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2010 Assessment of Meadows in the Merced River Corridor, Yosemite National Park

Resources Management and Science

April 2011 (Revised 2012)

Cook's Meadow in Yosemite Valley

Alpine meadow in the Triple Peak Fork

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Abstract

This study assesses the current condition of meadow and riparian complexes in the Merced River corridor in Yosemite National Park. Aiming to inform planning and management decisions related to the Comprehensive Management Plan for the Merced Wild and Scenic River, the study area encompasses a ¼-mile band along each side of the river. The study objectives included characterizing meadows in terms of vegetation, bare ground, wetland extent, stream characteristics, small mammal burrowing, impacts from recreational use, and vulnerability to future impacts. We surveyed nearly all meadows in the corridor, tailoring individual protocols to three groups: Yosemite Valley meadows (4,000 feet elevation), subalpine meadows (7,000 to 9,600 feet elevation), and alpine meadows (above 9,600 feet). In Yosemite Valley meadows, we sampled 5x5m plots on a grid across each meadow and collected additional information on two issues of concern, non-native plants and informal trails. In subalpine meadows, we used the same plot sampling method and collected additional information on pack stock impacts, a specific concern for these meadows. We also employed a peer-reviewed interagency stream monitoring protocol (Burton et al. 2011) to assess perennial stream conditions in subalpine meadows. For alpine meadows, we used a rapid assessment protocol to gather coarse quantitative data on meadow and stream characteristics. In alpine meadows we also adapted a rating system from neighboring wilderness areas (USDA 2003) to quantify indicators of meadow health, recreation impacts, and vulnerability to impact.

Vegetation plot data documented a diversity of species in the six Yosemite Valley meadows surveyed. The most common native species were *Carex senta* (rough sedge), *Carex lanuginosa* (wooly sedge), and *Leymus triticoides* (beardless wildrye). Non-native species were present in 81% of Valley meadow plots, with the greatest extent and density in drier meadows (El Capitan and Stoneman). *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) was a ubiquitous non-native in Valley meadows, and 38 other non-native species were present in lower abundance. Non-native cover was lowest in meadows with the greatest extent of saturated and inundated soils, suggesting that non-native species currently established in Yosemite Valley may not compete well with native species in wet soils. Informal trails were present in all Valley meadows, but were most extensive in El Capitan, Sentinel, and Bridalveil. Meadows with boardwalks (Cook's and Stoneman) had the lowest extent of informal trails.

Most of the 14 subalpine meadows surveyed were wetlands dominated by the hydric sedges *Carex vesicaria* or *C. utriculata* (bladder sedge). One Red Peak Fork meadow and all Triple Peak Fork meadows were exceptions, as they were drier, contained more subshrubs, and had higher extent of conifer encroachment and small mammal burrow disturbances compared with other subalpine meadows. Non-native species were absent from meadows above Washburn Lake (7,600 feet elevation) but were present in low abundance at lower elevation sites (Little Yosemite Valley, Echo Lake and Merced Lake-East). Of the subalpine sites, Little Yosemite Valley had the greatest abundance and diversity of non-native species. *Poa pratensis* ssp. *pratensis* was the only non-native

found within Little Yosemite Valley meadows, but other non-native species were found in proximity to the meadows.

Merced Lake-Shore had the highest extent of informal trails among subalpine meadows, where 1.6 km of trail segments connected the lakeshore with the High Sierra Camp and nearby formal trail. Bare ground areas from visitor recreation were also present at the edges of Merced Lake-Shore meadow. Overall, pack stock impacts on subalpine meadows were low with the exception of Merced Lake-East meadow. This meadow had extensive trampled and grazed areas. Manure, roll pits and informal trails were found in the meadow and surrounding forest. Merced Lake- East also exhibited lower vegetation cover and higher bare ground compared with other subalpine meadows, suggesting ecological impacts from stock use. No residual effects from stock use were apparent in nearby Merced Lake meadows that were grazed until the National Park Service closed them in the early 1990s.

Stream survey assessments using condition indicators generated with analyses from Burton et al. (2011) generally indicated good ecological condition for channel and bank characteristics in subalpine meadows. One exception may be Doc Moyle's- West meadow, where stream channel morphology suggested the area was recovering from past stock impacts that may have occurred during high levels of use in the mid 20th century. The stream channel at Doc-Moyle's appeared relatively wider than comparable sites. This widening may be linked to trampling impacts, which can lead to channel widening over time (Powell et al. 2000). Currently, water-loving sedges are developing on a bench within the stream channel below the scour line. The sedges appear to be narrowing the channel, possibly indicating channel recovery. Long-term monitoring could substantiate the trend at Doc Moyle's- West meadow.

Alpine meadows were steeper, rockier, and had thinner soils than lower elevation meadows. More subshrubs were present in alpine meadows, and vegetation overall appeared sparser and shorter. Most alpine meadows were free from visitor or pack stock impacts with the exception of meadows containing formal trails. In particular, a braided and rutted trail segment in meadow T10 may be altering local hydrologic processes. Rating criteria indicated that meadows with trails were also more vulnerable to impact. The lower productivity and recovery rates of alpine meadows are other considerations for alpine meadow vulnerability.

Introduction

The Merced Wild and Scenic River

This report contains an assessment of meadow and meadow stream conditions in the main Merced River corridor. A broad-based team including park leadership, tribal groups and interested members of the public identified meadow and riparian complexes as part of the “outstandingly remarkable biological values” of the Merced Wild and Scenic River. Understanding the condition of meadows and riparian areas is a critical first step to protect and enhance these river-dependent resources. The goals of this study are to:

> ***Yosemite Valley*** *- The large, moist meadows and associated riparian communities comprise one of the largest mid-elevation meadow complexes in the Sierra Nevada, supporting an exceptional diversity of plant and animal species.*
>
> Excerpt from Draft Outstandingly Remarkable Values Report for the Merced Wild and Scenic Comprehensive Management Plan, April 2011

1) Characterize current meadow and associated stream conditions with metrics that include vegetation, substrate, stream condition and other hydrologic characteristics
2) Evaluate existing impacts on meadows from recreational and administrative use
3) Assess meadow and stream vulnerability to impacts from ongoing or future use

Meadow values

Sierra Nevada meadows are groundwater-dependent ecosystems characterized by herbaceous plants such as sedges and grasses (Ratliff 1982, Barbour et al. 1999). Meadows occupy less than 3% of the area in Yosemite National Park, but the ecological value of Sierra Nevada meadows far exceeds their occurrence (Ratliff 1985). Meadows slow runoff from steep uplands, which allows for longer periods of water availability downstream. While slowing runoff, meadows trap sediments that would otherwise pollute downstream watercourses. They also assist in the breakdown of toxins and cycling of nutrients trapped in sediments. In these ways, meadows in the Merced River corridor provide substantial contributions to the functioning and water quality of the river ecosystem.

Meadows are productive environments, often forming dense mats of living plants (Photo 1) whose decomposition each year results in rich organic soils. Meadows are also high in biodiversity and play critical roles in the life cycles of many wildlife species. In the Sierra Nevada, meadows provide habitat for threatened or endangered species such as the willow flycatcher and Yosemite toad (Knapp et al. 1998, Martin 2008). Meadows support a high diversity and abundance of insects and other invertebrates that serve important ecological functions (Batzer and Sharitz 2006, Van der Valk 2006). Often thought of as food for vertebrate species such as frogs and birds, insects themselves often serve as high-level predators. Holmquist (2004a, unpublished report) found high invertebrate diversity in Tuolumne Meadows and Yosemite Valley meadows, with at least four trophic levels in arthropod populations (2004b).

Meadows help support aquatic life in the Merced River channel. During dry summer months, meadows sequester nutrients and organic materials particularly in shallow ponds, pools, and abandoned oxbows. A dense stew of invertebrates, cysts, seeds, microscopic life, and other organic material accumulates through the summer and winter until regular high water events flush it into the Merced River (Figure 1). In this manner, backwater areas of the floodplain store an annual source of food and nutrients for life in the main river channel, and provide a summer source of food for meadow wildlife (Junk et al. 1989).

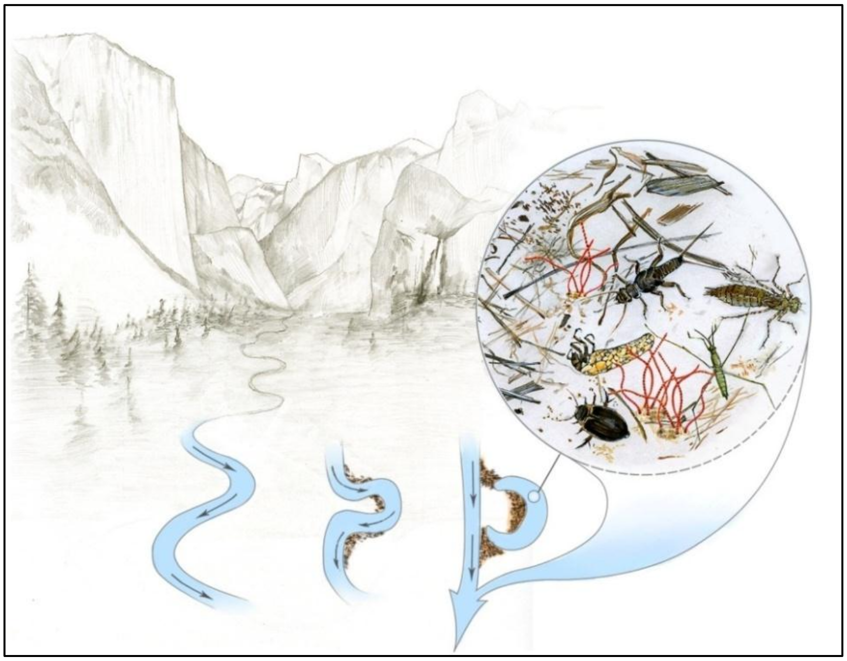


Figure 1. Organic matter and invertebrates concentrate in backwater meadow areas in dry summer months. Regular floods flush the organic material into the main river channel, providing a source of nutrients for life in the main river channel. (Illustration by Jane Kim).

Yosemite Valley meadows are unique in part because of their large size; they are among the largest meadows below 5,000 feet in the Sierra Nevada[1]. Complex meadow habitats in Yosemite Valley contain a wide array of microhabitats sustained by a variety of water sources coming from cliff walls and the Merced River. This diversity of meadow habitats supports a high number of native meadow plant species, a concept known as species richness. Botanists have collected about 30 different sedge species in Yosemite Valley meadows since the 1880s (Taylor 2010). Sedge experts consider meadows with as few as 15 sedge species to be exceptional in terms of species richness (Peter Zika, personal communication).

[1] In studies of the northern Sierra, the vast majority of meadows occur at higher elevations, between 6,500 and 8,500 feet, and most are less than 10 acres in size (EPA 2007 report on Sierra Meadows available at http://watershed.ucdavis.edu/pdf/SierraMeadows-2007.pdf, p 40)

Photo 1. Meadows foster high biomass production. NPS photo August 2010.

In addition to their ecological roles, meadows in the Sierra Nevada have high aesthetic and recreational value. Visitors are drawn to meadows for their scenic vistas and recreational opportunities. Pack stock are often used to transport visitors and their gear for wilderness recreation, and meadows provide most of the backcountry forage for these animals (Menke et al. 1996). In Yosemite, commercial outfitters from the Eastern Sierra operate pack trips in Yosemite Wilderness, and minimal private party stock use also occurs. Yosemite administrative operations rely on pack stock to meet many operational goals, including trail clearing, trail crew resupplies, backcountry utilities maintenance, support for search and rescue, and backcountry ranger patrols.

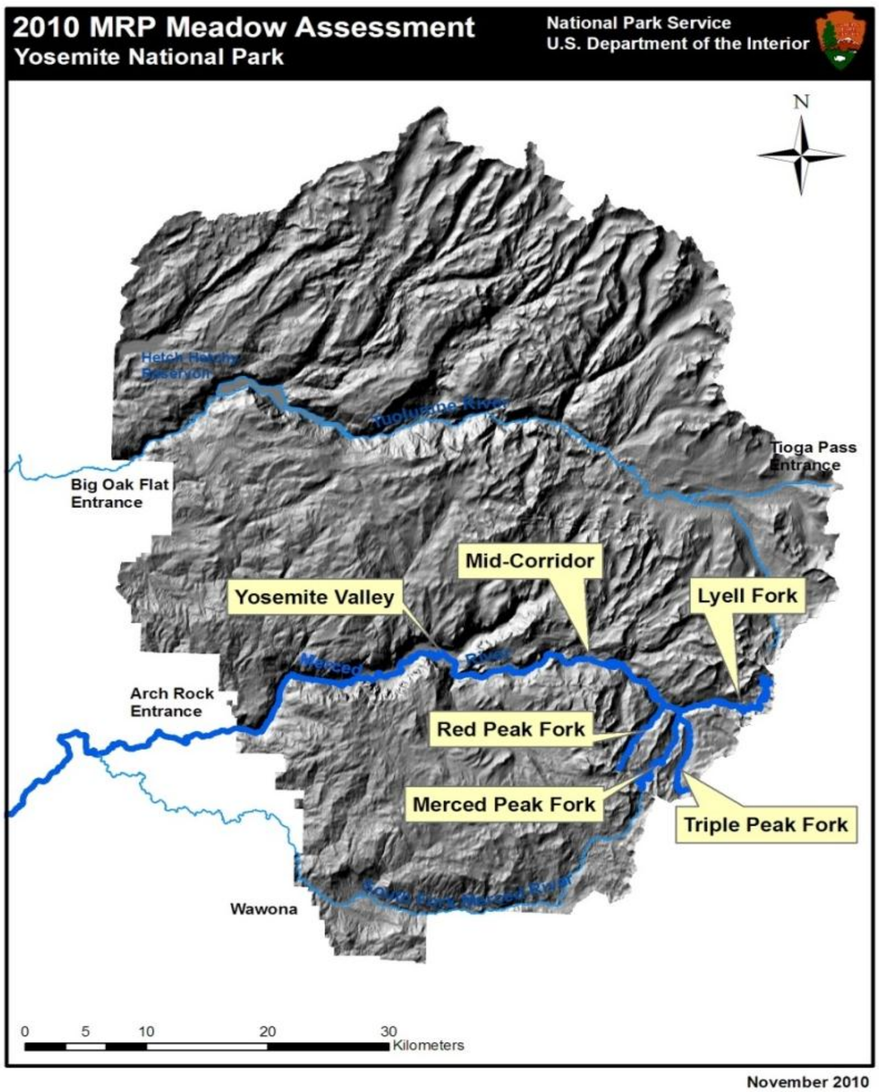
Issues

Meadows at different elevations in the Merced corridor have distinctive sets of issues. Water channelization, infrastructure, development, and historical land management practices, including the cessation of California Indian-ignited fires, strongly influence meadow size and condition in Yosemite Valley (Heady and Zinke 1978). At all elevations, recreational and administrative use can result in negative ecological impacts including:

- Stunted vegetation, increased bare ground, habitat fragmentation and impacts to invertebrate fauna from informal trails (Holmquist and Schmidt-Gengenbach 2008, unpublished report; Cole 2008, Newburger et al. 2011, unpublished report in prep.)
- Increased bare ground, soil compaction, erosion, shifts in plant species composition, decreased vegetative cover and productivity through overgrazing and trampling from stock use (Rauzi and Clayton 1966, Miller and Donart 1981, McClaran and Cole 1993, Trimble and Mendel 1995, Olson-Rutz t al. 1996, Cole et al. 2004)
- Sloughing and shearing of streambanks, changes in streambank vegetation cover, species composition and establishment due to trampling and heavy grazing (Kauffman et al. 1983)
- Changes to channel morphology including stream incision and/or channel widening, from heavy grazing and/or trampled streambanks (Platts 1981, Kaufman and Krueger 1984, Odion et al. 1988, Rosgen 1996, Belsky et al. 1999)

The 2010 Study

During the summer of 2010, a team of biologists and hydrologists from the Resources Management and Science division of Yosemite National Park assembled to collect data from as many meadow and riparian complexes in the Merced River corridor as possible. We selected a variety of attributes for study including vegetation, wetland extent, bare ground, non-native species invasion, conifer encroachment, and meadow stream condition. We also documented disturbances from small mammal burrows, informal trails, and pack stock use. The heart of this report is an analysis of new meadow data collected in the main Merced River corridor from Yosemite Valley to the headwaters of the Lyell Fork, Triple Peak Fork, Merced Peak Fork, and Red Peak Fork (Map 1). As it is important to view these data in their historic context, the following section contains a synthesis of historic data gathered from previous studies. The Background section also contains a summary of known meadow changes since 1987, when the Merced River was designated a component of the National Wild and Scenic River System.



