United States Department of the Interior

NATIONAL PARK SERVICE
Yosemite National Park
P. O. Box 577
Yosemite, California 95389

IN REPLY REFER TO:
L7615(YOSE-PM)

Memorandum

To: Sue Beatty, Project Manager, Yosemite National Park

From: Superintendent Yosemite National Park

Subject: NEPA and NHPA Clearance: 2016-009 Tuolumne River Plan: Tuolumne Meadows Native Plant Restoration and Carbon Sequestration (64489)

The Executive Leadership Team has reviewed the proposed project and completed its environmental assessment documentation, and we have determined the following:

- There will not be any effect on threatened, endangered, or rare species and/or their critical habitat.
- There will be no adverse effect on historical, cultural, or archeological resources.
- There will not be serious or long-term undesirable environmental or visual effects.

The subject proposed project, therefore, is now cleared for all NEPA and NHPA compliance requirements as presented above. Project plans and specifications are approved and construction and/or project implementation can commence.

For the proposed project actions to be within compliance requirements during construction and/or project implementation, the following mitigations must be adhered to:

- Should unanticipated artifacts be uncovered during the project, the Yosemite Anthropology Branch will document the discoveries.

Recommendations for Conditions or Stipulations: None

For complete compliance information see PEPC Project 64489.

*// Don L. Neubacher //*______________________________________
Don L. Neubacher

Enclosure (with attachments)

cc: Statutory Compliance File

Categorical Exclusion Form

Project: 2016-009 Tuolumne River Plan: Tuolumne Meadows Native Plant Restoration and Carbon Sequestration
PEPC Project Number: 64489
Description of Action (Project Description):

"This project was selected for implementation in the 2014 Record of Decision for the Tuolumne River Plan/EIS (PEPC 14043). This project must adhere to mitigation and stipulations specified in the Final EIS/Record of Decision, specifically the ecological restoration Appendix H.

In Tuolumne Meadows changes in the native plant composition have resulted in a substantial disconnect between plant and soil processes. Researchers have recently determined that the existing vegetation provides insufficient levels of soil organic matter (i.e., soil carbon) essential to sustain the functional contribution (i.e., soil moisture, water filtration, flood retention, diverse wildlife habitat) of Tuolumne Meadows to the greater watershed. Soil carbon is critical to retaining soil water. Vegetation changes that result in an annual net-loss of carbon can cause a concurrent loss in soil water holding capacity and nutrient availability. This can set up a feedback of degradation where the loss of soil water and nutrients limits vegetation growth and ground cover, decreasing the contribution of soil organic matter, and exposing more soil organic matter to drier and more oxygenated conditions, resulting in greater decomposition and erosion, and overall net loss. As the loss of organic matter occurs, meadow soils become increasingly dry, and less capable of supporting a diverse and rich plant composition. As this feedback loop persists meadows become increasingly dry, shifting to upland vegetation types, whereby the restoration of the original wetland sedge dominated community becomes increasingly difficult (in terms of degree of manipulation required and likelihood of success). Simultaneously, meadow ecosystem function and services become compromised, and wilderness character associated with those meadow ecosystems is altered towards upland and conifer types.

This project will address the loss of soil carbon by planting two species of sedges (Carex scopulorum, C. subnigricans) in 9 acres in the west end of the Tuolumne Meadows and monitoring the carbon budget and plant success.

Key actions of the project include:

• Plant 20,000 propagules/acre over three years. The first year 1acre, the second year 3 acres, and the third year 5 acres will be planted. Soil disturbance will be up to 5” deep.

• Install temporary small mammal exclusion fence around perimeter of plots. Exclusion fence will be 18" high wire mesh with a 4" band of tin flashing along the top. The fencing will be installed with 3 ft. rebar to hold it erect and staples to hold the wire mesh to the ground.

• Small mammals that get into the exclosures will be removed with live animal traps and released nearby, outside of the exclosure.

• Seed collection of the Carex sp. will occur over approximately 10 acres within Tuolumne Meadows (429 acres).

Research objectives will require the plots within the study area to be evaluated over the period of 5 years for planting survival and tillering (formation of new shoots from rhizomes), above- and below-ground biomass production, species composition, changes in shoot density, vegetation canopy cover, bare soil and litter cover, as well as greenhouse gas flux and soil carbon accumulation. Monitoring will also include evaluation of water table depth (using existing piezometer wells), and soil redox measurements (using electrodes at depths within the soil profile). Disturbance associated with monitoring includes soil disturbance, herbage removal, and above-ground installations (i.e. data loggers, solar panels, batteries and housings).

Project Locations:

Mariposa County, CA

Mitigations:

- Should unanticipated artifacts be uncovered during the project, the Yosemite Anthropology Branch will document the discoveries.

CE Citation: E.2 Restoration of noncontroversial native species into suitable habitats within their historic range and elimination of exotic species.

Explanation:

Decision: I find that the action fits within the categorical exclusion above. Therefore, I am categorically excluding the described project from further NEPA analysis. No extraordinary circumstances apply.

Superintendent: *// Don L. Neubacher //* **Date:** 7/6/2016

Don L. Neubacher

Extraordinary Circumstances:

If implemented, would the proposal...	Yes/No	Notes
A. Have significant impacts on public health or safety?	No	
B. Have significant impacts on such natural resources and unique geographic characteristics as historic or cultural resources; park, recreation, or refuge lands; wilderness areas; wild or scenic rivers; national natural landmarks; sole or principal drinking water aquifers; prime farmlands; wetlands (Executive Order 11990); floodplains (Executive Order 11988); national monuments; migratory birds; and other ecologically significant or critical areas?	No	
C. Have highly controversial environmental effects or involve unresolved conflicts concerning alternative uses of available resources (NEPA section 102(2)(E))?	No	
D. Have highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks?	No	
E. Establish a precedent for future action or represent a decision in principle about future actions with potentially significant environmental effects?	No	
F. Have a direct relationship to other actions with individually insignificant, but cumulatively significant, environmental effects?	No	
G. Have significant impacts on properties listed or eligible for listing on the National Register of Historic Places, as determined by either the bureau or office?	No	
H. Have significant impacts on species listed or proposed to be listed on the List of Endangered or Threatened Species, or have significant impacts on designated Critical Habitat for these species?	No	
I. Violate a federal, state, local or tribal law or requirement imposed for the protection of the environment?	No	
J. Have a disproportionately high and adverse effect on low income or minority populations (EO 12898)?	No	
K. Limit access to and ceremonial use of Indian sacred sites on federal lands by Indian religious practitioners or adversely affect the physical integrity of such sacred sites (EO 130007)?	No	
L. Contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area or actions that may promote the introduction, growth, or expansion of the range of such species (Federal Noxious Weed Control Act and Executive Order 13112)?	No	

ENVIRONMENTAL SCREENING FORM (ESF)

Updated Sept 2015 per NPS NEPA Handbook

A. PROJECT INFORMATION

Project Title:	2016-009 Tuolumne River Plan: Tuolumne Meadows Native Plant Restoration and Carbon Sequestration
PEPC Project Number:	64489
Project Type:	Other Study (STU)
Project Location:	
County, State:	Mariposa, California
Project Leader:	Sue Beatty

B. RESOURCE IMPACTS TO CONSIDER:

Resource	Potential for Impact	Potential Issues & Impacts
Air Air Quality	None	
Biological Nonnative or Exotic Species	None	
Biological Species of Special Concern or Their Habitat	None	
Biological Vegetation	Potential	This project will add two native species of sedges in order to increase the carbon budget and return the meadow ecosystem to the native, diverse plant composition instead of an upland community.
Biological Wildlife and/or Wildlife Habitat including terrestrial and aquatic species	None	
Cultural Archeological Resources	Potential	Should unanticipated artifacts be uncovered during the project, the Yosemite Anthropology Branch will document the discoveries.
Cultural	None	

Resource	Potential for Impact	Potential Issues & Impacts
Cultural Landscapes		
Cultural Ethnographic Resources	None	
Cultural Museum Collections	None	
Cultural Prehistoric/historic structures	None	
Geological Geologic Features	Potential	Soil disturbance includes up to five inches over nine acres during the five year period.
Geological Geologic Processes	None	
Lightscapes Lightscapes	None	
Other Human Health and Safety	None	
Other Operational	None	
Socioeconomic Land Use	None	
Socioeconomic Minority and low-income populations, size, migration patterns, etc.	None	
Socioeconomic Socioeconomic	None	
Soundscapes Soundscapes	None	
Viewsheds Viewsheds	Potential	Small rodent fences will be installed during the five year project. The visual impacts will be minimal and temporary.
Visitor Use and Experience Recreation	None	

Resource	Potential for Impact	Potential Issues & Impacts
Resources		
Visitor Use and Experience Visitor Use and Experience	Potential	The fence will be 18 inches high; visitors will be able to step over it. The fence will be removed when the project is complete.
Water Floodplains	None	
Water Marine or Estuarine Resources	None	
Water Water Quality or Quantity	None	
Water Wetlands	None	
Water Wild and Scenic River	None	
Wilderness Wilderness	Potential	Minimum Requirement Analysis is being prepared.

Recommended:

Compliance Specialists	Date
_*// Renea Kennec //*_________________________ Compliance Specialist – Renea Kennec	6/16/2016_______
_*// Madelyn Ruffner //*_______________________ Compliance Program Manager – Madelyn Ruffner	7/1/2016________
_*// Randy Fong //*___________________________ Chief, Project Management – Randy Fong	7/1/2016________

Approved:

Superintendent	Date
*// Don L. Neubacher //*________________________ Don L. Neubacher	7/6/2016________

ASSESSMENT OF ACTIONS HAVING AN EFFECT ON HISTORIC PROPERTIES

A. DESCRIPTION OF UNDERTAKING

1. Park: Yosemite National Park

2. Project Description:

Project Name: 2016-009 Tuolumne River Plan: Tuolumne Meadows Native Plant Restoration and Carbon Sequestration
Prepared by: Renea Kennec **Date Prepared:** 05/10/2016 **Telephone:** 209-379-1038
PEPC Project Number: 64489

Area of potential effects (as defined in 36 CFR 800.16[d])
Tuolumne Meadows Archeological District; Tuolumne Meadows Historic District

3. Has the area of potential effects been surveyed to identify historic properties?

____ No
__X__ Yes
Source or reference:

4. Potentially Affected Resources:

Archeological resources affected:
Name and numbers: Tuolumne Meadow Archeological District
NR status: 1 - Listed in Register and documented

Historical Structures/Resources Affected:
Name and numbers: Tuolumne Meadows Historic District
Location: Tuolumne Meadows

Cultural Landscapes Notes: Cultural landscape status was established in the Cultural Landscape Inventory (CLI) which was processed as a DOE for the district.

5. The proposed action will: (check as many as apply)

__No__ Destroy, remove, or alter features/elements from a historic structure
__No__ Replace historic features/elements in kind
__No__ Add non-historic features/elements to a historic structure
__No__ Alter or remove features/elements of a historic setting or environment (inc. terrain)

Yes Add non-historic features/elements (inc. visual, audible, or atmospheric) to a historic setting or cultural landscape

_No_ Disturb, destroy, or make archeological resources inaccessible

_No_ Disturb, destroy, or make ethnographic resources inaccessible

Yes Potentially affect presently unidentified cultural resources

_No_ Begin or contribute to deterioration of historic features, terrain, setting, landscape elements, or archeological or ethnographic resources

_No_ Involve a real property transaction (exchange, sale, or lease of land or structures)

___ Other (please specify): ____________________

6. Supporting Study Data:
(Attach if feasible; if action is in a plan, EA or EIS, give name and project or page number.)

B. REVIEWS BY CULTURAL RESOURCE SPECIALISTS

The park 106 coordinator requested review by the park's cultural resource specialist/advisors as indicated by check-off boxes or as follows:

[X] 106 Advisor
Name: Kimball Koch
Date: 06/02/2016

Check if project does not involve ground disturbance [ ]
Assessment of Effect: __ No Potential to Cause Effect __ No Historic Properties Affected _X_ No Adverse Effect __ Adverse Effect __ Streamlined Review
Recommendations for conditions or stipulations:

[X] Anthropologist
Name: Eirik Thorsgard
Date: 05/31/2016
Comments: No Ethnographic resources identified within project area. Tribal consultation done in April 2016 Tribal Spreadsheet, no tribal comments received regarding project.

