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My following comments discuss some of the major shortcomings in the Wilderness Stewardship Plan DEIS for Sequoia and Kings Canyon National Parks (SEKI), California, dated June 2014. My comments are based on my review of the DEIS, together with my more than 30 years of professional experience, my familiarity with Sierra Nevada ecosystems, and considerable expertise on the effects of grazing animals on soils, hydrology, water quality, aquatic systems, riparian vegetation, and the monitoring of these elements. In my comments, I focus on the many defects in DEIS related to the impacts of proposed stock management under the alternatives because these impacts are significant and DEIS has numerous deficiencies with respect to properly assessing and disclosing these impacts under the alternatives. I submit these comments with understanding that they are highly relevant to the National Park Service's requirements and duties under applicable policies and laws, such as the National Environmental Policy Act, the Wilderness Act, the Endangered Species Act, and the Administrative Procedures Act.

The DEIS fails to adequately assess and make known the impacts of alternatives on soil conditions.

The DEIS fails in many ways to properly assess the alternatives' stock management effects on soils. These are severe defects, because soils are a fundamental cornerstone of ecosystems. Their condition affects a host of critically important processes, including runoff, the infiltration, storage, and release of snowmelt and rain, resulting hydrologic conditions in meadows and streams, soil erosion and plant productivity and community composition.

Soil compaction and related impacts

The DEIS fails to reasonably assess the impacts of stock under the alternatives on soil compaction. This is a major defect, for several reasons. First, horses and mules inevitably and significantly compact soils that they travel over due to the relatively high pressure these animals exert on soils, which is up to 10 times greater than that from hikers (Pickering et al., 2010).

Second, all of the DEIS alternatives except Alt. 4 allow grazing by horse and mules in wet areas that are especially susceptible to compaction. It is exceedingly well-documented that soil compaction is particularly acute in wet soils, such as those found in wet and moist meadows and fens, which are subject to considerable grazing by horses and mules under all of the alternatives except Alt. 4.

Third, soil compaction has numerous adverse hydrologic impacts, including:

- reduction in infiltration rates, creating more surface runoff, which, in turn, elevates surface erosion, sediment delivery to streams, and transport and delivery of surficial contaminants, such as nutrients and biological contaminants in animal manure, to streams;
- increased stream channel erosion due to elevated runoff;
- reduction in the water storage capacity of soils, which combined with reduced infiltration, contributes to increased surface runoff, reduced late summer moisture levels, lower water table elevations, and reduced baseflows to streams (Kauffman et al., 2004; Beschta et al., 2013).

Fourth, these impacts of soil compaction are quite significant for aquatic and meadow ecosystems. The DEIS acknowledges that the functionality of several meadow types, such as fens, are dependent on near-surface water tables. The DEIS (p. 490) also recognizes that soil compaction's hydrologic impacts can eventually lower water tables in meadows and associated riparian areas. Viers et al. (2013) noted that lowered water tables in meadows contribute to stream incisement and loss of meadow functionality. The reduction in base flow contributions to streams due lowered water tables adds additional stress to imperiled aquatic biota (Viers et al., 2013; Beschta et al., 2013).

Fifth, it is well-documented that soil compaction lowers soil productivity significantly and persistently, due to its impacts on soil hydrology and root penetration. Although it is not made known in the DEIS, Wolf and Cooper (2012) documented that soil compaction significantly stunted plant growth in a meadow subject to restoration efforts in SEKI. Murray (1997 as cited in Abbott et al., 2003) recommended that some wet meadows should not be grazed, due to their susceptibility to damage from grazing, although this sound recommendation to protect meadows is not made known in the DEIS.

Sixth, although it is not reasonably disclosed in the DEIS, soil compaction is enduring. In most forest soils, it persists for 50-80 years, though still longer in soils with high clay content, in the absence of additional compaction impacts (USFS and USBLM, 1997; Beschta et al., 2004). Due to its persistence, soil compaction and its impacts are highly cumulative spatially and temporally. Newly compacted soils add to past soil compaction at the ecosystem scale, resulting in combined ecosystem impacts.

Seventh, the hydrologic and biotic impacts of soil compaction by stock are likely to combine with climate change impacts[1] to exacerbate total ecosystem impacts. Climate change is likely to

[1] The DEIS (p. 37) wrongly dismissed assessing the interaction of the effects of the alternatives with those of climate change, by speciously asserting that "…available information is not adequate to quantify the interaction of climate-change impacts on the consequences of the alternatives." This statement is in conflict with available scientific information, which includes many quantitative estimates of climate change effects (e.g., decreased low flows in streams, changes in snowmelt timing) published in scientific journals. However, it also misleads, because the general trend and type of climate change impacts that interact with the many of the consequences of the alternatives are generally agreed upon and have been increasingly documented (Beschta et al., 2013) (e.g., low flows in streams, changes in

advance snowmelt and thereby reduce late summer moisture levels in soils (Beschta et al., 2013), including those in Sierra Nevada meadows (Viers et al., 2013). These hydrologic climate change effects pose a significant threat to fens (Sikes et al., 2013). They are also likely to impact streamflow contributions from meadow systems (Viers et al., 2013), degrading aquatic ecosystems via reduction in low stream flows (Viers et al., 2013; Beschta et al., 2013).

Despite the obvious ecological importance of compaction and its inevitability with continued stock travel and grazing, especially in highly susceptible areas, the DEIS fails in many ways, to credibly assess the likely extent, degree, and distribution of soil compaction under the alternatives. The DEIS does not provide any reasonable estimate of the existing distribution and magnitude of soil compaction. This is a significant defect, because it is likely that most areas, particularly those with wetter soils, in SEKI that have been subjected to horse and mule grazing and/or travel during the past 30 years have some degree of soil compaction, due to the persistence and inevitability of compaction under these conditions. Existing soil conditions are critical to assess because they influence cumulative impacts on a host of ecosystem processes and conditions, as discussed.

Although it is not disclosed in the DEIS, SEKI's own reports provide data that can be used to examine and disclose meadows that are likely to have significant soil compaction. Hopkinson et al. (Table 2.1.6, 2013) includes data for animal unit nights (AUN) per acre for meadows from 1998-2009. Meadows that have been subject significant AUN levels have likely undergone significant soil compaction by stock, particularly in wetter meadows. This information must be disclosed and analyzed with respect to compaction and resulting effects in the FEIS.

The DEIS does not credibly differentiate among the alternatives with respect to stock-caused soil compaction. This is a severe defect because there is considerable difference among the alternatives in the total area, location of areas, and their susceptibility to compaction that are subject to stock travel and grazing. For instance, Alt. 2 allows for continued grazing by horses and mules in a significant amount of wetter meadows and wetlands of various types throughout SEKI, which is sure to cause persistent soil compaction due to these areas' susceptibility to compaction by stock. In contrast, Alt. 4 would allow travel over a smaller area on and off trails with no grazing in any meadow and/or wetland, clearly resulting in a much lower extent and degree of soil compaction relative to Alt. 2.

Alt. 4 would also likely result in a lower degree of soil compaction than Alt. 2, because the DEIS estimates that Alt. 4 would result in less stock use than Alt. 2. Further, under Alt. 4, previously compacted soils in formerly grazed areas that would be closed to grazing would recover over time in the absence of continued compaction from grazing animals, resulting in beneficial effects on soil hydrology, stream flow, and soil productivity (Kauffman et al., 2004). Although soil compaction cannot be rapidly restored or its effects fully mitigated, a critical approach to effective restoring soil productivity degraded by compaction and other impacts is too fully protect soils from additional impacts that can prevent or forestall recovery (Kattlemann, 1996;

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snowmelt timing (Stewart et al., 2005), increased air temperatures, etc.). This information is adequate to assess general interactions of climate change effects and many of the consequences of the alternatives' allowed stock activities (Beschta et al., Table 1, 2013). The DEIS must be revised accordingly.

USFS and USBLM, 1997; Beschta et al., 2004), such as grazing and trampling by stock. Therefore, it is likely that Alt. 4 is the only alternative would allow recovery to occur in all areas formerly subjected to grazing, although this important outcome is not made known in the DEIS.

Based on the foregoing, there are significant differences among the alternatives' stock-related soil compaction impacts, which would significantly affect an array of ecosystem processes and conditions, including soil and meadow hydrology, runoff, soil and channel erosion, soil productivity, wetland functions, and meadow productivity. However, the DEIS fails to adequately differentiate among these alternatives with respect to stock impacts on compaction and its consequent ecosystem effects. Instead of disclosing these significant differences among the alternatives, the DEIS incorrectly states:

> "In general, the potential for adverse soils impacts is associated with the amount of visitor use, but because of factors related to timing, site conditions, and various forms of mitigation, there is little difference among the alternatives in terms of the potential for adverse impacts on soils." (DEIS, p. 390)

> "The action alternatives would result in impacts on soils that are not substantially different than those occurring under current conditions… it can be concluded that the minimal beneficial or adverse impacts on soils from the action alternatives would not produce significant impacts on soils." (DEIS, p. 400)

These misleading statements are directly contradicted by the nature of the alternatives, available information on stock impacts on soil compaction, and compaction's persistent negative impacts on wide array of important ecosystem processes and conditions. In concert, this information clearly indicates that alternatives 1-3 and 5 will have decidedly different impacts on soil compaction and resulting persistent effects than Alt. 4. This, in turn, also demonstrates that the DEIS fails to properly make known the alternatives' stock management impacts on soils.

It is not reasonable for the DEIS to assume that the Stock Use and Meadow Monitoring and Management Strategy protocols (SUMP) outlined in the DEIS's App. D constrain compaction effects to an "acceptable" level or that it protects SEKI ecosystems from such impacts. Simply enough, this is because the DEIS is devoid of an analysis of compaction levels and resultant impacts under the SUMP. The DEIS is also devoid of a reasonable assessment of what SEKI deem are "acceptable" levels of persistent soil damage by compaction and resulting ecosystem impacts.

The DEIS must be revised to correct the foregoing defects. The FEIS must examine past stock grazing and travel use, including that in areas highly susceptible to compaction, to reasonably assess and make known the likely extent of existing soil compaction due to stock use. In order to reasonably differentiate among the alternatives, the FEIS must also credibly estimate the extent and degree of soil compaction under the alternatives, taking into account the area open to off-trail travel and grazing by stock, together with the susceptibility of these areas to compaction by stock. The FEIS must properly disclose that areas closed to grazing under the alternatives will begin to undergo some recovery in soil compaction and disclose the area affected. The FEIS must also properly make known how the impacts of existing soil compaction and that under the alternatives are likely to affect soil productivity, water quality, meadow functions, runoff, stream flow, surface and channel erosion, and meadow conditions.

Soil erosion and related impacts

The DEIS also fails, in many ways, to credibly assess stock-related erosion and resulting soil loss and sediment delivery to streams due to stock activities allowed under the alternatives. Available scientific literature unambiguously indicates that horse use elevates trail erosion. However, the DEIS fails to reasonably assess the magnitude and location of this elevated erosion and stream impacts under the alternatives, because it fails to examine and disclose the total number and length of locations where this is likely to occur under the alternatives. For instance, the DEIS (p. 474) acknowledges that stock activity at stream fords sites elevate soil erosion and delivers it to streams. It is likely that Alt. 4 has far fewer stream fords by trails open to stock than Alt. 3, because the Alt. 3 has 142 (or about 27%) more miles of trails open to stock travel than Alt. 4 (DEIS, Table ES-1, p. xv). However, the DEIS does not disclose the number of such stream crossings under the alternatives and, thus, fails to make known the number of locations where stock on trails are likely to significantly elevate erosion and the delivery of sediment to streams. In so doing, the DEIS fails to reasonably differentiate among the alternatives with respect to impacts on erosion and sediment delivery.

Similarly, it is well-established that a significant amount of sediment generated from disturbances that are within 100 feet slope distance of streams is ultimately delivered to the stream system (USFS and USBLM, 1997). The amount of trail within this distance of streams and lakes that is subject to stock use is also likely to significantly differ among some of alternatives due to the previously described differences in the length of trail open to stock travel (DEIS, Table ES-1, p. xv). However, the DEIS fails to assess and disclose the amount of trail subject to stock use that is within 100 feet of streams and lakes under the alternatives. Therefore, the DEIS failed to reasonably examine and disclose the magnitude of trails that are likely to contribute to increased sediment delivery due to accelerated erosion caused by stock use.

The DEIS also fails to reasonably disclose the erosional impact of bare ground in grazed meadows. Legions of studies have consistently documented that erosion on bare soil is vastly elevated relative to vegetated soils, although this well-documented effect is not adequately disclosed or properly analyzed.

This vastly increased erosion of meadow soils due to elevated bare ground levels is significant for several reasons, all of which are not reasonably made known in the DEIS. Topsoil loss caused by elevated erosion, and associated loss of soil productivity, is permanent and irretrievable (USFS and USBLM, 1997; Beschta et al., 2004), although this is not disclosed in the DEIS.