Map 1. Study area in the Merced River corridor, Yosemite National Park.

Background

Yosemite Valley Meadows: Pre-historic and Historic conditions

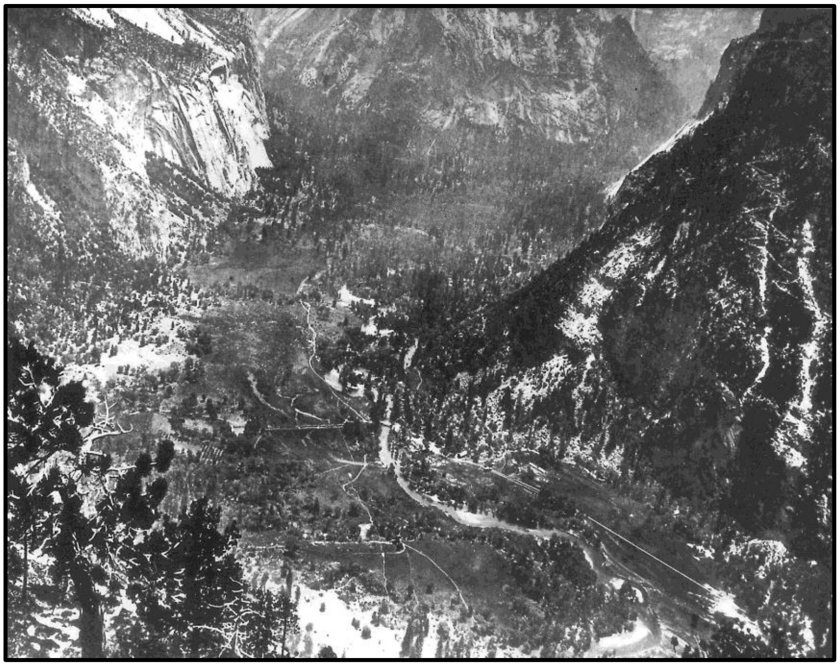


Photo 2. Yosemite Valley from Eagle Peak circa 1878 or 1879.

Archeological evidence suggests that California Indians occupied Yosemite Valley for over 7,000 years (Moratto 1999). Studies postulate that a cultural shift began approximately 650 to 750 yrs ago, leading to increased vegetation manipulation such as burning and clearing (Anderson and Carpenter 1991). California Indians conducted small, low-intensity surface fires to increase growth and yield of crops, aid in hunting and insect collection (Gassoway 2007), and perform other functions such as producing a high quantity of or materials required for basketry, cordage, and building (Anderson 2005). Systematic burning was likely a component in maintaining the open, park-like scenery described by early visitors and explorers (Greene 1987) (Photo 2).

Fire frequency increased after 1800, at least in the southwest part of Yosemite Valley[2] . Between 1800 and 1890, California Indians conducted burns at regular intervals in Yosemite Valley (Gassoway 2007; Taylor 2004, unpublished report). Smaller burns continued until the Yosemite Act of 1890 created Yosemite National Park and guardianship of the lands surrounding Yosemite Valley fell to the U.S. Calvary (Gassoway 2007; Taylor 2004, unpublished report).

In the mid 1800s, a rapid landscape-scale change began in the meadows of Yosemite Valley, resulting in a substantial reduction in meadow extent. Reflected as a “type conversion” from

[2] Fires can largely be attributed to anthropogenic sources in Yosemite Valley, as lightning-ignited fire is extremely rare. No lightning-ignited fires took place in Yosemite Valley between 1930 and 2003 (Gassoway 2007).

meadow to forest, most meadow loss occurred long before designation of the Merced River as a component of the Wild and Scenic River System.

> *My first visit to Yosemite was in the summer of 1855. At that time there was no undergrowth of young trees to obstruct clear open views in any part of the Valley from one side of the Merced River across to the base of the opposite wall. The area of clear open meadow ground, with abundance of luxuriant native grasses and flowering plants, was at least four times as large as at the present time.*
>
> Galen Clark
> Guardian of the Yosemite Grant (1884)

State Geologist J.D. Whitney mapped 745 acres (302 ha) of meadows in Yosemite Valley in 1866 (Hoffman 1866). The oldest trees seen today in the former meadows began to appear in 1870 (Gibbens and Heady 1964, Cooper and Wolf 2008). Seventy-one years later in 1937, National Park Service vegetation mapping projects mapped 327 meadow acres (132 ha) in Yosemite Valley. In 1960, Gibbens and Heady used aerial photographs to estimate 340 total meadow acres (138 ha) in Yosemite Valley, illustrating an estimated 54% reduction in size from the 1866 meadows[3]. In 2010, we estimated 269 meadow acres (109 ha) in Yosemite Valley[4] . This represents a 64% decrease in total meadow acreage in Yosemite Valley since 1866.

Scientists hypothesize that this rapid conversion from meadow to forest in Yosemite Valley stemmed from several origins including fire suppression, impacts to natural hydrologic flows, and agricultural practices that disturbed land and created conditions favorable for conifer germination (Cooper 2008, unpublished report). After Anglo-American contact in the mid 1800s, park managers steadily eliminated meadow burns that had been conducted in Yosemite Valley by California Indians for centuries (Gassoway 2007, Anderson 2005). Alterations to the natural stream system in Yosemite Valley are numerous and well documented (Milestone 1978). Historic photos and accounts capture glimpses into agricultural practices such as plowing, seeding and grazing in the early days of Yosemite as a National Park that may have promoted conifer encroachment. We may never know the relative contribution of fire suppression, hydrologic changes, and agricultural practices to the relatively rapid conversion from meadow to forest in Yosemite Valley, but these factors are all likely key influences in this change. See Appendix E for more detail regarding historic conditions in individual meadows.

Some anthropogenic impacts to stream systems in Yosemite Valley were purposeful. For example, in 1879 Galen Clark, Guardian of the Yosemite Grant, blasted the terminal moraine located just downstream of El Capitan meadow in an effort to drain upstream meadows (Milestone 1978). Some impacts were inadvertent, such as the effects of abandoned sewage lines that originate in meadows and leak in downstream forest areas. References such as “The Influence of Modern Man on the Stream System in Yosemite Valley” (Milestone 1978) and Monthly Superintendent’s reports document stream system alterations in detail. Most tributaries to the Merced River in Yosemite

[3] This study measured only large meadows.
[4] Estimation is based on the 1997 parkwide vegetation map in conjunction with NAIP digital ortho photo quads (2004). Includes small meadows.

> *The single most important factor in explaining the distribution of meadows is the existence of a shallow water table which provides for a high soil moisture content the year around.*
> Barbour and Major, 1977

Valley are channelized in part (Milestone 1978), altering the path of water that would naturally flow from cliff walls in a sheet or braided fashion across the meadows.

Stabilization channels, typically lined with riprap revetment, have the potential to produce drier meadow conditions. This is particularly detrimental, as soil moisture is one of the most important properties in determining the presence and character of meadows (Heady and Zinke 1978, Barbour and Major 1977, Allen-Diaz 1991). Milestone (1978) documented 14,518 linear feet of streambank riprap revetment in Yosemite Valley including 1,799 feet of riprap in Yosemite Creek, 1,744 feet of riprap in Lost Arrow Creek, and 560 feet of riprap in Tenaya Creek. Riprap, or other means of hardening stream or riverbanks, also limits natural sediment scour and deposition on riverbanks, prevents channel migration, and limits overbank flooding. Another hydrologic influence on meadow conditions is accelerated riverbank erosion that led to widening of the Merced River and contributes to a loss of overbank flooding and less saturated meadow soils (Cooper and Wolf 2008).

Through time, many park managers took action to control conifer encroachment in meadows. Galen Clark, initiated the first conifer thinning in Yosemite Valley in the early 1890s (Clark 1894). Clearing continued in the campgrounds and in El Capitan Meadow in 1919 (Greene 1987). Emil Ernst, Yosemite Park Ranger/Forester in the 1930-1950s, conducted thorough meadow studies and documented the history of forest encroachment and other impacts on meadows in Yosemite Valley. He championed and conducted large efforts to control conifer encroachment[5].

Yosemite Valley Meadows: Conditions at the Time of Designation

Meadow conditions at the time of designation (1987) were likely similar to current conditions (as described in detail in this report and Appendix E) with some notable exceptions.

All Meadows

- Continuing a practice initiated in 1970, the National Park Service systematically reintroduced fire into Yosemite Valley meadows on a rotating basis.
- Park staff and volunteers removed tens of thousands of conifer seedlings and saplings from Yosemite Valley meadows between time of designation and today (M. Acree, personal communication).
- Park staff and volunteers mapped and treated the high priority non-native species in Yosemite Valley (Martin Hutten, personal communication). Focusing on *Rubus*

[5] Ernst's 1944 map (Yosemite Museum) designates approved areas for conifer control in Bridalveil Meadow, El Capitan Meadow, and Stoneman Meadow (Ernst 1943). Approval for conifer control came directly from the Director of the National Park Service to the Regional Director in a 1944 memo. Ernst also designated areas for study before conifer eradication (parts of Leidig Meadow, Sentinel Meadow, Cook's Meadow, the area around Residence 1, and in the schoolyard vicinity. Other areas slated for conifer removal, upon submission of a plan, included the bank of the Merced River north of Valley View, the old El Capitan picnic area, the Yosemite Falls view corridor, the Lamon's orchard meadow, the Ahwahnee Meadow, and the edge of Royal Arch meadow (Director's Memo 09/16/1944).

armeniacus (Himalayan blackberry), *Cirsium vulgare* (bull thistle), *Hypericum perforatum* (St. John's wort), and *Holcus lanatus* (velvet grass), crews mapped populations in 2009 and have treated 35 of 42 hectares of *R. armeniacus*, 4.9 of 5.3 ha of *C. vulgare*, and 0 of 2 ha of *H. perforatum* to date. Crews mapped 32 ha of *H. lanatus* and conducted limited experimental treatments on this species.

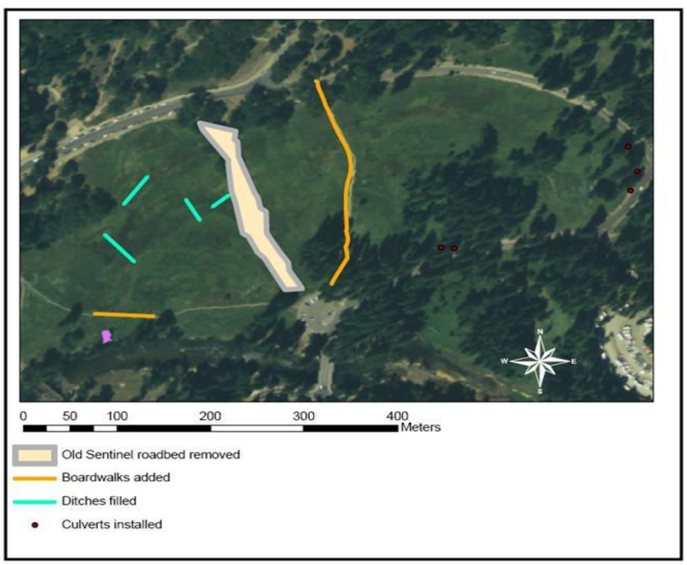
Ahwahnee Meadow

- In 1988, the National Park Service installed a high voltage line in the path of a historic road feature on the east side of the meadow.
- In 2010, the National Park Service removed the utility line.

Bridalveil Meadow

- The natural spring on the south edge of the meadow (Moss Spring) disappeared since production of the 1970 USGS topographic map of Yosemite Valley (original aerial photo 1955, limited revisions in 1970). Cause is unknown.
- A deep gully along the west edge of the meadow, more than ten feet deep in places, developed when a culvert was placed under South Side Drive in the late 1920s. In 2007, National Park Service crews partially filled in the gully north of the road and raised the culvert, as part of the Valley Loop Road Rehabilitation project. The section of the gully closest to the river and south of the road remains incised.)

Cooks Meadow



Map 2. Site of restoration actions in Cook's meadow

- Cook's Meadow was the site of a comprehensive restoration project to restore natural topography, native plant diversity and composition, and hydrologic regime (Map 2). In 1998, National Park Service filled artificial drainage ditches and outlets, removed abandoned roadbed fill material, replaced paved trails with elevated boardwalks, installed additional culverts under roads, and removed exotic species (Niederer 2007, unpublished report).

- National Park Service Crews removed approximately 5,000 cu. yards of fill from a historic, abandoned roadbed. Crews used the fill to restore four agricultural ditches and one artificial drainage outlet to natural conditions. Many of these features had historic value, and they were removed if consistent with the National Historic Preservation Act.
- The National Park Service installed two culverts under Sentinel Crossover Road to capture surface water run-off that was bypassing the meadow.
- The National Park Service constructed two boardwalks over the wettest parts of the meadow, replacing causeways and removing approximately 500 cu. yards of fill.
- In 2010, the National Park Service removed an underground utility lines.

Royal Arch Meadow

- The National Park Service burned Royal Arch meadow in 2006 in cooperation with California Indian groups associated with Yosemite. The primary purpose was to control non-native species. This burn was particularly important as it was ignited and conducted using Native American techniques. Despite major reduction in Himalayan blackberry cover immediately after the burn, control was short term. Crews mowed blackberry with brush-cutters in 2008. In 2009, volunteers treated the infestation with hand tools. Himalayan blackberry again dominated large portions of the meadow by 2010 and was treated with herbicide. Several other invasive plant species including *Cirsium vulgare* (bull thistle), *Hypericum perforatum* (St. John's wort), and *Holcus lanatus* (velvet grass) remain in the meadow.

Sentinel Meadow

Photo 3. Previous location of Pavilion Square in Sentinel Meadow. National Park Service crews restored this area to natural conditions in 1994.

- In 1990, National Park Service crews constructed two boardwalks and fencing along the strip parking area, reducing a network of 29 informal trails measuring 1.9km in combined length. Crews rehabilitated informal trails to natural conditions.

- Pavilion Square, a movie house and dance hall, was constructed in Sentinel Meadow in 1901. Two floods damaged the structure and it was subsequently repaired, until it was partially destroyed by fire and razed in 1963 (Johnston 1995). The imported fill used for a foundation remained in place, visible from the top of Yosemite Falls (Photo 3), until the area was restored to natural conditions in 1994.
- The Sentinel Bridge parking lot expanded slightly into the meadow when Sentinel Bridge was rebuilt.

Stoneman Meadow

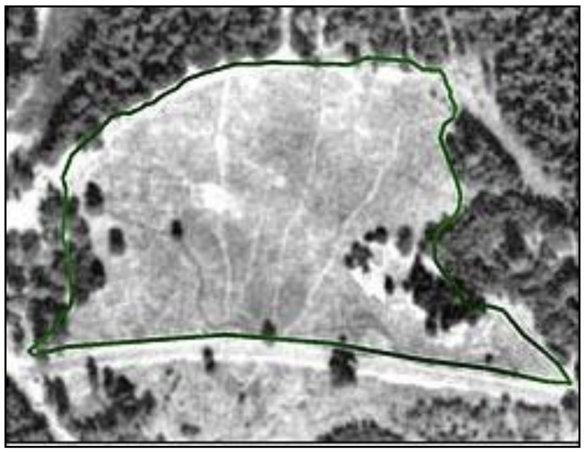


Photo 4. Stoneman Meadow in 1944, with network of social trails and trampled vegetation. These trails across the meadow were reduced to one main boardwalk in 1987.

- In 1987, National Park Service and Youth Conservation Corps crews constructed a boardwalk across the meadow, reducing a network of 25 social trails (measuring 2.4 km in combined length) to one boardwalk and one dirt path around the outskirts of the meadow (Photo 4). They restored the informal trails to natural conditions.
- The National Park Service closed an east-to-west trail in the southern half of the meadow; the subgrade remains in place.
- Gardeners began planting *Bromus inermis* (smooth brome), a highly invasive nonnative grass, as part of the Curry Village landscaping approximately 15 years ago. The species has spread dramatically throughout the meadow.

Subalpine Meadows: Conditions at the Time of Designation

In general, the drier, upland edges of subalpine meadows in the Sierra Nevada became more forested in the last century. A comprehensive study by Millar et al. (2004) determined that subalpine meadows in the Sierra Nevada became more forested during a "single distinct climatic pulse" that occurred from 1946 to 1975. The sub-alpine meadow sites used in the study are not specifically along the Merced River drainage, however, a strong correlation may be inferred since the parameters of the research include long-term climatic effects that most likely influenced the entire region. The study demonstrated that meadow invasion occurred between 1946 and 1975 during a unique climatic condition that included warm dry years with little annual variability. These conditions foster pine seed germination and deep root growth beyond the root zone of forb and grass competition. Conifer invasion in meadows has also been linked to historic sheep grazing (Sharsmith 1959, Dunwiddie 1977) and fire suppression (DeBenedetti and Parsons 1979). Extensive sheep grazing, before it was eliminated in the park, may have decreased rhizomatous herbaceous vegetation, creating conducive conditions for lodgepole pine establishment (Cooper et al. 2006). Therefore, pack stock grazing and fire suppression that occurred between 1946 and 1975 may have contributed to the forest invasion by adding more stress to grazed meadow plants. It is difficult to ascertain the extent, timing or causes of this forest spread in the subalpine Merced River corridor a lack of studies for these more remote areas of the park, and a lack historic record or consistent documentation of conifer removal activities in the past 150 years.