Check if project does not involve ground disturbance [ ]
Assessment of Effect: __ No Potential to Cause Effect _X_ No Historic Properties Affected __ No Adverse Effect __ Adverse Effect __ Streamlined Review
Recommendations for conditions or stipulations:

[X] Archeologist
Name: Sara Dolan
Date: 05/16/2016

Check if project does not involve ground disturbance [ ]
Assessment of Effect: __ No Potential to Cause Effect _X_ No Historic Properties Affected __ No

Adverse Effect __ Adverse Effect __ Streamlined Review
Recommendations for conditions or stipulations: Should unanticipated artifacts be uncovered during the project, the Yosemite Anthropology Branch will document the discoveries.

Doc Method: Park Specific Programmatic Agreement

[X] Historian
Name: Scott Carpenter
Date: 06/01/2016

Check if project does not involve ground disturbance [ ]
Assessment of Effect: __ No Potential to Cause Effect __ No Historic Properties Affected _X_ No Adverse Effect __ Adverse Effect __ Streamlined Review
Recommendations for conditions or stipulations:

[X] Historical Architect
Name: Scott Carpenter
Date: 06/01/2016
Comments: No historic buildings or properties within project area.

Check if project does not involve ground disturbance [ ]
Assessment of Effect: _X_ No Potential to Cause Effect __ No Historic Properties Affected __ No Adverse Effect __ Adverse Effect __ Streamlined Review
Recommendations for conditions or stipulations:

[X] Historical Landscape Architect
Name: Kimball Koch
Date: 05/17/2016
Comments: Project will restore meadows which are considered contributing resources to the historic district.

Check if project does not involve ground disturbance [ ]
Assessment of Effect: __ No Potential to Cause Effect __ No Historic Properties Affected _X_ No Adverse Effect __ Adverse Effect __ Streamlined Review
Recommendations for conditions or stipulations:

Doc Method: Park Specific Programmatic Agreement

No Reviews From: Curator, Other Advisor

C. PARK SECTION 106 COORDINATOR'S REVIEW AND RECOMMENDATIONS

1. Assessment of Effect:

_________ No Potential to Cause Effects

_________ No Historic Properties Affected

____X____ No Adverse Effect

_________ Adverse Effect

2. Documentation Method:

[ ] A. STANDARD 36 CFR PART 800 CONSULTATION
Further consultation under 36 CFR Part 800 is needed.

[ ] B. STREAMLINED REVIEW UNDER THE 2008 SERVICEWIDE PROGRAMMATIC AGREEMENT (PA)

The above action meets all conditions for a streamlined review under section III of the 2008 Servicewide PA for Section 106 compliance.

APPLICABLE STREAMLINED REVIEW Criteria
(Specify 1-16 of the list of streamlined review criteria.)

[ ] C. PLAN-RELATED UNDERTAKING

Consultation and review of the proposed undertaking were completed in the context of a plan review process, in accordance with the 2008 Servicewide PA and 36 CFR Part 800.
Specify plan/EA/EIS:

[X] D. UNDERTAKING RELATED TO ANOTHER AGREEMENT
The proposed undertaking is covered for Section 106 purposes under another document such as a statewide agreement established in accord with 36 CFR 800.7 or counterpart regulations.

1999 Programmatic Agreement as amended in 2016

[ ] E. COMBINED NEPA/NHPA Document
Documentation is required for the preparation of an EA/FONSI or an EIS/ROD has been developed and used so as also to meet the requirements of 36 CFR 800.3 through 800.6

[ ] G. Memo to SHPO/THPO

[ ] H. Memo to ACHP

SHPO/THPO Notes:

3. Additional Consulting Parties Information:

Additional Consulting Parties: No

4. Stipulations and Conditions:

Following are listed any stipulations or conditions necessary to ensure that the assessment of effect above is consistent with 36 CFR Part 800 criteria of effect or to avoid or reduce potential adverse effects.

5. Mitigations/Treatment Measures:

Measures to prevent or minimize loss or impairment of historic/prehistoric properties:
(Remember that setting, location, and use may be relevant.)

- Assessment of Effect - Should unanticipated artifacts be uncovered during the project, the Yosemite Anthropology Branch will document the discoveries.

D. RECOMMENDED BY PARK SECTION 106 COORDINATOR:

Kimball Koch *// Kimball Koch //* **Date:** 6/16/2016

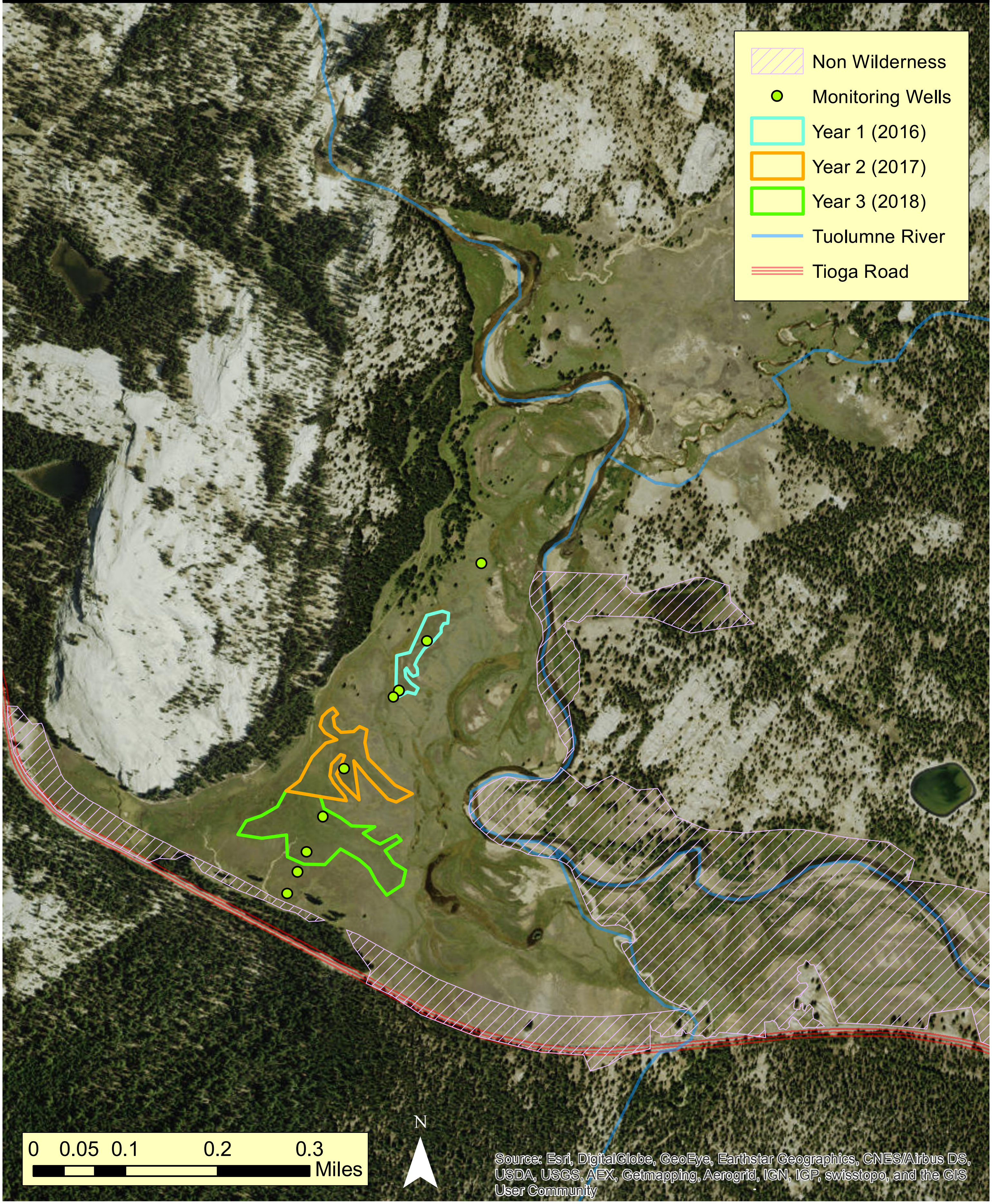
E. SUPERINTENDENT'S APPROVAL

The proposed work conforms to the NPS *Management Policies* and *Cultural Resource Management Guideline*, and I have reviewed and approve the recommendations, stipulations, or conditions noted in Section C of this form.

Superintendent: *// Don L. Neubacher //* **Date:** 7/6/2016

Don L. Neubacher

TM Native Plant & Carbon Study (TM Area)



Minimum Requirements Analysis for Potential Enhancement of Tuolumne Meadow Resistance and Resiliency to Anthropogenic-Induced Climate Change by Planting *Carex scopulorum*

Step 1: Problem Statement

Briefly describe the threat to wilderness character that is prompting consideration of management action in wilderness.

Hydro-ecological conditions at many meadows in the Sierra Nevada have been driven to alternative ecological states (Allen-Diaz and Bartolome 1998; Berlow et al. 2002; Stringham et al. 2003; Loheide II and Gorelick 2007; Norton et al. 2011; Viers et al. 2013; Morris et al. 2016), and now provide a reduced level of ecosystem function and services (Ratliff 1985; Kaufman 1997; Norton et al. 2011; Emmons et al. 2013; Veirs et al. 2013). A problem reported at a nine acre wetland complex in the western portion of Tuolumne Meadows, studied between 2012 and 2015 (Wolf and Cooper, in prep), is that these areas now exhibit an annual net loss of soil carbon, which the researchers attribute to changed vegetation from communities once dominated by clonal perennial sedges to shallow- or tap-rooted species such as *Oreostemma alpigenus* (Alpine aster, formerly *Aster alpigenus*). This problem represents changing conditions, and are certainly a reason for further investigation, if management chooses to take action (intervention and restoration), that action is well-informed.

Soil carbon is vitally important to soil water holding capacity and nutrient cycling (Hudson 1994; van Erp et al. 2001; Saxton and Rawls 2006; Ankenbauer 2014), researchers postulate the loss of soil carbon maintains the changed plant communities and thus manifests as a feedback loop that is unlikely to return to the former plant communities without intervention. The effects from the loss of soil carbon and reduced water holding capacity are likely to be exacerbated by the effects of climate change.

High organic content at these locations were likely generated by centuries of organic matter contributed from deep-rooted graminoids, not by the shallow- or tap-rooted forbs that currently dominate (Wolf and Cooper, in prep). For Sierra montane and sub-alpine meadows, if graminoids are missing from the contemporary vegetation community, the plant composition likely changed (Ratliff 1982). Furthermore, the existing forbs do not grow as densely as long-lived rhizomatous and clonal plants, and do not reduce areas of bare soil. Thus, areas with a high proportion of forbs are also at higher risk of soil erosion and loss of soil organic matter (Cooper and Wolf 2006). Ultimately, areas with high forb:graminoid ratios and high levels of bare ground are not likely to revegetate on their own (Wolf and Cooper, in prep). Furthermore, drier plant communities tend to exhibit greater levels of bare soil (NPS 2014), and higher streambank instability (Michelli and Kirchner 2002), both of which have been observed in Tuolumne Meadows (Ballenger and Acree 2009; NPS unpublished data).

Climate change has resulted in warmer temperatures, which manifests a longer vegetation growing season in areas near Tuolumne Meadows (Arnold et al. 2014). This effect, combined with earlier timing of snowmelt (Stewart et al. 2004), meadow soils will dry earlier in the season causing an onset of plant water stress and senescence (Arnold et al. 2014; Moore et al. 2013). These conditions may promote and sustain vegetation compositional change to drier types. As such, the effects of anthropogenic-induced climate change may affect the long-term stability of Sierra meadow ecosystems, whereby many may be lost from the landscape without intervention aimed to increase resistance and resilience.

The integrity of meadows was selected as an Outstandingly Remarkable Value in the Tuolumne Wild and Scenic River Comprehensive Management Plan final environmental impact statement (NPS 2014). Functional attributes of meadows, including Tuolumne Meadows, contributes to the inherent wilderness character of Yosemite Wilderness. Specifically, the reported effects of soil carbon loss limits the ability of meadows to provide water filtration, flood retention, and diverse wildlife habitat, and impact the Natural wilderness quality of Tuolumne Meadows, as well as reduce Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation, and Other Features of Value. Overall soil carbon loss limits the functional contribution of Tuolumne Meadows to the greater watershed and the preservation of wilderness character associated with this meadow ecosystem is diminished.

This minimum requirements analysis is associated with Research Permit application: *Potential Enhancement of Tuolumne Meadow Resistance and Resiliency to Anthropogenic-Induced Climate Change by Planting Carex scopulorum* (# 87357).

Step 2: Background

Include any pertinent background that helps explain the history or nature of the threat(s) to wilderness character and the values that are being threatened.

