%	1677	25%	114		114	21
38-3	Lwr Blue Cyn	8000	D	L	L	0.9	100%	875	25%	6		6	0
39-2	Big Pete	9230	W	U	H	3.2	75%	1382	35%	36	50	50	52
39-3	Little Pete	8860	W	U	L	10.3	60%	1515	25%	73		73	42.2
39-4	Ladder Cmp	8310	D	L	H	3.5	50%	821	35%	16	50	50	54.4

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
39-6	Palisade Cr Jct	8020	D	L	L	1.4	50%	872	25%	5		5	1.2
39-7	Stillwater; Lwr Deer	8430	M	L	L	5.8	60%	1985	35%	76		76	11
39-8	Deer	8840	W	U	H	15.4	25%	1523	35%	64	100	100	35.2
42-1	Dusy Cr	9500	M	L	L	1.2	50%	1638	35%	11		11	18.2
45-1	Palisade Lks	10650	M	U	L	26.7	40%	1264	25%	105		105	27.6
46-1	Upr Basin	11200	M	U	L	204	25%	1085	25%	432		432	53.6
46-2	South Fk Kings River	9900	M	U	H	51.3	30%	1508	35%	254		254	73
46-3	Bench Lk/John Muir Trail Jct	10900	W	U	L	50.6	80%	781	25%	247		247	19
46-4	Bench Lk	10550	M	U	L	4.6	60%	1296	25%	28		28	1.8
46-6	Lk Marjorie	11150	M	U	L	14.9	20%	1101	25%	26		26	1.2
51-1	Simpson	5930	M	L	H	22.8	25%	2798	45%	224		224	87.6
51-2	Tehipite Vly	4100	D	L	L	13	10%	1558	25%	16		16	5.8
51-3	Gnat	7850	M	L	L	5.5	25%	2174	35%	33		33	0
51-4	Hay	7320	M	L	L	5	50%	2346	35%	64		64	0
52-1	Volcanic Lks Basin	10000	M	U	L	46.5	10%	1475	25%	54		54	5.8
52-2	Kennedy Cyn	9300	M	U	L	32.4	60%	1703	25%	259		259	0
52-3	Upr Kennedy Cyn	9540	M	U	L	15.3	30%	1625	25%	58		58	0
52-4	Kennedy Pass	10400	M	U	L	19.1	25%	1345	25%	50		50	0
52-5	West Kennedy Lk	9963	M	U	L	4.3	25%	1487	25%	12		12	0
52-6	Frypan	7800	M	L	L	5.8	50%	2190	35%	69		69	0
52-8	Jug	9860	D	U	L	6.8	25%	550	25%	7		7	0
52-9	Big Cmp	9900	M	U	L	14.7	25%	1508	25%	43		43	0

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
53-1	Horseshoe	10200	M	U	L	25.1	20%	1410	25%	55		55	0
53-2	Horseshoe Lks Turnoff	10500	M	U	L	12.9	40%	1313	25%	53		53	0
53-3	State Lks Area	10400	M	U	L	39.6	30%	1345	25%	125		125	0
53-4.1	Dougherty	9500	M	U	L	7.1	50%	1638	25%	45		45	0
53-4.2	Glacier Vly	9950	M	U	H	25.7	40%	1491	35%	168		168	12.4
53-5	Fallen Moon	9540	W	U	H	18.8	25%	1271	35%	65		65	21.6
53-6	Volcanic Trail Jct	9420	W	U	L	2.3	50%	1314	25%	12		12	0
53-7	Shorty's	10070	W	U	H	7.8	50%	1080	35%	46		46	41.8
53-8	Granite Pass	10300	W	U	L	9.3	45%	997	25%	33		33	0
54-2	Granite Basin	10000	M	U	L	109.5	30%	1475	25%	379		379	22.5
54-3	Grouse Lk	10473	M	U	L	11.4	20%	1321	25%	24		24	0
54-4	Halfmoon	10260	M	U	L	6.1	75%	1391	25%	50		50	14.5
54-5.1	Upr Tent	8200	D	L	L	2.9	25%	840	25%	5		5	0
54-5.2	Lwr Tent	8200	D	L	L	2.3	25%	840	25%	4		4	0
56-1	High south of Pinchot Pass	11200	M	U	L	157.1	20%	1085	25%	266		266	31.2
56-2	Twin Lks Area (Woods Cr)	10600	M	U	L	89.7	20%	1280	25%	179		179	34
56-3	White Fk Cmp/Ghost Forest Cmp	9780	W	U	L	1	50%	1184	25%	5		5	2
57-1	Woods Lake Basin	10800	W	U	L	117.3	15%	817	25%	112		112	13
58-1	Castle Domes	8130	M	L	H	4.4	70%	2083	45%	90		90	36.8
58-2	Woods Cr Xing	8500	M	L	H	3	100%	1963	45%	83	75	75	95.2
58-3	Baxter Cr Drift Fence	9450	W	U	H	2.3	100%	1303	35%	33	40	40	45.6
63-1	Charlotte Cr	10000	W	U	H	30.1	25%	1105	35%	91		91	78.2