Conditions at the time of designation were likely similar to conditions of today, with a notable exception. The meadows at Merced Lake- West and Merced Lake- Shore were open to concessioner stock grazing at the time of designation. Trampling and grazing impacts were widespread and severe (Sharsmith 1961). In the early 1990s, the National Park Service closed these meadows to grazing and the vegetation appears to have recovered. The 1987 conditions at the Merced Lake- West and Merced Lake- Shore meadows were likely similar to the current condition of Merced Lake- East meadow, which currently serves as a pasture for National Park Service stock.

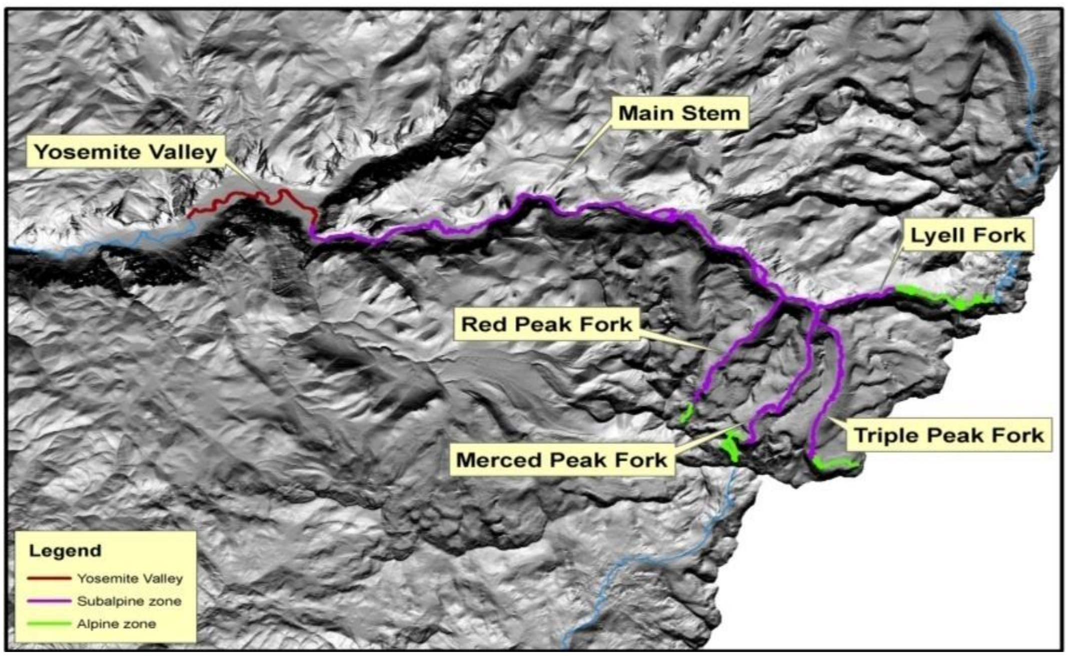
Alpine Meadows: Conditions at the Time of Designation

There is scant scientific documentation of the condition of alpine meadows in the river corridor during the first half of the 20th Century. There is some evidence that large backcountry outings took a high toll on mountain meadows. In the early 1960s, Carl Sharsmith and George Brigs completed studies on backcountry areas in the Park, yet these studies did not specifically include alpine meadows in the Merced River drainage. Conditions at the time of designation (1987) in alpine meadows were likely similar to conditions of today, with the exception of increased conifer encroachment.

Methods

Overview

The Wild and Scenic River corridor of the Merced River extends ¼ mile of either side of the Merced River from its headwaters in the South Fork, Lyell Fork, Triple Peak Fork, Merced Peak Fork, and Red Peak Fork, to the park boundary in El Portal. We did not include the South Fork of the Merced River in this study. We selected all meadows in the main Merced corridor and divided them into three groups based on elevation, differences in types or patterns of use, and resource concerns: (1) Yosemite Valley meadows (4,000 feet elevation), (2) subalpine meadows (approximately 7,000 to 9,600 ft in elevation), and (3) alpine meadows (above 9,600 ft in elevation). The subalpine group contained some sites that would be better classified as "upper montane" (Little Yosemite Valley, Echo Valley and possibly Merced Lake). We did not separate these sites from the subalpine group since they shared the same sampling strategy and resource concerns as subalpine meadows. Map 3 illustrates the extent of study area comprised of these three groups.



Map 3. Extent of each ecological zone in the Merced River corridor.

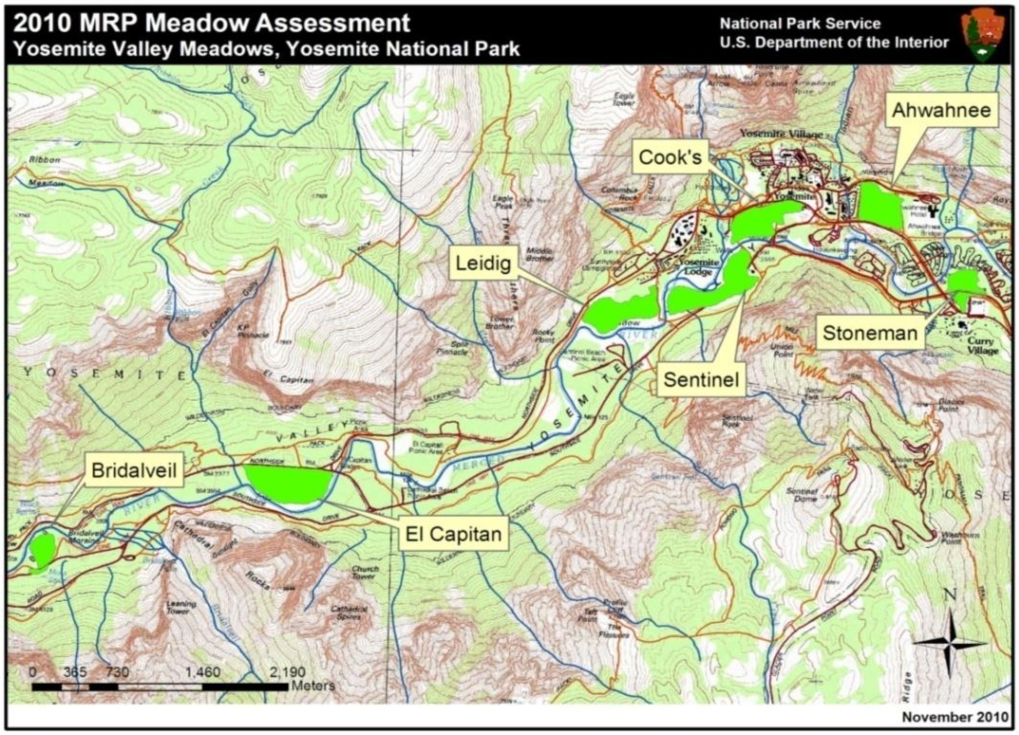
We tailored meadow assessment protocols to accommodate differences in these three groups. In Yosemite Valley and subalpine sites, we collected data using methods adapted from Ballenger et al. (2011), in which data were collected from 5x5m temporary plots across a grid in each meadow. This approach provides a spatially-balanced, quantitative dataset for metrics of interest from each meadow. In Yosemite Valley meadows, where visitor foot traffic and non-native plant invasion are issues of concern, we collected additional information on invasive plants, informal trails and observed causes of bare ground. In subalpine meadows where pack stock use is an issue of concern, we collected additional data on stock impacts and characterized the condition of meadow streams using a protocol designed by the US Forest Service and Bureau of Land Management (called Multiple Indicator Monitoring) for monitoring streams in grazed meadows (Burton et al.

2011). We used a rapid assessment protocol for alpine sites (adapted from USDA 2003), since access difficulties and the campfire prohibition above 9,600 feet may result in lower visitation and impact to these meadows. The rapid assessment of alpine meadows involved characterization of each meadow and associated stream using a set of pre-established criteria and a rating system to score meadow condition and vulnerability to impacts (USDA 2003).

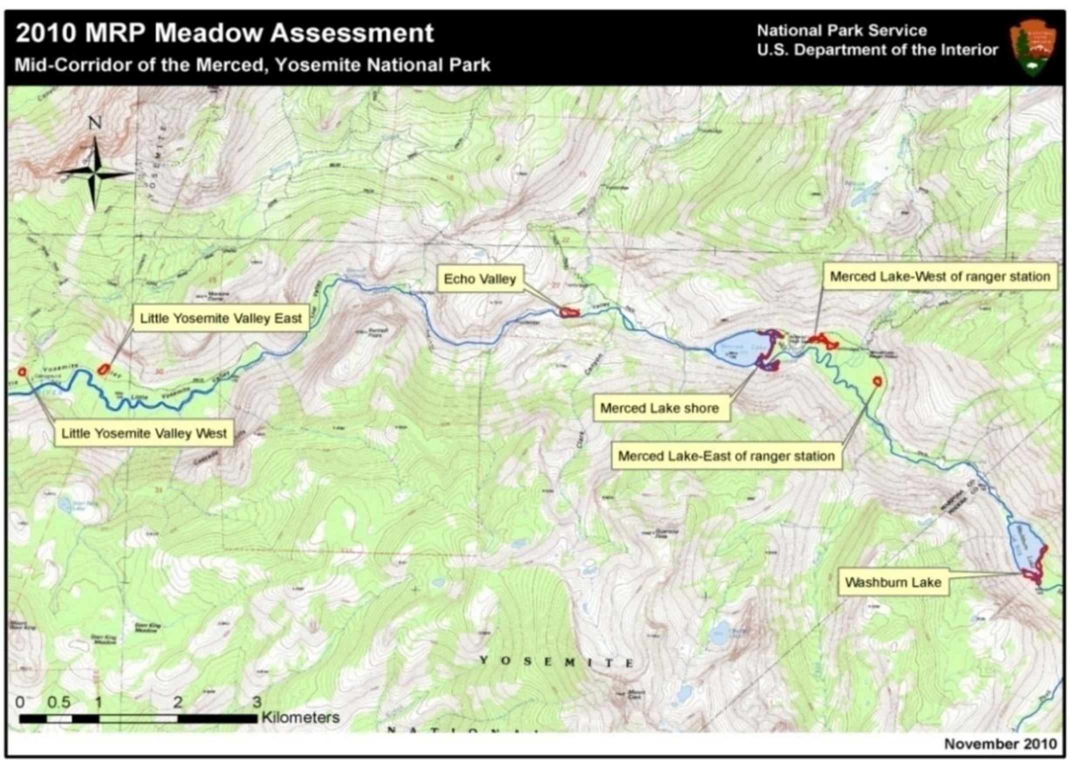
Site selection

In Yosemite Valley, we sampled a core group of meadows with the heaviest visitor use to provide meadow data: Bridalveil, El Capitan, Leidig, Cook's, Sentinel (north of the road), Ahwahnee, and Stoneman (Map 3). This complements ongoing studies on the ecological effects of informal trails (Leung et al. 2011, in prep) Of the total meadow acreage in Yosemite Valley (109 hectares), we surveyed approximately 86 hectares, or 79% of Yosemite Valley meadows. In alpine and subalpine zones, we selected all meadows in the Merced River corridor for this study. We located meadows in ArcMap 9.3.2 using a GIS shapefile of the Yosemite National Park vegetation map and associated classification (Natureserve 2007). We overlaid this shapefile on 2005 NAIP (National Agricultural Imagery Program) shapefile and edited it to refine the meadow boundaries visible on the aerial imagery. In addition, if a meadow photo-signature was apparent on the 2005 NAIP imagery but was not delineated on the vegetation map (as in the case of Echo Valley and Triple Peak Fork- north), we delineated these meadows in ArcMap and added them to the pool of subalpine and alpine meadows.

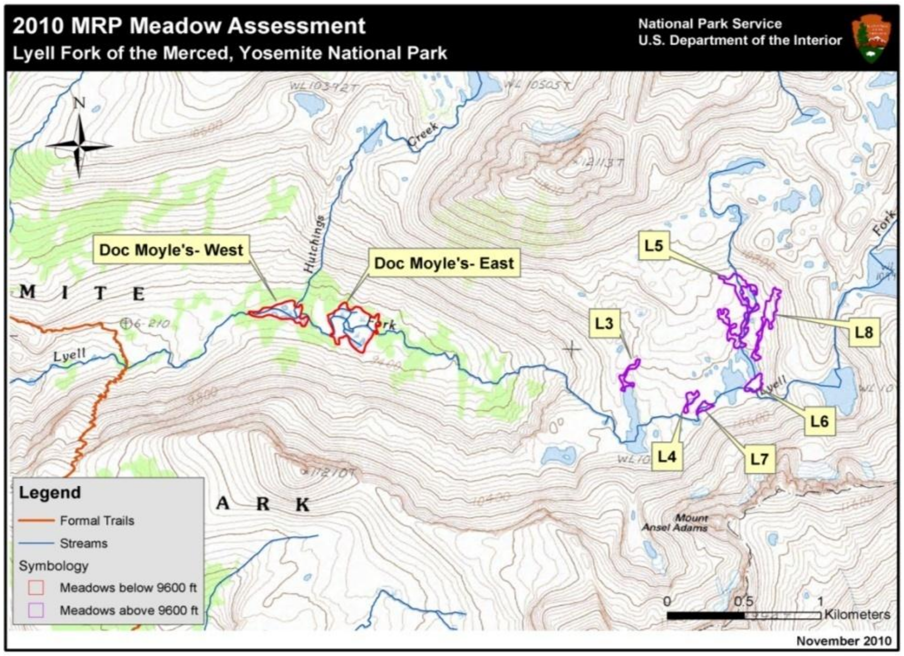
Wherever possible, we used existing names for each meadow, but most subalpine and all alpine meadows required naming. We assigned alpine meadows a letter corresponding to the river fork where they were located as well as a unique number. (For example, meadow L6 in the Lyell Fork or M2 in the Merced Peak Fork). We named subalpine meadows according to fork and cardinal direction, unless they were near a known place name (as in Little Yosemite Valley, Doc Moyle's camp, Merced Lake, or Washburn Lake). Merced Lake meadows were named according to their proximity to the lake and ranger station (Merced Lake-shore for the shoreline meadow, Merced Lake- West for the meadow west of the ranger station, and Merced Lake-East for the administrative meadow east of the ranger station). Maps 5-7 show the location and names of subalpine and alpine meadows in this study.



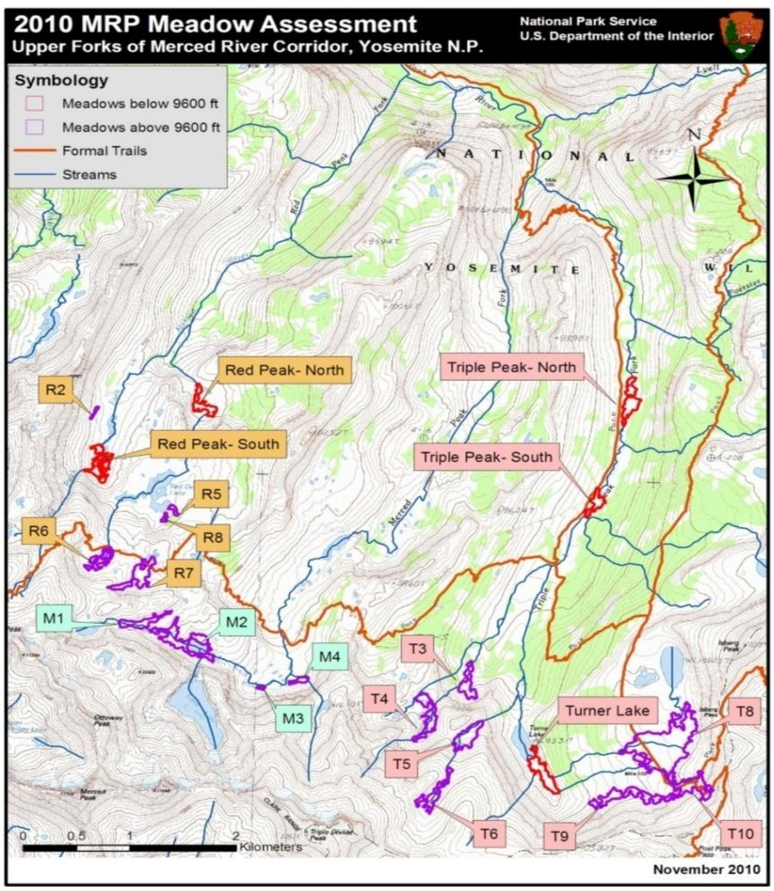
Map 4. Yosemite Valley meadows surveyed in the Merced River corridor.