Elevated erosion from bare ground near streams contributes to elevated sedimentation, turbidity, and suspended sediment levels. These impacts adversely affect aquatic macroinvertebrates, as the DEIS acknowledges. Elevated sediment delivery to lakes reduces their volume over time, contributing to accelerated lake loss via sedimentation. Elevated turbidity harms the natural aesthetics of wilderness streams.

The DEIS fails to analyze and disclose bare ground conditions in meadows and it's effect on soils and resources affected by soil loss and sediment-related impacts. SEKI's own data indicate several meadows have significantly elevated levels of bare ground, although this is not analyzed or described in the DEIS. Based on the bare ground criteria for ecological condition classes among Sierra Nevada meadow types (DEIS, App. D, Table D-3, p. D-25), bare ground data for grazed meadows (Abbott et al., 2003; Haultain and Frenzel, 2012; Hopkinson et al., 2013), meadows with elevated bare ground levels indicative of low ecological condition include: Colby, Redwood, Big Pete, Wallace, Lower Crabtree, Rock Creek Crossing, and Rock Creek Lake meadows. There are but a few examples from available data—it is likely there are many more meadows in low ecological condition due to elevated bare ground within SEKI.

These bare ground conditions in grazed meadows, and their impacts, must be disclosed in the FEIS. The FEIS must also take a thorough examination of available bare ground data for grazed meadows, disclose it meaningful way (such as by moisture class and elevation), and disclose the location, number, and area of grazed meadows that are in low, moderate, and high ecological condition, based on available bare ground criteria for meadow condition. Such an analysis is eminently tractable. SEKI has the data.

The DEIS also fails to adequately analyze the likely impacts of the alternatives allowed stock grazing on bare ground levels and related erosional impacts in meadows subject to stock grazing. Notably, the DEIS (p. 416) acknowledges that grazing can increase bare ground in meadows. Cole et al. (2004) documented that bare ground increased with increased grazing in mountain meadows. The DEIS's failure to reasonably examine bare ground effects under the alternatives is a considerable defect. The alternatives differ considerably in the extent and level of stock grazing, which affect bare ground levels. This defect must be rectified by assessing likely impacts of the alternatives on bare ground levels in meadows, taking into account existing bare ground conditions, and resulting impacts on erosion, topsoil loss, soil productivity, sediment delivery and affected aquatic systems.

It is not reasonable for the DEIS to assume that the SUMP protocols outlined in the DEIS's App. D constrain bare ground and resulting accelerated erosion effects from stock impacts to an "acceptable" level or that it protects SEKI ecosystems from such impacts. Simply enough, this is because the DEIS is devoid of an analysis of bare ground conditions and resultant impacts under the SUMP. The DEIS is also devoid of a reasonable assessment of what SEKI deem are "acceptable" levels of bare ground in meadows, and resulting ecosystem impacts. Further, as will be discussed in greater detail, the SUMP does not ensure or require timely adjustment of stock use in response to even quite high increases in bare ground and resulting erosion of meadow soils.

Organic matter

The DEIS fails to reasonably assess the impacts of stock activities allowed under the alternatives on organic matter in soils. This is key defect because organic matter is vital to important soil functions, such as soil productivity (the capacity of soil to provide plant growth) and soil hydrology, including the ability of soils to absorb, store, and release water from snowmelt and rain. Soils higher in organic matter are have higher infiltration rates and are able to store more water, other factors being equal. All of these factors influence the function and condition of meadows and affected aquatic ecosystems.

Second, stock grazing removes plant material that is the source of organic matter in soils, as the DEIS concedes. Vegetation is a critically important source of soil organic matter, high levels of which are a major feature of meadow soils. The loss organic matter due the removal plant biomass in meadows by grazing is irretrievable and cumulative, although this is not properly made known in the DEIS.

For these reasons, it is critical to assess the cumulative effects on soil organic matter under the alternatives and its related effects. However, the DEIS fails to do so.

SEKI's own reports and residual biomass monitoring data indicate that stock grazing in SEKI has likely significantly reduced sources of organic matter in meadow soils, resulting in organic matter impoverishment in soils, although this important information is not disclosed in the DEIS. These reports (e.g.., Abbott et al., 2003; Hopkinson et al., Table 2.2.2, Table 2013) indicate that stock grazing in many meadows have commonly removed considerably more plant material than needed to meet targets for residual plant biomass in meadows. Although it is not disclosed in the DEIS, Hopkinson et al. (2013) demonstrated that SEKI's RBM data indicate 38% of the meadow-years did not meet the SEKI's residual biomass targets. Hopkinson et al. (2013) documented that RBM data indicated that out of the 25 meadows assessed, 10 meadows (40%) (McClure, Little Pete, Junction/Bubb's Creek, Austin Camp Creek Crossing/Trail Crew Camp, Lake South America, Upper Crabtree, Lower Funston, Forester Lake, South Fork Meadow, and South Fork Pasture) had residual biomass below the target in 50% or more of the years reported for those meadows.

This is significant because these residual biomass targets are primarily based on exceedingly crude estimates of biomass decomposition rates[2] (Neuman, 1993; Abbott et al., 2003), which influence the amount of organic matter in meadow soils. Nonetheless, taking the biomass targets and their bases at face value, the frequent failure to meet the targets indicates that stock grazing has caused significant losses of organic matter in many meadows, which will persistently affect related ecosystem functions, including soil productivity and hydrology.

These defects related to stock impacts on organic matter in soils must be rectified in the DEIS. The FEIS must disclose the location, number, and area of meadows that have likely undergone significant depletion of sources of organic matter, based on the failure to meet residual biomass

[2] Actual decomposition rates are influenced by a complex array of factors, including moisture availability, temperature, biotic decomposing communities, and plant material. Notably, there is no indication that actual plant material decomposition rates in SEKI meadows have been measured under an array of *in situ* conditions. Cole et al. (2004) noted that SEKI's residual biomass targets, which are based on biomass decomposition estimates, are set too low and likely result in continued declines in meadow productivity, even if the targets are met, which is frequently not the case.

targets. The FEIS must also examine and disclose the depletion of sources of organic matter in soil due to the stock activities allowed under the alternatives, and its persistent effect on ecosystem functions and conditions.

Soil productivity

Stock grazing and trampling degrades soil productivity in numerous ways, including via the combined impacts of compaction and the loss of topsoil and organic matter in soils. However, the DEIS does not reasonably assess cumulative soil productivity impacts due to stock activities allowed under the alternatives. This is a severe defect, because it is well-established that stock grazing impacts reduce soil productivity, as Cole et al. (2004) also documented in mountain meadows.

The DEIS does not properly make known that there is considerable evidence that soil productivity has been significantly diminished by stock in many grazed meadows in SEKI. RBM data indicate that many of these meadows are in a poor condition with respect to the production of plant biomass. Abbott et al. (2003) assessed plant biomass data from core grazed areas and reference[3] areas for six years from 1995 to 2000 and compared these data to biomass production criteria[4] for four condition classes: Excellent, Good, Fair and Poor. Based on this analysis, more than 87% (seven of eight) of the meadows above 9700 elevation assessed in Abbott et al. (2003) had plant biomass production in reference areas that were in a "Poor" condition class in at least one of the years they were monitored from 1995 to 2000. Two of these meadows were identified as being in a Poor condition class with respect to biomass production in every year they were monitored.

Low biomass production conditions, indicative of impaired soil productivity, in meadows at 9700 feet or higher are not relegated to the period from 1995 to 2000. Based on the Abbott et al. (2003) biomass production condition class criteria, Colby Meadows (elevation = ca. 9700 feet), had biomass production levels that equate to a "Poor" condition class in 10 of 12 years that residual biomass was measured in reference areas from 1995 to 2009 (Abbott et al., 2003; Haultain and Frenzel, 2012). In the other two years, plant biomass in this meadow was at levels that only constituted a "Fair" condition (Abbott et al., 2003; Haultain and Frenzel, 2012).

Thus, available SEKI data indicate that majority of meadows near or above 9700 feet that have been subject to stock grazing in SEKI have frequently been in poor condition with respect to plant biomass production, indicating significantly degraded soil productivity. It is highly likely that stock grazing, which has numerous adverse and persistent impacts on soil productivity,

[3] Reference areas are selected for monitoring in given year based primarily on an *apparent* lack of significant packstock grazing *over the current season at the time of monitoring* (Neuman, 1994). Because the locations of reference areas are not fixed in areas where it is assured that grazing has not occurred, it is likely reference areas have been subjected to past or recent grazing. Thus, reference areas sampled in a given year may have been significantly grazed and trampled in prior years, cumulatively degrading biomass productivity on the reference site in a persistent fashion.

[4] These condition class criteria are based on meadow elevation and moisture status (Abbott et al., pp. 62-63, 2003).

combined with the inherent sensitivity of these meadows, has contributed to these poor plant production conditions.

The DEIS fails to disclose that similar to meadows above 9700 feet, Evolution Meadow consistently produces low levels of plant biomass. Abbott et al. (pp. 62-63, 2003) noted plant biomass production in both grazed "core" and "reference" areas in Evolution Meadow were in a Poor condition class in all five years that residual biomass was measured from 1995 to 2000. Based on the same biomass condition class criteria for Evolution Meadow (Abbott et al., 2003) and biomass data (Haultain and Frenzel, 2012), Evolution Meadow was in a Poor condition class in nine out of 10 years that residual biomass was measured in reference areas from 2001 through 2011; in the only other year during this period, the meadow only produced residual biomass at levels that were at the lower end of the "Fair" condition class. As is the case with meadows above 9700 feet, it is likely that many adverse impacts of stock use of meadows have cumulatively contributed to the low levels of plant production in Evolution Meadow. Although undisclosed in the DEIS, the low biomass production in Evolution meadows is indicative of diminished soil productivity.

McClure Meadow also produces relatively low levels of plant biomass, indicative of degraded soil productivity. Based on the biomass data in Haultain and Frenzel (2012) and biomass condition class criteria (Abbott et al., 2003), McClure meadow was in Poor condition in two of the three years that data were collected from 2009 through 2011. In the other year, biomass production was at the low end of the Fair condition class. As is the case with meadows above 9700 feet, it is likely that McClure Meadow's elevation (9630 feet), combined with the numerous adverse impacts of past grazing on soil productivity have contributed to the relatively low levels of plant biomass production in this meadow. Notably, soil productivity in McClure Meadow is vulnerable to damage by stock grazing because it is a wet meadow. As previously discussed, wet meadow soils are highly vulnerable to soil compaction by stock, which persistently reduces soil productivity. Hence, it is likely that soil compaction by stock use has contributed to diminished soil productivity in this meadow.

Although it is not disclosed in the DEIS, several other SEKI meadows have produced relatively low residual biomass, including, East Lake Meadow (67-1), Grave Meadow (71-2), Lower Whitney Creek Meadow (83-7), Middle Rattlesnake Canyon (89-9), Hockett Pasture (90-5.2), Nathan's Meadow (85-10), South Fork Meadow (90-10), and Lower Rock Creek Lake Meadow (85-8) (Abbott, p. 65, 2003). These low levels indicate diminished soil productivity.

The DEIS fails to assess and make known this important information related to long-term soil productivity in meadows. This defect must be rectified in the FEIS, by disclosing the number, location, and area of meadows with diminished existing soil productivity based on biomass data. The FEIS must also disclose the long term nature of these impacts.

The DEIS (e.g., App. D.) concedes that proposed grazing levels under several of the alternatives will further degrade productivity in many meadows. The FEIS must examine these alternatives' continued impacts on soil productivity in combination with existing conditions to reasonably differentiate among the alternatives with respect to soil productivity. The FEIS must also disclose that the Alt. 4 is likely to contribute to increasing soil productivity over time in the meadows of SEKI by reducing grazing and associated trampling impacts due to the alternatives' prohibition on grazing by stock.

Soil nutrification

The DEIS fails to reasonably examine soil nutrification due to stock activities allowed under the alternatives. This is a severe defect, because nutrient enrichment of soil by horses is known to be a significant impact (Pickering et al., 2010), although this is not adequately examined or disclosed in the DEIS. Due to the volume and composition of excreta, horses have far greater effect on soil nutrient enrichment than hikers (Pickering et al., 2010). Horse excreta introduces about 19 g of phosphorous and 100 g of nitrogen per horse per day, based on the data of Westendorf (2004). Trails, tethering areas, and other areas with considerable use can become considerably enriched with nutrients, favoring non-native vegetation (Pickering et al., 2010). Nutrients leached from nutrient-enriched soils to water bodies accelerate eutrophication, including increased algal biomass, loss of water clarity, and degradation of natural aesthetics. This is already happening in SEKI where data indicates that phosphorus is elevated in surface water draining areas with stock use (Clow et al., 2014). Research has documented elevated algal biomass in waters draining areas with stock use in SEKI (Ursem et al., 2009; Derlet et al., 2012). This contribution to accelerated eutrophication of alpine lakes is significant because it interacts with climate change, which is likely to accelerate eutrophication in various ways (Jeppesen et al., 2010).