Tuolumne Meadows in Yosemite National Park (Yosemite) is a readily accessible high elevation meadow with inherent wilderness character. To many visitors Tuolumne Meadows is a pastoral symbol of wilderness, with ample scenic vistas and connotations of a functioning meadow ecosystem. Tuolumne Meadows is a widely recognized landscape feature, exceptional at this elevation, in size and hydrology, in the Sierra Nevada. Yosemite's 2020 Strategic Vision (NPS 2012) highlights alpine meadows along with giant sequoias as resources of great importance, and the final environmental impact statement for the Tuolumne Wild and Scenic River Plan (NPS 2014) emphasizes conservation of the biological integrity of meadows.

The hydro-ecological importance of functioning montane, sub-alpine, and alpine meadows has been widely reported. The benefits of functioning meadows include: carbon sequestration and nitrogen fixation (Kayranli et al. 2010; Norton et al. 2011; Blankinship et al. 2014; Wolf et al., in prep), flood retention (Welsh et al. 1995; Smakhtin and Batchelor 2004), water filtering and storage (Junk et al. 1989; Loheide et al. 2009; Forrester et al., in prep), and high diversity of vegetation types that provide an array of above-ground habitat structure (Kauffman et al. 1997). Meadows are also frequently visited landscape features that attract visitors for their aesthetic and recreational opportunities.

Despite meadows being characterized as permanent geomorphic and ecological landscape features in the Sierra Nevada (Wood 1975; Bartolome et al. 1990), and that the floristic composition of meadow vegetation had been relatively constant for thousands of years (Dull 1999), current evidence suggests that many meadows are in a declining or degraded condition (Allen-Diaz and Bartolome 1998; Berlow et al. 2002; Veirs et al. 2013).

One indicative sign of critical changes to the natural wilderness quality of Tuolumne Meadows is the reduction and loss of indigenous deep-rooted perennial plant species like *Carex scopulorum* and *C. subnigracans* from wetland areas where they formerly occurred. Researchers theorize that changes in plant community composition in portions of Tuolumne Meadows occurred in the past, because the existing plant communities are unlikely to have produced the amount of carbon that is currently stored within the underlying soils (Wolf and Cooper, in prep). Higher root-to-shoot ratios promote greater belowground productivity and are likely to result in greater soil carbon formation (De Deyn et al. 2008). Root-derived carbon resides in the soil 2.4 times longer than shoot-derived carbon (Rasse et al. 2005). *Carex scopulorum* has a root-to-shoot ratio between 4 and 5 (Bowman and Bilbrough 2001). No direct measures of the root-to-shoot ratio are available for *Oreostemma alpigenum*, but one study evaluated the ratio of a 3-plant community including *Oreostemma alpigenum* and measured root-to-shoot ratios ranging from 0.6 to 1.9 (Cole 2007). Replacement vegetation that is readily evident in portions of Tuolumne Meadows today includes depressional wetland areas now dominated by annual shallow- or tap-rooted species such as *Oreostemma alpigenus*. This difference in allocation of belowground resources is likely to cause a significant difference in carbon soil contribution in communities dominated by *Oreostemma alpigenum* as compared to those dominated by *Carex scopulorum*.

Arnold et al. (2013) described the balance between plant productivity (i.e., soil organic matter input) and carbon loss via ecosystem respiration. In terms of meadow condition, Norton et al. (2011) found twice the amount of soil carbon and dissolved carbon in properly functioning meadows than those functioning at-risk or nonfunctioning. As the loss of soil carbon occurs, meadow soils become increasingly dry, and less capable of supporting a diverse and rich plant composition, and meadow plant communities shift to upland vegetation types. As dry conditions persist meadow ecosystem function and services are compromised (Ababneh and Woolfenden 2010), and wilderness character associated with those meadow ecosystems is lost to upland and conifer types. Simultaneously, the restoration of natural wilderness quality and the original wetland sedge dominated community becomes increasingly difficult (in terms of degree of manipulation required, and likelihood of success).

Climate change has been noted as the most prevalent widespread stressor currently confronting the integrity of the National Park Service and its mission to preserve resources unimpaired for future generation that have ever been experienced (Jarvis 2009). Several key climate science studies, including those by the U.S. Global Change Research Program and the Intergovernmental Panel on Climate Change, concluded that human-caused emission of heat-trapping gases, such as carbon dioxide, are the primary cause of climate change (IPCC 2013). Meadow distribution, type and vegetation density are primarily determined by hydrology, and meadows are particularly sensitive to drying caused by reduced snowpack, erosion resulting from shifts from snow to rain, and extreme rain events (Hauptfeld et al. 2014). Specific effects of climate change are forecast to include increased temperatures, rising snowlines and decreased snowpack particularly between 1300 and 2700 m (Knowles and Cayan 2004), shifts towards more frequent and intense rain events than snow (Knowles et al. 2006), lower stream base flows especially in the central Sierra (Null et al. 2010; Andrews 2012), and drier late-summer soil conditions (Dettinger et al. 2004).

Notably, Tuolumne Meadows at 2600 m elevation is located near the upper end of this range, whereby the source watershed is above this elevation. Nonetheless, findings at Dana meadows (2,965 m elevation) in Yosemite by Arnold et al. (2014), documented warmer temperatures and a longer vegetation growing season. Given reduced durations of snow cover and earlier snowmelt, meadow soils will dry earlier in the season and are expected to cause an earlier onset of plant water stress and senescence (Arnold et al. 2014; Moore et al. 2013). Snow water equivalent (SWE) is an important aspect of snowpack as a driver of meadow moisture and stream flow in the Sierras, but presents a more complex story than air temperature or the timing of snow melt. First, SWE is highly variable, so an exceptionally large data set is needed to detect significant changes (Andrews 2012). From analysis of Sierra Network 1950-2008 snow survey data, Mote et al. (2005) reported 8,500 feet elevation as an apparent threshold where snow courses below this elevation showed decreases in SWE, and courses above this elevation showed slight increases. From snow course data available for Tuolumne meadows (1930-2008), at 8,500 feet elevation, Andrews (2012) reported SWE has increased, by about 2 inches. Nonetheless, based on changes in temperature alone, using fairly conservative precipitation inputs from 1965-1987, Knowles and Cayan (2002) reported a modeled change in April 1 SWE, and reported greatest changes at elevations between approximately 6000 and 9000 feet elevation for the west slope of the Sierra Nevada, with predicted decreases exceeding 70% by 2060 and 85% by 2090.

Loarie et al. (2008) predicted that 66% of California's native flora will experience greater than 80% reduction in range size by 2100, and that the loss of plant species and lower overall diversity will likely be greatest in mountainous landforms. Other studies highlight a greater likelihood of conifer and shrub (especially sagebrush and rabbitbrush) invasion resulting in the loss of meadow landforms (Ababneh and Woolfenden 2010; Abatzoglou and Kolden 2011; Zald et al. 2012). In Yosemite National Park concern for these "vanishing meadows" was voiced as early as 1910 (Bradley 1911) and stimulated ongoing investigations (Ernst 1949, Vale 1981, Cunha 1992, Millar et al. 2004). As meadows convert to conifer forest substantial benefits of meadow ecosystems decline, including water filtration, flood retention, and diverse and abundant wildlife habitat (Sahin and Hall 1996; Jackson et al. 2002; Haugo and Halpern 2007; Emmons et al. 2013). In response to lodgepole pine establishment within Tuolumne and other nearby meadows, between 2005 and 2007, NPS staff removed approximately 70,000 individual conifer (ranging from seedling to 6 inch diameter trees) to help preserve meadow function (NPS 2008). Findings from Millar et al. (2004) and Lubetkin et al. (in prep) report that conifer establishment in meadows is primarily driven by higher ambient air temperature and micro-site conditions (vicinity to available seed source, available soil moisture, and inter-plant competition). From climate change projections and evaluation of conifer germination, establishment, and growth rates in Tuolumne and other Yosemite meadows, Lubetkin et al. (in prep) postulated that meadows would be highly encroached or lost to conifer forest by 2100.

The completed 2012-2015 CESU experimental study (Wolf and Cooper, in prep) was conducted in control (unfenced) and treatment (herbivore exclusion with sedge plantings) plots in Tuolumne Meadows, and included two plots in each of two nearby meadows (Delaney and Lower Tuolumne Meadows) as reference for existing sedge dominated communities. This experiment a test of sedge plantings and herbivory-exclosures on vegetation survival and carbon flux in fenced and control (unfenced) plots. Overall, they observed significant differences among control and reference plots for net ecosystem exchange of soil carbon and gross primary production; treatment plots showed improved carbon production and sequestration over the control plots. Notably, from the reference meadow plots, the intact sedge dominated vegetation persisted and was determined to be carbon storing despite being subjected to on-going herbivory by native wildlife, which suggests the presence of sustainability at a plant-density threshold. In addition, this study also showed that plantings of deep-rooted native sedges such as *Carex scopulorum, C. subnigricans* and exclusion of grazing—by mule deer (*Odocoileus hemionus* ssp. *californicus*) and various types of rodents such as vole (*Microtus* spp.), pocket gopher (*Thomomys* spp.), Belding's ground squirrel (*Urocitellus beldingi*)— is sufficient to significantly increase soil carbon sequestration in this wetland area.

Notable uncertainty exists regarding specific causation of the change in vegetation composition, however the investigation of causal factors is a sideline aspect of this problem. Rather, the specific problem is the presence of the altered vegetation community and its inherent lack of traits that provide for soil carbon enrichment and maintenance; this problem of the reported change in composition is relevant to the longevity of this wetland complex and its ability to resist or recovery from the effects of anthropogenic-induced climate change, not the particular causation of such vegetative change from past to current conditions. Nonetheless, other anthropogenic factors that may have caused changes in the greater Tuolumne Meadows may include: filling in the old road and social trails at the base of Pothole (possibly with limiting human use); filling in ditches that were dug to drain areas of the meadows, building check dams at headcut gullies. These specific issues are planned to be addressed through implementation of the Tuolumne Meadow Restoration Plan (NPS 2014), because these impacts are geographically and hydrologically disjunct in-relation to the wetland complex at focus here.

Step 3: Consider Actions Outside of Wilderness

Explain how any actions outside of wilderness may or may not mitigate or resolve the threats noted in step 1.

The threats noted in Step 1, above, are that a wetland complex in the western portion of Tuolumne Meadows exhibits an annual net loss of soil carbon, and does not align with conditions under which the carbon-rich wetland soil formed in the past. Soil carbon is critical to water holding capacity and nutrient cycling. Continued loss of soil carbon may initiate or further reinforce a feedback loop whereby drying conditions in the wetland complex inhibit the recovery of a sedge dominated plant community, and promote the maintenance of the now existing plant community that is dominated by *Oreostemma alpigenus*. Drier meadow conditions will likely be augmented by the effects of anthropogenic-induced climate change, which include warmer temperatures and an earlier annual onset of snowmelt. As soil carbon loss and climate change continue over time, resistance and resilience of the wetland and adjacent meadow area to functional change, as well as the long-term stability of this area, will likely be reduced. Thus, any future intervention to enhance the functionality and persistence of this wetland would likely require a greater degree of intervention and manipulation.

The completed CESU was completed at the identified 9 acre wetland (see Map Figures), and is the specific location that researchers have found the aforementioned disconnect between the existing plant communities and the underlying soil, and where temporary exclusion of herbivory by small mammals has been shown to yield positive effects on vegetation productivity and carbon sequestration. The completed CESU study was a spatially limited plot-based study. In contrast, this proposed study extends that same approach and therefore tests its feasibility at a greater spatial scale. Other meadows, or locations within Tuolumne Meadows, have not been observed or reported with similar conditions.

Moreover, unpublished NPS indicator monitoring data suggest that Tuolumne Meadows currently exhibits low levels of streambank stability and high bare soil, investigations to further inform management of options to enhance ecosystem processes (i.e., decrease levels of bare soil) in Tuolumne Meadows are warranted.

Step 4: Necessity for Action

Explain why any action in wilderness is necessary to preserve wilderness character.

The background for this problem, above, describes the current condition of the wilderness character of Tuolumne Meadows and the feedback loop between plant and soil processes that would likely cause future restoration efforts to be more costly and manipulative, or even infeasible. Without manipulative actions to reverse the feedback loop, it can be expected that Tuolumne Meadows, and its inherent meadow ecosystem characteristics, will likely convert to conifer forest within a measurable human-timescale.

The need for hydro-ecological restoration of Tuolumne Meadows is described as a high priority goal in Yosemite's 2020 Strategic Vision (NPS 2012), and supported by the Tuolumne Wild and Scenic River Plan final environmental impact statement (NPS 2014) based on observed conditions of the bare soil and streambank stability indicators for this river segment.