Map 5. Subalpine meadows surveyed in the mid-corridor section of the Merced River corridor.



Map 6. Subalpine and alpine meadows surveyed in the Lyell Fork of the Merced River corridor.



Map 7. Subalpine and alpine meadows surveyed in the Red Peak, Merced Peak, and Triple Peak forks of the Merced River corridor.

In order for a site to be considered a “meadow” by our criteria, it must be dominated by herbaceous vegetation and have less than 50% tree, shrub, wood, or rock cover. Alpine meadows needed to have pockets of herbaceous vegetation at least 50x50m in area, but several adjacent pockets separated by rock outcrops could be considered one meadow site. “Meadows” of all types and hydrologic regimes were included; no distinction was made between fens, marshes, wet or upland meadows during data collection or analysis. During subalpine and alpine meadow visits, we excluded sites that did not fit the criteria of our meadow definition. For example, we rejected “meadows” in Little Yosemite Valley and Echo Valley because of excessive fallen snags and tree cover. We excluded some alpine sites in the Merced Peak and Lyell Peak Forks because they had high rock cover and relatively little herbaceous vegetation. We excluded all *Carex filifolia* (shorthair sedge) “meadows” above 9,600 feet elevation because they had greater than 50% rock cover.

Timing of fieldwork was constrained by the narrow window in which we could identify plants, and vegetation maturation in 2010 was slowed by the particularly cool and wet spring that year. Although optimal sampling time for mature vegetation in most meadows would have been August, logistical constraints resulted in a staggered timeframe. We conducted fieldwork in Yosemite Valley meadows mainly in June of 2010, with some follow-up work in July-September for areas that were flooded in June. We surveyed subalpine and alpine meadows in July-September. Due to logistics and time constraints, we did not visit five alpine meadows near the headwaters of the Lyell Fork, although based on photo-signature these meadows would likely have been excluded from the study due to high rock cover. Table 1 provides basic information on all the meadows in this study.

We conducted stream assessments in subalpine meadows in August-September 2010, after stream levels dropped and during the peak of visitor use. First, we evaluated each stream for its suitability to the Multiple Indicator Monitoring (MIM) protocol (Burton et al. 2011). To be suitable for MIM, a stream must be low-gradient, perennial or intermittent flowing, and have a well-developed alluvial channel with banks dominated by meadow vegetation. It should be in an area that may receive pack stock use, and would be sensitive to management actions. When a stream was suitable, we conducted either a MIM survey or a rapid assessment (depending on time constraints). We surveyed four stream sites using MIM and three sites using rapid assessment.

Table 1. Study meadows listed by group and location. N/A= not applicable, NC= did not fit criteria, NR= not reported in Wilderness database, SRA= stream rapid assessment, "association only"= vegetation community type was the only data collected. Stock nights are defined as 1 stock night equals 1 horse or mule grazing a meadow for 1 night. For example, 5 stock staying 2 nights at a meadow would equal 10 stock nights.

Group/ Zone	Meadow name	Size (ha)	Elev-ation (ft)	# grid plots	Stream data? (MIM)	Stock Nights (7 yr avg)	Comments
Yosemite Valley (montane)	Ahwahnee	11.5	4000	10	N/A	N/A	10 plots total (in a transect) due to time constraints
	Bridalveil	5.5	3920	81	N/A	N/A	6 plots association only
	Cook's	13.4	3960	136	N/A	N/A	6 plots association only
	El Capitan	18	3953	183	N/A	N/A	
	Leidig	16.2	3960	168	N/A	N/A	3 plots association only
	Sentinel	16.5	3965	124	N/A	N/A	Meadow south of road not surveyed
	Stoneman	7	4000	101	N/A	N/A	
Mid corridor- subalpine (subalpine)	Little YOSE Valley- West	0.5	6120	11	NC	N/A	7 plots were association only
	Little YOSE Valley- East	0.9	6120	13	NC	N/A	
	Echo Valley	1.6	7000	6	NC	8	Open areas north of the river and south/east of trail junction were surveyed for stock impacts
	Merced Lake- Shore	1.6	7202	59	NC	N/A	Adjacent to lake, near HSC. 4 plots association only
	Merced Lake- West	1.8	7267	35	NC	N/A	Near DNC corral west of ranger station
	Merced Lake- East	0.6	7307	17	NC	169	2 plots association only
	Washburn Lake	2.9	7605	53	NC	19	11 plots were association only
Upper Forks- subalpine (subalpine)	Doc Moyle's- West	2.8	9305	31	Yes	8	
	Doc Moyle's- East	6.6	9334	62	No	8	3 plots association only
	Red Peak- North	2.2	9377	32	Yes	N/A	1 plot association only
	Red Peak- South	4.1	9495	44	SRA	N/A	14 plots association only
	Triple Peak- North	3.7	9019	53	SRA	NR	6 plots association only
	Triple Peak- South	2.0	9062	33	Yes	NR	1 plot association only
	Turner Lake	4.2	9544	66	Yes	NR	4 plots association only
Lyell Fork (alpine)	L3	0.6	10270	N/A	N/A	N/A	
	L4	0.5	10355	N/A	N/A	N/A	
	L5	3.6	10496	N/A	N/A	N/A	
	L6	0.8	10391	N/A	N/A	N/A	
	L7	0.4	10371	N/A	N/A	N/A	
	L8	1.9	10525	N/A	N/A	N/A	
Merced Peak Fork (alpine)	M1	2.7	10145	N/A	N/A	N/A	
	M2	6.2	9889	N/A	N/A	N/A	
	M3	0.2	9669	N/A	N/A	N/A	
	M4	0.8	9672	N/A	N/A	N/A	
Red Peak Fork (alpine)	R2	0.2	9599	N/A	N/A	N/A	
	R5	0.5	9754	N/A	N/A	N/A	
	R6	1.9	10069	N/A	N/A	NR	Formal trail on north end of meadow
	R7	4.5	10027	N/A	N/A	NR	Formal trail on north end of meadow
	R8	0.3	9751	N/A	N/A	N/A?	Stock sign present (though more than ¼ mi off trail)
Triple Peak Fork (alpine)	T3	2.8	10263	N/A	N/A	N/A	
	T4	4.1	9793	N/A	N/A	N/A	
	T5	4.0	9735	N/A	N/A	N/A	
	T6	3.0	9948	N/A	N/A	N/A	
	T8	22.5	10342	N/A	N/A	NR	Formal trail on west end of meadow
	T9	5.4	10063	N/A	N/A	N/A	Most of meadow not stock-accessible
	T10	5.2	9971	N/A	N/A	NR	Formal trail on west end of meadow.

Field data collection

Gridpoint plot collection (Yosemite Valley and subalpine meadows)

In Yosemite Valley and subalpine meadows, we collected data in 5x5m plots using methods adapted from Ballenger et al. (2011). We generated survey points on a grid across each meadow using HawthsTools in ArcMap 9.3.2 software. Grid spacing was 20m, 25m, or 30m depending on meadow size, with small meadows receiving the tighter spacing to increase sample size. We located each sampling point with Trimble GPS units and relogged the point if satellite reception was adequate. We then established a temporary 5x5m square plot and recorded ocular estimates for cover class data (Table 2) in the GPS data dictionary for vegetation cover, species composition (including invasive plants), substrate characteristics, and other metrics. Cover class data provided a rapid method for collecting quantitative data at each plot so that many plots could be collected in each meadow. To improve data consistency, field staff were thoroughly trained in cover estimations and calibrated at the start of each field trip and/or meadow. In addition, the same staff collected data throughout the summer to minimize differences among observer estimates. We visualized shriveled or dried vegetation late in the growing season in its fully alive condition for cover estimates.

Table 2. Cover class breaks for gridpoint plot data for the MRP meadow.

Cover Class	Percent Cover
T	Trace (<1%)
P	Present 1-5%
1a	6-10%
1b	11-15%
02	16-25%
03	26-35%
04	36-45%
5a	46-50%
5b	51-55%
06	56-65%
07	66-75%
08	76-85%
09	86-95%
10	96-100%

We collected a variety of metrics at each plot (Table 3). In Yosemite Valley meadows, we added some metrics (indicated with asterisks) to capture data relevant in these meadows, and did not collect pack stock data since stock are not turned out for grazing in Yosemite Valley. We collected additional information on informal trails and observable causes of bare ground in Yosemite Valley plots to aid in related analyses on the relationship between informal trails, meadow fragmentation, and the ecological variables data collected in our study (Leung et al. 2011).

Table 3. Data collected at each gridpoint plot for the MRP meadow assessment in Yosemite National Park. Fields with "*" were collected only in Yosemite Valley Meadows. Stock use data were only collected in subalpine meadows.

Data Field	Definition
Total vegetation	Total cover of all vascular vegetation in the plot (could not exceed 100%, does not account for layered vegetation)
Graminoid cover	Total cover of all grasses, sedges, and rushes
Forb cover	Total cover of all non-graminoid herbaceous species
Subshrub cover	Total cover of all shrub species with height generally less than 0.5m at maturity
Shrub cover	Total cover of all shrub species with height generally greater than 0.5m at maturity
Fern/ allies cover	Total cover of all fern/ fern ally species
Tree canopy cover*	Total cover of tree canopy greater than 2m in height (tree may be rooted outside plot). This was a rough ocular estimate perfomrmed by the observer gazing skyward from the plot.
# Seedling/saplings	Stem count of trees in the plot less than 2m in height.
Dominant species (3)	Up to three dominant species and their cover were recorded at each plot. Dominant 1 was the species with the greatest cover. Dominant 2 and Dominant 3 were recorded if they had at least half the relative cover of Dominant 1.
Other species (3)	Up to three other common species (with less than half the relative cover of Dominant Species 1) were recorded . These were listed in decreasing order of cover.
Non-native cover*	Total cover of all non-native species in the plot.
Non-native species* (3)	Up to three non-native species were listed, if present, in order of decreasing cover.
Velvetgrass cover*	Cover of *Holcus lanatus* (velvet grass)
Association name	The vegetation community of the plot and surrounding area (10m in any direction) was assigned a name from the 1997 Yosemite floristic classification (Natureserve 2007). This field characterized a larger area than the 5x5m plot, to minimize the effect of plots falling on an anomalous concentration of a particular species.
Association comments	If the community did not fit any of the association names from the 1997 Yosemite floristic classification (Natureserve 2007), a new name and comment was recorded in this field.
Moss	Total cover of all moss in the plot. Cover for dormant moss was estimated as if it were in a fully green condition
Bare ground	Cover of all bare ground was included in this estimate. Gravel (less than 2cm diameter) was included in bare ground. If bare ground was covered by water, we included an estimate of the bare ground under water.
Bare ground type*	Two types of bare ground could be entered, if cause of bare ground could be identified with confidence. If bare ground appeared undisturbed and no obvious cause could be identified, "undisturbed" was entered.
Litter	Ground-level plant material that was dead before the current year's growing season, either detached or present in the form of thatch (in perennial graminoid communities). If litter was covered by water, we included underwater litter in the estimate.
Water	Cover of all standing or flowing water (regardless of depth) at the time of plot collection.
Burrow	Cover of all burrow holes and excavation tailings.
# Burrow holes	All small mammal burrow entrances (recent or old), were counted in the plot.
Social trails*	Cover of informal trail area in the plot, including all classes of trail (Newburger et al. 2011, unpublished report).
Trail classification*	Category of informal trail in plot, either "Stunted vegetation," "Some bare ground," or "Barren"
Manure	Cover of pack stock manure (fresh or old)
Hoofpunches	Cover of distinguishable hoof marks >1cm deep, which break through the root mat in vegetated areas.
Hoofprints	Cover of distinguishable hoof prints <1cm deep that do not break through the root mat were estimated.
Grazed vegetation	Cover of vegetation that had been grazed, regardless of residual height.
Litter depth	Distance from the soil surface to the surface of the litter/thatch, measured at two randomlyselected locations in the plot.
Vegetation height	Distance from soil surface to the top level of dominant herbaceous canopy (generally vegetative structures, not inflorescences) measured at the two randomly-selected litter depth locations in the plot

If a gridpoint fell on an anomalous area in a meadow[6] , the data collector would either move the plot by pacing 5m away from the anomalous location, or reject the plot if moving it did not resolve the situation. If a gridpoint plot fell in a shrub community (often thick monoculture of willows), the plant association was recorded but no other data was collected. This enabled comparison of data from mainly herbaceous meadow communities across meadows without skewing the results with shrubland plots.

Stream Assessments (subalpine meadows- MIM)

We used the *Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation* protocol to assess streambank and channel conditions (Burton et al. 2011). This peer-reviewed inter-agency protocol was developed by the US Forest Service and Bureau of Land Management to assess the impacts of grazing (mainly from livestock) on small and medium-sized, low-gradient perennial mountain streams fed primarily by snowmelt (Burton et al. 2011). Because of its applicability to pack stock use of meadows, we evaluated this protocol at two sites in the Tuolumne River watershed in 2009 and determined it was suitable for Yosemite environments.

The MIM protocol collects data for up to ten indicators at once, and allows users to choose only those that are relevant to their study. Indicators provide information on both biological and physical condition of the riparian ecosystem. Indicators are classified as long-term or short-term, where long-term indicators provide information about components of the system that take years to change and short-term indicators provide information on impacts in the current season (Table 4). Once a designated monitoring area (DMA) is established, a full MIM survey (of all indicators) is typically conducted every 3 to 5 years and an abbreviated survey (only short-term indicators) should be conducted every year (Burton et al. 2011). In 2010, we customized the protocol for conditions in Yosemite by eliminating the pool depth and frequency indicator and adding a headcut component. Pool depth and frequency was eliminated because the majority of sites surveyed in this study have very low-gradient channels that do not form distinct pool and riffle sequences. Furthermore, this indicator has been found to have poor repeatability among observers when pool structure within the channel is complex (Burton et al. 2011). Headcut erosion features were added since headcuts can be indicators of an unbalanced hydrological system (Brooks et al. 2003). Although headcuts can have natural origins, headcut erosion is typically found in disturbed areas, often resulting from land use or management actions (Brooks et al. 2003). The size and number of headcuts at a site in conjunction with bank stability indicators can help describe condition streambank condition. Changes in headcut erosion severity over time can inform trend at a site (Brooks et al. 2003).

[6] Criteria included: in a creek, on the transition between two distinct plant communities, on rocks that were greater than 10% cover, in an area of thick conifer encroachment, or on a meadow border with significant needle cast from surrounding forest

Table 4. Multiple Indicator Monitoring (MIM) Indicators for subalpine meadow stream assessments.

Indicator Name	Indicator Type	Description/Use
Woody Species Use	short-term	Used to monitor the severity of livestock grazing (adapted from U.S. Bureau of Land Management 1996a). Woody species use is given as an approximate percent of the current season's growth that was browsed for woody plants that are available (up to 2m, within reach) for browsing and within 2 meters (6.6 feet) of the greenline.
Stubble Height	short-term	Measures residual height of key herbaceous species after grazing. Approximate height of the key herbaceous forage species was recorded within 5 cm (2 in) of sampling frame handle. If more than one key species was present, only that closest to the handle was selected. Stubble height is recorded regardless of whether or not grazing is evident.
Steambank Alteration	short-term	Used to measure presence and absence of stock at the site and provides an easily comparable quantification of current use severity. Alteration must be from the current grazing season, identifiable as being made by a horse or a mule. Hoof punches of deer or people are not counted. The number of hoofprints at each plot is counted (up to 5).
Greenline Composition	long-term	Used to characterize the vegetation of the riparian corridor. Composition is given as percent foliar cover of each constituent in the sample plot that covers at least 10% of plot area. Constituents can be vascular plants, anchored wood, or embedded rock. Wood and rock must be greater than 15 cm (6 in) in diameter. Species names are recorded for all vascular plants. Areas of understory and overstory are counted separately. Cover of bare ground, litter, and non-vascular plants are not included.
Woody Species Height Class	long-term	Used to calculate woody biomass production and shading of the water in the stream channel. Can also be used to monitor changes in establishment of woody plant species over time. Height classes for woody species were recorded for all plants rooted within or having foliar cover above the sampling plot. Height class delineations as defined in Burton et al. (2011).
Woody Species Age Class	long-term	Used to describe health of the population and monitor the trend of woody species recruitment along the streambank. Age class and number of woody plants rooted in a plot twice the size of (and perpendicular to) the monitoring frame were recorded. Woody species age classes are "seedling", "young", or "mature" as defined by Burton et al. (2011).
Stream Bank Stability and Cover	long-term	Summarizes streambank stability at each plot. Takes bank type into consideration (erosional or depositional), amount vegetation present (covered or uncovered), and active erosion presence (fracture, slump, slough, eroding, or absent). Depositional plots were those where clay, silt, sand, or gravel, were actively being deposited by the stream, often at channel margins adjacent to the greeenline. "Covered" plots were those with at least 50% of the area between the greenline and the scour line supported with perennial vegetation, large rock, or embedded wood. "Stable" plots were those with no erosion features present.
Greenline to Greenline Width (GGW)	long-term	Measures width of the channel by using the greenline to define the channel margins. GGW is often synonymous with bankfull width, as the greenline is typically at or near bankfull stage. GGW is measured perpendicular to flow at every sample plot. GGW is an effective measure of large or rapid increases in stream width that may be the result of local disturbances and channel instability.
Substrate	long-term	Estimates bed particle size distribution useful in indicating the condition of and monitoring trends in the energy balance of the stream). At every other plot, 10 bed particles are selected at evenly spaced intervals across the active channel, providing a sample size of at least 200 (10 particles at each of 20 transects) for each stream.
Headcuts	long-term	Measures headcut erosion features along the length of the streambank located within the DMA. Headcuts are erosion features that result in the formation of new stream channels off of the main channel. They are formed where sheet flow across a meadow becomes channelized and begins to scour out the streambank. This channelization causes a drying effect to a meadow's water table. Erosion features like headcuts and gully erosion are evidence that a stream channel is not stable (Brooks 2003).