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
65-3	Upr Vidette	10680	W	U	H	5.7	50%	860	35%	27		27	1.2
65-4	Upr Bubbs Cr	10400	M	U	H	39.3	25%	1345	35%	145		145	119
66-1.1	Sphinx Cr Conf	6240	D	L	L	2.5	75%	1183	25%	17		17	0
66-1.2	Angleworm	6840	D	L	L	0.2	75%	1078	25%	1		1	0
66-2	Charlotte Cr Conf	7300	W	L	L	18.5	10%	2077	25%	30		30	0
66-3	Junction (Bubbs Cr)	8130	D	L	H	7	25%	852	35%	16	50	50	49.2
67-1	East Lk	9550	W	U	H	4.8	50%	1267	35%	33	50	50	56
67-2	Ouzel	9580	M	U	L	1.8	70%	1612	25%	16		16	0.2
68-1	Screwball	8550	W	L	L	2.4	50%	1627	25%	15		15	2.8
69-1	The Big Hole	7600	M	L	L	0.6	100%	2255	35%	15		15	0
69-2.1	Lwr West Side Roaring River	7200	D	L	L	2.4	100%	1015	25%	19		19	0
69-2.2	Upr West Side Roaring River	7600	D	L	H	1.5	100%	945	35%	16	75	75	45.4
69-3	JR Past; Allen Cmp	7380	M	L	H	0.9	100%	2327	45%	29	50	50	49.4
69-4	Lackey Past; Scaffold	7370	M	L	H	1.9	75%	2330	45%	47	55	55	48.4
69-5.1	Scaffold Tourist Past	7360	M	L	H	9.5	60%	2333	45%	187		187	311
69-5.2	Grasshopper	7700	M	U	H	3.1	60%	2223	35%	45		45	22
69-6.1	Moraine	8160	W	U	L	6	80%	1767	25%	66		66	0
69-6.2	Moraine Stringers	8800	W	U	L	10.4	80%	1537	25%	100		100	0
69-6.3	Metroyhoy	9500	W	U	L	11.3	80%	1285	25%	91		91	0
70-1.1	Grasshopper Cmp; Brewer Cr Conf	7980	M	L	L	1.4	50%	2132	35%	16		16	0.6
70-1.2	Brewer Stringers	10400	M	U	L	4.2	50%	1345	25%	22		22	5.6
70-2	Barton Stringers	9400	M	U	L	8.8	50%	1670	25%	57		57	0