The DEIS's significant defects regarding soil nutrient enrichment by stock must be rectified. SEKI has data to tractably provide estimates of nutrient loading to soils by stock, including animal unit night (AUN) estimates for different areas (e.g., Hopkinson et al., 2013). This can be used with animal/day nutrient excreta data to provide estimates of nutrient input to soils. The FEIS should also identify areas that are likely hotspots for soil nutrient enrichment. The DEIS's deficiencies in these respects should also be corrected by properly discussing the impacts of soil nutrient enrichment on critical ecosystem processes and conditions, including nonnative invasive vegetation, water quality, synergy with climate change, and the naturalness of ecosystem appearance and function.

The DEIS did not adequately assess the alternatives cumulative impacts on the spread and establishment of nonnative vegetation.

The DEIS (p. 416) correctly notes that the susceptibility of areas to invasion by nonnative vegetation increases with increasing levels of bare ground, especially when combined with exposure to stock, which distribute and deliver nonnative vegetation propagules in many ways. Nonnative vegetation is a significant problem in several areas of SEKI. As the DEIS (pp. 416-417) acknowledges, available information indicates that stock have played a role in existing infestations in SEKI due the combined impacts of stock on native vegetation, bare ground, and the distribution and delivery of nonnative vegetation propagules.

Despite the DEIS's recognition that bare ground and stock grazing increase the probability of additional nonnative vegetation invasions, the DEIS does not assess the interaction of existing bare ground in meadows that are subject to grazing under the alternatives. As previously noted, SEKI has data on bare ground levels in meadows, making such an analysis tractable. The DEIS's failure to assess bare ground conditions in meadows subject to grazing under the alternatives renders the assessment of grazing impacts on nonnative vegetation flawed and inadequate.

The DEIS also fails to reasonably assess the effectiveness of proposed measures related to stock management effects (App. D) and nonnative vegetation strategy (App. N) with respect to limiting the spread of nonnative vegetation. This is a serious deficiency in the DEIS, because the approaches in App. N and App. D are unlikely to be effective in stemming ongoing nonnative vegetation invasions due to the lack of required effective measures to reduce the spread of nonnative vegetation. For instance, continued stock travel and grazing in areas with existing nonnative vegetation is likely to contribute to continued spread of nonnative vegetation. However, neither App. D nor App. N requires closure of such areas to stock travel and grazing. Similarly, these strategies do not require immediate cessation of stock use of meadows with high levels of bare ground, which are especially susceptible to nonnative vegetation invasion. As another example, App. N recognizes that stock manure is a vector for weed spread and requires that it be removed from corrals. However, App. N makes no similar requirement for the significant amount of stock manure deposited in backcountry wilderness areas. This is significant defect, because stock unquestionably introduce a significant amount of manure[5] into wilderness areas annually and would continue to do so under the alternatives. Further, as the DEIS (p. 417) recognizes, the introduction of nonnative vegetation via manure in wilderness off-trail areas and in meadows is far more likely to go undetected than such vegetation in front country areas, such as corrals. For these reasons, the lack of effective measures plainly limits the effectiveness of proposed strategies to constrain the spread of nonnative vegetation in SEKI by stock activities and must be made known.

Instead of applying more effective measures to limit nonnative vegetation spread and establishment, such as those previously discussed, App. N and App. D primarily rely on detection of infestations and post-detection treatments. It has long been recognized that post-detection treatments are generally ineffective at stemming nonnative vegetation invasions and are far more ineffective than preventing nonnative vegetation establishment. These limitations of the nonnative vegetation strategies in App. D and N must be adequately assessed and disclosed in the FEIS.

The DEIS does not reasonably analyze and disclose the impacts of allowed pack stock activities under the alternatives on ecosystem hydrology (quantity, pathways, and timing).

The DEIS did not properly assess the cumulative effect of existing conditions and stock activities allowed under the alternatives on the timing, quantity, pathways and storage of water in SEKI ecosystems. This a severe defect, because: a) these hydrologic conditions and processes

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[5] The DEIS not provide any reasonable estimate of the amount of excreta annually deposited in wilderness by stock. However, the DEIS (p. 419) indicates that average stock nights over the past decade has been on the order of 6,800, which does not appear to include stock day use in wilderness. Using an AUN of 7.000 to account for day use, together with the data in Westendorf (2004), nearly 300,000 pounds of wet manure are annually deposited in SEKI wilderness areas by stock.

profoundly affect ecosystems; b) they have already been significantly altered by stock grazing and trampling, particularly in meadows; d) the impacts are on hydrology are highly persistent, and, c) they will continue to be significantly affected by stock activities allowed under the alternatives.

As previously discussed, the DEIS failed to properly examine the alternatives' cumulative effects on soil compaction by stock. Soil compaction strongly affects ecosystem hydrology, as previously noted, by increasing surface runoff and decreasing infiltration rates, soil water storage, and water table elevation in meadows. Although this is not disclosed in DEIS, these compaction impacts are likely already particularly severe in meadows subjected to grazing, and particularly those with soils that are wetter and/or have higher clay content.

The work of Kauffman et al. (2004) demonstrates that the loss of the ability of soils compacted by grazing to absorb, store and ultimately release water to streams and wetlands is far from trivial. Kauffman et al (2004) documented that the mean infiltration rate in soils that had been excluded from grazing for more than a decade was 2.33 to 13 times greater than in compacted soils in otherwise comparable grazed areas. Kauffman et al. (2004) estimated that soils compacted by grazing lost the ability to store about 121,000 liters of water per hectare (or about 13,000 gallons per acre) in *just the top four inches of soil* in wet meadows. This clearly indicates that compaction by stock seriously alters the amount of surface runoff and the amount of water that can be stored in meadow soils, especially in wet meadows, which are the most susceptible to compaction by stock.

Similarly, the hydrology of many meadows in SEKI has also likely been significantly affected by the loss of organic matter, which also significantly influences infiltration rates and water storage capacity in soils. However, the DEIS failed to properly examine the loss of organic matter in soils due to stock grazing and its effects on meadow and watershed hydrology.

Stock trails also significantly alter hydrology in areas with naturally high water tables, such as wet meadows. Stock use significantly deepens trails (Abbott et al., 2003; Pickering et al., 2010). Deepened trails are more likely to intersect shallow groundwater in wetter meadows, effectively acting as groundwater drains that lower water tables, desiccating meadows and reducing late summer and fall sources of streamflow. The physics of water flow in soils makes this draining of groundwater inevitable when trail incisions intersect water tables (Kirkby, 1978) and the phenomena is commonly and easily observable in wet meadows with deep stock trails in the Sierra Nevada. The incisions by stock-deepened trails in meadows also act as barrier to downslope movement of water in soils (Kirkby, 1978), which can result in desiccation of areas downslope of entrenched trails.

These hydrologic impacts are an extremely significant, as previously discussed. The hydrologic alteration of wetter meadows, such as fens, adversely impacts their functionality (Sikes et al., 2013). These stock-related impacts also cumulatively contribute to reductions in low flows in streams. Although it is not properly assessed in the DEIS, these hydrologic impacts of stock trampling and grazing interact with climate change effects (Beschta et al., 2013), which are likely to reduce late summer moisture levels in meadows and reduce low flows in streams (Beschta et al., 2013; Viers et al., 2013).

The DEIS must be revised to rectify the defects related to the hydrologic impacts of packstock. In order to provide indices of hydrologic alteration, the FEIS must identify the number, area, location and types (e.g. fen, wet, etc.) of meadows that have had significant reductions in organic matter sources and soil compaction due to grazing. As discussed in the foregoing, SEKI has the data on stock use and biomass to provide such indices. The FEIS should also assess and make known the number, area, location and types (e.g. fen, wet, etc.) of meadows affected by stock trails, in order to provide an index of hydrologic alteration due to stock trails. Because hydrologic alteration also affects stream flows, these indices of hydrologic alteration must be assessed and made known at the scale of subwatersheds.

These same indices of hydrologic alteration by stock activities must be assessed and disclosed for the alternatives, in order to adequately differentiate among them. This is critical because, as previously discussed, there are considerable differences among the alternatives with respect to hydrologic impacts: such impacts in grazed meadows will continue and increase under all of the action alternatives, except Alt. 4, which prohibits grazing in all meadows in SEKI.

The hydrologic impacts of stock grazing clearly combine with those that are likely due to climate change (Beschta et al., 2013). Therefore, in order to reasonably assess cumulative effects, the FEIS must also examine the impacts of stock activities under the alternatives combined with those that are likely due to climate change, such as reduction in low stream flows, earlier snowmelt, etc. The FEIS must disclose that the elimination of stock grazing can help offset some of the adverse impacts of climate change on the hydrology of wildland ecosystems (Beschta et al., 2013).

The DEIS does not properly assess the impacts of allowed pack stock activities under the alternatives on water quality.

Nutrients and eutrophication of SEKI waters

As previously discussed, stock, particularly horses and mules, introduce a significant amount of manure to wildlands in SEKI, resulting in significant nutrient loading to SEKI watersheds. This includes the direct deposition of stock manure at stream fords, which the DEIS (p. 474) acknowledges, but fails to properly assess in regard to nutrient loading and consequent eutrophication of water bodies. Nutrients from stock manure are also ultimately transported to SEKI waters via surface runoff (Clow et al., 2013) and leaching from soils.

Nutrient delivery to SEKI waters is extremely significant impact because it accelerates eutrophication, including increased algal growth which causes a loss of water clarity and degradation of natural aesthetics. Elevated nutrient loading of surface waters is already happening in SEKI where data indicates that phosphorus[6] is elevated in surface water draining

[6] Most aquatic systems in the Sierra Nevada are strongly nitrogen limited. As a result, nitrogen is rapidly taken up by algae. For these reasons, relatively low nitrogen concentrations in lakes and rivers do not indicate that elevated nitrogen delivery to aquatic systems is not a problem. Notably, Clow et al. (2013) found evidence of nitrogen uptake in aquatic systems, which is consistent increased algal activity and eutrophication of water bodies. The positive relationship between nitrate concentrations and

areas with stock use (Clow et al., 2014). Elevated algal biomass in water draining areas stock use in SEKI has been documented (Ursem et al., 2009; Derlet et al., 2012). Backcountry ranger reports have long called attention to high levels of algae in wilderness streams and rivers in SEKI affected by stock manure and expressed concern about the problem, as well as suggesting reductions in stock use to address the problem (Kenan, 2001). None of the foregoing is made known in the DEIS, which is a severe defect.

Increased algal biomass severely degrades wilderness aesthetics—the alpine lakes of SEKI have long been revered for their clarity, which is dependent on their natural oligotrophic (low nutrient loading and algal biomass) condition. Eutrophication degrades ecosystem function, by fundamentally altering food and nutrient webs. The increased algal biomass caused by eutrophication also poses a significant threat to human health because it harbors high levels of harmful bacteria (Derlet et al., 2012). Climate change is likely to accelerate eutrophication. Thus, the eutrophication of alpine lakes and streams by stock manure is likely to interact with climate change impacts on the alpine lakes of SEKI.

Despite the ecological and aesthetic importance of the alpine lakes of SEKI, the DEIS is devoid of any analysis of stock impacts under the alternatives on nutrient loading, trophic conditions in affected aquatic systems, and resulting aesthetic and ecological impacts. These are major flaws because these impacts, including those of stock manure on nutrient loading and the effects of increased nutrients on aquatic trophic conditions and associated impacts, have long been known (Pickering et al., 2010), including in the Sierra Nevada (e.g., Rhodes, 1985), and documented in SEKI (Kenan, 2001; Derlet et al., 2012).

These DEIS's severe defects regarding stock-related eutrophication of SEKI waters must be rectified. SEKI must estimate nutrient loading in watersheds and to water bodies by stock. SEKI can tractably do so--it has animal unit night (AUN) estimates for different areas (e.g. Hopkinson et al., 2013), which can be used to provide estimates of nutrient loading at the scale of drainages. This must be done in order to reasonably assess water quality impacts. The FEIS must particularly examine nutrient loading at the scale of drainage areas to sensitive lakes, particularly those that are have undergone significant nutrient loading due past stock use levels. This must be also be done by alternative in order to adequately differentiate among the alternatives' effects on eutrophication.

The DEIS must be rectified to asses the direct deposition of stock manure in streams, which it acknowledges occurs at stream fords, but does not reasonably assess. The FEIS must assess and make known the number of stream fords by trails open to stock use and stock use levels under the alternatives, in order to provide a index of the direct deposition of manure and associated nutrients in streams and lakes. Such indices are also needed to reasonably differentiate among the alternatives, because there are differences among the alternatives with respect to the amount of trails open to stock use (DEIS, Table ES-1, p. xv), and, hence, stream fords subject to stock use. The FEIS must also factor in stock use levels under the alternatives, because the DEIS notes that the amount of stock in wilderness is likely to vary among some of the alternatives.

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elevation in SEKI waters found by Clow et al. (Fig. 5, 2013) is also consistent with algal uptake of elevated nitrogen levels in the waters of SEKI.