The Yosemite Wilderness Management Plan states that "The Primary objective of the natural resources management program is the perpetuation of the natural processes which have had a dynamic influence on the development and maintenance of park ecosystems." The Tuolumne River Plan provides guidance for Scenic segments (including Tuolumne Meadows): "After research is conducted, conduct appropriate ecological restoration to restore meadow and riparian habitat." (pg. 8-25). However, this guidance doesn't apply to wilderness: "This discussion pertains only to the nonwilderness portions of Tuolumne Meadows and Lower Dana Fork segments. The portions of these segments within designated Wilderness would be managed the same as the wild segments." Restoration guidance for wild segments and designated wilderness in scenic segments only mentions "localized areas disturbed by human and pack stock use in Lyell Canyon" (pg 8-21, 8-99). The restoration plan (Appendix 8) states "Areas outside of designated wilderness will be the first priority for restoration." Other than two specific prescriptions for Glen Aulin HSC and Lyell Canyon, no distinction between wilderness and non-wilderness is made, even though the prescriptions in the text of the plan differ between wilderness and non-wilderness. Under "research" the Appendix states "If research indicates that vegetation communities are in an altered state due to anthropogenic influence (such as historic sheep grazing), restoration actions to restore these plant communities may be desired and appropriate." (pg H-37).

The Wilderness Act defined wilderness as an area that is "in contrast with those areas where man and his own works dominate the landscape," and where "the earth and its community of life are untrammeled by man…" and as "an area of undeveloped federal land retaining its primeval character and influence…which is protected and managed to preserve its natural conditions and which generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable."

House Report 98-40: Congress gave specific guidance to the agencies about intervening in natural processes when they established the Yosemite Wilderness: "...wilderness is not a garden. Preparation of seed beds, planting of crops, spraying of fertilizer, and other farming-type activities and the creation of open spaces by the removal of timber or other vegetation are unacceptable practices in wilderness..." The challenge to wilderness managers, then, is to meet the Wilderness Act mandate of maintaining the wilderness character of an area (including its native wildlife populations) through utilization of the minimum necessary tool when implementing management programs while at the same time assuring a continuing untrammeled (left to operate freely) condition.

NPS Management Policies 4.3.3 assigns policy direction for designated wilderness to Chapter 6. Guidance in Chapter 6 for intervening in natural processes is found in **6.3.7** (NPS Reference Manual

41; NPS 1999) described that the principle of non-degradation will be applied to wilderness management, and each wilderness area's condition will be measured and assessed against its own unimpaired standard. Natural processes will be allowed, in so far as possible, to shape and control wilderness ecosystems. Management should seek to sustain natural distribution, numbers, population composition, and interaction of indigenous species. Management intervention should only be undertaken to the extent necessary to correct past mistakes, the impacts of human use, and the influences originating outside of wilderness boundaries. Management actions, including restoration of extirpated native species, altered natural fire regimes, controlling invasive alien species, endangered species management, and the protection of air and water quality, should be attempted only when the knowledge and tools exist to accomplish clearly articulated goals.

The NPS National Wilderness Steering committee has issued two white papers that are pertinent to this issue. While not policy, these papers allows for a way to evaluate the appropriateness of restoration and other conservation actions.

Guidance White Paper #2 (NPS National Wilderness Steering Committee, 2004) explained that there are numerous valid reasons for increasing intervention in wilderness including pervasiveness of regional and global anthropogenic stressors such as contaminants, light and sound pollution, and climate change. This Paper also discusses "*What constitutes appropriate conservation and restoration activities in wilderness?*" and offers a classification scheme for restoration activities based on their sustainability. This Paper does not comment on the issue of uncertainty; rather it assumes that anthropogenic nature of the threat and the likely results of any restoration activity are well proven. Guidance White Paper #4 describes "*Embracing the Distinction between Wilderness and Backcountry in the National Park System*", and specifically covers natural resource management. For NPS backcountry, management goals can be viewed as primarily "anthropocentric" in that we actively manage that which we believe we can control or steer seeking an optimum balance of conservation and use in a park-like natural setting. This Paper also describes that the Wilderness Act is decidedly more "biocentric" in context, defining wilderness to be a place set aside "…in contrast with those areas where man and his own works dominate the landscape…recognized as an area where the earth and its community of life are untrammeled by man…." (Section 2(C)). The concept of "wildness" emphasizes self-organization of natural systems on "self-willed" lands and implies significant restraint in respect for "wildness" when considering modifying actions. Lastly, Guidance Paper #4 concludes by saying: Wilderness can only endure if it is a place of purposeful restraint for managers as well as visitors (Pinchot Report 2001). Restraint arises from the humility born of realizing the awesome responsibilities of caretaking forever these remnants of wild America. That humility demands that we for once reject our most basic tendency to modify and manipulate the world around us.

Reintroduction of native species (in this case the native sedges that once occurred in Tuolumne Meadows) is described in Guidance Paper #2, as Class I of three activity categories. Class I entails one-time reversals of anthropogenic changes that, once accomplished, are self-sustaining. In other words, the reintroduction of self-sustaining native species can be viewed as a short-term disturbance leading to the long-term preservation of wilderness character, but hinges on the idea of a one-time intervention to create a self-sustaining system without need for further manipulation. Similarly, the Revisting Leopold report (NPS Advisory Board Science Committee 2012) urged NPS to consider actions that would preserve the longevity of its resources despite uncertainties. Landres et al. (2008) described consideration of short-term tradeoffs for long-term gains may be important to preserve wilderness character for future generations.

Although uncertainties exist regarding the potential effects of climate change and past conditions of Tuolumne Meadows, especially prior to the era of prolific sheep grazing, research at this and other nearby locations indicate that warmer temperature and longer growing seasons ((Arnold et al. 2013), the reduction and loss of soil carbon (Arnold et al. 2013; Wolf and Cooper in prep), lower base flows (Null et al. 2010; Andrews 2012), and the stagnation of the Lyell Glacier (Stock et al. in prep), are likely to have effects on the longevity of this meadow ecosystem. Apart from the chance occurrence of unanticipated effects associated with uncertainties of climate change (i.e., the manifestation of cooler temperatures and wetter trends), it can be anticipated that vegetation and soil conditions in Tuolumne Meadows is likely to continue a drying trend, changing to upland species and conifer (Millar et al. 2004; Lubetkin et al., in prep), and the loss of meadow function and the iconic wilderness character of Tuolumne Meadows is likely without intervening actions. Thus, investigations to inform management on options to preserve meadow ecosystem function and the wilderness character of Tuolumne Meadows, especially Class I type interventions that evaluate the resistance and resilience of ecosystems to anthropogenic-induced effects of climate change over a long-term, are valuable.

Step 5: Alternatives

Describe alternatives that address the threat(s) noted above.

Alternative A. No Action.

No research and monitoring actions would occur in association with the proposed action, or otherwise. Strictly Observation Studies would continue, but little insight would be gained into options to enhance wetland resistance and resilience to climate change.

Alternative B. Proposed Action.

The goal of the proposed action is to study the effects of four separate treatments to reduce or eliminate the loss of carbon from soils in this wetland complex, and thereby more closely align with the range of natural variability as based on concurrent observations in the reference meadow plots. The results from this research will provide management tools to reverse the trend of carbon loss should restoration actions be undertaken. The objective of this project is to evaluate a fully factorial experimental design in field plots within a nine acre portion of western Tuolumne Meadows (Figure 1) to assess the effects of small mammal exclusion and sedge planting treatments to increase soil carbon sequestration and soil moisture relative to control plots and reference meadow plots. We hypothesize that planting roughly 20,000 clonal sedge plants and reducing small mammal herbivory in the study area will increase the vegetation cover, above- and below-ground biomass production, and increase soil carbon stores within five years.

In Year 1 of the study, a two-way factorial design (producing four types of plots) would be established, and include planting *Carex scopulorum* seedlings vs. no plantings, crossed with short stature fences to exclude small mammal herbivory vs. no fencing. For this, across the nine acre area, 20 - 20 by 20 m square plots would be randomly assigned treatments (see Figure 2): five polygons would be assigned as control plots (i.e., including neither planting nor fencing), five would be fenced and not planted, five would have unfenced plantings, and five would have fenced plantings. Fenced plots would be oversized to allow for a 1 m buffer inside the perimeter that would not be treated, to avoid edge effects. In total, roughly one acre of nine acre wet meadow area would be fenced, but 0.7

acres would be treated through plantings. In addition, all control and treatment plots from the 2012 – 2015 CESU study in Tuolumne Meadows and reference meadow sites (Figure 3) would continue to be maintained and monitored to increase the temporal strength of these research findings.

These results will be compared with control plots (unfenced, and without plantings) in two reference meadows that receive no treatments. Response variables and success criteria that would be measured include the survival of planted seedlings, total canopy cover, soil temperature, soil water content, above and below ground production, and greenhouse gas dynamics. In addition, variation in planting density would also be tested, to determine the effectiveness of this factor. Ultimately, findings from this research project would inform park management of the feasibility and potential success of a one-time human intervention into wilderness meadows to increase carbon sequestration and maintain or enhance meadow soil moisture, and in effect enhance meadow/wetland resistance and resilience to the effects of anthropogenic-induced climate change.

Study Years 2-5 would be dependent upon the success of each subsequent year study, and would be accomplished through subsequent research permit proposals (and Minimum Requirements Analyses). For implementation of Year 2, Year 1 success criteria includes high survival rate (e.g., > 75%) of planted sedge seedlings within fenced plots. Qualitatively, we would also expect to see new tiller production leading to the formation of a sod-type ground cover, augmented soil carbon budgets compared with the unplanted control plots and reference meadow plots. Herbivory rates would be monitored and assessed to further determine the necessity of the small mammal exclusion fencing. Year 2 would have larger planting area with more plants, and monitoring of plants and soil from the year 1 and year 2 areas. Year 3 would be a larger planting area again, and include monitoring of the years 1, 2, and 3 areas. Year 4 would be no planting, just monitoring. Year 5 would include removal of all small mammal exclusion fencing, and continued monitoring of project success without exclusion of small mammal herbivory.

Treatment actions would include a combination of the following: 1) Seed collection and plant propagation of the target sedge species (*Carex scopulorum*) (note: seed collection was conducted in Fall 2015, and plant propagation occurred between Fall 2015 and Spring 2016); 2) Establishment of temporary small mammal exclusion fencing, and; 3) Out-planting propagated sedge species as soon as the snow melts. Small mammal exclusion fencing (rebar posts with 30 cm tall galvanized wire mesh and wire ground staples) will be established and native sedge seedlings planted. If successful, this same procedure would be expanded in 2017 and 2018 (Year 2 and 3) to additional (60 and 100 plots) areas within the nine acre wetland area. Within each treated area we will randomly choose approximately 20 plots per acre for quantification of the variables described above. Existing research plots where vegetation composition and cover has been monitored for the past 10 years will be used as control plots. In Year 5 all components of the exclusion fencing will be removed. Table 1 lists specific temporary installations and other impacts to wilderness required for implementation of the proposed action; Table 2 lists temporary installations and other impacts to wilderness for research and monitoring associated with the proposed action.

Table 1, Temporary installations and other impacts to Yosemite Wilderness required for implementation of the proposed action for Year 1 of the study. Expansion of the study in Year 2 is dependent upon the success of Year 1, and would be accomplished through subsequent research proposals (and Minimum Requirements Analyses). Implementation of Year 1 of this study would impact roughly one acre of nine acre wet meadow area through small mammal exclusion fencing; of that one acre, 0.7 acres would also be treated through plantings. Installations associated with research components are described separately below and see Table 2.

Proposed Action	Equipment	Quantity	Manipulation	Timing
2016 (Year 1)				
Installation of small mammal exclusion fence (0.7 acres planted, 1.0 acres fenced to allow 1 m buffer around planting)	**Wire mesh fence**	**800 m long, 30 cm high**	**Above ground obstruction.**	**June - July**
	4" Green tin flashing	**800 m long**	**Above ground obstruction.**	**June - July**
	Rebar	**0.9 m long (0.6 and 0.3 above ground), 200 count**	**Soil disturbance**	**June - July**
	Staples	**6" long, 800 count**	**Soil disturbance**	**June - July**
Small mammal exclusion	**Live animal traps**	**20 traps**	**Displacement of native fauna**	**July - October**
Plantings	**Native sedge seeding plants.**	**20, 000 count, 6 cubic inch root-soil volume**	**Soil Disturbance, installation of nursery grown plants (from seed collected Tuolumne Meadows)**	**June- July**
Hole and nursery soil, as a treatment control for the plantings	**Potting soil**	**100 count, 6 cubic inch soil volume**	**Soil Disturbance, installation of nursery soil, treated exactly as the plantings but without plants**	**June- July**
Sedge seed collection	**N/A**	**N/A**	**Reduction of available seed crop from source areas**	**Sept – Oct 2015**

Table 1. Temporary installations and other impacts within wilderness required for scientific study associated with Year 1 of the proposed action.