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
70-3	False Cement Table	8430	M	U	L	3.6	60%	1985	25%	34		34	0
70-4	Cement Table	8540	W	U	H	5.9	75%	1631	35%	79		79	17.2
70-5	Big Wet	8740	W	U	H	29.4	35%	1559	35%	175		175	26.2
70-6	Grand Palace Hotel	9040	M	U	H	5.7	45%	1787	35%	50		50	14.2
70-7	Colby Lk	10620	D	U	L	4.4	20%	417	25%	3		3	0.6
71-1	Austin Cmp (all)	7950	M	U	H	5	60%	2141	35%	70		70	58.6
71-2	Grave	8400	M	U	H	5.1	50%	1995	35%	56		56	37.8
71-3	Ranger (all)	8780	W	U	H	49.5	35%	1544	35%	293		293	86
71-4	Upr Ranger	9230	M	U	L	11.7	30%	1725	25%	47		47	2.6
71-5	Upr Deadman Cyn	9400	M	U	L	35.4	5%	1670	25%	23		23	0
72-1	Pond	8500	W	L	L	2.5	50%	1645	25%	16		16	0
72-2	Catch'em	8900	W	L	L	2.9	50%	1501	25%	17		17	0
72-3	Willow (Sugarloaf Cr)	9200	W	L	L	9.9	50%	1393	25%	54		54	0
72-4	Mitchell (Sheep Cr)	9600	W	U	L	25.6	50%	1249	25%	125		125	0
72-5	Quartz	8920	M	U	L	5.4	20%	1826	25%	15		15	0
72-6	Williams	8020	M	L	L	31.8	20%	2119	35%	147		147	0
72-7	Comanche	7820	W	L	L	4.3	20%	1890	25%	13		13	0
72-8	Sugarloaf	7300	M	L	L	23.2	50%	2353	35%	298		298	52.2
72-9	Little Sugarloaf	7200	M	L	L	3.6	50%	2385	35%	47		47	0
72-10	Sugarloaf Cr Cmp	6960	D	L	L	0.7	50%	1057	25%	3		3	0
72-11	Tom Sears; Honeymoon	7100	W	L	L	2.3	10%	2149	25%	4		4	0
72-12	Boggy	7240	M	L	L	2.1	50%	2372	35%	27		27	0

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
72-13.1	Cabbage	7760	D	L	L	2.9	50%	917	25%	10		10	0
72-13.2	Crowley Cyn	8000	D	L	L	1.1	50%	875	25%	4		4	0
72-13.3	Upr Crowley Cyn Pockets	8940	M	U	L	20.5	25%	1820	25%	73		73	0
72-14.1	Lwr Box Cyn	8200	W	U	L	1.6	25%	1753	25%	5		5	0
72-14.2	Suez Canal	9140	W	U	L	5	25%	1415	25%	14		14	0
72-14.3	Upr Box Cyn	9750	W	U	L	16.2	25%	1195	25%	38		38	0
72-16.1	Lwr Paradise	8980	M	U	L	5.6	40%	1807	25%	32		32	0
72-16.2	Upr Paradise	9150	M	U	L	14.3	40%	1751	25%	78		78	0
72-17.1	Lwr Log	8780	M	U	L	2.6	25%	1872	25%	10		10	0
72-17.2	Upr Log	8900	M	U	L	6	25%	1833	25%	21		21	0
72-17.3	Salt Log	8940	M	U	L	0.6	25%	1820	25%	2		2	0
72-17.4	Ditch	8980	W	U	L	1.3	25%	1472	25%	4		4	0
72-17.5	Sheep Pen Meadow	9020	W	U	L	8.5	25%	1458	25%	24		24	0
72-18	Ferguson	8637	M	U	L	9.4	50%	1918	25%	70		70	3.2
72-19	Long (Ferguson Cr)	9590	W	U	L	66.1	40%	1253	25%	259		259	0
72-20.1	Lwr Lewistall	8580	W	U	L	4.5	50%	1616	25%	28		28	0
72-20.2	Upr Lewistall	8820	W	U	L	2.6	50%	1530	25%	16		16	0
72-21	Little Jack	9380	W	U	L	1.3	50%	1328	25%	7		7	0
72-22	Scenic	9780	M	U	L	32.7	35%	1547	25%	138		138	0
73-1	Sheep Cmp (Sugarloaf Cr)	8270	M	U	L	2.4	60%	2037	25%	23		23	0
73-3	Lovelace Cabin	8740	M	U	L	2.8	80%	1885	25%	33		33	0
73-4	Lost Lk	9130	W	U	L	0.8	60%	1418	25%	5		5	5.2