Because it is well-established that a significant fraction of surficial contaminants, such as stock manure, deposited within 100 feet of water bodies is ultimately delivered to those water bodies, the FEIS must make known the length of trail open to stock use within 100 feet slope distance of water bodies by alternative. For the same reason, the DEIS must be revised to make known the area open to stock grazing and camping with stock within 100 feet of water bodies by alternative. Wetter meadows are often hydrologically connected to streams and lakes, therefore, in order to adequately differentiate among the alternatives, the DEIS must be revised to disclose the number, area, and location of wetter meadows that are likely hydrologically connected to streams and lakes that are subject to stock grazing by alternative. These attributes of stock activities allowed under the alternatives are absolutely essential to reasonably assessing the alternatives' likely impacts on nutrient pollution and eutrophication of water bodies by stock in SEKI.

Sediment-related water quality degradation

Available information and SEKI data indicate that stock have degraded water quality conditions related to sediment via elevated erosion, although the DEIS does not properly examine and disclose this. As previously discussed, many grazed meadows have elevated levels of bare ground, which greatly elevates erosion and sediment delivery to water bodies, although the DEIS completely failed to assess this impact on water quality. Stream fords and trails near water bodies subject to stock use also elevate sediment delivery. Clow et al. (2013) documented large increases in turbidity in waters draining areas subject to stock use.

The DEIS fails to provide an index of the magnitude of water quality degradation by sediment under the alternatives, because the DEIS did not examine and disclose the total number of locations where sediment delivery from stock impacts are likely to occur under the alternatives. The DEIS (p. 474) acknowledges that stock use at stream fords results in the delivery of elevated soil erosion to streams. However, the DEIS does not examine or make known the number of such fords by trails open to stock use under the alternatives. The DEIS also fails to assess and disclose the amount of trail subject to stock use and meadows open to grazing that is within 100 feet of streams under the alternatives. In so doing, the DEIS did not even provide indices of the impacts of allowed stock activities under the alternatives, and, thus, fails to adequately differentiate among the alternatives with respect to their sediment-related impacts on water quality.

The DEIS fails to adequately assess stock impacts on stream banks, and resulting effects on sediment-related water quality conditions due to stock activities. Streambank damage by stock is especially likely where stock graze along stream banks or access streams for water.[7] This physical damage reduces bank stability, leaving remaining banks oversteepened and devegetated, which elevates bank erosion. Bank damage and trampling can also cause banks to collapse into streams, degrading water quality. As a BLM publication (Cowley, 2002) on bank alteration noted, "[i]t is well documented that large herbivores such as cattle, **horses,** sheep, bison, elk, and

[7] A 1,100 pound working horse typically consumes in about 10 to 18 gallons of water per day. This level of water consumption requires packhorses to access water sources multiple times on a daily basis. http://www.ag.ndsu.edu/pubs/ansci/livestoc/as954w.htm

moose can alter the physical dimensions (e.g., increasing the bankfull width) of stream channels by bank trampling and shearing…Increasing the bankfull width makes the stream shallower, **increases sediment,** decreases the floodplain, increases temperature, and increases the adverse [effects on] the physical functioning of a stream, its associated riparian area, and aquatic habitat…" (emphasis added).

Ostensibly, SEKI has information on bank conditions in grazed areas based on site visits (DEIS, D-27, App-D[8]). However, the DEIS provides no assessment of existing bank conditions or those conditions likely under the alternatives and their consequent effect on sediment related water quality. If the SEKI bank condition information for grazed meadows is inadequate to make a reasoned assessment of sediment-related water quality effects, this must be disclosed. At a minimum, the FEIS must provide at least an index of bank damage and sediment impacts under the alternatives by assessing and disclosing the length of streams subject to stock impacts: a) in areas open to grazing; b) areas open to stock travel. The FEIS must also properly disclose that alternatives with greater levels of streams subject to stock grazing will contribute significantly higher levels of sediment-related aquatic pollution than alternatives with lower levels of stock grazing.

[8] Notably, the cover photo for the Appendix D of a grazed meadow along Wales Creek shows banks that have been significantly damaged and destabilized by stock impacts, as well as large mobile deposits of fine sediment that result from bank damage and contribute to sediment-related water quality degradation (See Photo 1 in these comments).

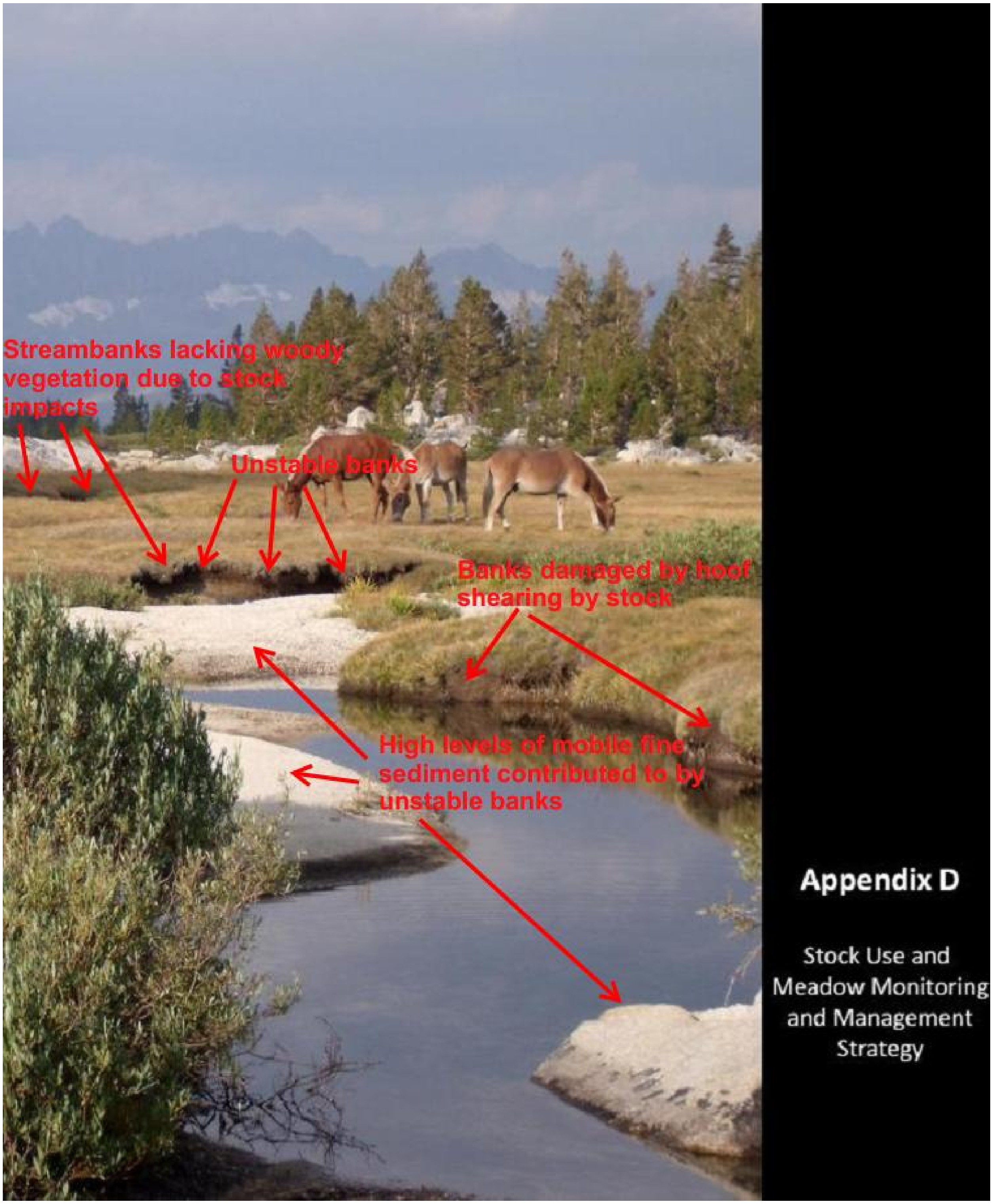

Photo 1. This photo is taken from the cover page of App. D of the DEIS, but with text and arrows in red added to point out specific attributes of stock-related damage to stream banks and stream conditions that are shown in the photo.

Biological water pollution

Water quality research in SEKI has clearly shown that stock impacts are seriously polluting water bodies in SEKI with biological contaminants that pose a health problem if consumed. Clow et al. (2013) found that there was no statistical difference in the mean concentrations of *E. coli* between sampled waters draining areas with "minimal" use and areas used by backpackers in the absence of stock. In contrast, waters draining areas affected by stock and backpackers had mean *E. coli* concentrations that were higher than waters draining areas with minimal use or use by only backpackers, clearly demonstrating that stock cause significant *E. coli* pollution in SEKI waters. The mean *E. coli* concentrations in waters draining stock-affected areas were approximately 255% higher than in waters draining areas affected only by backpackers and 933% higher than in waters draining areas with minimal use.

These results of Clow et al. (2013) corroborate those of Derlet et al. (2008), which documented that coliform levels were higher in water draining areas subject to stock than waters draining areas with only backpacking or little use. Derlet et al. (2008) documented that elevated coliform levels occurred far more frequently water draining areas with stock use than those draining areas with only backpacking or little use.

E. coli and total coliform concentrations increased in waters flowing through areas subject to stock use in SEKI and the increase of these contaminants in these areas was highly statistically significant (Clow et al., 2013). In contrast, there were no statistically significant increases in these biological contaminants in waters flowing through areas in SEKI subject to little or only backpacker use. The results in Clow et al. (2013) document that the pollution of SEKI waters by biological contaminants in areas subject to stock use underwent major increases during storm events. *E. coli* concentrations in water draining a meadow subject to stock use (Sandy Meadow) underwent vast increases (ca. 1000%) relative to pre-stock use levels soon after stock were allowed to use the meadow (Clow et al, 2013), although this result is never disclosed in the DEIS. After stock use was allowed in the meadow, *E. coli* concentrations downstream of the meadow increased sharply and peak concentrations were more than 2000% higher than upstream of the grazed meadow, which Clow et al (2013) explicitly noted was evidence that the meadow had sources of *E. coli*. However, the DEIS fails to disclose this vital information demonstrating significant biological pollution of SEKI water by stock impacts.

In aggregate, these data clearly demonstrate that stock use is significantly polluting SEKI waters with biological contaminants on a widespread and regular basis. This contamination not only indicates a threat to human health from pathogenic coliforms, but also several other associated pathogenic contaminants in stock excreta (Derlet et al., 2008; Clow et al., 2013).

The DEIS fails to reasonably assess and make known these impacts of stock activities in SEKI. Instead of properly disclosing the information, the DEIS makes untenable and unsound characterizations of the information. For instance, the DEIS (p. 366) incorrectly asserts that the documented contamination cannot be attributed to particular sources, such as stock. However, the nature of the foregoing multiple lines of evidence clearly indicate that the documented pollution is most likely from stock. There is simply no sound evidence from the two studies that wildlife or backpackers are likely sources of the widespread and significant pollution documented by Derlet et al. (2008) and Clow et al. (2013). In fact, the results convergently indicate that stock are the primary source of this biological pollution.

The DEIS (p. 366) further mischaracterizes the magnitude of biological pollution from stock documented in the studies as “small.” However, the documented increases in the biological contaminants on the order of 255% to more than 2000% cannot be legitimately characterized as “small.” These are major increases in pathogenic contaminants that threaten human health.

Instead of properly making known the ramifications of the results of these studies, the DEIS (p. 401) speciously speculates that studies documenting the widespread and serious biological contamination of SEKI waters may be incomplete due to limitations of information in the studies on the following in areas drained by sampled waters: levels of wildlife, human, and stock use; differences in ease of access, remoteness; or variation in the outdoor ethics among individuals; and, a litany of other speculative factors. This speculation in the DEIS is plainly without sound bases—SEKI ostensibly has access to the aforementioned factors, but the DEIS is devoid of any analysis indicating that the inclusion of information would, in any way, alter the studies' overall results, which robustly indicate that stock are the primary cause of widespread biological pollution of SEKI waters.

The DEIS provides no evidence that wildlife use is heavier in areas with stock that had significantly elevated levels of biological pollution in the waters that drained them. Further, available evidence clearly contradicts the DEIS's speculative argument that more easily accessed areas may have higher levels of biological pollution due to lower levels of backpacker hygiene: as previously discussed, Clow et al., (2013) documented large increases in biological contamination downstream of Sandy Meadow after the onset of stock use. This meadow is at an elevation of approximately 10,600 feet (Abbott et al., 2003) and is not easily accessed.

The DEIS (p. 402) also speciously asserts that there are “concerns” with sample design[9] of Derlet et al. (2008), but fails to identify these concerns. While the DEIS notes that holding times for the water samples of Derlet et al. (2008) did not always comport with USEPA standards for coliform samples, the DEIS fails to properly assess that this is likely to result in lower coliform concentration due bacteriological degradation in water samples.