Proposed Action	Study Factor	Equip-ment	Quantity (unit)	Location	Manipu-lation (methods of use)	Timing
Research soil carbon and nutrient flux.	**Photosynthesis and respiration**	**Clear plastic chamber equipped with an infrared gas analyzer (IRGA, PP Systems EGM-4)**	**1 (portable; temporary)**	**Repeated measures at 40 plots in Tuolumne Mdws. and 16 reference meadow plots)**	**Biweekly field measures. Transitive equipment; no soil disturbance for measurements.**	**June 2016 – October 2020.**
	Greenhouse Gas flux (winter)	**Soil probe.**	**1 (portable; temporary)**	**Repeated measures at 10 plots in Tuolumne Mdws. and 4 reference meadow plots).**	**Monthly measurements. Soil disturbance via insertion of rod, but no soil removal.**	**Nov – June 2016- 2020**
	Plant phenology	**Wingscapes PlantCam**	**4 (fixed)**	**Repeated measures at 2 plots (1 planting**	**Continuous field measurements. Above ground manipulation,**	**June 2016 – October 2020.**

				area, 1 control plots, and 4 reference meadow plots).	mounted on exclusion fence rebar.	
	soil temperature	Onset Computer Corp. Hobo water temp sensor	4 (fixed)	Repeated measures at 2 plots (1 planting area, 1 control plots, and 2 reference meadow plots).	Continuous field measurements. Probes Installed @ 10 cm depth, by pushing into soil, attached by cable to a 10 cm by 10 cm square above-ground logger.	June 2016 – October 2020.
	soil moisture	Spectrum Technology TDR soil moisture probe	1 (portable; temporary)	Repeated measures at 40 plots in Tuolumne Mdws. and 16 reference meadow plots).	Biweekly field measures. Transitive equipment.	June 2016 – October 2020.
	Soil redox potential	3 automated redox potential measuring systems. Each station will be powered by a solar panel with battery, and a Campbell CR1000 data logger. Platinum tipped electrodes will be paired with a Beckman Calomel reference electrode, and eight pairs of electrodes will be installed at 10–20 cm soil depth at each site.	3 stations (fixed)	2 in each Planting areas in Tuolumne Meadows, and 1 in a Tuolumne Meadows control.	Continuous field measurements. Soil disturbance: 3 holes (20 cm deep, 15 cm wide) for electrodes. Above ground manipulation: data loggers; solar panel (50cm by 50cm), battery and housing (20cm by 30cm); cables and wires.	June 2016 – October 2020.
Research water table depth	Water depth	Existing groundwater piezometers	10	Tuolumne Meadows.	Continuous field measurements. Above ground manipulation: ~6" of well head (loggers in existing wells).	June 2016 – October 2020.

	Water depth	New ground water piezometers (no above ground installation, wells would be cut-off sub-surface)	4	Reference Meadows: Delaney and Lower Tuolumne	Continuous field measurements. Above ground manipulation: ~6" of well head	June 2016 – October 2020.
Vegetation sampling	Planted seedling survival, vegetation composition, and canopy bare soil, and litter cover. Changes in shoot density, formation of new shoots from rhizomes.	Various measurement	N/A	Repeated measures at 100 plots (60 planting area, 20 control plots, and 20 reference meadow plots).	No manipulation. Bi-weekly, randomly selected plots.	June 2016 – October 2020.
	Above and below ground seedling biomass production.	Plant collection	20 plantings, annually	Planting areas and control plots in Tuolumne Meadows, and reference meadow.	Annual measures of from spatially stratified random sample. Soil disturbance using hand trowel. Herbage removal and via clippings.	June 2016 – October 2020.
	Mineral sediment deposition	Sediment disks	100	Planting areas, and control plots in Tuolumne Meadows	Annual measurements of transects.	June 2016 – October 2020.

Other study related installations located outside of wilderness would include the Solar Radiation and Air Temperature and Pressure station, located at approximately UTM 4194473E and 291469N (Zone 11 North) for continuous measurements. The solar radiation sensor (about the size of a baseball) will be mounted about 1 foot above the ground on a piece of rebar; the air temp and air pressure sensor will be housed in a 1.5" diameter, 12" long piece of PVC pipe, mounted to a tree at about 7-feet up the trunk.

NPS staff will continue to search for funding to further support monitoring findings of this study after Year 5, in terms of long-term (i.e., 5 – 20 years) success of the study to enhance carbon sequestration in this wetland complex.

Alternative C: Former Proposed Action

This alternative was originally considered as the Proposed Action, but is focused as a restoration project rather than as research. It is similar in nature to the Proposed Action (Alternative B, above) but is not a plot-based study, and did not leave any portion of the 9 acre area as an overall control to verify what would likely happen if no intervention was conducted. The primary goal of this alternative is to restore a carbon-storing native sedge ecosystems to 9 acres (~2% of Tuolumne Meadows, 450 acres) that more closely aligns with the range of natural variability as based on concurrent observations in the reference meadow plots.

Native sedge ecosystems will be restored through a combination of the following: 1) Seed collection and plant propagation of the target sedge species (*Carex scopulorum, C. subnigricans*) (note: seed collection was conducted in Fall 2015, and plant propagation occurred between Fall 2015 and Spring 2016); 2) Establishment of temporary small mammal exclusion fencing around planting sites, and; 3) Out-planting propagated sedge species as soon as the snow melts. In 2016 (Year 1 of 5), small mammal exclusion fencing (rebar posts with 30 cm tall galvanized wire mesh and wire ground staples) will be established and native sedge seedlings planted at a density of 4 plants per square yard (i.e., roughly 20,000 plants per acre), at a selected one acre site. This same procedure would be expanded in 2017 and 2018 (Year 2 and 3) at the selected 3 and 5 acre locations (Figure 2). Within each treated area we will randomly choose approximately 10 plots per acre for quantification of the variables described above. Existing research plots where vegetation composition and cover has been monitored for the past 10 years will be used as control plots. In Year 5 all components of the exclusion fencing will be removed.

Tasks for implementation of this alternative include: (1) late summer seed collection of target species (*Carex scopulorum, C. subnigricans*) and seedling propagation in available greenhouse plant nursery, (2) planting seedlings in Tuolumne Meadows as soon as the snow melts each year, (3) building and maintaining small mammal exclusion fencing around planting sites (fences will be erect during the summer, and laid flat in winter and, (4) establish research study plots to track success. Table 3 lists specific temporary installations and other manipulations required for this alternative.

Table 3, Temporary installations and other impacts to Wilderness required for the Alternative C within Yosemite wilderness for project study Year 1 through Year 3 across 1, 3, and 5 acres (respectively, of Tuolumne Meadows (9 acres in total; 2% of the meadow area). Year 4 would be limited to small mammal exclusion, and Year 5 would include removal of all project installations. Installations associated with research components during Years 1 through 5 of Alternative C, are described separately below and see Table 4.

Action	Equipment	Quantity	Manipulation	Timing
2016 (Year 1)				
Installation Small mammal exclusion fence (1 acre)	**Wire mesh fence**	**450 m long, 30 cm high**	**Above ground obstruction.**	**June - July**
	4" Green tin flashing	**450 m long**	**Above ground obstruction.**	**June - July**
	Rebar	**0.9 m long (0.6 and 0.3 above ground), 148 count**	**Soil disturbance**	**June - July**
	Staples	**6" long, 450 count**	**Soil disturbance**	**June - July**
Small mammal exclusion	**Live animal traps**	**20 traps**	**Displacement of native fauna**	**July - October**
Plantings	**Native sedge seeding plants.**	**20, 000 count, 6 cubic inch root-soil volume**	**Soil Disturbance, installation of nursery grown plants (from seed collected Tuolumne Meadows)**	**June- July**
Sedge seed	**N/A**	**N/A**	**Reduction of available seed**	**Sept - Oct**

collection			crop from source areas	
2017 (Year 2)				
Installation and maintenance of small mammal exclusion fence (3 acres)	Wire mesh fence	978 m long, 30 cm high	Above ground obstruction.	June - July
	4" Green tin flashing	978 m long	Above ground obstruction.	June - July
	Rebar	0.9 m long (0.6 and 0.3 above ground), 331 count	Soil disturbance	June - July
	Staples	6" long, 978 count	Soil disturbance	June - July
Small mammal exclusion	Live animal traps	40 traps	Displacement of native fauna	July - October
Plantings	Native sedge seeding plants.	60, 000 count, 6 cubic inch root-soil volume	Soil Disturbance (digging with trowels), installation of nursery grown plants	June- July
Sedge seed collection	N/A	N/A	Reduction of available seed crop from source areas	Sept - Oct
2018 (Year 3)				
Installation and maintenance of small mammal exclusion fence (5 acres)	Wire mesh fence	830 m long, 30 cm high	Above ground obstruction.	June - July
	4" Green tin flashing	830 m long	Above ground obstruction.	June - July
	Rebar	0.9 m long (0.6 and 0.3 above ground), 272 count	Soil disturbance	June - July
	Staples	6" long, 830 count	Soil disturbance	June - July
Small mammal exclusion	Live animal traps	60 traps	Displacement of native fauna	July - October
Plantings	Native sedge seeding plants.	60, 000 count, 6 cubic inch root-soil volume	Soil Disturbance (digging with trowels), installation of nursery grown plants	June- July
2019 (Year 4)				
No new manipulations planned	N/A	N/A	N/A	N/A
Small mammal exclusion	Live animal traps	No additional traps used (60 maximum).	Displacement of native fauna	July - October
2020 (Year 5)				
Small mammal exclusion	Live animal traps	No additional traps used (60 maximum).	Displacement of native fauna	June - October
Removal of all installations and fencing			Soil disturbance	October
Table Notes: Soil disturbance associated with planting seedlings will be done via manual digging with trowels for insertion of seeding and soil volume equivalent to the dimensions of a 6" d-pot (5.5" long, 1.5" wide).				

Late summer seed collection of target species (*Carex scopulorum, C. subnigricans*) for propagation in commercial nurseries is anticipated to occur over no more than 10 acres annually. Depending on annual fecundity rates of available established sedge plants. Collection procedures would be limited to less than 10% of available seed to retain sufficient seed at source sites for community sustainability.

Native sedge plantings would occur in Year 1, 2, and 3, at 1, 3, and 5 acres (respectively) of the 9 acre study area. This would include temporary soil disturbance (via small trowel), and each planting (i.e., estimated 20,000 native sedge seedlings in Year 1, 60,000 in Year 2, and 100,000 in Year 3). Planting efforts would be scheduled as close to the completion of snow melt each year to maximize survival of the plantings.

Building and maintaining small mammal exclusion fencing around planting sites would entail manipulation to 2,258 linear meters total at the perimeter of the 1, 3, and 5 acre study areas. Fencing material would be 30 cm tall wire mesh and secured to rebar via wire ties. Rebar would be 50 cm long (30 and 20 cm above- and belowground). Four inch tin flashing would be secured along the top of the length of the fence to prevent animal from climbing over top. The flashing would be painted dull green to eliminate visual glare. One six inch long metal soil staple will be used roughly each meter of the fence perimeter to secure contact to the ground and prevent access by small mammals. Fence installation would be scheduled as close to the completion of snow melt each year to minimize the number of small mammals living within the exclosure area. The wire mesh fence would be erect during the summer, and laid flat in winter. It will be stapled to the ground to limit small mammal entry. Small mammals within the project area will be live trapped and moved to outside of the perimeter. A sufficient number of traps will be used such that the study area remains free of small mammal herbivory for the 5 year study period (i.e., up to a maximum 20, 40, and 60 traps for each annual project area). Trapped animals will be moved outside the fence exclusion area.

Research objectives will require the following manipulations. Plots within the study area will be evaluated over time for: planting survival and tillering (formation of new shoots from rhizomes), above- and below-ground biomass production, species composition, changes in shoot density, vegetation canopy cover, bare soil and litter cover, as well as greenhouse gas flux and soil carbon accumulation (i.e., CO_2, CH_4, and N_2O emissions and net ecosystem exchange, rates of carbon fixation). Monitor will also include evaluation of water table depth (using existing piezometer wells), and soil redox measurements (using electrodes at depths within the soil profile). Monitoring for these study factors will occur through a combination of continuous, bi-weekly, monthly and annual sampling intervals (see Table 4), typically between June and October of each study Year 1 -5. Disturbance associated with monitoring includes soil disturbance, herbage removal, and above-ground installations (i.e. data loggers, solar panels, batteries and housings).

Table 4, Temporary installations and other manipulations within wilderness that are required for scientific study Alternative C within Yosemite wilderness, Year 1 through Year 5.