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
73-5	Ranger & Beville Lks	9142	W	U	L	4	50%	1414	25%	22		22	5
74-1	Twin Lks (Clover Cr)	9430	M	U	L	5.7	50%	1660	25%	37		37	0
74-2	Pattee	9260	M	U	L	9.4	50%	1716	25%	63		63	0
74-3	Clover Cr	8434	M	U	L	33.9	50%	1984	25%	263		263	0
74-4	Cahoon (Silliman Cr)	7760	W	U	L	14.9	50%	1911	25%	111		111	0
75-1	Lone Pine	8800	M	U	L	9.4	25%	1865	25%	34		34	13.2
75-2	Tamarack Lk	9215	M	U	L	4.1	15%	1730	25%	8		8	7.2
77-1	Bearpaw	7460	M	L	L	1.3	75%	2301	35%	25		25	1.4
77-2	Lwr Bearpaw	6860	M	L	L	9.1	60%	2496	35%	149		149	0
77-3	River Vly	6480	D	L	L	0.7	100%	1141	25%	6		6	0
77-5	Redwood	6040	M	L	L	10	40%	2762	35%	121		121	35.8
77-6	Cliff Cr	7400	M	L	L	4.6	40%	2320	35%	47		47	3.4
77-7	Pinto Lk	8700	M	U	H	5.6	50%	1898	35%	58		58	33
79-1	Cold Springs Cmp Area	9180	W	U	H	16	50%	1400	35%	123		123	126
79-3	Rockslide Lk	9050	M	U	L	12.1	25%	1784	25%	42		42	0
79-4	Lwr Kern-Kaweah River	9700	M	U	L	12.2	35%	1573	25%	52		52	35.8
79-5	Gallats Lk	10030	M	U	H	33.2	25%	1465	35%	133		133	30.4
79-6	Upr Kern-Kaweah River	10350	M	U	L	146.9	9%	1361	25%	141		141	52.4
80-2	Tyndall Cr/JMT Frog Ponds	11050	M	U	L	29.3	40%	1134	25%	104		104	7.4
80-3	Tyndall Cr	10600	M	U	H	14.6	50%	1280	35%	102		102	96.2
80-4	Sheep Cmp (Tyndall Cr)	11400	M	U	L	796.4	20%	1020	25%	1269		1269	15.6
80-5.1	Lk South America	11950	M	1	0	22.8	50%	841	25%	75		75	0

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
80-6	Kern Headwaters	11200	W	1	0	201.8	10%	673	25%	106		106	21.8
81-1	Wright Cr Drainage	10900	M	U	L	507	25%	1183	25%	1171		1171	100.6
81-2.1	Wallace Cr/JMT Jct	10400	M	U	H	3.2	30%	1345	35%	14		14	9.6
81-2.2	Wallace Cr	10500	M	U	L	7.3	50%	1313	25%	37		37	18.6
81-2.3	Wallace Cr Waterfall	10860	W	U	L	9.8	40%	795	25%	24		24	0
81-2.4	Marshy	11100	W	U	L	5.4	40%	709	25%	12		12	0
82-1	Junction (Kern)	8050	W	L	L	1.7	65%	1807	25%	16		16	6.6
82-2	One mi below Junction	8000	D	L	L	0.3	100%	875	25%	2		2	1.8
82-3	Three mi below Junction	7700	D	L	L	1.4	100%	928	25%	10		10	0
83-4	Upr Crabtree	10460	W	U	H	38.9	30%	939	35%	120		120	76.6
83-6	Crabtree Lks	10900	M	U	L	9.2	70%	1183	25%	59		59	0
83-7	Lwr Whitney Cr; Strawberry	9950	M	U	H	5.9	30%	1491	35%	29		29	44.8
83-8	Sandy	10600	M	U	H	47.9	30%	1280	35%	201	300	300	258
84-2	Lwr Rock Cr Xing	9500	M	U	H	47.1	25%	1638	35%	211		211	184.2
84-6	Siberian Outpost	10780	D	U	L	270.6	40%	389	25%	329		329	1.2
85-4	Penned-up	10650	W	U	H	10.8	50%	871	35%	51		51	25.8
85-6	Lwr Soldier Lk	10800	W	U	L	25	20%	817	25%	32		32	3.6
85-7	New Army Pass Jct	10920	M	U	L	50.1	25%	1176	25%	115		115	3.6
85-8	Rock Cr Lk (all)	10430	W	U	L	32.5	40%	950	25%	97		97	29.2
85-10	Nathan's	10020	M	U	H	15.7	50%	1469	35%	126	75	75	43.5
86-1	Kern Bridge Cmp	6800	W	L	H	6.1	75%	2257	35%	113	150	150	297.8
86-2	Upr Funston	6700	M	L	H	10.3	30%	2548	45%	111		111	59.6