The DEIS fails to note that the documented elevated biological pollution in waters draining areas subject to stock use in SEKI comport with the nature of excreta deposition by stock. Unlike hiker excrement, which is buried, stock excreta is deposited on the soil surface where it is easily transported by surface runoff. Stock animals also produce far greater levels of excreta than hikers (Pickering et al., 2010). As the DEIS acknowledges, stock excreta is also commonly deposited directly in streams at fords. Although it is not made known or analyzed in the DEIS,

[9] The DEIS must apply a consistent standard in the assessment of study design for studies cited in the DEIS. For instance, the DEIS should be revised to note that the analysis of bare ground in five paired meadows in Hopkinson et al. (2013) has extremely low sample numbers, resulting in low statistical power, and that the selection of the five meadows is not based on any rigorous sample design that assures that they are representative. Further, this analysis does not include information on the following in the five paired meadows: levels of wildlife and human stock use; differences in ease of access, or remoteness. The DEIS cannot apply different yardsticks to different studies.

stock excreta is also frequently deposited directly in streams in areas open to stock grazing. Many wet meadows subject to stock grazing are also hydrologically connected to streams and lakes, resulting in the relatively efficient and rapid conveyance of significant levels of biological contamination to water bodies. It is well-established that stock manure, particularly from horses, has appreciable levels of pathogenic contaminants (Derlet et al., 2008; Pickering et al., 2010).

For these reasons, the DEIS must be rectified to properly make known that it is clear from available data and information that stock activities in SEKI have significantly polluted waters with biological contaminants found in stock excreta. The DEIS must be revised to reflect that magnitude of documented biological pollution is considerable and widespread.

The DEIS must also be revised to properly assess the impacts of stock activities allowed under the alternatives on biological contaminant pollution, by assessing the following indices of biological contamination of water by stock under the alternatives:

- number of stream fords open to stock use;
- length of trails within 100 feet slope distance of streams and lakes;
- area of meadows open to grazing that are contiguous with streams and lakes;
- area of wet meadows open to grazing;
- estimated AUN in meadows subject to grazing and camping.

These indices are also necessary to assess and disclose in order to reasonably differentiate among the alternatives with respect to their likely impacts on biological pollution of SEKI waters.

The DEIS fails to reasonably examine and disclose impacts of stock activities allowed under the alternatives on meadow function and vegetation.

Stock grazing and elevation

The DEIS does not properly disclose that SEKI's own report assessing meadow vegetation and residual biomass in grazed meadows (Schelz, 1996) recommended that meadows at elevations greater than 9,700 feet in SEKI be closed to grazing due to their low production of vegetation and their high degree of sensitivity to the adverse impacts of grazing. Backcountry reports have also recommended closing meadows above 10,000 feet to grazing due to their sensitivity to impacts (Kenan, 2001). The DEIS fails to disclose this information and that SEKI's own data indicate, in several ways, that these recommendations are sound.

First, the production of plant biomass in meadows in SEKI decreases with elevation and is quite low in meadows near and above 9700 feet in elevation. The DEIS (App. D) concedes that elevation exerts a powerful control on biomass production in meadows, as does Hopkinson et al. (2013).

The analysis in Schelz (1996) documented that biomass production declined steeply with the average elevation of the meadows in five production classes. This is consistent with the meadow biomass data grouped by elevation categories in Abbott et al.(2003), a report commissioned by SEKI, but that is never discussed or cited in the DEIS.

This relationship is quite clear and consistent in plant biomass production data for 38 meadows in SEKI over six years (1995 to 2000) in the study of Abbott et al. (2003). Straightforward analysis of the biomass production data averaged by elevation category in Abbott et al. (2003) using common statistical methods indicates that the decline in mean biomass production by elevation category is distinct and highly statistically significant in each of the six years and for all combined data over the entire six year period of data. These data indicate that the decline in meadow plant biomass production with elevation is particularly steep between meadows at elevations of 8000 to 8999 feet and those at 9000 to 9999 feet. The biomass production data in Abbott et al (2003) demonstrate that over the six years of data collected from 1995 to 2000 in SEKI meadows, the average level of biomass production in meadows at greater than 9000 feet was well *less than half* (about 41%) of the average level of biomass produced in meadows at 8000 to 8999 feet. In each of the six years of data averaged by elevation category presented in Abbott et al (2003), there was never any overlap between the average biomass production in meadows at elevations of 8000 to 8999 feet and those at 9000 to 9999 feet— the lowest mean level of biomass production measured over six years in meadows at elevations of 8000 to 8999 feet was still considerably greater than the highest mean level of biomass production measured over six years in meadows at elevations of 9000 to 9999 feet. The statistical relationship of average biomass production with elevation category was quite strong in all six years. In aggregate, these results clearly demonstrate that the production of plant biomass declines significantly with elevation and is consistently much lower in meadows above 9000 feet in elevation than it is in meadows that are below 9000 feet in elevation (See Figure 1 below). This straightforward analysis of that data in Abbott et al. (2003) indicates that the analytical results in Schelz (1996) regarding the effect of elevation on plant biomass production levels in meadows are sound

However, while sound, the recommendation of Schelz (1996) to suspend packstock grazing in meadows above 9700 feet in elevation in order to protect meadow functions and aesthetics is not particularly conservative with respect to protecting sensitive meadows that are vulnerable to damage from packstock grazing, because the biomass drops steeply above an elevation of 9000 feet, hence, there is a sound ecological basis for eliminating grazing in meadows above this elevation.

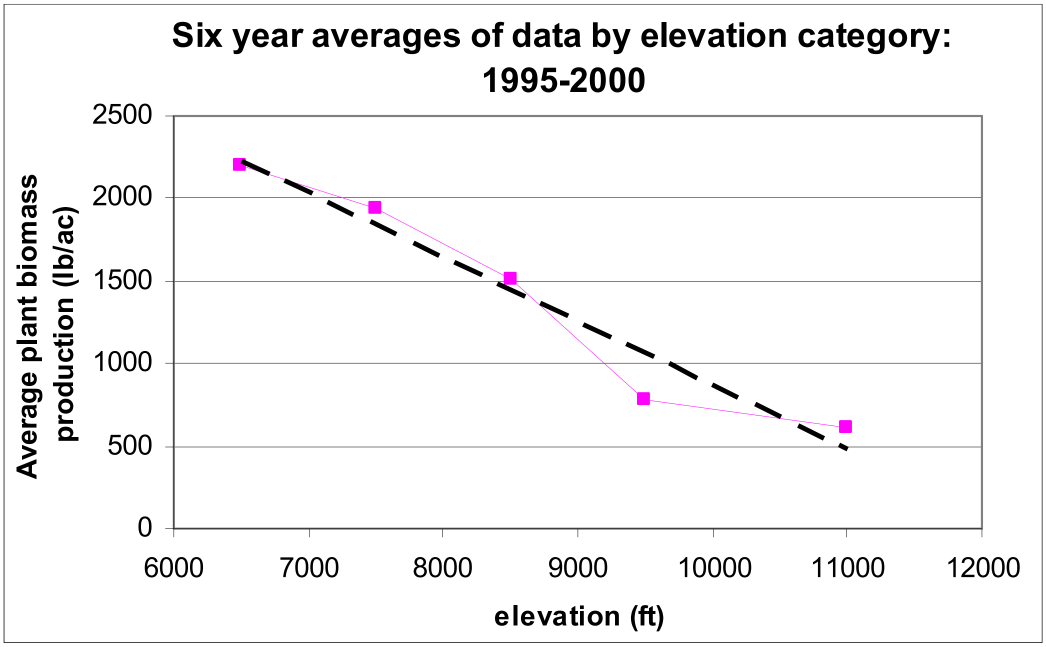

Figure 1. Average biomass production in meadows by elevation category over six years (1995 – 2000) in 38 moist-wet meadows (data from Abbott et al., 2003). The dashed line is the best fit statistical regression line through the data and shows that average biomass production is highly correlated with elevation with relatively little scatter. As the figure indicates, there is a steep decline in actual average biomass production from meadows at 8000-8999 feet to those at greater than 9000 feet in elevation, which is also the consistent case in each of the six years of data in Abbott et al. (2003).

Notably, assessments in Schelz (1996) and Abbott et al. (2003) involve data from far more meadows than does SEKI's monitoring of bare ground and species composition trends in five paired meadows (Hopkinson et al., 2013). Therefore, it is highly likely that the results of 1996 Schelz and Abbott et al. (2003) analysis are far more representative of meadow conditions in SEKI than are the results of SEKI's paired meadow monitoring.

The relatively low level of biomass produced on meadows at elevations above 9700 feet is significant to the impacts of grazing on meadow functions and aesthetics. At these relatively low levels of plant production, these meadows cannot sustain much plant removal by grazing without causing meadow degradation via the removal of the sources of organic matter in soils that are vital to important meadow functions, such as soil productivity (the capacity of soil to provide plant growth) and the ability of meadow soils to absorb, store, and release water from snowmelt and rain. Further, because plant production is relatively low, limits on the consumption of plant biomass are easily exceeded even at relatively low levels of grazing, as Schelz (1996) noted and Cole et al (2004) also noted for similar meadows.

Soil conditions are a second reason for suspending grazing above 9700 feet in order to protect the ecological functions and aesthetics of these meadows. As mentioned, organic matter in soils are critical to meadow soil productivity and other functions. Plant biomass is the primary source of soil organic matter. Thus, at higher elevations where plant biomass production is relatively low, levels of soil organic matter also tend to be relatively low. A relatively small loss of plant biomass can significantly reduce soil organic matter and, consequently soil productivity, in these higher elevation meadows with low biomass levels. This impact is also exacerbated because at higher elevations, the conversion of plant material to organic matter tends to be slower than at lower elevations.

Meadows at higher elevations also likely require more time to recover from the loss of plant biomass. This is due to the relatively low levels of annual plant production that is the primary source of soil organic matter and relatively slow rate of the conversion of plant material to soil organic matter at higher elevations. Thus, the impacts of the loss of plant biomass on meadow functions and aesthetics due to grazing impacts are likely more persistent in meadows at higher elevations than in meadows at lower elevations.

Another compelling reason for suspending packstock grazing in meadows above 9700 feet is that biomass monitoring indicates that many of these meadows are in a poor condition with respect to the production of plant biomass, as previously discussed. Based on Abbott et al. (2003), more than 87% (seven of eight) of the meadows above 9700 elevation that were assessed had plant biomass production in reference areas that were in "Poor" condition class in at least one of the years they were monitored from 1995 to 2000; two of these meadows were identified as being in a Poor condition class with respect to biomass production in every year they were monitored.

For these reasons, the DEIS's failure to examine and make known the foregoing information from SEKI's own reports is a severe defect. The DEIS must be revised to examine and disclose this information in order to reasonable assess whether grazing high elevation meadows is scientifically and *ecologically* sound and comports with SEKI's obligation to manage meadow systems consistent with wilderness requirements and NPS mandates.

The foregoing also plainly indicates that the DEIS's (p. 221) dismissal from detailed analysis of an elevation limit to grazing is without sound ecological bases. The foregoing clearly indicates demonstrates that the condition and attributes of meadows provide compelling ecological and logistical reasons for setting an elevational limit of ca. 9,000 feet above which meadows would not be subject to grazing.

The DEIS's (p. 221) suggestion that the meadow moisture availability at higher elevations affects productivity is not particularly relevant nor does it provide a sound reason for eliminating grazing of higher elevation meadows. Wetter meadows, which tend to have higher plant productivity than drier meadows, are more susceptible to persistent and highly cumulative physical damage to from stock grazing, as previously discussed. Further, the DEIS's own estimates of plant productivity for moist and wet meadows are made solely as a function of elevation, under the incorrect assumption that they are in "good" condition (pp. D-42 to D-43, App. D).

As will be discussed in greater detail, allowed forage utilization levels for all of the alternatives except 4 (which allows no grazing) are primarily based on grazing logistics considerations, rather than ecological resilience to grazing impacts. These allowed forage utilization levels are made without any explicit assessment of the innate sensitivity and/or the condition of meadows, in conflict the DEIS's (p. 221) unwarranted assertion that the allowed utilization levels and related estimated grazing capacities are “informed” by meadows’ vulnerability to erosion or change in hydrologic function, susceptibility to invasion by nonnative plants, and the habitat requirements of sensitive plants and animals. In fact, as discussed in greater detail in these comments, the forage capacities and utilization levels for alternatives 1-3 and 5 are set in the absence of reasonable assessment of the impacts of grazing on meadow hydrology, erosion, nonnative plant invasions, based on consideration of the condition and attributes of meadows proposed for grazing. In sum, the DEIS provides no credible bases for dismissing a detailed assessment of an ecologically sound an elevation limit to grazing.

Estimated grazing capacity and estimated biomass production versus actual biomass production in SEKI meadows

Available data for meadows in SEKI indicate that the DEIS (App. D) significantly overestimates biomass productivity in SEKI. In so doing, the DEIS also significantly overestimates stock grazing capacity for SEKI meadows. Because biomass monitoring proposed under the alternatives are inadequate to prevent consistent biomass removal by stock that exceeds forage utilization targets, this is likely to result in levels of residual biomass in meadows that are far below the targeted levels in the alternatives.[10] These are significant defects.