MIM methods involved first selecting a designated monitoring area, approximately 110 meters in length, following the rules detailed in Burton et al. (2011). We then implemented a systematic, random-stratified sample design using a double Daubenmire quadrat frame (40 X 100 cm) to collect data at 2.75m intervals along both banks, resulting in a total of 80 plots read for each stream survey reach. Some metrics (woody species use, height and age class) were measured in a plot (40 x 200 cm) expanded outward from the Daubenmire quadrat. At each plot location, we measured channel width. At every other plot location, we randomly sampled substrate particles at 10 random locations across the stream channel. We collected GPS data on stream endpoints using Trimble Juno SB units and TerraSync software. We entered stream data directly into a Microsoft Excel workbook (provided by the authors of the MIM protocol) using the Trimble GPS. See Burton et al. (2011) for complete details on the MIM protocol.

We conducted rapid assessments of streams at sites that generally fit project objectives and monitoring criteria for MIM, but where a full MIM survey was not prudent due to project priority and/or time constraints. The purpose of the rapid assessment was to collect enough data from the site to inform general condition and suitability for future monitoring. We developed a standardized protocol that included a general site description, specific information about vegetation communities, streambank integrity, stream reach size and form, substrate, and erosion features. We took site photos and recorded photo point locations with GPS. We also used GPS to map the entire length of the stream through the meadow (from stream centerline where possible) and the locations of stock camps where applicable. We recorded evidence of pack stock use, including browsed vegetation, hoof punches, manure piles, and stock camps.

Rapid Assessments of (alpine meadows and streams)

Rapid assessments of meadows above 9,600 feet involved three main components: meadow characterization, stream characterization and rating criteria. We collected data for these components by walking a meadow in its entirety (visually surveying the entire area), taking pertinent notes along the way, and then completing data forms to record our observations.

Meadow characterization: We estimated the relative proportion (out of 100%) for each of the following categories (i.e., each category totaled 100%).

- <u>Coarse composition</u>: Vegetation life forms (tree, shrub, subshrub, graminoid, forb) and substrate (bedrock, boulder, rock, gravel[7], bare ground, ponds, moss, and litter).
- <u>Plant communities</u>: Up to four dominant vegetation communities and a fifth community called "other", which included common species not represented in the first four communities. Species names were recorded under "other".

[7] Boulders defined as "basketball-sized" or larger rock (>40cm). Rocks defined as "softball to basketball-sized" rock (15-40cm). Cobbles defined as "golfball to softball-sized" rock (3-15cm). Gravel defined as 0.3-3cm particles. Bare soil or fine sediment defined as <0.2cm particles.

Stream characterization: If a perennial stream flowed through the meadow, we estimated the average channel width, depth, and length encompassed by the meadow. We also estimated the percent of streambank with active erosion (fracturing or sloughing). We then estimated the relative proportion (out of 100%) for each component of the following categories:

- Channel substrate composition: Percent of visible substrate composed of bedrock, boulder, rock, cobble, gravel, and fine sediment)
- Streambank composition: Percent of banks covered by shrubs, subshrubs, trees, herbaceous vegetation, rocks of various categories, and bare ground)

Rating criteria: We adapted the rating criteria protocol used by the Inyo and Sierra National Forests for meadow surveys (USDA 2003) to develop a numerical "score" that could be related to condition and/or vulnerability to impact of meadows and streams. Table 5 details the rating factors and scoring system. Higher ratings indicate higher levels of impact, vulnerability or poorer condition.

In addition to rapid assessments, we also surveyed each meadow for select features and impacts (see following section), which we mapped with GPS units. We took representative photos of each meadow, noted wildlife sightings, and estimated the cover of small mammal burrows, hummocky topography (similar to mima mounds), sphagnum mounds and/or fen areas. We also recorded slope, aspect, and a descriptive narrative at each meadow.

Table 5. Meadow/ stream rating criteria for alpine meadows. Right column details the numerical ratings.

Rating factor	Score: Definition
Slope rating (considering majority of meadow area)	**1**: 0-2% slope= low gradient **2**: 3-9% = moderate **3**: 10-30% = high gradient meadow **4**: > 30% = extreme slope
Trail extent (formal or informal trails)	**0:** No trails in meadow **1**: Trail on meadow periphery (consider potential to impact meadow resources) **2**: One trail through meadow **3**: more than one trail through meadow
Trail level	**1**: Sod unbroken over at least 90% of the trail. **2**: Sod broken over more than 10% of the trail, and trail up to 12" wide. **3**: Sod broken over all the trail, and trail up to 24" wide, over 12" wide for at least 50% of the trail. Major trail. **4**: Trail as in #3 above, and sections of braiding present.
Trail incision/ severity	**1**: Incision on up to 5% of the trail within the meadow **2**: Incision on up to 25% of the trail within the meadow **3**: Incision on over 25% of the length of the trail within the meadow
Human impacts	**0:** No observable signs of visitation **1**: Slight impacts (fire ring adjacent to meadow or few footprints visible in meadow) **2**: Moderate impacts (fire ring inside meadow or multiple rings outside meadow or many footprints visible in meadow) **3**: Severe impacts (explain in comments)
Pack stock impacts	**0:** No sign of pack stock **1**: Manure or few hoofpunches visible, but only near formal trail corridor **2**: Little manure or few hoofpunches visible in meadow away from trail corridor **3**: Many piles of manure or many hoofpunches / trampling in meadow away from trail corridor

Rating factor	Score: Definition
Presence of fen	**0** : No fen characters present. **1** : Sphagnum or other SNFPA (Sierra National Forest Plan Amendment) fen indicator species present in patches **2** : Fen in 25-50% of meadow. Indicator plant species may be present. **3:** Fen throughout most to all of meadow. Deep organic soil (>40 cm thick) and fen hydrology.
Conifer encroachment	**0** : Little to no (<5%) area of conifer encroachment **1** : 5-10% of area with conifer encroachment **2** : 10-25% of meadow with conifer encroachment **3:** 25-50% of meadow with conifer encroachment **4:** >50% of meadow with conifer encroachment
Bare ground	**0:** No bare soil observed **1**: Rarely present, less than 5% of meadow area. **2**: Moderate extent, from 6-15% of meadow area **3:** Widespread. Greater than 15% of the meadow area
Streambank erodibility	**1**: Low erosion potential – armored with rocks or dense vegetative cover (over 90% of bank armored) to protect from erosion **2**: Moderate erosion potential – some rocks, boulders, or vegetative cover (75-90% cover) **3**: High erosion potential – No rocks, boulders, vegetative cover or other armoring to prevent streambank erosion (cover less than 75% of bank length)
Lakeshore erodibility	**1**: Low erosion potential – armored with rocks or very high vegetative cover to prevent erosion **2**: Moderate erosion potential – some rocks, boulders, or vegetative cover **3**: High erosion potential – No rocks, boulders, vegetative cover or other armoring to prevent erosion
Streambank or lakeshore impacts	**0:** No impacts observed **1**: Slight impacts observed (explain in comments). **2**: Moderate impacts observed (explain in comments). **3**: Severe impacts observed (explain in comments).
Stream headcut severity	**0:** No headcuts observed **1:** Small headcut(s) observed. Height less than rooting depth. Not actively migrating or causing erosion away from the headcut. **2:** Moderate-sized headcut(s) observed (up to rooting depth of sod). May be leading to incision upstream, downstream, or laterally away from the stream. **3:** Large headcut(s) observed. Headcuts deeper than rooting depth of sod. May be leading to incision upstream, downstream, or laterally away from the stream.
Stream headcut extent	**0**: No headcuts observed **1**: One headcut observed or more than one headcut, but concentrated in a local headcut complex. **2**: More than one headcut observed in two or more distinct areas (ie – 3 distinct headcuts on the same stream, but one headcut 100 feet downstream from the other) **3:** Many headcuts observed on the stream in the meadow (ie – headcuts observed on most stream reaches in the meadow, creating a series of continuous headcuts)
Stream headcut location	**0:** No headcuts observed **1**: Upper 1/3 of meadow **2**: Middle 1/3 of meadow (could also include upper 1/3) **3**: Lower 1/3 of meadow (could also include upper 2/3)
Stream incision severity	**0:** Streambanks are stable and show no evidence of incision beyond that naturally expected. The stream can access its floodplain. **1:** Slight incision, less than rooting depth of sod **2**: Moderate incision, up to rooting depth of sod **3**: Severe incision, deeper than rooting depth of sod
Stream incision extent	**0**: No stream incision observed or trace amounts of incision (<0.5%) **1**: Up to 5% of the channel within or adjacent to the meadow incised **2**: Up to 20% of the channel within or adjacent to the meadow incised **3**: Over 20% of the channel within or adjacent to the meadow incised
Streambank erosion	**0:** Streambanks are stable and show no evidence of calving or sloughing. **1**: Streambanks have slight disturbance, with slight broken sod or chiseling, no evidence of active erosion. **2**: Streambanks have moderate disturbance, with banks partially bare of sod. Evidence of slight active erosion. **3**: Streambanks are bare of sod and are actively eroding

Mapping and quantification of select features and impacts (all meadows)

We systematically surveyed all meadows (by walking the entire meadow) for features that aid in assessment of conditions or quantify impacts (Table 6). We mapped these features with Trimble GPS units and collected data corresponding to each feature with the GPS data dictionary. Photo illustration for a selection of these features is located in Appendix A. We recorded anecdotal wildlife observations in the notes for each meadow except in the case of special status amphibian species Yosemite toad (*Anaxyrus canorus*) and Sierra Nevada yellow-legged frog (*Rana sierrae*), which we mapped with GPS points.

Table 6. Mapped features and impacts for the MRP meadow assessment in Yosemite National Park. Appendix A contains photo illustrations of a selection of these features.

Feature Name	Feature Type	Definition/ attributes
Bare ground	Area	Area at least $10m^2$ with <25% vegetation cover. Attributed with "completely barren," "mostly barren," or <25% vegetation. Also attributed with possible cause, such as "alluvial deposits," "mammal burrows,""unknown," "human," or "stock".
Headcut	Point and line	A sudden change in elevation or knickpoint at the leading edge of a gully. Headcuts are observed where sheet flow occurs above the headcut (and more hydric vegetation is supported) and flow is channeled below the headcut (where vegetation communities are more xeric due to the lowered water table.) A point feature was mapped to mark the top of the headcut, and line feature used to map the extent of the channel below the headcut.
Pond	Area	Area at least $10m^2$ with standing water for most of the growing season and observable "banks". Presence of amphibian species was recorded, and range of depth on the survey date was estimated. Ponds large enough to be mapped using aerialimagery were not mapped in the field.
Informal Trail	Line	All social trails (not formal hiking trails) at least 7m long were mapped with line features according to the Yosemite National Park protocol for informal trails mapping (Yosemite National Park 2009)[8]
Fire ring	Point	Usually circular arrangement of rocks with fire scarring on the interior surfaces. No distinction was made between fire rings showing current use and old rings.
Stock Camp	Area	The perimeter of the camp (area showing impact from tents, pack stock holding areas, etc) was mapped.
Roll pit	Area	A concave area of disturbed bare ground at least $10m^2$ created by pack stock rolling.
Manure	Point	Pack stock manure was attributed with density (piles per 5m), either "single," low (2 piles)", "medium (3-4 piles," or "high (5+ piles)".
Hoofpunches	Point	Any distinguishable hoof marks >1cm deep, penetrating the root mat in vegetated areas. Hoofpunches were attributed with the same density values as manure, and surrounding plant community was noted.
Trampling	Area	Areas at least $10m^2$ of often overlapping hoof-punches that are less than 0.5m apart. Soils usually have a churned appearance. Surrounding plant community was noted.
Grazed area	Area	Areas at least $10m^2$ that have continuous vegetation grazed to within 50% of canopy height. Plant community was noted.
Photopoint	Point	At least two representative photos were taken at each meadow, to capture landscape appearance. Headcuts and bare ground areas were also photographed. Digital photo filename and azimuth of the camera angle were recorded at each photopoint.

Methods for Data Summary and Analysis

Gridpoint plot collection (Yosemite Valley and subalpine meadows)

We downloaded gridpoint plot data from the GPS units and exported them to ArcMap, MS Access, and MS Excel for summary and analysis. We created vegetation maps for each meadow by displaying plant communities from plots and other mapped features (see below "Select features

[8] Informal trails data for Yosemite Valley meadows was collected by the Visitor Use and Social Sciences branch at Yosemite.

and impacts”). We summarized many metrics of interest by determining the proportion of plots in each meadow with a given characteristic. For instance, by determining the proportion of plots containing tree seedlings in a meadow, we could infer the extent of tree encroachment in that meadow. We followed the same approach to examine the extent of non-native species invasion, pack stock impacts, informal trailing, and small mammal burrowing. Because of the regular spacing of plots across a grid in the meadow, this approach enabled inferences about the spatial extent of occurrence for certain metrics. A “Total” bar was added to charts to show the percentage of plots across all meadows.

We converted cover class data to numerical data (using the midpoint of each cover class) for analyses where mean values per meadow were calculated (as in vegetation cover, bare ground, litter, etc.) A “Total” bar was added to charts to display the mean value across all meadows. We merged cover class categories in the graphical display for certain metrics of interest, such as non-native vegetation cover where the proportion of plots with greater than 75% cover of non-natives, 50% cover of non-natives, and 25% cover of non-natives was calculated.

We used the system defined by Cowardin et al. (1979) to estimate wetland extent in each meadow. This system is the current standard for implementing Executive Order 11990, Wetland Protection[9] in national parks (National Park Service 1998). Wetlands defined under the Cowardin standard must meet one of three criteria: 1) the area must be predominantly hydrophytic vegetation (wetland vegetation), 2) the substrate must be undrained hydric soil, or 3) the substrate must be non-soil and saturated or covered with water at some time during the growing season (NPS 2008). Using the vegetation parameter, we classified plots as either “wetland” or “upland” by first crosswalking the dominant species to their regional wetland indicator status[10] (available at http://plants.usda.gov/wetinfo.html or http://www.fws.gov/nwi/Plants/list88.html). We next calculated the proportion of hydrophytic species at each plot (having indicator status of OBL, FACW, or FAC). We then classified plots as “wetland” if at least 50% of dominant species in the plot were hydrophytic, and “upland” if less than 50% of dominant species were hydrophytic. By calculating the proportion of plots classified as wetland, we inferred the extent of wetland in each meadow. As we used only the vegetation parameter to classify wetland due to lack of soils and hydrologic data, wetland extent may be underestimated.

Stream Assessments (subalpine meadows)

Following the MIM protocol, we imported all indicator data to an analysis spreadsheet (Data Analysis Module) created in MS Excel by Burton et al. (2011). Using site data such as percent foliar

[9] Activities that result in the discharge of dredged or fill material in wetlands or other “waters of the United States” must also comply with Section 404 of the Clean Water Act and procedures for delineating wetlands as regulated by the U.S. Army Corps of Engineers.