Action	Study Factor	Equip-ment	Quantity (unit)	Location	Manipu-lation (methods of use)	Timing

Research soil carbon and nutrient flux.	Photosynthesis and respiration	Clear plastic chamber equipped with an infrared gas analyzer (IRGA, PP Systems EGM-4)	1 (portable; temporary)	Repeated measures at 40 plots in Tuolumne Mdws. and 16 reference meadow plots)	Biweekly field measures. Transitive equipment; no soil disturbance for measurements.	June 2016 – October 2020.
	Greenhouse Gas flux (winter)	Soil probe.	1 (portable; temporary)	Repeated measures at 10 plots in Tuolumne Mdws. and 4 reference meadow plots).	Monthly measurements. Soil disturbance via insertion of rod, but no soil removal.	Nov – June 2016-2020
	Plant phenology	Wingscapes PlantCam	4 (fixed)	Repeated measures at 2 plots (1 planting area, 1 control plots, and 4 reference meadow plots).	Continuous field measurements. Above ground manipulation, mounted on exclusion fence rebar.	June 2016 – October 2020.
	soil temperature	Onset Computer Corp. Hobo water temp sensor	4 (fixed)	Repeated measures at 2 plots (1 planting area, 1 control plots, and 2 reference meadow plots).	Continuous field measurements. Probes Installed @ 10 cm depth, by pushing into soil, attached by cable to a 10 cm by 10 cm square above-ground logger.	June 2016 – October 2020.
	soil moisture	Spectrum Technology TDR soil moisture probe	1 (portable; temporary)	Repeated measures at 40 plots in Tuolumne Mdws. and 16 reference meadow plots).	Biweekly field measures. Transitive equipment.	June 2016 – October 2020.

	Soil redox potential	3 automated redox potential measuring systems. Each station will be powered by a solar panel with battery, and a Campbell CR1000 data logger. Platinum tipped electrodes will be paired with a Beckman Calomel reference electrode, and eight pairs of electrodes will be installed at 10–20 cm soil depth at each site.	3 stations (fixed)	2 in each Planting areas in Tuolumne Meadows, and 1 in a Tuolumne Meadows control.	Continuous field measurements. Soil disturbance: 3 holes (20 cm deep, 15 cm wide) for electrodes. Above ground manipulation: data loggers; solar panel (50cm by 50cm), battery and housing (20cm by 30cm); cables and wires.	June 2016 – October 2020.
Research water table depth	Water depth	Existing groundwater piezometers	10	Tuolumne Meadows.	Continuous field measurements. Above ground manipulation: ~6" of well head (loggers in existing wells).	June 2016 – October 2020.
Vegetation sampling	Planted seedling survival, vegetation composition, and canopy bare soil, and litter cover. Changes in shoot density, formation of new shoots from rhizomes.	Various measurements	N/A	Repeated measures at 100 plots (60 planting area, 20 control plots, and 20 reference meadow plots).	No manipulation. Bi-weekly, randomly selected plots.	June 2016 – October 2020.
	Above and below ground seedling biomass production. Seedling tillering rates.	Plant collection	20 plantings, annually	Planting areas and control plots in Tuolumne Meadows, and reference meadow.	Annual measures of from spatially stratified random sample. Soil disturbance using hand trowel. Herbage removal and via clippings.	June 2016 – October 2020.

	Mineral sediment deposition	Sediment disks	100	Planting areas, and control plots in Tuolumne Meadows	Annual measurements of transects.	June 2016 – October 2020.

Other study related installations located outside of wilderness would include the Solar Radiation and Air Temperature and Pressure station, located at approximately UTM 4194473E and 291469N (Zone 11 North) for continuous measurements. The solar radiation sensor (about the size of a baseball) will be mounted about 1 foot above the ground on a piece of rebar; the air temp and air pressure sensor will be housed in a 1.5" diameter, 12" long piece of PVC pipe, mounted to a tree at about 7-feet up the trunk.

Alternatives Evaluated but Omitted From Further Consideration

- An alternative also considered was the complete exclusion of all grazing, because grazing by mule deer may confound study findings. In this alternative, the native plantings and all research study components would proceed as described under Alternative C. This approach would enhance the likelihood of success for this study. This additional exclusion could occur via two feasible methods, first, complete grazing exclusion could be accomplished through use of the same materials described in Alternative C, but with additional wire mesh used to effectively create a "roof" type structure. Second, complete grazing exclusion could be accomplished through the establishment and combination of a low lying small animal exclosure fence (as described in Alternative C) and supplemented with approximately 1.8 m (8-10 feet) high chain-link. Fencing at this height would also require substantially greater support by 2" diameter galvanized steel posts. Because this option has obvious extreme impacts to the wilderness character of Tuolumne Meadows.
- Use of herbicides to reduce competition to sedge planting survival. This alternative could be effective to increase planting survival, but would be increased manipulation of wilderness character in Tuolumne Meadows. Furthermore it is anticipated that the plantings will readily outcompete the dominant forb (*Oreostemma alpigenus*) without the use of herbicides. This alternative was evaluated, but omitted from further consideration.
- Use heavy equipment to remove existing plant community and grow out *Carex* species in a roll of sod to replace current vegetation. This technique was successfully used at Halstead Meadow in Sequoia Kings National Park. This technique was dismissed as to protect existing soils and avoid heavy equipment in this wilderness meadow. It was determined that hand planting would be less impactful and as successful. This alternative was evaluated, but omitted from further consideration.

Step 6: Effects on Wilderness character

1. No Action Alternative

Untrammeled: No effect

Natural: There are currently numerous ongoing impacts to this section. These would continue under this alternative unless other actions are taken to mitigate them

Undeveloped: The wells and other scientific installation remaining in this area of wilderness were required to be removed under an existing MRA, but are still present. They would be removed under the no action alternative, improving this quality.

Unconfined: No effect

Solitude: no effect

Primitive: Slight positive effect from the removal of the current installations

Other: No effect

2. Action alternatives.

While years 2-5 of the "proposed action" alternative are presented as conditional, the criteria for success after year 1are almost certain to be met, so all five years will be evaluated here. The effects for the two action alternatives are virtually the same. The only unknown is whether the fencing for the "proposed action" surrounds individual plots or a larger area. If it is a larger area with plots contained within, then the two alternatives are essentially identical.

Untrammeled: These actions are a major, permanent impact to the untrammeled quality. See more discussion in the conclusion.

Natural: It is unknown whether this area is within the range of natural variation, or if these actions will move it toward or away from that range. The fencing may help reduce human trampling in the area, although the researchers and other staff will also be repeatedly walking through the area.

Undeveloped: These actions will have a major negative impact to this quality, with a large amount of low fencing. The fencing is 30 cm high with green metal flashing and is installed with rebar and staples. If large areas are fenced, this will amount to a mile and a half of fence with 800 pieces of rebar and 2600 staples. If each fenced plot has its own fence, the total will be approximately four and a half miles of fence with 1800 pieces of rebar and 7200 staples. In addition, numerous scientific instruments will be installed or retained, including at least 7 very obtrusive ones, some with solar panels.

Unconfined: minor negative effect as visitors will be fenced out of part of the meadow.

Solitude: Minor negative effect from staff presence. Expectations for solitude are low in this area.

Primitive: These action will have a major negative effect on opportunities for primitive recreation- The installations noted above will be very visible to the thousands of visitors who hike along Pothole Dome each summer, and some may even be visible to the hundreds of thousands driving along the road looking into wilderness. While expectations for primitive experience are low this close to the road and developed area, the sheer amount of installations and the number of people that will see them still means this is a serious impact.

Other: 180,000 small holes will be dug to plant sedge. It is unknown if there are archeological sites in the project area.

Step 7: Analysis of Effects on Safety and Economics

Safety

Alternative A. No Action.
The No Action alternative would have no effect upon safety.

Alternative B.
Safety considerations include: individual and team fitness (for researchers, NPS staff and project volunteers), communications, travel plans, supervision, and job hazard analysis. In general, for project installations, teams of two or more people are required for safety purposes. Small mammal trapping throughout the life of the project would be conducted by researchers also in pairs for efficiency and to minimize potential impacts to trapped mammals. Research on soil carbon and nutrient flux, water table depth, and vegetation sampling would be conducted by individuals, pairs, or up to 3 for efficiency and to minimize time of human presence at the study sites.

Alternative C.
Same as Alternative B, above.

Economics

Describe the costs for implementation of each alternative.

Alternative A. No Action.

The No Action alternative would have no effect upon economics.

Alternative B.

Table of Funding Sources and Cost Share SOURCE OF FUNDS	CASH	IN-KIND (If Applicable)	TOTAL
CDFW	$587,996	$	$587,996
Other State Agency(ies) (List by name)	$	$	$
Federal (List by name)	$	$	$
Applicant (Indicate if Federal)	$	Federal (Yosemite NP) $404,590	$404,590
Other(s) including partners (if applicable, state name)	$	Subcontractor (Colorado State University) $142,610	$142,610

Total Project Cost	$587,996	$547,200	$1,135,196

Alternative C.
Same as Alternative B, above.

Alternative D.
Same as Alternative B, above.

Step 8: Decision

The alternative labeled "proposed action" in this document consists of two parts; year one is experimental research: approximately one acre of wilderness in Tuolumne Meadows will be manipulated in order to initiate a change in the plant community there. If that manipulation is judged to have succeeded, in years two and three that same manipulation will be applied to a further eight acres.

What constitutes a threat to wilderness character?

Clearly articulating the threat to wilderness character is essential for establishing what response, if any, is the minimum appropriate action. In this case the natural quality of wilderness character is at issue: Because ecosystems are endlessly dynamic, the natural quality is better considered as the range of natural variation- variation within that range is more likely to be natural instead of anthropogenic and will often not justify management action, whereas conditions that are clearly outside of that range are more likely to be anthropogenic and may justify a management action. To understand a threat to the natural quality one must then try to understand the stressors that have been placed on an ecosystem. In this case that means a consideration of potential past actions, current conditions, and reasonable assumptions of future trends.

The past: Tuolumne Meadows has had a long history of both deliberate ecological manipulations and inadvertent impacts. Deliberate manipulations include:

- Digging ditches to drain wet areas to reduce mosquitoes
- Spraying pesticides on wet areas to reduce mosquitoes
- Spraying malathion, DDT, and other pesticides to prevent lodgepole pine mortality
- Repeated cutting of lodgepole pine at the meadow edge
- Possible sheepherder burning of the meadow
- Fire suppression

Inadvertent impacts include:

- Road construction related impacts
- Deep trenching for utility lines with possible interruption of sub-surface flow
- Decades of camping and related impacts: soil compaction, vegetation damage, and erosion
- Decades of driving across the meadow to campsites and other destinations causing soil compaction, vegetation damage, and erosion
- Social trails/ general trampling

- Sheep grazing
- Administrative and concession packstock grazing

Other impacts may be significant but are not well understood such as the effect of modern human activity on deer populations and the attendant effect on herbivory. For a more detailed discussion of some of these impacts see Snyder (2010).[1]

Current conditions:

Cooper and Wolf have discovered that the soils under approximately nine acres in the wilderness portion of Tuolumne Meadows appear to have been formed by a different plant community than the one now present (although the Peer Review presented significant issues with this assertion). No evidence is presented as to when or how this change took place, or which of the above stressors may have caused it. The researchers, and this MRA, assert that this change is unlikely to reverse on its own.

There are also many statements in the MRA about many other conditions related to the current plant community such as:

- a reduced level of ecosystem function and services
- an annual net loss of soil carbon
- low soil water holding capacity
- low diversity of vegetation types
- low carbon sequestration and nitrogen fixation
- low "functional contribution" —low water filtration, flood retention, and diversity of wildlife habitat

None of these, by themselves, however, constitute a threat to wilderness character, regardless of whatever other social value they may have. The pertinent question is whether the existence of this plant community in this location is within the range of natural variation.

Two factors support the idea that this area may be outside of that range. The first is the number and potential effects of past impacts noted above. The second is the discrepancy, if it exists, between the soils and the current community. Many of the past actions noted above could certainly have caused this change or, as one researcher noted for another meadow, "the actual scenario may be a far more complicated interplay of causative factors"[2].

The change in plant community could also be natural, however- a natural evolution in the life of the meadow ecosystem, possibly caused by past natural stochastic events or a long term drought such as the ones noted by Scott Stine that allowed large trees to grow on the bed of Tenaya Lake. So while we now have evidence that this area once hosted a plant community likely to produce such soils, we don't understand when, or why it changed, and the answers to both of these questions are essential to understanding whether the change is anthropogenic and, if so, what might be the minimum action to

[1] Snyder, James A comment on the study of meadows and 19th Century grazing, Memo to Director, Yosemite Field Station, July 29, 2010
[2] Dull, 1999, pg 910

return the area to the range of natural conditions. As noted in the Peer Review, the existing science does not support the idea of "restoring" the area to some hypothesized previous condition.