The DEIS (App. D) provides estimates of biomass productivity per area for meadows as a function of elevation, moisture regime and <u>assumed</u> condition (pp. D-42 to D-43, App. D). These estimates are key part of estimating stock use in meadows subject to grazing under several of the alternatives, as described in App. D. Therefore, the potential accuracy of the productivity estimates is a key issue both for stock management and the ultimate impacts on meadow systems under all of the alternatives except Alt. 4, which does not allow stock grazing. If the productivity estimates are too high, forage utilization will be higher than anticipated under the alternatives, resulting in residual biomass levels that are well below targets under the alternatives, which will, in turn have persistent negative impacts on meadows. However, despite the importance of this estimate of biomass productivity and potential forage available to stock, the DEIS makes no reasonable assessment of the potential accuracy of these estimates, which is a major defect in the DEIS.

SEKI has relatively abundant data on biomass production in the meadows of SEKI that can be assessed the accuracy of plant production estimates and resulting estimates of forage availability and use levels in App. D. However, the DEIS is devoid of any such tractable and critically important analysis.

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[10] Under the RBM, percent residual biomass remaining in grazed areas relative to reference areas is calculated as follows:

$$\% \text{ RB} = 100 * \text{RB}_{core} / \text{RB}_{ref}$$

where: RB_{core} = measured residual biomass in core, grazed areas, and RB_{ref} = measured residual biomass ungrazed or “lightly grazed” reference areas. It follows, then, that the amount of residual biomass consumed by stock (or forage utilization), as estimated by RBM is equal to: 1 - %RB. Thus, if %RB = 21%, the estimate via RBM of biomass lost due to forage use by stock = 79%.

The DEIS (pp. D-42 to D-43, App. D) assumed that SEKI meadows were in a "good" condition with respect to productivity, producing 65% of maximum meadow plant productivity. Based on available biomass productivity data (Abbott et al., 2003), the DEIS's estimates of biomass production in meadows as a function of elevation and moisture regime in App. D are inaccurate, overestimating actual biomass productivity in moist and wet meadows, especially those above 9,000 feet in elevation. The actual average plant productivity of moist and wet meadows (Abbott et al., 2003) fall well below the estimated meadow productivity with elevation at all elevations in SEKI for moist-wet meadows in "good condition" in the DEIS (Figure D-1, p. D-43, App. D.), but particularly for meadows above 9,000 feet (See Figure 2 below). In fact, the mean value for productivity in Abbott et al. (2003) for wet-moist meadows above 9,000 feet are less than estimated in the DEIS for moist and wet meadows in "fair" condition DEIS (Figure D-1, p. D-43, App. D.), (which are estimated to produce only 44% of maximum productivity (p. D-42, App. D). Actual mean production for moist meadows above 10,000 feet (Abbott et al., 2003) are less than estimated in the DEIS for meadows in "poor" condition (which are estimated to produce only 25% of maximum productivity (p. D-42, App. D).

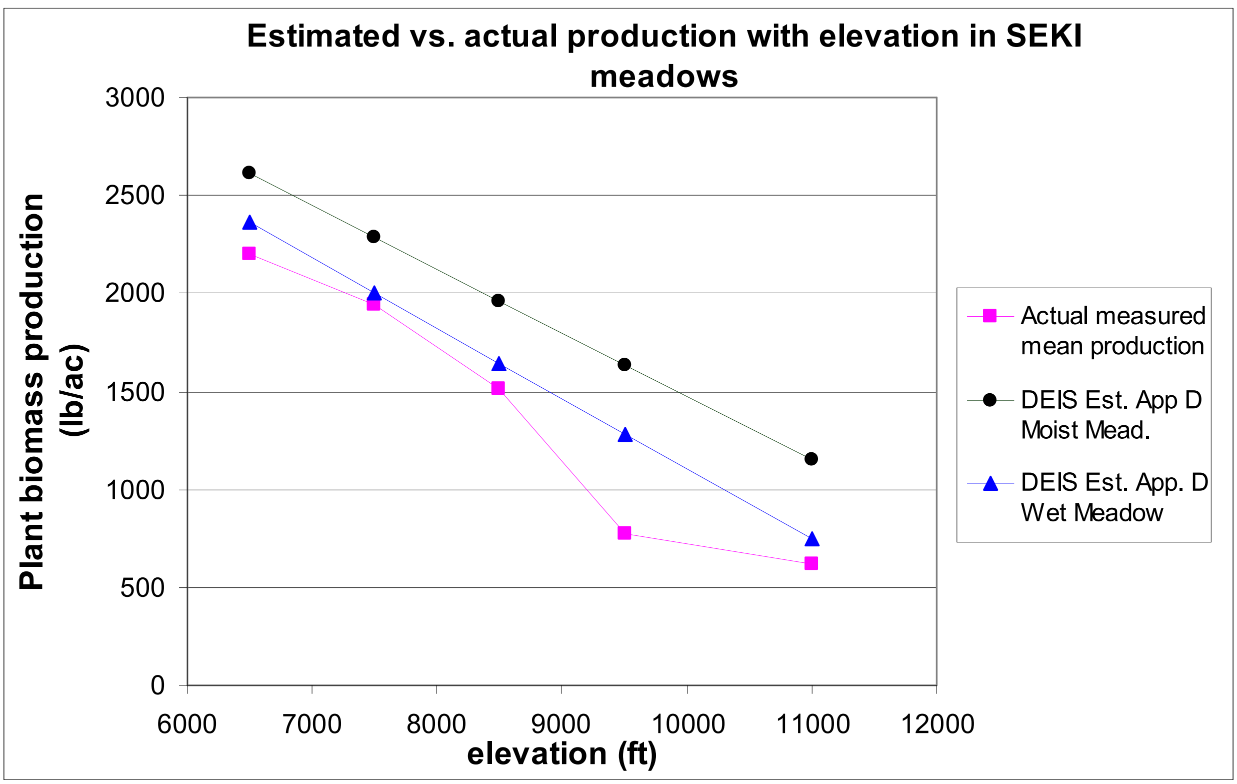

Figure 2. Average *measured* plant biomass production in 38 moist-wet meadows in SEKI by elevation category over six years (1995 – 2000) (Abbott et al., 2003), together with the overestimated production levels from the DEIS (App. D) for meadows incorrectly assumed to be in "good" condition with respect to productivity. As the figure indicates, there is a steep decline in actual average *measured* plant production from meadows at 8000-8999 feet to those at greater than 9000 feet in elevation, which is also the consistent case in each of the six years of data in Abbott et al. (2003). These data clearly demonstrate that DEIS grossly overestimated meadow productivity, and, hence grazing capacity in SEKI.

The foregoing demonstrates that: a) DEIS significantly overestimates meadow productivity and grazing capacity in SEKI meadows; and, b) that the DEIS's unwarranted assumption that SEKI meadows are in "good" condition with respect to productivity (DEIS, p. D-42 to D-43, App. D) is unsound and in conflict with available data on actual plant biomass productivity in the meadows of SEKI. The DEIS plainly failed to use SEKI's own data to reasonably assess meadow productivity and grazing capacity. These defects must be rectified in the FEIS.

Meadow condition

The DEIS fails to examine and disclose the condition of meadows in SEKI, including those that would be subject to grazing under the various alternatives. This is a key defect in the DEIS, because continued grazing of degraded meadows is likely to perpetuate or exacerbate their degraded condition. Such an assessment of meadow condition is quite tractable.

As previously discussed, SEKI has bare ground criteria for ecological condition classes for Sierra Nevada meadow types (DEIS, App. D, Table D-3, p. D-25) and bare ground data for many SEKI meadows (e.g., Haultain and Frenzel, 2012; Hopkinson et al., 2013). However, the DEIS did not use these criteria and data to assess the ecological condition of meadows in SEKI. This is a severe defect, because available information indicates meadows with elevated bare ground levels indicative of low ecological condition include: Colby, Redwood, Big Pete, Wallace, Lower Crabtree, Rock Creek Crossing, and Rock Creek Lake meadows. There are but a few examples from available data—it is likely there are many more meadows in low ecological condition due to elevated bare ground within SEKI.

High levels of bare ground are not only indicative of ecological meadow condition, but also increase the susceptibility of meadows to nonnative vegetation invasions, as the DEIS (p. 416) acknowledges. The DEIS (p. 416) also acknowledges that grazing is a significant vector for the spread of nonnative vegetation propagules. The combination of stock grazing's effects on propagules introduction and bare ground greatly increases the likelihood of the establishment and spread of nonnative vegetation (DEIS, p. 416). Therefore, the DEIS's failure to assess bare ground conditions in meadows subject to grazing under the alternatives renders the assessment of grazing impacts on nonnative vegetation severely flawed and inadequate.

The DEIS also failed to examine meadow condition based on their measured production of plant biomass. As discussed, available information indicates that many meadows are in "Poor" condition with respect to the production of biomass, including Evolution, Colby, McClure, East Lake Meadow (67-1), Grave Meadow (71-2), Lower Whitney Creek Meadow (83-7), Middle Rattlesnake Canyon (89-9), Hockett Pasture (90-5.2), Nathan's Meadow (85-10), South Fork Meadow (90-10), and Lower Rock Creek Lake Meadow (85-8) (Abbott, p. 65, 2003). Again, these low levels indicate diminished soil productivity, although the DEIS fails to assess or make known these soil and plant productivity conditions.

Similarly, the DEIS is devoid of an assessment of other existing manifestations of meadow damage from stock. Although soil compaction by stock is persistent, cumulative, inevitable (especially in wetter meadows) and profoundly affects meadow functions and conditions, the DEIS is without any rational assessment of compaction conditions in meadows. Similarly, the

DEIS fails to properly assess and identify meadows that have been robbed of significant sources of organic matter, which the DEIS concedes is critically important to meadow productivity and function. Notably, many meadows have frequently been grazed at levels that leave too little residual biomass to maintain the organic matter in meadow soils that is essential to the maintenance of meadow productivity. Although SEKI has data to identify these meadows, the DEIS makes no such critically important assessment of organic matter and meadow productivity conditions.

It is well-established that heavy stock, such as horse and mules, cause streambank damage, especially where stock graze along stream banks or access streams for water. This physical damage reduces bank stability, leaving remaining banks oversteepened, devegetated, and highly vulnerable to additional erosion by streamflow (See Photo 1), which degrades meadow conditions and functions. However, the DEIS makes no assessment of bank conditions in meadows.

These are key failures, because meadows in poor condition that are subject to stock grazing are likely to be further damaged or prevented from recovering. Sikes et al. (2013) noted regarding fen meadows in the Sierra Nevada that "…it is likely that even relatively light grazing will maintain degraded sites in a degraded condition for many decades," although this is never made known in the DEIS. Although the impacts of stock grazing in meadows are strongly influenced by ecological conditions in meadows, the DEIS failed to assess actual meadow conditions in assessing the impacts of allowed grazing in meadows under the alternatives. Therefore, the DEIS failed to reasonably assess grazing impacts and properly differentiate among the alternatives. These defects must be rectified by rationally factoring meadow conditions in meadows subject to grazing under the alternatives into the assessment of grazing impacts under the alternatives.

In order to be ecologically sound, at a minimum, allowed levels of forage use by stock must be predicated on the ecological condition of meadows. There is no indication in the DEIS that the proposed forage utilization guidelines in App. D for several of the alternatives are premised, in any way, on the actual ecological condition of meadows subject to grazing. These defects must be rectified by assessing meadow condition and setting forage utilization limits for stock under the alternatives that allow grazing, based on meadow condition, likely grazing impacts, and SEKI's obligations and requirements for wilderness resources and conditions.

Inherent meadow sensitivity to grazing-related impacts

Meadows have intrinsically variable sensitivity to grazing impacts due to setting, soils, and local hydrology. Wet meadows are particularly vulnerable to compaction by stock, which contributes to long-term degradation of meadow function and productivity.

Wet meadows are frequently in direct hydrologic communication with lakes or streams. Grazing such meadows delivers, in the relatively efficient manner, biological contaminants and nutrients in stock manure to water bodies. The delivery of nutrients causes eutrophication of water bodies. The delivery of biological contaminants to water poses a hazard to human health if consumed.

Meadow stream banks with non-cohesive soils, in areas with high water tables, and/or lacking deep-rooted vegetation are particularly susceptible to bank damage by stock, especially horse and mules (See Photo 1). Therefore, the ecological impacts of grazing on streams in or near meadows are plainly influenced by meadow attributes.

However, the DEIS failed to assess the inherent sensitivity of meadows in assessing the impacts of stock activities under the alternatives. In so doing, the DEIS failed to properly assess and disclose the full suite of actual impacts of grazing meadows. These defects must be rectified by properly factoring inherent meadow sensitivity to grazing impacts into the assessment and disclosure of the impacts of grazing on SEKI meadows and water bodies.