[10] Species are assigned one of the following wetland ratings: obligate wetland species (OBL) occur in wetlands with 99% probability, facultative wetland species (FACW) occur in wetlands with greater than 67% probability, facultative species (FAC) equally occur in wetlands and non-wetlands, facultative upland species (FACU) occur in wetlands with 1-33% probability, and upland species (UPL) occur in wetlands with 1% probability.

cover of each species and height of woody species along the greenline, the spreadsheet generated 25 metrics. Macros in the spreadsheet then used these metrics to generate site ratings and indices based on life history traits, rooting characteristics, and wetland ratings of species present.
Of the 25 automatically-generated metrics, 13 were most relevant for assessing conditions in subalpine streams (Table 7a). For stream rapid assessments, we summarized data for the following indicators: greenline vegetation composition, woody species composition, greenline-to-greenline width (GGW), substrate, and presence of erosion features. From these data, we obtained general information on riparian conditions and suitability for future monitoring. Condition ratings and indices generated were then assigned rating classes based on Burton et al. (2011) (Table 7b, 7c).
We estimated headcut severity classes by comparing headcut width, depth, and length among headcuts to obtain severity ratings of low, moderate and high. Low severity headcuts were generally less than 1m long/wide/deep, moderate severity headcuts were generally about 3m long/wide/deep. High severity headcuts would be greater than 3m long/wide/deep, but we did not encounter headcuts of this type at any site.

Table 7a. MIM Condition metrics for subalpine meadow stream assessments (from Burton et al. 2011).

Stream Survey Metric	**Metric Type**	**Description/Measure**
Site Ecological Status Rating	Rating	Weighted average of ecological status ratings for all species at the site. Dominant plants are double weighted. Ecological status is calculated using plant successional status ratings and Winward's Riparian Capability Groups.
Site Wetland Rating	Rating	Weighted average of wetland ratings for all species at the site as computed using Wetland Indicator Status (USDI 1997).
Site Winward Greenline Stability	Rating	Weighted average of Winward stability ratings for all species at the site. Dominant plants are double weighted.
Plant Diversity Index	Index	Measure of species richness at the site. Species richness is calculated by multiplying the number of plant species by average species composition of the plots divided by standard deviation of relative plant species composition.
Biomass Index	Index	Measure of vegetation density on the greenline at the site.
Percent Woody	Proportion	Percentage of plots containing woody plants. Woody plants include shrubs, sub-shrubs, and rhizomatous woody species, such as willows.
% Rhizomatous Woody	Proportion	Percentage of woody plants that are rhizomatous woody species, such as willows.
Percent Hydric	Proportion	Percentage of plots containing hydric plants.
Percent Hydric Herbaceous	Proportion	Percentage of plots containing herbaceous hydric plants.
Mean Alteration	Proportion	Arithmetic mean of alteration values (for all plots on the survey reach).
Mean Woody Use	Proportion	Arithmetic mean of percent woody use (for all plots on the survey reach).
Percent Stable	Proportion	Percent of total plots classified as “stable” (i.e., those with no active erosion).
Percent Bank Cover	Proportion	Percent of total plots classified as “covered” (i.e., those that have more than 50% vegetation cover from the plot to the scour line).

Table 7b. MIM Rating and Index Condition Classes for subalpine meadow stream assessments, scale of 0-100 (from Burton et al. 2011). PNC=Potential Natural Community, UPL=Upland FACU=Facultative Upland, FAC=Facultative, FACW=Facultative wet, OBL=Obligate.

Ecological Status Rating	*Ecological Status Classification*	*Site Wetland Rating*	*Site Wetland Classification*	*Vegetation Biomass Index*	*Vegetation Biomass Classification*
0-15	Very Early	0-15 (UPL, UPL+)	Very poor	<10	Very Low
16-40	Early	16-40 (FACU- , FACU, FACU+)	Poor	10 - 20	Low
41-60	Mid	41-60 (FAC-, FAC, FAC+)	Fair	20 - 30	Moderate
61-85	Late	61-85 (FACW-, FACW, FACW+)	Good	30 - 40	High
86+	(PNC) Potential Natural Community	86+ (OBL-, OBL)	Very Good	>40	Very High

Table 7c. MIM Rating and Index Condition Condition Classes for subalpine meadow stream assessments, scale of 0-10 (from Burton et al. 2011).

Modified Winward Greenline Stability Rating	*Winward Stability Classification*	*Plant Diversity Index*	*Plant Diversity Classification*	*Shade Index*	*Shade Classification*
<4	Low	<1	Very Low	<.5	Very Low
5-6	Mid	1-2	Low	.5-0.99	Low
>8	High	3-4	Moderate	1-1.99	Moderate
		5-6	High	2-3.99	High
		>6	Very High	>4	Very High

Rapid assessment of meadows and streams (alpine meadows)

We summarized the field data for coarse composition and plant communities in tables showing individual values for each meadow as well as a mean value across all meadows. We summarized rating criteria values by summing the scores for rating factors in each meadow, resulting in a total score for each meadow.

Mapping and quantification of select features and impacts (all meadows)

We exported mapped features as shapefiles to ArcMap, where we edited line and area features using a standardized method to correct for outlying vertices. We presented these features on maps of each meadow, also displaying vegetation communities from gridpoint plots. For certain features, we summarized data by the feature type and divided by meadow area in order to normalize for meadow size and more accurately compare features across meadows. Impact features (such as informal trails, manure, hoofpunching) outside the meadow boundary but within 50m of it were included in these summaries because of their potential effects on adjacent meadow areas.

Results

We present the results according to Yosemite Valley, subalpine, and alpine meadow groupings. Plant association lists for meadows surveyed with gridpoint plots are found in Appendix B, and species recorded in gridpoint plots is found in Appendix C. Alpine meadow communities and common species from rapid assessment surveys are located in Appendix D. Maps and site descriptions for each meadow surveyed with gridpoint plots are located in Appendices E-F.

Yosemite Valley Meadows

We collected 778 plots across six meadows in Yosemite Valley[11]. We collected an additional 62 plots from areas with higher concentrations of informal trails, to aid in an analysis to correlate informal trail metrics with ecological condition. Those results are reported in Leung et al. 2011 and data from those plots are not incorporated in summaries here.

Vegetation and Wetlands

Mean vegetation cover in Yosemite Valley meadows ranged from 50-70%. El Capitan and Leidig meadows had the lowest mean vegetation cover (50% and 51%) and Cook's had the highest mean vegetation cover (Figure 2).

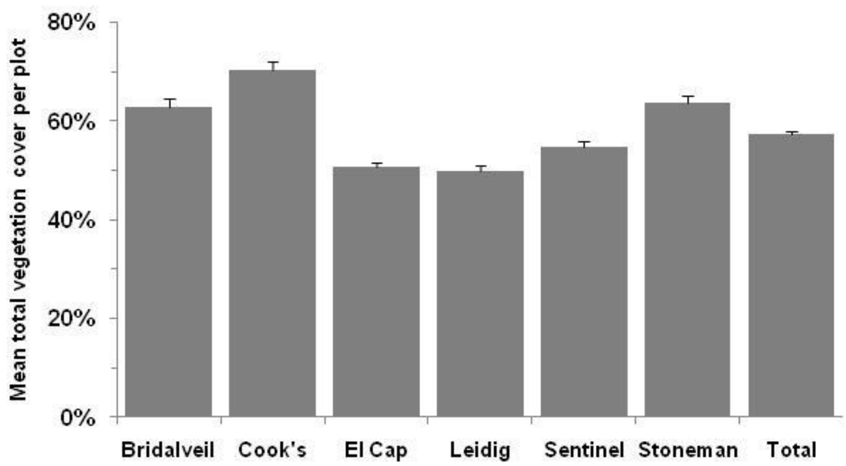


Figure 2. Mean total vegetation cover in Yosemite Valley meadows with error bars showing standard error.

Graminoids (grasses, sedges, and rushes) are the dominant life form in Yosemite Valley meadows, ranging from 37-56% cover on average (Figure 3). Mean forb (non-graminoid herbaceous species) cover in Valley meadows ranged from 8-18%. Shrubs and ferns had low cover in Yosemite Valley meadows with the exception of El Capitan Meadow, which had an average of 7% cover of ferns and fern allies. Subshrubs were absent from Yosemite Valley meadows.

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[11] We did not include Ahwahnee meadow data in summary graphics with the other meadows due to insufficient sample size from time constraints (N=10). Ahwahnee meadow information is located in the site descriptions (Appendix E.)

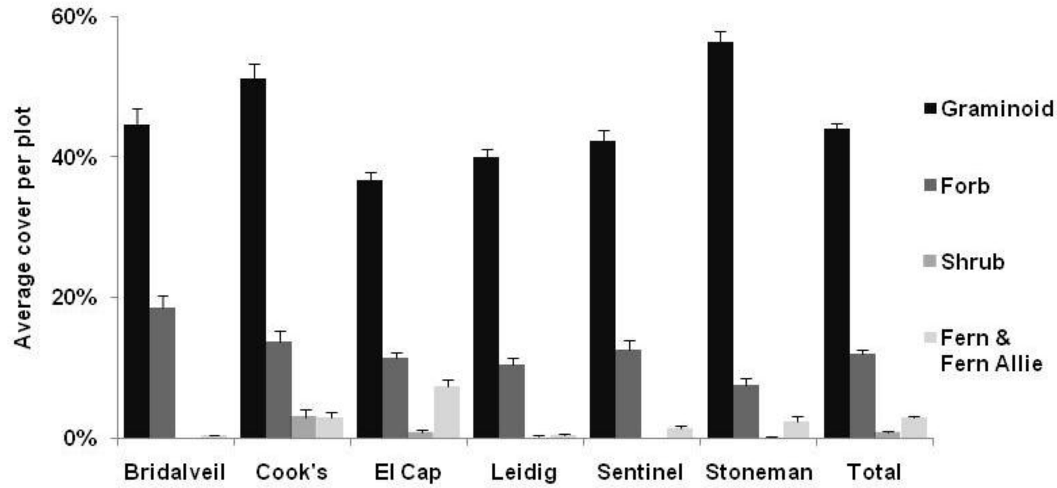

Figure 3. Mean cover of life forms (excluding tree seedlings) in Yosemite Valley meadows with error bars showing standard error.

We summarized tree seedling data by the proportion of plots with seedlings present, to estimate the extent of recent tree encroachment in meadows (Figure 4). El Capitan and Stoneman meadows had the highest proportion of plots with seedlings present (32%). Leidig had no seedlings in plots, and Sentinel had only 2%. Tree seedling occurrence was patchy in Yosemite Valley meadows, in that plots with any seedlings usually had at least 2-3 seedlings per plot, and these plots usually occurred near meadow edges. Seedling species most common were *Pinus ponderosa* (ponderosa pine) or *Quercus kellogii* (California black oak), with a few seedlings of *Calocedrus decurrens* (incense cedar).

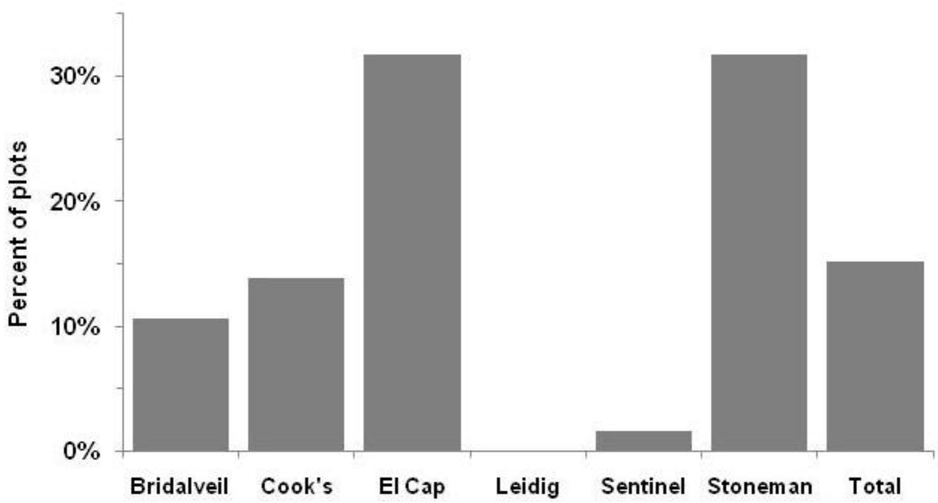

Figure 4. Tree seedling presence in Yosemite Valley meadows.

A total of 41 plant communities were documented in Yosemite Valley gridpoint plots. *Carex* (sedge) communities were most prevalent, with 44% of plots across all meadows characterized as a sedge community (Figure 5). The most common sedge in many meadows was *Carex senta* (rough sedge), although *Carex lanuginosa* (wooly sedge) was also very common, especially in its vegetative form, making it difficult to identify with confidence. Communities of these two sedges were particularly abundant in Bridalveil and Cook's meadows, where they characterized 57% and 69% of plots, respectively. *Leymus triticoides* (beardless wildrye) and the non-native *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) were the most common grasses, characterizing communities in 14% and 20% of plots across all meadows, respectively. *Leymus triticoides* was most abundant in Sentinel meadow, where it dominated 41% of plots. *Poa pratensis* ssp. *pratensis* was most abundant in El Capitan and Stoneman Meadows, where it dominated 35% and 37% of plots, respectively. A complete listing of plant communities and their relative abundance across each meadow is located in Appendix B.

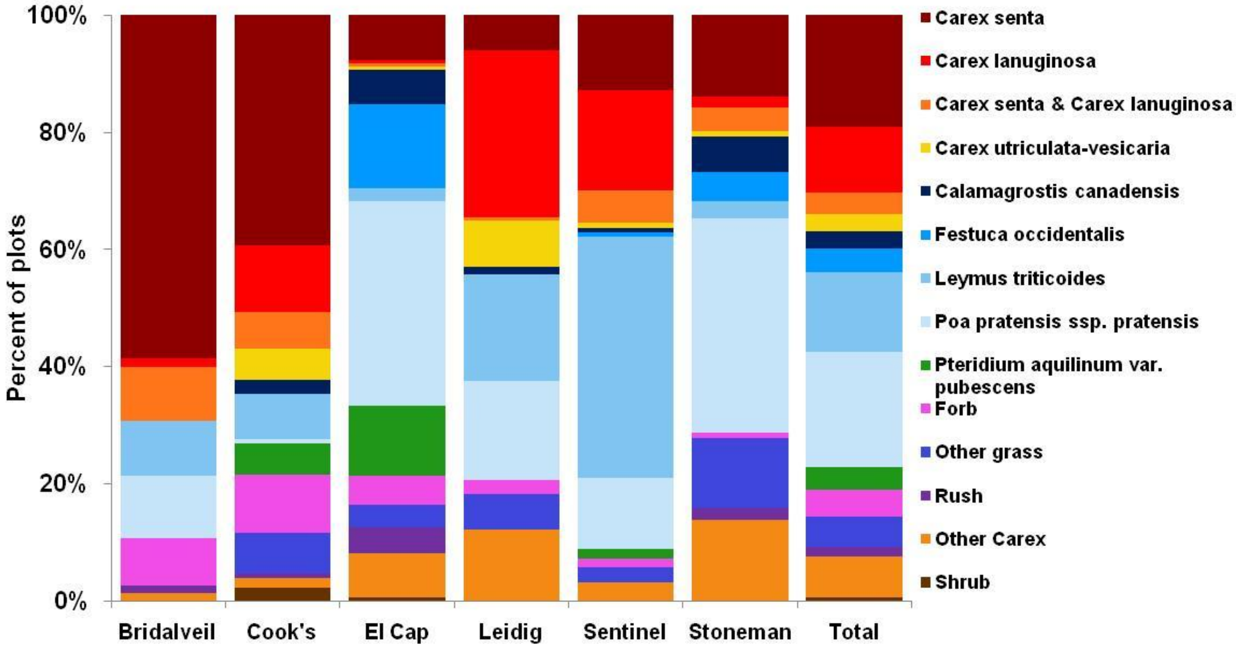

Figure 5. Vegetation communities in Yosemite Valley Meadows. Values are proportion of 100% total vegetation in each community. Communities with fewer than 20 plots across all meadows were combined according to life form (Forb, Grass, Rush, *Carex* (sedge), or Shrub). *Poa pratensis* is non-native.

Gridpoint plot data captured the presence of 170 plant species across Yosemite Valley meadows. Because we documented only dominant, common, and up to three non-native species in plots, these data do not represent a comprehensive species survey of Yosemite Valley meadows. However, they do supply some information on the heterogeneity of dominant species composition. Bridalveil meadow had the lowest number of species documented in plots (43) while Cook's had the highest (85). A species list for each meadow is located in Appendix C.