The future:

The MRA correctly identifies climate change as an anthropogenic effect that is likely to affect plant communities in Tuolumne and notes recent trends: So far, total snowpack in Tuolumne has remained fairly steady, although it is reasonable to suspect this may change in the near future. The snowpack is already melting earlier, resulting in drier conditions in late summer and fall.

While it is difficult to understand the complex interplay of past impacts to the meadows, it is even more difficult to predict both the future nature of climate change and its effects on a specific place like Tuolumne. The continuation of recent trends will increase the stressors on the meadow communities and is likely to cause significant changes. The longer term trends and how they will affect the meadow is much harder to predict and is not mentioned in this MRA.

Alternatives:

This MRA considers a no action alternative and two action alternatives. The first action alternative is described above: a one year, one acre experiment to test a proposed manipulation designed to change the plant community in the nine acres at issue, followed by applying that manipulation to the remaining eight acres in the following two years. The second two years are dependent on the success of the first year's success, with success defined as results similar to the previous research: that planting and herbivory exclusion will result in more vegetation along with the expected ecological components that go with more vegetation. This alternative also includes a research component at nearby reference meadows.

The second action alternative was the one previously proposed: Applying the same treatment over three years (one, three, and five acres in each of the first three years) and removing the fence in the fifth year. Both action alternatives have an accompanying research component.

Unfortunately there are no alternatives that attempt to address the significant uncertainties noted above; no alternatives investigate possible causes of the noted vegetation change or do more to attempt to determine if the change is natural or anthropogenic or help understand the range of natural variation. Nor are there any that consider attempting to address other better understood impacts that may be affecting the area in question. This is an important omission because in many cases these impacts have a higher degree of certainty as to anthropogeniety; a better understanding of cause and effect, and much simpler, and better proven methods of addressing the impact- they are , in a wilderness sense, more minimal.

Instead, any such consideration of such research or actions is dismissed with the claim that "the investigation of causal factors is a sideline aspect of this problem". But the cause is central to the question because addressing the cause, or causes, may be more minimal (and less risky) than the manipulations proposed here. The MRA also states that all other impacts "are geographically and hydrologically disjunct in-relation to the wetland complex at focus here." Yet some of the impacts-like old roads, social trails and trampling- are in the area, and some are immediately adjacent to it. A recent MRA, for instance, stated that the old road and social trails at the base of Pothole Dome impacts meadow hydrology; it goes on to say that "water is concentrated in these ruts, soils are heavily compacted reducing percolation into the soil, soil loss and erosion are increased (often developing into headcuts)..." whereas restoring these impacts would "promote natural function to meadow habitat restoring native plant communities and support ...sheet flow hydrology."[3] Two of the old roads/social trails go through the middle of the wetland complex. A third (the one in question in the 2012 proposal) is at one point only 13 meters from the area, between the Dome and the wetland. Presumably, the interruption of sheet flow cause by the road would affect the wetland.

The consideration of addressing other potential causes with more minimal associated mitigation actions is a required component of MRAS. Here is binding guidance from the Ninth Circuit Court of Appeals:

> The Wilderness Act imposes a strong prohibition on the creation of structures, subject only to an exception for structures that are *necessary* to meet the Act's *minimum* requirements. Just because a particular variable affects the sheep's viability, the Service is not free to create structures addressing that variable without regard to any other variables at play. The Act certainly provides for some flexibility to address a given situation, even with imperfect information and time and budget constraints. But, unless the Act's "minimum requirements" provision is empty, the Service must, at the very least, *explain* why addressing one variable is more important than addressing the other variables and must *explain* why addressing that one variable is even necessary at all, given that addressing the others could fix the problem just as well or better.
>
> As in High Sierra, "[n]owhere in the [record] does the . . . Service articulate why "the action taken is "necessary" to meet the "minimum requirements" of the Act. Id. (emphasis added). And, as in High Sierra, that failure is fatal. Where, as here, the record demonstrates that many alternative actions not prohibited by the Wilderness Act very well could have attained the Service's goal, a single yes/no question cannot suffice to invoke the very limited exception for structures that are necessary to meet the minimum requirements for the administration of the purposes of the Wilderness Act.[4]

Further, neither action alternative allows sufficient time to understand the sustainability of the proposed action (more on this below) The "proposed action" allows for two years of monitoring in the last two years of the project, but by then all nine acres would be manipulated; which means the results of that monitoring can do nothing to reduce or eliminate the impacts to wilderness character caused by this project. A meaningful monitoring period for such a project should include the expected range of variation for crucial variables: wet and dry years, herbivore population variation, etc. - certainly much longer than two years- and to be meaningful from the wilderness perspective, that monitoring has to be before any further manipulative management action takes place, not after.

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[3] Buhler, Monica Informal Trail Removal in Tuolumne Meadows, Minimum Requirement Analysis, 2012
[4] Wilderness Watch v. USFWS (Ninth Circuit, 2010)

Criteria for decisions on potential manipulative actions in wilderness

The title of the MRA, "Potential Enhancement of Tuolumne Meadow Resistance and Resiliency to Anthropogenic-Induced Climate Change by Planting Carex scopulorum" suggests that this action is neither research nor restoration, but rather an ecological manipulation to "resist" the effects of climate change (more on this below). The "proposed action," however, describes one year of manipulative research followed by two years of manipulative management action-whether that action is backward looking—i.e. "restoration," as described in the first version of the MRA for this project- or forward looking- i.e. "building resistance," is somewhat immaterial as the manipulative action is exactly the same in both cases. And it can't be thought of as "applied research" because the entire known area in this condition in the Yosemite Wilderness (or the Sierra Nevada, for that matter) will be treated during this project- so there won't be anywhere to "apply" the results of the research unless other meadows are studied and found to have this same soil/plant community discrepancy.

Potential manipulative actions in wilderness are assessed using twelve criteria.

Threat Criteria:

Magnitude: While the threat of anthropogenic climate change is global, the action proposed here would only attempt to address that threat on nine acres of land. The results of the research might be applicable elsewhere if any meadows are found with similar conditions.

Risk of spreading impacts: The impacts of climate change are already universal. Some specific impacts to wilderness ecosystems are expected to spread upward in elevation and south to north as temperatures warm, although predicting such effects in particular locations is difficult.

Recovery time: Because we don't know if the soil/plant discrepancy is natural or human caused, it isn't clear whether there is anything to recover from. No "peak" has been identified for the general trend in warming temperatures on a global scale, so any "recovery" that depends on lower temperatures or conditions more like the past cannot be anticipated..

Irreversibility: The MRA states that as conditions get drier, it will be harder to cause the proposed change in plant communities through manipulation. But in this case "reversibility" may not be the goal since we are deliberately creating a particular condition rather than attempting to return an area to within the natural range of variability.

Anthropogeneity: Past, present, and future threats to the natural quality of wilderness character are described above. While some of those threats are clearly anthropogenic and the cause and effect are fairly well understood, the particular current "threat" at issue here is not- in fact, no threat has been established as it is unclear whether the soil/plant discrepancy is natural or anthropogenic, or what the natural range of variability is for plant communities in Tuolumne. The future threat from warming global temperatures is clearly anthropogenic. Short term predictions about hydrology and plant communities, based on recent observed trends and research, have at least a small degree of certainty, but longer term predictions are much more conjectural and are not discussed at all in the MRA.

Manipulation Criteria

Intensity: This proposed action has a moderate to high level of intensity: it involves planting 180,000 new plants in trying to change the plant community in these nine acres of wilderness and interferes with natural herbivory and animal movement.

Risk: The risks of unintended ecological consequences outside of the study area are relatively small as the cultivated plants are native species. There may be risk to the small mammal population as its food supply will be reduced and population density increased through translocation, particularly in years two and three.

Probability of Success: The MRA defines success as increasing "soil carbon sequestration and soil moisture" presumably as a proxy for the conversion to a wetter, more "resilient" sedge community. Because this is a new, experimental treatment for a newly discovered set of conditions, we know little about the probability of success. In this case, success is directly tied to sustainability.

Sustainability: The draft MRA states repeatedly that the proposed actions will be sustained- that once the fences come down the newly created plant community will remain and thrive. There is no evidence for this, however- the previous experiment did no monitoring post-fence. As noted above, the revised MRA allows for a short period of monitoring after all the manipulation is completed rather than waiting to see if the action is sustainable before proceeding. In the short term, the action may fail if the herbivores respond to the increase in food supply with increased herbivory.

Long term sustainability is also a concern. With global climate change we can only address symptoms rather than root causes. There is little value in addressing the symptoms, however, if that means repeated "gardening" actions for an indefinite time period. The MRA states that predicted climate trends "may promote and sustain vegetation compositional change to drier types." Presumably "enhancing resistance and resiliency" in this case means creating sedge dominated plant community which will be wetter than the current community. There is no discussion or evidence presented at all, though, about how long the sedge community may persist in the face of ever drier conditions. Since there is no apparent end or "peak" to current climate trends (not to mention substantial uncertainty in those trends or their effects) it is reasonable to assume that if those trends continue the community will again change or will again have to be manipulated using more intensive methods.

Magnitude: This action will occur on 9 acres of the Yosemite Wilderness, but will involve all known meadow areas with the presumed soil/plant discrepancy.

Cumulative effects: There is a large amount of manipulation already occurring in the Yosemite Wilderness including wildfire suppression and management, prescribed burning, invasive plant removal, campsite and trail restoration, bear conditioning, invasive fish removal, Sierra Nevada Yellow Legged Frog treatment and translocation, Bighorn Sheep translocation, and Fisher translocation.

Sierra wide there are other meadow restoration projects both in and out of wilderness, although they are typically more traditional efforts aimed at reversing grazing caused hydrologic impacts through well tested treatments. No other areas have been identified with this soil/plant discrepancy; once it is manipulated there will be no chance to study an unmanipulated meadow with the same condition unless similar areas are discovered.

Impacts to other qualities of wilderness character: Other than the major impacts to the untrammeled quality, the significant impacts from this proposal are to opportunities for primitive recreation and the undeveloped quality due to structures and installations. With the possible exception of the replacement of the Wilma Lake cabin and the construction of the LYV composting toilet (both permanent), this project will be the greatest impact to the undeveloped quality of wilderness character due to structures and installations since wilderness designation 32 years ago: if all three years are carried out, there would be at least a mile and a half of low fencing with metal flashing, held in place with 800 pieces of rebar and 2600 staples with numerous scientific instruments including 14 PVC wells, 4 "plant cams", 3 soil instruments with solar panels and antennas, 100 sediment discs, as well as numerous (20 the first year; 60 by the third year) small mammal traps. For the first year, there would be a half mile of fencing, and the instrumentation is the same for all years of the project- and possibly longer if funding can be found for further monitoring.

These same installations will cause major impacts to opportunities for primitive recreation. While expectations for primitive experience are lower due proximity to non-wilderness, these installations will be very visible and located in an area visited by thousands of hikers every summer. In addition, some installations (such as the solar panels and antennas) may be visible from non-wilderness- the closest plot is approximately 300 meters from the Pothole Dome pullout, which is considered to be the highest value viewpoint in the Tuolumne Meadows area according to the Scenic Vista Management Plan.[5] As noted above, the project area is immediately adjacent to the popular Pothole Dome trail and will be very obvious to hikers on that trail.

Opportunities for solitude will also be somewhat affected by staff carrying out this project, both during fence construction and during ongoing trapping and monitoring.

Cumulative effects: Research on hydrologic and ecological aspects of the wilderness section of Tuolumne has been conducted for ten years, including scientific installations. Here is the history of allowed exceptions to Section 4 (c) for this area:

<u>2006</u>: Wells permitted; to be removed by RMS Fall 2011

<u>2008</u>: More wells and instruments permitted; to be removed by RMS Fall 2011

<u>Fall 2011</u>: Installations not removed. New MRA; all wells stay in place, plus new instruments, plus 136 pieces rebar, plus 24 exclosures; all installations to be removed by RMS or researcher fall 2013

<u>Fall 2013</u>: Installations not removed.

[5] Tuolumne Wild and Scenic River Final Comprehensive Management Plan, appendix I

Spring 2014: MRA addendum prepared. Allowed installations until fall 2015; RMS to remove all installations by fall 2015.

Fall 2015: Installations not removed.

There are numerous scientific installations throughout the Yosemite Wilderness, including many wells/piezometers in meadows. The NPS Inventory and Monitoring program, for instance, is in the process of installing 45 permanent wells (as well as 180 rebar markers) in meadows across the wilderness; 37 wells installed in 2007 for this program are scheduled for removal but have not yet been removed. Numerous other wells for research and monitoring are located in other wilderness meadows.