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
86-3	Big Arroyo Conf	6640	D	L	L	1.6	40%	1113	25%	6		6	0
86-4	21-inch Cmp	6580	M	L	L	3.1	30%	2587	35%	26		26	7.4
86-5	Lwr Funston	6480	W	L	H	4.4	50%	2372	35%	57		57	0
86-6	Rattlesnake Cmp; River Past	6390	M	L	L	1.1	50%	2648	35%	16		16	0
86-7	Lewis Cmp Large Past	6400	M	L	H	9	60%	2645	45%	201	220	220	182
86-8	Kern Station Small Past	6440	M	L	L	1.5	50%	2632	35%	22		22	1.4
87-1	Upr Big Arroyo	9960	D	U	L	84.9	85%	532	25%	300		300	73.4
87-2	Little Upr Big Arroyo	9780	M	U	L	6.6	40%	1547	25%	32		32	0
87-3	Big Arroyo Patrol Cabin	9510	W	U	H	5.3	95%	1281	35%	71		71	47
87-4	Lwr Big Arroyo	9200	M	U	L	26.2	80%	1735	25%	284		284	73
87-5	Chagoopa Plateau #1	10460	W	U	L	10.1	40%	939	25%	30		30	0
87-6	Chagoopa Plateau #2	10430	W	U	L	8.7	75%	950	25%	48		48	0
87-8	Chagoopa Plateau #4	9960	W	U	L	14.3	75%	1119	25%	94		94	0
87-9	Chagoopa Plateau Treehouse	10380	M	U	L	14.1	66%	1352	25%	98		98	0
87-10	Sky Parlor	9150	D	U	L	66.2	60%	674	25%	209		209	34.4
88-1	Lwr Little Five Lks	10420	M	U	L	54	10%	1339	25%	56		56	2.6
88-2	Upr Little Five Lks	10520	W	U	L	14.8	50%	918	25%	53		53	3.2
88-3	Big Five Lks Lwr	9900	W	U	L	5.4	50%	1141	25%	24		24	2.4
88-4	Big Five Lks Upr	10220	W	U	L	22.2	35%	1026	25%	62		62	4.4
88-5	Big Five Lks Upr Stringer	10580	W	U	L	2.5	100%	896	25%	18		18	0.6
89-2	Upr Lost Cyn (all)	10100	M	U	L	31	40%	1443	25%	140		140	55.4
89-3	Lower Lost Cyn (all)	9650	M	U	H	20.2	30%	1589	35%	105		105	102.2