Non-native species were present in all Yosemite Valley meadows (Table 8). Of the 170 species documented in gridpoint plots, 39 were non-native species. Extent of meadow area with non-native species present can be inferred from Table 8, as well as the prevalence of more dense infestations (plots with greater than 25%, greater than 50%, and greater than 75% cover of non-natives). El Capitan meadow had the highest extent of non-native species with 96% of plots containing non-natives. Bridalveil and Cook's had the lowest proportion of plots with non-natives with 51% and 60% respectively, although Cook's had a relatively high proportion of plots with dense infestations, with 15% of plots having greater than 25% cover of non-native vegetation. Stoneman had the highest proportion of plots with dense non-native cover; 40% of plots had 25% or more cover of non-natives.

Table 8. Percent of plots with non-native plants present, more than 25% non-native plant cover (>25%), more than 50% non-native plant cover (>50%), and more than 75% non-native plant cover (>75%) in Yosemite Valley meadows.

	Present	>25% cover	>50% cover	>75%cover
Bridalveil	51%	0%	0%	0%
Cook's	60%	9%	5%	1%
El Capitan	96%	11%	1%	0%
Leidig	80%	11%	2%	0%
Sentinel	90%	10%	2%	0%
Stoneman	92%	29%	7%	4%
Total	81%	12%	2%	1%

Poa pratensis ssp. *pratensis* is the most common non-native species in Yosemite Valley meadows. It was present in 67% of plots across all meadows, and was most common in El Capitan meadow, where it was present in 91% of plots. Because early Anglo settlers seeded *Poa pratensis* ssp. *pratensis* in Yosemite Valley meadows (Gibbons and Heady 1964), we investigated the prevalence of *Poa pratensis* ssp. *pratensis* compared to other non-native species in each meadow (Figure 6). In general, *Poa pratensis* ssp. *pratensis* was the most common non-native species present across all meadows, although Cook's meadow had a higher proportion of plots with other non-native species present. Detailed information on the composition and abundance of non-native species in each meadow can be found in the site descriptions, Appendix E.

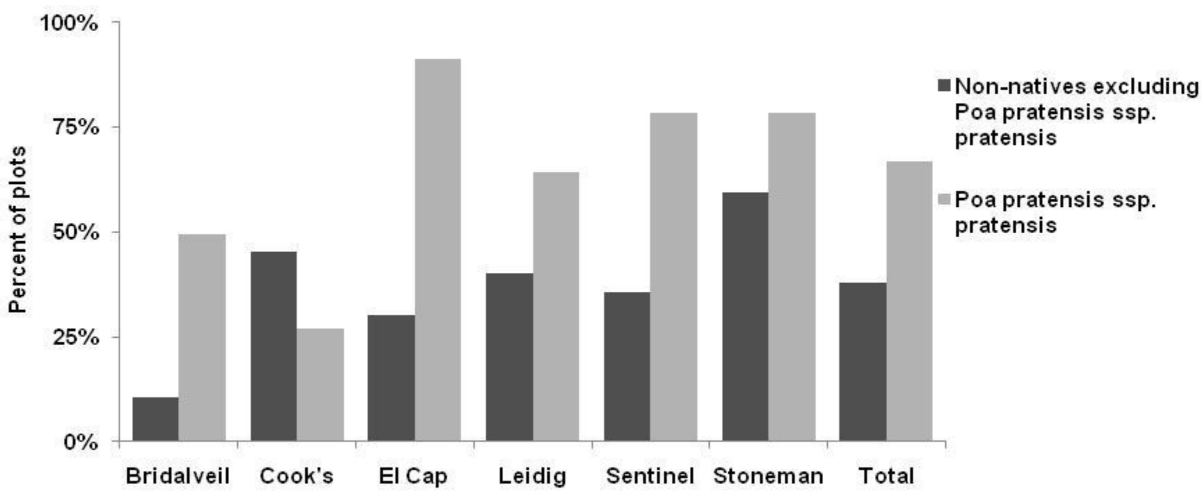

Figure 6. Percent of plots with non-native species other than *Poa pratensis ssp. pratensis* vs. proportion of plots with *Poa pratensis* ssp. *pratensis*.

We compared mean cover of non-native plants across all meadows for plots of different surface soil moisture categories collected in June (Figure 7). Non-native plant cover was lowest in saturated and inundated plots. Dry and moist plots had two to three times the cover of non-native plants as plots with early-season saturated or inundated soils.

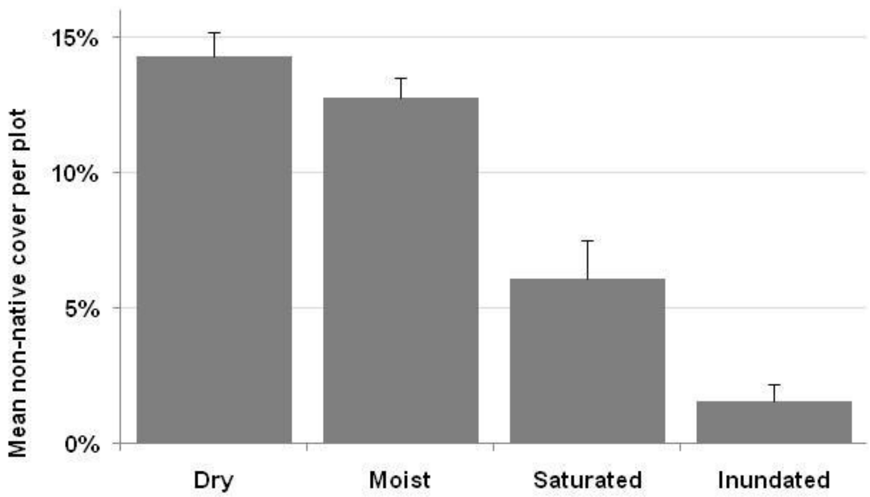

Figure 7. Mean non-native vegetation cover in Yosemite Valley for four surface soil moisture categories. Standard error is displayed with each bar.

One Yosemite special status plant species (rare plant) was observed in gridpoint plots. This rare sedge, *Carex buxbaumii* (Buxbaum's sedge) was found in four of the meadows (Ahwahnee, Cook's, El Capitan, and Stoneman) in a total of 11 plots. Colwell and Taylor (2011, unpublished report) presents more detailed information on special status plants found in Valley meadows and near developed areas in Yosemite Valley.

Across all Yosemite Valley meadows, at least 50% of plots were wetland (Figure 8). Leidig, Sentinel, and Cook's meadows had the highest proportion of wetland plots (84-86%). Stoneman and El Capitan meadows had the lowest proportion of wetland plots with 52% and 50% respectively, and therefore the greatest extent of area classified as upland (41% and 49%)[12].

[12] Wetland and upland percentages are not inverses of one another due to presence of plots in data set classified as undetermined.

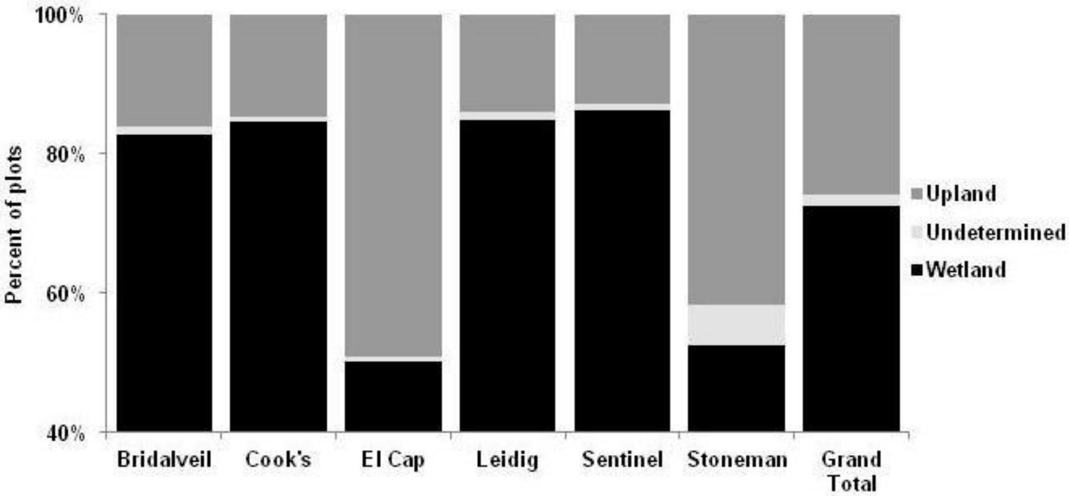

Figure 8. Proportion of plots classified as wetland for Yosemite Valley meadows. "Undetermined" indicates plots where half or more of the dominant species lacked information for wetland indicator rating.

Substrate and Bare Ground

Mean cover of bare ground in Yosemite Valley meadow plots ranged from 2-13% (Figure 9), with Bridalveil having the lowest mean bare ground (2%) and Cook's and Leidig having the highest mean bare ground (13%).

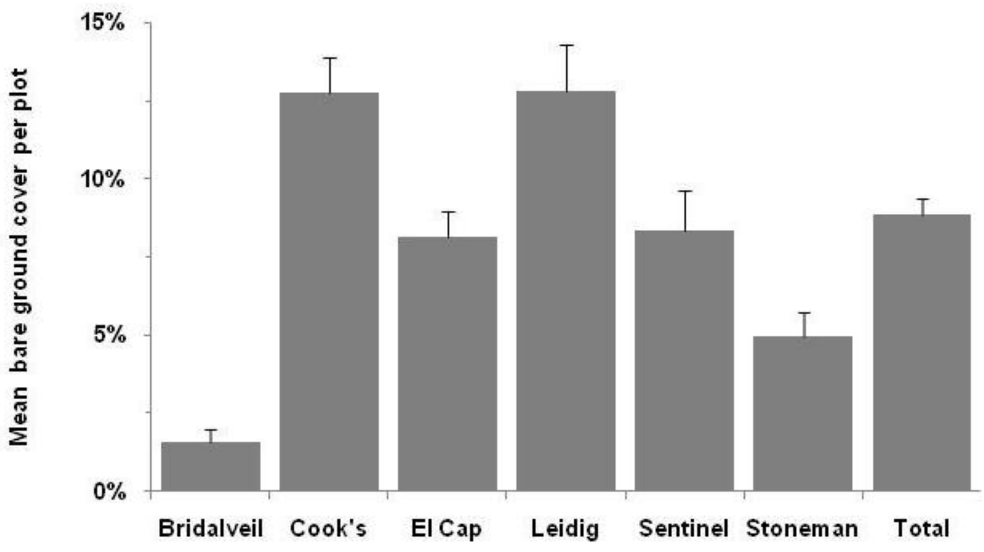

Figure 9. Mean bare ground cover in Yosemite Valley meadows with error bars showing standard error.

We also summarized bare ground in terms of the proportion of plots with high levels of bare ground (Figure 10). Bridalveil and Stoneman have the lowest proportion of plots with >16% cover of bare ground, whereas Cook's and Leidig have the highest. However, Leidig has the highest proportion of plots with >35% cover of bare ground and Cook's has more plots in the 16-25% bare ground category.

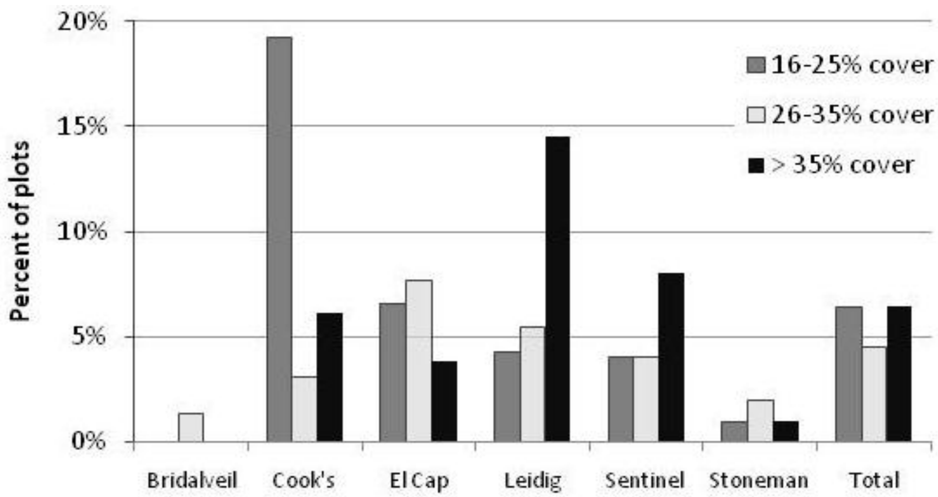

Figure 10. Proportion of plots with high bare ground cover in Yosemite Valley meadows.

The most common type of bare ground recorded was "undisturbed," which was found in 56-80% of plots across all meadows (Table 9). Small mammal burrowing was the second most common type, with the highest levels recorded in 66% of plots in El Capitan and 37% of plots in Stoneman. Bare ground from small mammal burrowing was least common in meadows with the highest extent of wetland plots (Bridalveil and Cook's meadows). Bare ground from ephemeral ponds was present in 10% of plots across all meadows, and was highest in meadows with old oxbow river channels and standing water at the time of survey (Cook's and Leidig). Bare ground from informal trails ranged from 1-14% of plots across all meadows, with the highest levels found in El Capitan (14%), Sentinel (8%), and Bridalveil (7%). Cook's and Stoneman (meadows with boardwalks) had the lowest levels of bare ground from informal trails (1%).

Table 9. Bare ground types in Yosemite Valley meadows. Values are the proportion of plots per meadow with each bare ground type. Up to two bare ground types were listed per plot. "Total" is proportion of plots across all meadows.

	Bridalveil	Cook's	El Capitan	Leidig	Sentinel	Stoneman	Total
Undisturbed	56%	69%	77%	65%	78%	80%	72%
Compacted Soil		1%	1%	3%	1%		1%
Deer prints			1%	2%		2%	1%
Ephemeral pond	1%	24%	3%	16%	3%	8%	10%
Erosion			1%	3%	10%		2%
Footprints		1%	2%	1%			1%
Other		2%	2%	1%	1%	1%	1%
Sediment deposition			2%	2%	4%		2%
Small mammals	4%	6%	66%	26%	14%	37%	29%
Informal trails	7%	1%	14%	6%	8%	1%	7%

Mean litter cover per plot ranged from 32-63%, with a mean of 53% across all Yosemite Valley meadows (Figure 11). Sentinel, Leidig, El Capitan, and Bridalveil had similarly high mean cover of litter (56-63%), whereas Cook's had the lowest mean litter cover in this group (32%).

Moss cover data was not summarized because moss cover was extremely low in Valley Meadows. The mean value for moss cover across all Valley meadows was 0.2% per plot.

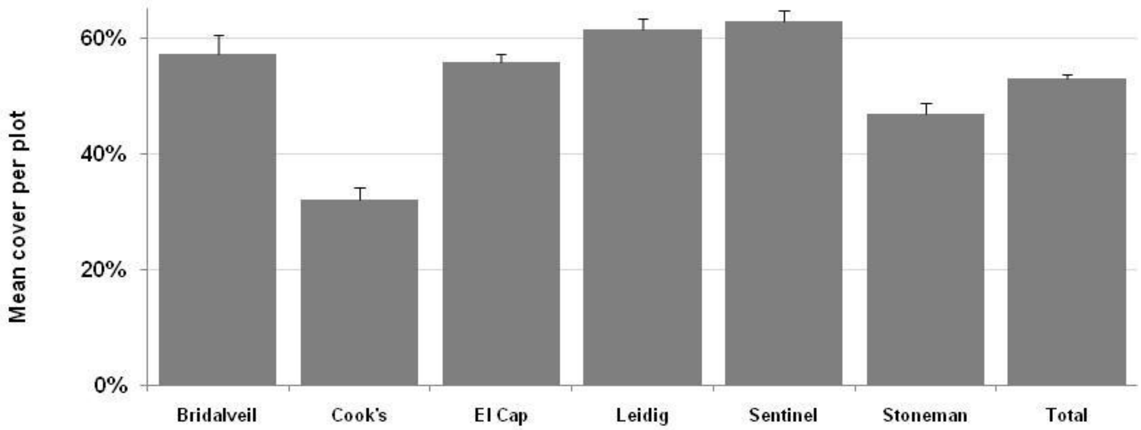

Figure 11. Mean litter cover in Yosemite Valley meadows with error bars showing standard error.

Disturbance features

Ground disturbance from small mammal burrowing was highest in El Capitan meadow, where 59% of plots contained burrowing evidence (Figure 12). Bridalveil and Cook's had the lowest extent of burrowing (5% and 6% of plots with small mammal burrows). Most plots with small mammal burrows had only trace amounts; very few plots had greater than 25% cover of small mammal burrowing per plot.