Policy

The relationship between the protection of untrammeled and natural values in designated wilderness has generated a large amount of discussion in the last several decades.[6] Many scholars feel that the section 2 untrammeled mandate is the heart of the Act, the essence of wilderness character, and therefore any proposed projects that have a major impact to that quality should be carefully and thoroughly justified.[7]

The most specific problem listed in step one is "an annual net loss of soil carbon" and the effects of such loss: "the ability of meadows to provide water filtration, flood retention, and diverse wildlife habitat." The problem statement also mentions the soil/plant discrepancy and the unlikelihood of a natural return to a hypothesized former plant community. The validity of all these observations, however, has been discounted by the Peer Review.

In at least one place in the MRA it is suggested that increasing carbon sequestration by manipulating wilderness plant communities is a worthy goal in itself. Manipulating wilderness ecosystems to sequester carbon does not in any way fulfill the purpose of the Wilderness Act and the courts have been very clear that section 4 (c) prohibitions are only justified if they are the minimum to preserve wilderness character.

The only identified problem not discounted by the Peer Review is a hypothesized future problem: that warmer temperature, a longer growing season, and earlier timing of snowmelt may promote and sustain vegetation compositional change to drier types. Recent trends in temperatures and snowpack supports the supposition that this direction may continue.

NPS Management Policies allows for the possibility for intervention in wilderness ecosystems in some circumstances: "Management intervention should only be undertaken to the extent necessary to correct past mistakes, the impacts of human use, and influences originating outside of wilderness

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6 See Cole, David N., and Yung, Laurie, Beyond Naturalness, Rethinking Park and Wilderness Stewardship in an era of Rapid change, Island Press, 2010.

7 Scott, Douglas, "Untrammeled," "Wilderness Character," and the Challenges of Wilderness Preservation, Wild Earth, Fall/Winter 2001-2002 pp. 72 and 75 See also McGlothlin, Robert A., "A Case for Untrammeledness as the Foundational Goal of Wilderness Management" (2016).Theses, Dissertations, Professional Papers. Paper 10707

boundaries."[8] Climate change, in some sense, might be said to originate outside of wilderness boundaries. Management Policies does not mention intervening in *anticipation* of such impacts, however- only addressing current conditions.

Two more forward looking guidance documents have been recently issued for the National Parks: The Revisiting Leopold Report and the related Policy Memorandum 16-1, Resource Stewardship for the 21st Century – Interim Policy. These documents consider the effects of climate change and other pervasive anthropogenic impacts to park ecosystems while offering guidance on stewardship. Revisiting Leopold, for instance mentions managing for resilience a half-dozen times- but the only management strategy suggested for doing so-and coupled with that discussion every time but one- is to manage at a larger geographic scale- allowing for connectivity and spatially integrated management. The type of action contemplated in this proposal- deliberately changing an existing ecosystem component that may be within the range of natural variability to one that may better resist changes in the future- is never mentioned in either document.

Both documents recommend managing for ecological integrity. The National Park Service Ecological Integrity Framework stresses attempting to manage for the range of natural variation, even in the face of the uncertainty of global climate change:

> Given these challenges, some argue that the concept of "natural range of variation" has no practical utility for the management of biological resources. However, these critics tend to overlook the central importance of this concept to managing natural systems, and the ways it can be appropriately applied. First, it is the *knowledge* of natural variation that informs our goals and evaluations of current conditions, but this knowledge does not *a priori* constrain how we state desired conditions (see next section). Second, if resource managers do not apply this knowledge, they by necessity assume the task of *engineering* or *micro-managing* all aspects of ecosystem composition, structure, and dynamic process. There are few instances (beyond intensive agriculture and urban ecosystems) where anyone is adequately equipped to take on this role.[9]

The current proposal doesn't consider the range of natural range of variation at all, but rather attempts to engineer aspects of ecosystem composition in the wilderness portion of Tuolumne Meadows.

The Interim Policy directs us to base stewardship decisions on best available sound science, accurate fidelity to the law, and long-term public interest. While the policy applies to all NPS lands, *accurate fidelity to the law* means that those lands designated by Congress as wilderness will have a fundamentally different stewardship approach, because that is what the Wilderness Act mandates. *Revisiting Leopold* states that such fidelity to the law means that "NPS decisionmaking process must adhere with precision to law, (and) be mindful of legislative intent."

[8] NPS Management Polices 6.3.7

[9] National Park Service Ecological Integrity Framework, 2009, pg 33.

The difference between stewardship of designated wilderness and other NPS lands have been discussed in several NPS guidance documents. One paper stated that

> Management decisions and actions that affect wilderness must be considered in light of wilderness values of solitude, unrestricted natural forces and the all-too-human tendency to "trammel" all things natural.[10]

More recent guidance specifically covers natural resource management. For NPS backcountry,

> …management goals can be viewed as primarily "anthropocentric" in that we actively manage that which we believe we can control or steer seeking an optimum balance of conservation and use in a park-like natural setting.

Whereas for NPS wilderness, the paper states that

> The Wilderness Act is decidedly more "biocentric" in context…, defining wilderness to be a place set aside "… in contrast with those areas where man and his own works dominate the landscape…recognized as an area where the earth and its community of life are untrammeled by man…." (Section 2(C)). The concept of "wildness" emphasizes self-organization of natural systems on "self-willed" lands and implies significant restraint in respect for "wildness" when considering modifying actions.

It concludes by saying

> Wilderness can only endure if it is a place of purposeful restraint for managers as well as visitors (Pinchot Report 2001). Restraint arises from the humility born of realizing the awesome responsibilities of caretaking forever these remnants of wild America. That humility demands that we for once reject our most basic tendency to modify and manipulate the world around us.[11]

One of the difficulties of stewardship in the age of global climate change is the uncertainty of both climate trends in a particular location and the reaction of the ecosystems in that location to the changing climate. As the discussion under "sustainability", above, describes, this proposal does not look forward to the point when the created sedge community, if successfully established, would itself change to a drier type, losing any "resilience" benefit obtained while still incurring major impacts to wilderness character. Both the NPS Organic Act and the Wilderness Act direct us to manage for future generations. This perspective is reflected in *Revisiting Leopold*: "The key is "long-term," which is a necessary consequence of the NPS mission and reflects—at minimum—concern for multiple future generations in time."

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[10] Jarvis, Jon, The Wilderness Act and the NPS Organic Act, a White Paper Discussion. March 1994

[11] National Park Service, National Wilderness Steering Committee, Guidance Paper No. 4, Embracing the Distinction between Wilderness and Backcountry in the National Park System", 2005

Conclusion

Any alternative which proposes deliberately altering existing wilderness ecosystems despite little to no knowledge of whether they are within the natural range of variation cannot be the minimum requirement to preserve wilderness character. This is true whether the action is proposed in the context of restoration, or building resiliency. We have already allowed a small scale experiment that included such manipulation. As outlined above under "manipulation criteria," the "proposed action" and "former proposed action" alternatives are simply not justified considering the significant unknowns, the scale of the proposed manipulations, and the major impacts to the untrammeled, undeveloped, and primitive qualities of wilderness character.

Instead, the first year of Alternative B, the research component, is considered the minimum requirement for the preservation of wilderness character. This research will increase our understanding of this ecosystem and correct some of the deficiencies of the recent work identified by the Peer Review. Further research about the natural range of variation for Yosemite meadow ecosystems, the past, current, and future impacts to those ecosystems, and possible management responses to such impacts may be appropriate in wilderness, but the action alternatives as presented here are not justified in designated wilderness.

Limits on structures and installations:

At the end of year 1 all fencing would be removed and no more manipulative actions will occur. Observational research and/or monitoring may occur in years 2-5, dependent on the research questions raised by the results of year 1, and subject to further minimum requirement analyses. Only those scientific instruments that are determined to be the minimum will remain for such research. All other instruments associated with this research will be removed by October 15, 2017.

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Tuolumne Meadows Native Plant Restoration and Carbon Sequestration Investigation

Check one:

✓ The proposed action is a temporary, one time activity.
☐ The proposed action will be an on-going, long term activity.

Submitted By:

Sue Beatty 03/18/2016
Date

Reviewed By:

6/30/16
Division Chief - RMS Date
(Attach any comments and conditions)

for 6/30/16
Wilderness Manager Date
(Attach any comments and conditions)

6/30/16
Chief Ranger Date
(Attach any comments and conditions)

Approved By:

6/30/16
Superintendent Date
(Attach any comments and conditions)

Attachments

Figure 1. Overview map of proposed study area (polygons delineated by red lines) and reference meadow plots (depicted as red dots).

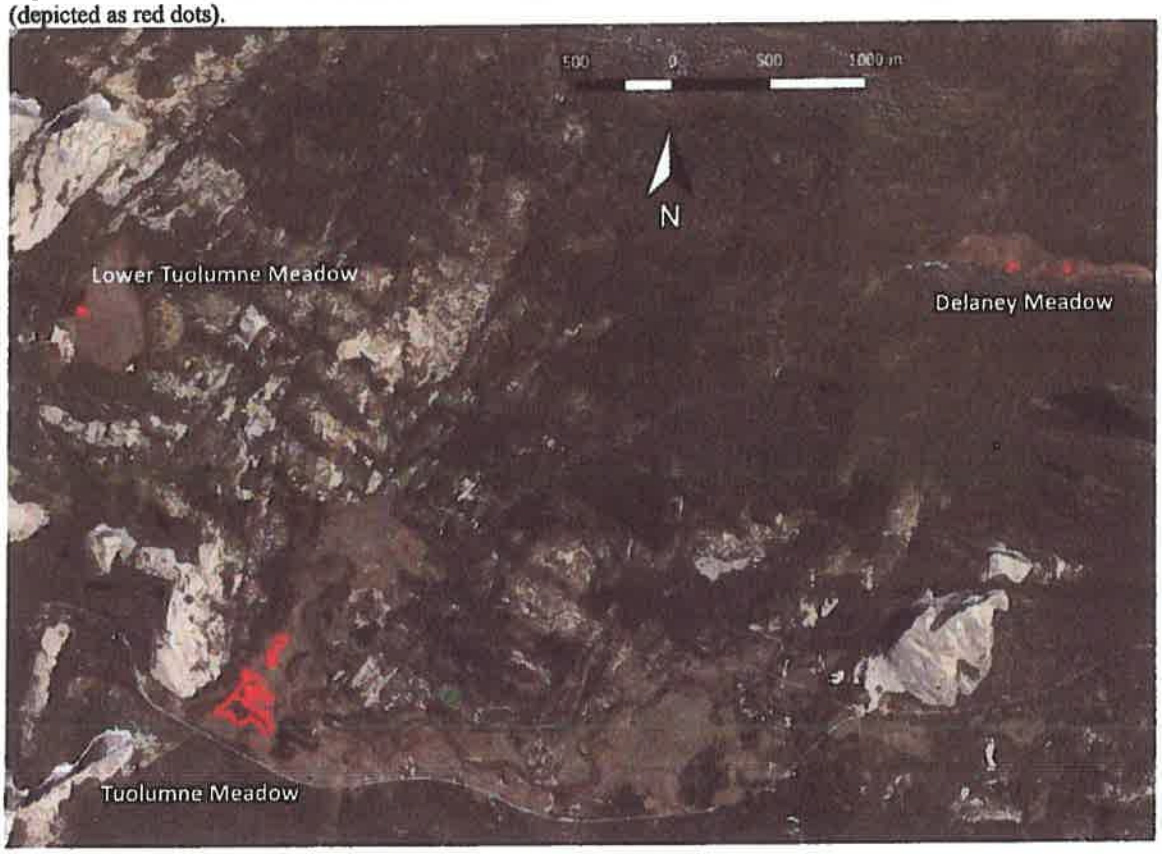

Figure 2. Map of proposed action study area within the 9 acre wetland complex (polygons delineated by red lines) in the western portion of Tuolumne Meadows. Green dots depict approximate locations of 20 randomly selected 20 by 20 m plots: 5 would be assigned as control plots (i.e., including neither planting nor fencing), 5 would be fenced and not planted, 5 would have unfenced plantings, and 5 would have fenced plantings. Blue dots depict existing groundwater wells. In total, roughly 1 acre would be fenced, but 0.7 acres would be treated through plantings.

Figure 3. Map of proposed action reference meadows with control plots and proposed groundwater well locations (red dots). These plots would be used to compare the effectiveness of the four study treatments and control plots applied within the nine acre wetland, in the western portion of Tuolumne Meadows. Proposed well locations are within 5 m of the plots, to correlate the well water levels with gas flux measurements.