Because impacts vary with meadow attributes, ecologically sound standards for forage use by stock must be predicated on the inherent sensitivity of meadows. For instance, based on the their susceptibility to persistent damage from even light grazing, assessments have recommended that wet meadows not be subjected to grazing (See Abbott et al., 2003; Sikes et al., 2013). Similarly, assessments of grazing impacts on streams have recommended that stream banks that inherently susceptibly to grazing damage should not be subject to stock grazing, because it is not possible to graze such areas without significant bank damage (Rhodes et al., 1994). However, there is no indication that the proposed forage utilization guidelines in App. D for the alternatives with stock grazing take into account the actual ecological attributes of meadows and their sensitivity to grazing impacts. These defects must be rectified by assessing meadow attributes and sensitivity to impacts, including those on water pollution, soil conditions, productivity, local hydrology, meadow function, and stream banks, and setting forage utilization limits for stock under the alternatives that allow grazing, based on meadow sensitivity, likely grazing impacts, and SEKI's obligations and requirements for wilderness resources and conditions.

Stock utilization limits

The stock utilization limits for all of the action alternatives, except Alt. 4, are without any ecologically sound bases and fail to address key SEKI's touted aspirations for park wilderness. Those aspirations include (DEIS, p. 6) that natural processes dominate ecosystem structure and function; water quality and quantity; decomposition, nutrient cycling and soil forming processes; and, meadow and wetland productivity. However, as previously described, there is no indication in the DEIS that the forage utilization limits for stock grazing are based on any reasonably thorough examination of the effects of proposed utilization levels on ecosystem structure and function; water quality and quantity; nutrient cycling and soil forming processes; or, meadow and wetland productivity. This is because there is no explicit examination in the DEIS of key impacts on these elements and processes that are likely to occur in meadows subject to grazing. As previously discussed, meadows have inherently different sensitivity to grazing impacts, however, forage utilization levels set under the DEIS are not premised on the innate susceptibility of meadows to degradation. For instance, wet meadows are clearly prone to soil damage and contributions to water quality problems from grazing, warranting a lower limit on forage utilization or complete prohibition of grazing, but the DEIS does not set lower forage utilization levels for such sensitive meadows.

Meadows degraded by stock, of which there are many in SEKI, also warrant lower levels of forage utilization if they are to recover from past damage. Even light grazing by stock is likely to maintain degraded meadows in a degraded state. However, the DEIS fails to set lower forage limits for degraded meadows that are subject to grazing.

Instead of assessing the full suite of ecological impacts of grazing in meadows based on their innate attributes and condition, and comparing these impacts to SEKI's wilderness obligations, the DEIS clearly based stock utilization levels solely on the basis of stock-grazing logistics and overestimation of plant biomass productivity (App. D; See also Fig. 2). Meadows deemed to be more valuable to grazing have higher forage utilization levels, regardless of the condition or attributes of those meadows, which, notably, are not assessed or made known in the DEIS.

The amount of residual biomass left on site under the limits is not the only issue due to associated impacts of grazing on meadows. As Abbott (2003) correctly noted, SEKI's biomass data "…is not sufficient to determine residual biomass needed to maintain present ecological condition or to improve meadow conditions to a more desirable state." A more complete consideration of grazing impacts and meadow susceptibility is needed to provide sound limits, but this was not done in the DEIS.

Although the DEIS makes some estimates of the magnitude of meadow productivity sacrificed for the sake of stock grazing, based on Cole et al. (2004), these estimates are extrapolated in erroneous fashion. The losses in meadow productivity documented by Cole et al. (2004) were from a study spanning five years. There is no indication in Cole et al. (2004) that the documented losses in meadow productivity caused by stock grazing at relatively light levels would not continue to increase over time due to the cumulative impacts of stock grazing, although this is not or assessed or disclosed in the DEIS.

The proposed SUMP in the DEIS is inadequate to consistently prevent significant damage to meadows, identify meadow damage in a timely fashion, or ensure consistent compliance with forage utilization limits.

> *SUMP, Residual biomass monitoring (RBM), the impacts of stock trampling, and resulting effects on the condition and ecological functions of meadows.*

The SUMP does not provide or require any sound monitoring of trampling impacts. The RBM in the SUMP only measures residual biomass and bare ground in some "core" (grazed) and "reference" (ungrazed or "lightly" grazed) areas in some meadows estimated to have undergone relatively heavy stock use over several years (Neuman 1993; 1994). This monitoring is not adequate to capture how stock trampling impacts significantly affect meadow function, conditions, and aesthetics.

Neither the SUMP nor the RBM assess the inevitable soil compaction and meadow damage caused by stock use. This is a significant defect, because, as previously discussed, soil compaction has numerous persistent adverse impacts on meadow function and condition. The proposed monitoring (App. D) of deep (ca. 1 inch or greater) hoofprints is not a surrogate for monitoring of soil compaction, because significant compaction can occur in the absence of such hoofprints, especially in drier meadows.

Stock, especially horses and mules, deepen trails (Abbott et al., 2003) which can also significantly contribute to meadow desiccation. Deepened trails that intersect shallow groundwater in wetter meadows, effectively act as groundwater drains that lower water tables in meadows, altering meadow function and reducing late season sources of streamflow. The SUMP and the RBM do not require any systematic assessment of trail deepening or its significant adverse hydrologic effects.

Because RBM only focuses on residual biomass and bare ground in "core" and "reference" areas, it likely does not capture soil compaction effects and trail effects on meadows and related ecological functions. Stock grazing soil impacts from trampling are unlikely to correlate completely with effects on residual biomass for at least two reasons. First, soil damage from trampling is not simply a function of stock use, because the degree of soil damage varies considerably with soil attributes such as soil wetness and texture.

Second, areas that incur significant trampling damage may not always be associated with grazed core areas. As an obvious example, trails through meadows are subject to severe soil damage even though such areas may not be significantly grazed. Therefore, the RBM is not adequate to monitor such damage and impacts in meadows subject to packstock use, because RBM potentially ignores areas where very significant soil damage occurs outside of the core areas.

It has long been recognized that stock grazing and trampling have significant adverse impacts on stream banks. For this reason, the monitoring of bank stability has been long recommended as a critical component of assessing the impacts of stock on stream conditions (Rhodes et al., 1994; Cowley, 2002). However, the SUMP does not include any systematic monitoring[11] of bank stability or bank damage in streams in or near areas open to grazing.

For these combined reasons, the SUMP and RBM are not adequate for assessing the impacts of stock trampling on meadows. These limitations of the RBM and SUMP are significant because the impacts of trampling by stock persistently affect meadow function and condition in numerous ways. Therefore, RBM and SUMP have very limited utility in consistently identifying and assessing these impacts, resulting conditions, and the status of affected ecological functions of meadows.

Stock impacts on meadow aesthetics

Many of the previously discussed impacts of stock use that are not captured by the SUMP or RBM also affect the aesthetics of meadows, including streambank damage, bare ground,

[11] App. D suggests that site visit and associated condition assessments will occur and staff would evaluate and describe "bank shearing." However, such evaluations fall short of systematic monitoring of bank stability and bank damage that is needed to establish condition and trend. Further, the timing, number, and frequency of such site visits are not described or specified in App. D, making the value of such ad hoc qualitative assessments even more dubious.

deepened and/or widened trails, and drier meadows. However, the RBM has several other shortcomings with respect to aesthetic impacts.

Stock excrement in meadows is an obvious aesthetic impact. However, the SUMP and RBM does not assess the magnitude of stock excrement in meadows or the resulting impacts on aesthetics.

RBM and proposed forage utilization guidelines (App. D) do not protect vegetation attributes that are important components of meadow appearance. The DEIS suggests limiting grazing utilization to targets of about 25 to 45% of biomass produced in meadows subject to grazing mainly as a function of touted logistical value to facilitate stock grazing. Meeting these quantitative goals is highly unlikely to protect vegetation conditions that affect meadows aesthetics, because the removal of half the height of meadow plants only equates to a forage utilization of 20% of the biomass of these same plants (Neuman, 1993). The loss of more than half of the height of grazed vegetation would be an aesthetic impact that is easily observable, yet be considered to meet forage utilization goals for most meadows subject to grazing under the SUMP. Therefore, the proposed utilization levels clearly do not protect meadow aesthetics.

SUMP "Thresholds for Management Action" (TMA)

The SUMP's TMA are not adequate to protect meadow systems from major degradation due to grazing impacts. The TMA are also inadequate to ensure that effective measures are taken in timely manner to arrest and reverse meadow degradation by grazing.

Under the SUMP TMA, once significant degradation has been documented, more monitoring is called for rather than arresting the cause of degradation, as exemplified for bare ground (Table D-4, App. D). Notably the SUMP TMA do not require that the additional monitoring be completed within a specific timeframe. As a result, serious and major degradation can persist or be exacerbated by continued grazing before additional monitoring assessments are made. Importantly, the TMA for bare ground in Table D-4 (App. D) are not true thresholds that require management action. Instead, they are clearly identified as "potential" thresholds for bare ground conditions.

Notably, Table D-4 suggests that if monitoring ultimately indicates that bare ground levels in meadows indicates that they are in low ecological condition, grazing rest or reductions in grazing levels *might* eventually be considered. However, the DEIS provides strong evidence that this will not consistently occur in a timely fashion, because SEKI already has considerable data that indicate that many meadows are in low ecological condition based on SEKI monitoring, yet the DEIS fails to set lower forage utilization levels for such meadows.

Importantly, even if additional monitoring ultimately confirms degradation well beyond the TMA, no sound response that effectively arrests the cause of the grazing-related degradation is required under the SUMP (App. D.). Instead, the SUMP only suggests a litany unspecified changes in grazing management would be *considered* and *might* be taken. This is, in no way, ensures that effective measures are consistently implemented in a timely manner to arrest and reverse stock-related degradation in SEKI meadows.

The SUMP and TMA (App. D) plainly do not include concrete requirements to implement specific on-the-ground measures to reduce, arrest, or reverse meadow degradation by stock that might ultimately be identified. Therefore, the DEIS must make known that the outcome of SUMP, if adopted, cannot be assessed with any certainty, because there are no specific measures that certain to be implemented. Instead, the SUMP only provides a menu of approaches that might be taken, several of which, such as increasing "education" (Table D-4, App. D), do not have predictable on-the-ground outcomes.

For these reasons, the SUMP TMA are inadequate to ensure that meadow degradation is identified in a timely manner. The SUMP TMA also do not ensure that grazing-related causes of documented degradation are arrested in a timely and effective fashion. These are significant defects because meadow damage is persistent and recovery from degradation in many meadows is exceedingly slow due to their condition and innate characteristics. The DEIS must be revised to properly make known that the SUMP TMA do not ensure that meadows are protected from continued degradation by stock activities allowed under the alternatives, nor do they provide any certainty that any degraded meadows will begin to undergo recovery.

The problem of reference area applicability in RBM

The selection and applicability of "reference" areas are major problems that seriously affect the veracity of RBM results. These are critical issues because the RBM uses reference areas as: 1) the indicator of the amount of residual biomass produced/present in meadows in the absence of consumption by stock; 2) as a "yardstick" to estimate of residual biomass consumption (forage utilization) by stock in core, grazed areas; and 3) assess the consistency of residual biomass in core areas relative to reference areas with management targets for forage utilization and/or percent residual biomass in meadows grazed by stock. Therefore, RBM results are quite sensitive to reference area conditions.

If reference area biomass production is not completely representative to that in the corresponding core area, the RBM results are inaccurate and biased. In particular, if biomass production in reference areas is lower than in an applicable core area, the resulting percent residual biomass estimates are erroneously inflated, and corresponding estimates of forage utilization by stock are erroneously low, which, in many cases, can lead to the erroneous conclusion that forage utilization or percent residual biomass in core areas complies with management targets.

There are several reasons why biomass production in reference areas under the RBM does not likely provide accurate estimates of biomass production in core areas. First, as previously discussed, stock impacts persistently degrade soil productivity, reducing related biomass production in an enduring fashion. This can easily occur in reference areas, because reference areas are selected for monitoring in given year based primarily on an apparent lack of significant stock grazing over the current season at the time of monitoring (Neuman, 1994). Thus, reference areas sampled in a given year may have been significantly grazed and trampled in prior years, cumulatively degrading biomass productivity on the reference site in a persistent fashion.

The use of reference sites with degraded biomass production innately leads to managing for degraded conditions under RBM and associated percent residual biomass targets for core areas.

This is a likely problem, because many meadows and, especially wet meadows, have been significantly degraded by past grazing (Abbott et al., 2003; Gage et al., 2009). Many grazing impacts that reduce soil productivity are highly persistent. The use of reference areas with degraded soil productivity under RBM leads to inaccurate results with respect to estimating forage utilization levels and the percent of biomass retained in core grazed areas relative to reference sites.

A second, related problem with reference areas is that soil productivity, which strongly affects biomass production, is inherently variable, even in the absence of past cumulative effects, due to variation in soil and hydrologic conditions, other factors remaining equal.[12] Thus, even in the absence of present degradation from past impacts, monitored reference areas may not produce biomass at levels that are comparable to that in corresponding core areas. The use of such reference sites leads to inaccurate results with respect to estimating the forage utilization and the amount biomass retained in core grazed areas relative to reference sites.