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
89-4	Soda Cr Cyn	9200	M	U	L	23.8	50%	1735	25%	161		161	0
89-5.1	Forester Lk Bench	10760	M	U	L	29.4	75%	1228	25%	212		212	1.6
89-5.3	Forester Lk Pocket	10710	M	U	L	6.3	50%	1244	25%	31		31	0
89-6	Upr Rattlesnake Cyn	10440	M	U	L	6.4	50%	1332	25%	33		33	14.8
89-7	Shotgun Pass	10585	M	U	L	20.5	50%	1285	25%	103		103	0.4
89-8	South Rattlesnake Cyn	10320	W	U	L	20.9	30%	990	25%	48		48	0
89-9	Middle Rattlesnake Cyn	9500	W	U	H	7.2	60%	1285	35%	61		61	47.2
89-10	Cow Cmp (Rattlesnake Cr)	8720	M	U	H	14.4	25%	1891	35%	74		74	49
89-11	Laurel Cr Basin	10400	M	U	L	77	25%	1345	25%	202		202	0
89-12	Crytes Cr	10650	M	U	L	26	35%	1264	25%	90		90	0
89-13	Coyote Cr	9400	M	U	L	36.6	50%	1670	25%	239		239	0.6
90-1	Horse Cr	8580	M	U	L	1.8	75%	1937	25%	20		20	0
90-2	Ansel Lk	10540	M	U	L	19.9	10%	1300	25%	20		20	0
90-3	Evelyn Lk	8700	M	U	L	0.8	50%	1898	25%	6		6	0
90-4	Cow Cmp (Hockett)	8470	M	U	L	5.3	30%	1972	25%	24		24	1.6
90-5.1	Hockett	8500	M	U	H	42.1	35%	1963	35%	316		316	179.6
90-5.2	Hockett Past	8500	M	U	H	8.3	65%	1963	35%	116	100	100	63
90-6	Sand	8540	W	U	L	43.8	50%	1631	25%	279		279	2.4
90-8	Tuohy Cr Jct	8275	D	U	L	3.2	50%	827	25%	10		10	0
90-9	Lwr South Fk	8500	D	U	H	18.2	50%	788	35%	78		78	58
90-10	South Fk Mdw	8515	M	U	H	13.2	50%	1958	35%	141		141	45.4
90-11	South Fk Past	8560	M	U	H	9.3	50%	1943	35%	99		99	34.4

Table D-17: Estimated Grazing Capacities for Forage Areas Open to Grazing under the NPS Preferred Alternative (continued)

Forage Area Number	Forage Area Name	Elevation, feet	Moisture	Vegetation Zone	Logistical Value	Area, acre	Preferred vegetation	Productivity, pounds /acre	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights	Avg. grazing stock nights/ year 2009-2013
90-12	Blossom Lk	10200	M	U	L	5.9	30%	1410	25%	19		19	0
90-13	Slim's	8860	M	U	H	8	50%	1846	35%	81		81	60.8
90-14	Green; Cabin	9350	M	U	L	44.1	20%	1686	25%	116		116	29.2
90-15	Tuohy	8350	M	U	L	5.8	50%	2011	25%	46		46	0
90-16	Summit	8980	M	U	L	13.5	50%	1807	25%	95		95	0
90-17	Cyclone	9290	W	U	L	31.4	40%	1361	25%	134		134	1
90-18	Summit Lk	9340	W	U	L	3.9	35%	1343	25%	14		14	0
90-19	Quinn	8340	M	U	L	23.8	50%	2015	25%	187		187	8
91-1	Ladybug Cmp	4280	D	L	L	0.4	100%	1526	25%	5		5	0
91-2	Whiskey Log Cmp	5300	D	L	L	0.4	100%	1348	25%	4		4	0
91-3	Cahoon (Hockett)	7340	M	L	L	18.5	50%	2340	35%	237		237	0
96-1	North Fk Kaweah River	1900	D	L	L	9.7	90%	1943	25%	132		132	0

Notes: Forage area number is “travel zone – number.”
Moisture is D = dry, M = moist, W = wet.
Vegetation zone is U = upper montane and subalpine, L = lower montane and woodland.
Logistical value is H = higher, L = lower.
Preferred vegetation is the percentage of the meadow area which is preferentially grazed by stock.
Productivity is 65% of the maximum productivity from Ratliff et al. (1987).
Utilization is the maximum percentage of annual plant production that may be grazed.
Model capacity is total production divided by consumption rate.
Evaluated capacity is capacity developed through an evaluation of past use and impacts.
Proposed capacity is the evaluated capacity (if listed) or model capacity.

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