The RBM includes no rigorous requirements to ensure that biomass productivity on monitored reference areas is truly representative of that in core areas in the absence of significant impacts. Thus, it is likely that the foregoing problems with reference sites occur with some regularity, leading to inaccurate and biased results.

It is easy to identify *obvious* cases where residual biomass production in reference areas is inapplicable to corresponding core areas, because if residual biomass in core areas where biomass has been consumed by grazing is greater than in reference areas that have been ungrazed or lightly grazed,[13] then the residual biomass levels in the reference are clearly not applicable to the corresponding core area. Simply enough, this is because if reference areas are to provide an accurate yardstick of the amount of residual biomass that would exist in corresponding grazed core areas in the absence of grazing, then residual biomass in reference areas *must* be greater than in core areas, because the latter has had biomass removed.

There is clear evidence in SEKI RBM data that biomass in reference areas are often greater in core areas than reference areas (Abbott et al., 2003; Haultain, 2008). For instance, in 1995, in montane meadows, measured residual biomass in reference areas was less, on average, than in corresponding core grazed areas (Abbott et al., 2003). In 1998, measured residual biomass in reference areas in montane meadows was less than half, on average, of the average in corresponding core grazed areas (Abbott et al., 2003). In 1998, reference areas in subalpine meadows had mean measured residual biomass that was less than the mean in core grazed areas (Abbott et al., 2003). In 2007, three out of 14 (about 21%) paired reference and core areas had measured residual biomass in core areas that was higher than in corresponding reference areas (Haultain, 2008). These instances clearly demonstrate that reference area biomass conditions

[12] Several other factors also affect biomass production, including climate. However, over relatively small areas and short timeframes, these factors are unlikely to vary considerably.

[13] If an ungrazed reference area cannot be found, the RBM allows the use the reference areas that have been "lightly grazed" which Neuman (1993) suggests is equivalent to about 10% removal of plant height by grazing.

that lead to biased, inaccurate assessments of forage utilization levels, biomass conditions and impacts in core areas occur with some regularity.

While it is obvious that reference areas that have residual biomass greater than in core areas lead to inaccurate RBM results, there is considerable potential for conditions under which reference areas may have lower biomass production than core areas, but to a degree that is not readily identifiable due to core area grazing. Although such situations would not be readily identifiable, they would still leads to inaccurate results. For instance, consider the scenario where residual biomass production on a reference area is only 90% of that on a corresponding core area and stock have consumed 35% of the biomass in the core area. Under such a scenario, the reference area residual biomass measured via RBM would be greater than in the corresponding core due to stock grazing. Hence, the bias caused by the lower biomass production in the reference area relative to the core area would not readily ascertainable. However, under such a scenario, RBM would indicate that the percent residual biomass in the grazed core area was about 78%, with about 22% consumed by grazing, based on comparison to the reference area. However, in such a scenario, 35% of the biomass on the core area had actually been consumed by grazing and only 65% of residual biomass on the core area remained. This scenario is but one of many possible permutations where reference site conditions lead to biased and inaccurate estimates of the actual amount of biomass retained or consumed in core grazed areas in meadows, without being readily identifiable. Therefore, it is entirely possible that many similar situations occur with regularity without being readily apparent.

Reference area biomass measurements and conditions strongly affect the veracity of RBM results. Therefore, the fundamental problems related to the applicability of reference areas presents a major obstacle to accurate assessment of meadow impacts, forage utilization, and meadow biomass conditions and trends via RBM, although the DEIS fails to disclose these obvious and major limitations of the SUMP and RBM.

Implementation and establishment of residual biomass standards

The shortcomings of the SUMP and RBM are significant because meadow vegetation is a critically important source of soil organic matter, high levels of which are a major feature of meadow soils. Importantly, the loss of biomass from meadows by grazing is irretrievable and, hence, cumulative.

As previously discussed the proposed limits for forage utilization (App. D) and targets for residual biomass may not prevent additional meadow degradation or allow the recovery of degraded meadows for several reasons. First, as previously discussed, RBM does not capture many other impacts by stock to meadow conditions and functions, such as those from trampling. Hence, current residual biomass targets are likely inadequate with respect to stock impacts that are not well-correlated with residual biomass.

Second, the susceptibility of meadows to additional grazing damage varies with inherent meadow attributes (soils, vegetation, hydrology), as well as ecological condition. As Abbott et al. (2003) noted, meadow condition is a key element in setting biomass standards. Because the forage utilization levels (App. D) are not set on the basis of meadow condition or susceptibility to impacts they are highly unlikely to ensure the protection and restoration of meadows subjected to stock grazing.

Due to their inherent susceptibility and/or degraded condition, it is likely that the recovery of many meadows requires the suspension of grazing. For instance, RBM results clearly indicate that many meadows produce anomalously low levels of biomass (Abbott et al. 2003, p. 65), which likely indicate that soil productivity has been significantly degraded. It is extremely unlikely that continual removal of residual biomass in such area is consistent with the recovery of biomass productivity, due to the importance of residual biomass as a source of soil organic matter that is vital to soil productivity. Studies and assessments have repeatedly noted that the most effective approach to restoring damaged soil productivity is to protect soils from further impacts, such as soil trampling, and to retain all sources of vegetation that provide organic matter to soils (USFS and USBLM, 1997; Beschta et al., 2004). Sikes et al. (2013) also noted that even light grazing was likely to perpetuate degraded conditions in fens. Because forage utilization levels allowed under most of the alternatives will cause continual biomass removal and other soil impacts from packstock in meadows that produce low levels of biomass, the proposed forage utilization levels are not consistent with the restoration of many degraded and/or inherently sensitive meadows.

Third, there is not strong scientific evidence that currently recommended forage utilization limits are adequate to protect and restore meadow conditions, functions, and aesthetics. These DEIS's numerical targets are primarily based only on estimates of value to grazing logistics. Their impact on meadow productivity in the DEIS are based on biomass decomposition rates, which influences the amount of organic matter in meadow soils, or the single study by Cole et al (2004) on meadow productivity and stock grazing. Notably, although it is not made known in the DEIS, Cole et al. (2004) noted that basis for assessing productivity effects based on residual biomass decomposition rates in SEKI are not sound and do not reflect likely declines in meadow productivity caused by forage utilization and the loss of residual biomass. As Abbott (2003) noted, the biomass data "…on core and reference areas is [sic] not sufficient to determine residual biomass needed to maintain present ecological condition or to improve meadow conditions to a more desirable state." Therefore, the DEIS's assessment of the impacts of forage utilization levels for lower elevation meadows in SEKI, which are partially based on a consideration of decomposition rates, and, hence, the provision of organic matter to meadows, may not protect meadow functions associated with organic matter and residual biomass in meadows, due to cumulative effects.

The current biomass targets also fail to account for the ecological importance of some meadows, which is likely to vary considerably. For instance, some meadows may provide vitally important or rare habitats for imperiled flora or fauna that are highly sensitive to grazing impacts. Such meadows should be afforded greater protection in the form of more stringent residual biomass targets. However, the current targets do not appear to reflect this important consideration.

There are also major problems with the implementation of forage utilization limits. RBM only occurs towards the end of the grazing season, which is highly inadequate for ensuring that forage utilization limits on biomass loss are not exceeded. It is well-established that the successful implementation of utilization limits requires that utilization levels are monitored *during* the period of grazing and with the data used to suspend grazing *before* utilization limits are exceeded.

RBM and related management approaches do not include these measures that are necessary to *prevent* the exceedance of limits on forage utilization in grazed meadows, which makes it quite likely that limits are frequently exceeded. Therefore, it is not surprising that forage use in grazed meadows has been far below the targets with considerable regularity (Abbott et al., 2003; Haultain, 2008: Hopkinson et al., 2013). For instance, in 2007, four of 14 meadows (about 29%) with RBM data for both reference and core areas had residual biomass levels in core areas that were clearly below the target for residual biomass.[14] Of those four, three had residual biomass that was only about 40 to 60% of the recommended minimum levels. In 1996, the mean residual biomass in 12 core areas in subalpine meadows was 53%, which is well below the target for residual biomass.

These implementation defects clearly indicate that RBM and associated management approaches do not ensure that current residual biomass targets are consistently met. Therefore, RBM and associated management approaches do *not prevent* long-term damage due to the loss of high levels of biomass that is critical to the appearance and many ecological functions of meadows.

One obvious approach to compensating for the loss of biomass in excess of current management targets is to *require* reduction in forage utilization levels in subsequent years. For instance, if the forage utilization target for the core area is <35%, but monitoring for a given year indicates that it has been 50%, in the subsequent 2 years, management could prescribe that no grazing occur in the meadow to compensate for previous biomass losses. However, there are no such effective compensatory management requirements in the SUMP. Therefore, the lack of compensatory management mechanisms is another significant shortcoming related to RBM and the SUMP.

Statistical considerations related to forage utilization limits

A related key statistical consideration related to protection efforts is the setting of the level of statistical significance, which should be premised on consideration of the ecological costs of making "type II" errors (Peterman, 1990). In the case of RBM, a type II error occurs when residual biomass is actually less than the target, but is concluded to be the same or more than the target, due to the combined statistical effect of sample number, measurement variability, and the magnitude of statistical confidence intervals. The probability of such an error increases with an increase in the percent confidence level. That is, in some statistical analyses of whether measured residual biomass is different than a quantitative biomass limit, a type II error is more probable with a 95% confidence interval than it is for 60% confidence interval. Notably, type II errors are often more ecologically costly than type I errors,[15] especially with fragile resources

[14] Due to the previously discussed problems with reference area applicability, there may have been more core areas where residual biomass was actually below the minimum target levels. In 2007, three of 14 reference areas monitored in tandem with core areas had greater residual biomass than corresponding core areas, indicating that these three reference areas were plainly not applicable.

[15] In the case of RBM, a type I error occurs when measured residual biomass is actually within the limit for residual biomass, but is considered to be lower than the limit.

where effects are not quickly reversible (Peterman, 1990; Rhodes et al., 1994). This is likely the case for residual biomass levels in meadows.

The most rational approach to setting levels of statistical significance is to base it on the expected ecological costs associated with making Type II and Type I errors, respectively. However, these considerations do not appear to have been incorporated into the RBM. As a result, it is likely that costly type II errors will regularly occur in the assessment of whether residual biomass levels and/or forage utilization levels comply with targets. The DEIS fails to disclose the significant probability of Type II errors inherent in RBM monitoring and analysis.

Trend analysis and related considerations

Trend assessment of conditions in meadows is plainly desirable, especially because many meadows have been degraded and recovery is desirable. However, RBM is not particularly amenable to evaluating trends, because the locations of both core and reference areas are not fixed (Neuman, 1994). The locations of these sampling areas shift depending on grazing use, because core areas are located in areas with the heaviest browse, while reference areas are located in areas with no or light grazing over the grazing season (Neuman, 1994).

This shifting of locations occludes the elucidation of actual trends in meadow biomass and bare ground, because, as previously discussed, reference area sampling may occur in areas that have been cumulatively degraded by grazing in previous years. The significant impacts of grazing in previous years can easily carryover to the year of sampling. In such situations, data from reference areas do not reflect actual trends in meadow areas that are unaffected by grazing, because the data incorporates the effects of past grazing. For these reasons, it is unlikely that RBM data on bare ground and biomass in meadows can be used to accurately assess trends in these meadow conditions.

Abbott et al. (2003) recommended fixed reference and core monitoring areas in order to reduce variability introduced by the mobility of these areas. While such an approach would likely result in improvements in trend assessment, it may not reflect grazing impacts, which can shift in a meadow over time.

RBM does not provide data that can be used to assess many meadow conditions affected by grazing, as previously discussed. Thus, RBM data cannot be used to assess trends in these conditions.

The lack of reliable up-to-date, sound information on the ecological condition of meadows significantly hobbles the proper assessment of the ecological and management ramifications of monitored trends. As Abbott et al. (2003) correctly acknowledged, static trends in bare ground or biomass do not indicate satisfactory meadow conditions. In fact, static trends in highly degraded meadows clearly indicate that greater protection measures are needed in order to restore such meadows. However, this context for assessing the ecological impacts of trends and needed management changes is lacking in the DEIS.

The DEIS failed to properly determine that Alternative 4 is clearly the environmentally preferable alternative.

The DEIS (pp. xxiii, 222) provides no sound rationale for identifying Alternative 5 as the environmentally preferable alternative. The DEIS's assessment, although highly inadequate, nonetheless clearly indicates that Alt. 4, relative to the other alternatives, would have less extensive and intensive negative impacts on nonnative vegetation, water quality, and soils due to Alt. 4's restrictions on stock grazing and use in wilderness. For these same reasons, available information indicates that Alt. 4 would have far greater ecosystem benefits to aquatic resources and meadows than any of the other alternatives. Alt. 4 also has far less impacts on alpine vegetation, wood, and soil conditions due its restrictions on campfires.

The selection of Alternative 5 as the environmentally preferable alternative is unsound and conflicts with available scientific information on the likely impacts of that alternative. The DEIS must be revised to properly identify Alternative 4 as the environmentally preferable alternative.

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