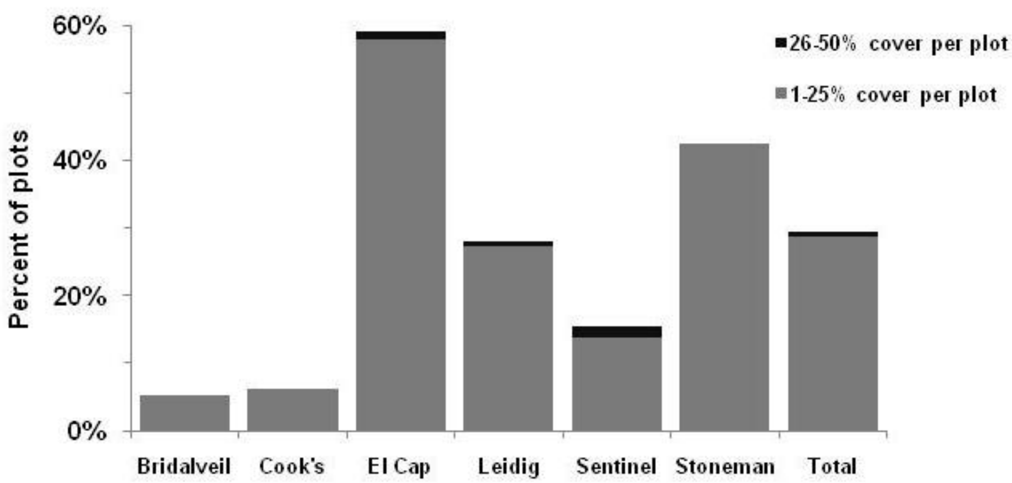

Figure 12. Proportion of plots with small mammal burrowing activity in Yosemite Valley meadows.

Extent of informal trails can be inferred by comparing the proportion of plots containing trails in each meadow (Figure 13). El Capitan had the highest extent of trailing (19% of plots), and Sentinel and Bridalveil had slightly less trailing (16% and 15% of plots, respectively). Stoneman and Cook's had the lowest extent of informal trails (3% and 5% of plots, respectively). Detailed information on the extent of informal trails in Yosemite Valley meadows can be found in Newburger et al. (2011, unpublished report).

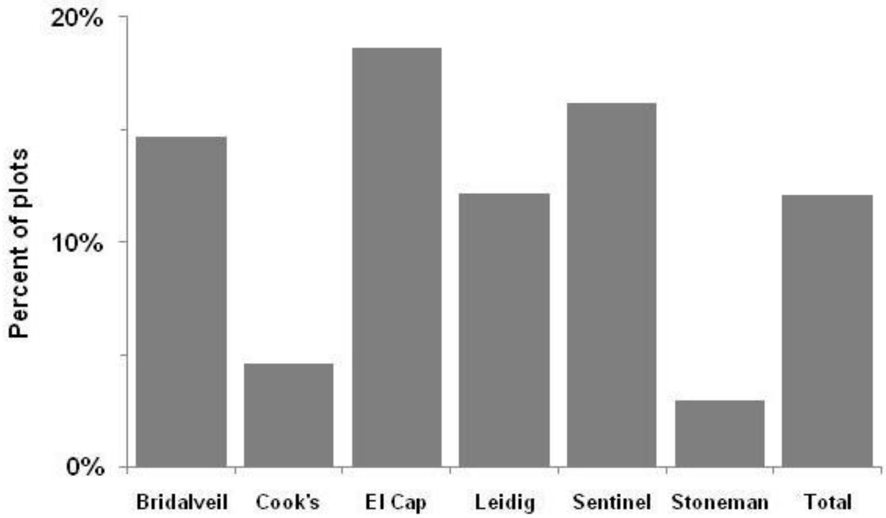

Figure 13. Proportion of plots with informal trails present in Yosemite Valley meadows.

Subalpine Meadows

We collected 462 full gridpoint plots in 14 subalpine meadows, with an additional 53 plots where only plant association was recorded. We conducted MIM (Multiple Indicator Monitoring of streams) in subalpine meadows with streams that fit the criteria for the MIM protocol (5 of 13 sites). We excluded Echo Valley from summary graphics due lack of meadow area and insufficient sample size (6 plots were collected in one small meadow area, but most of Echo Valley is thick with deadfall and resprouting with sapling pines after a severe fire killed most of the large trees in 1988). At Little Yosemite Valley- West, we only collected plant community information from most plots because the site had large inundated areas at the time of our visit. We excluded Little Yosemite Valley- West from all summary graphics except for those pertaining to plant communities. Information from Echo Valley and Little Yosemite Valley- West is located in the site descriptions of Appendix E.

Vegetation and Wetlands

Mean vegetation cover ranged from 32-60% in subalpine meadows (Figure 14), and mean vegetation cover across all subalpine meadows was 52%. Merced Lake- East had the lowest mean vegetation cover of all subalpine meadows surveyed (32%), and Little Yosemite Valley- East had the second lowest (42%). Red Peak- South and Triple Peak- North had the highest mean vegetation cover per plot (60% and 58%, respectively).

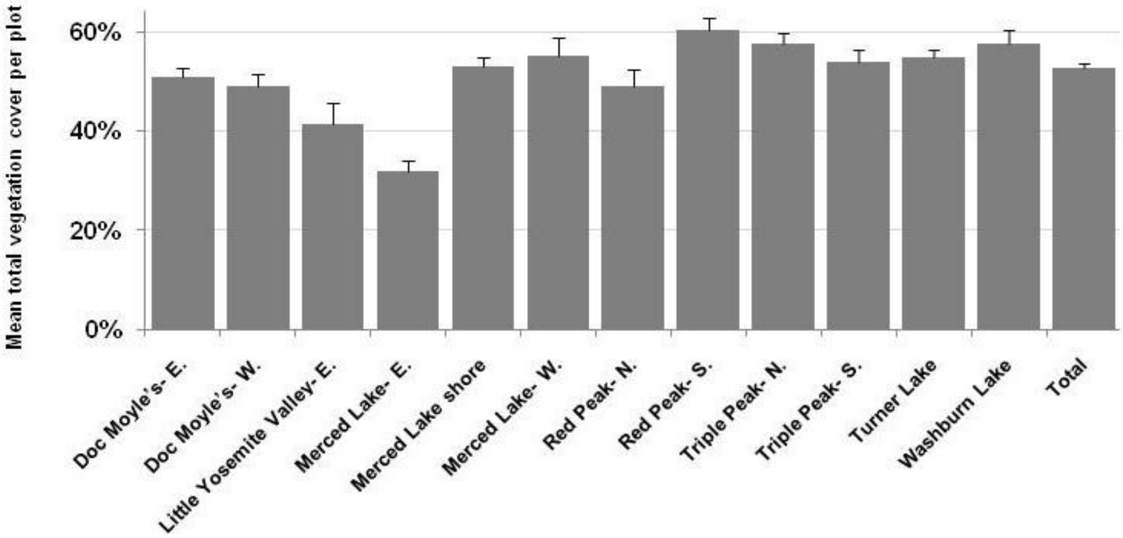

Figure 14. Mean total vegetation cover subalpine meadows with error bars showing standard error.

Graminoids dominated the vegetation across all subalpine meadows (Figure 15), although meadows in the Red Peak Fork and Triple Peak Fork (including Turner Lake) had a relatively high proportion of subshrubs (mainly *Vaccinium caespitosum,* dwarf bilberry). Meadows in these two forks also had a higher proportion of forbs than the other subalpine meadows surveyed. Shrubs were absent from nearly all plots, although patches of tall willow communities were noted in some subalpine meadows surveyed (especially Merced Lake- Shore, Red Peak- South and Washburn Lake).

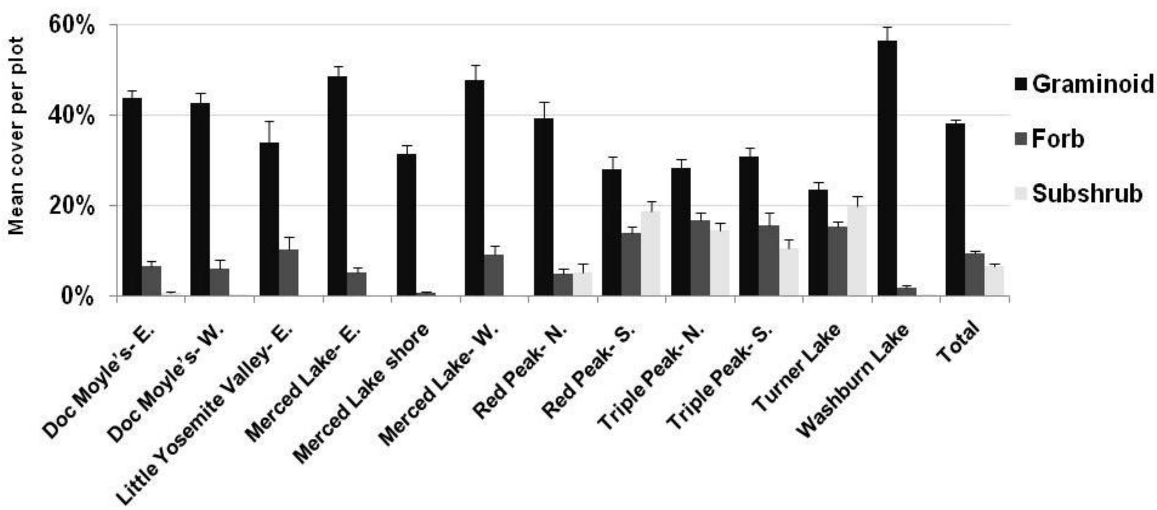

Figure 15. Mean cover of life forms in subalpine meadows (excluding tree seedlings) with error bars showing standard error. Shrubs were nearly absent from plots across all meadows, so they were omitted in this summary graph.

Extent of conifer seedlings (e.g. conifer encroachment) varied widely across subalpine meadows (Figure 16), from no seedlings present in any plots (Merced Lake- East and Little Yosemite Valley- East) to 45% of plots containing seedlings (Turner Lake and Triple Peak- North). Red Peak South also had high conifer encroachment relative to other subalpine sites (37% of plots with seedlings).

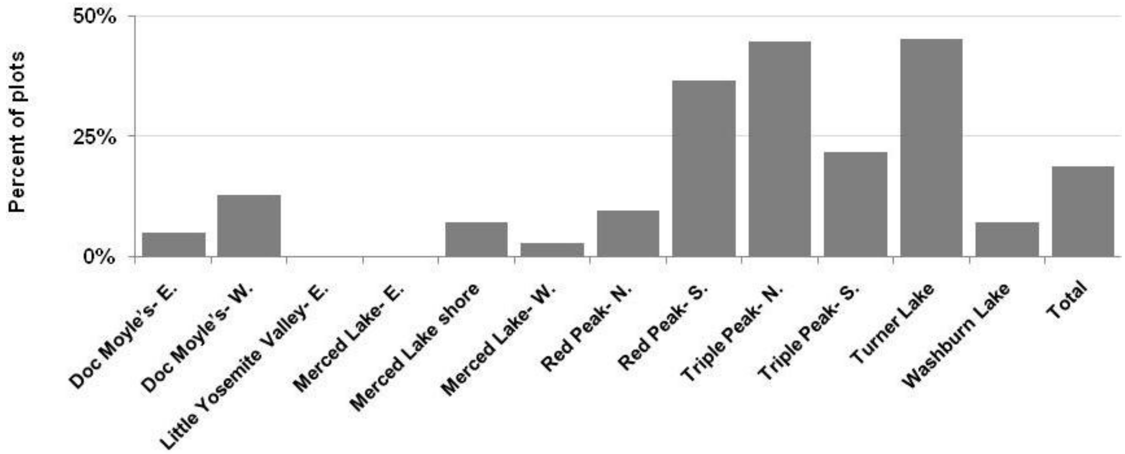

Figure 16. Conifer seedling presence in subalpine meadows. Values are percent of plots with seedlings present.

A total of 41 plant communities were documented in gridpoint plots across all subalpine meadows surveyed. Communities of the species *Carex utriculata-vesicaria*[13] (bladder sedge) dominated most meadows, comprising 32% of communities across all meadows (Figure 17). Some meadows were near-monocultures of this community (Merced Lake-East, Merced Lake-West, and Little Yosemite Valley- West). Subshrub communities of *Vaccinium caespitosum* (dwarf bilberry) and *Kalmia polifolia* (alpine laurel) were more prevalent in Red Peak and Triple Peak Fork meadows (including Turner Lake.)

[13] *Carex utriculata* and *Carex vesicaria* are difficult to distinguish in the field during some life stages, and are functionally similar as they are obligate wetland species that usually grow in inundated areas and form dense-rooted mats. We did not distinguish these two species data collection.

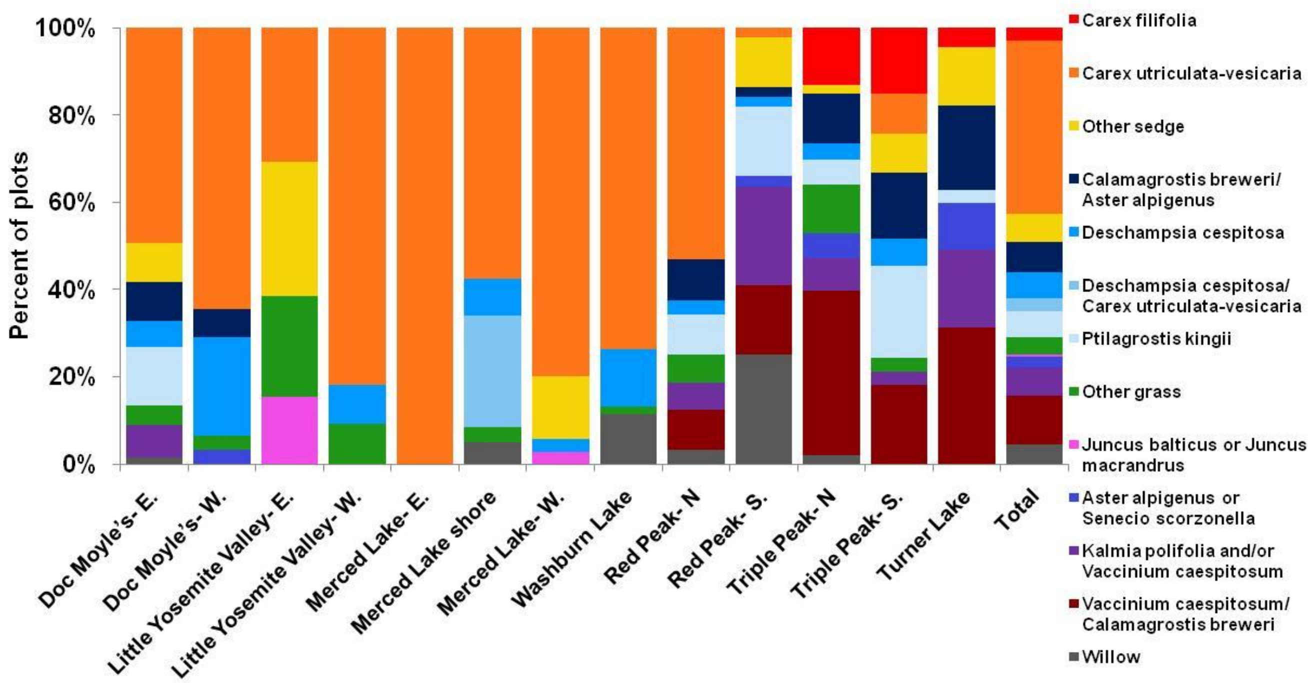

Figure 17. Vegetation communities in subalpine meadows. Values represented are proportion 100% vegetation in each plant community. Communities with fewer than 13 plots across all meadows were combined according to life form (sedge, grass, and willow).

We documented 111 plant species in subalpine meadow gridpoint plots. Because we only recorded up to 6 dominant and common species in plots, these data do not represent a comprehensive species survey for these meadows. However, they do supply some information on the heterogeneity of species composition for dominant species. Turner Lake had most species documented in gridpoint plots (34), whereas Merced Lake- East had the least (3). Other Merced Lake meadows had more species recorded in plots: 19 species at Merced Lake- West and 21 species at Merced Lake- shore. A species list for each subalpine meadow is located in Appendix C.

Non-native species were nearly absent from subalpine meadows, with a few exceptions. *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) was common in the drier areas of Little Yosemite Valley- East, and one *Taraxacum officinale* (dandelion) plant was found at Washburn Lake. We mapped isolated *Cirsium vulgare* (bull thistle) plants in the wooded area outside Merced Lake- East meadow, and scattered throughout Echo Valley (see site maps in Appendix F). Yosemite wilderness restoration crews mapped other non-native species in Little Yosemite Valley and Echo Valley outside the meadows (see site descriptions in Appendix F). No non-native species were observed in any meadows in the Merced River corridor above Washburn Lake. The special status (rare) sedge *Carex fissuricola* (cleft sedge) was common in three subalpine meadows (Doc Moyle's- East, Red Peak- South, and Triple Peak- North).

Wetland area was extensive in subalpine meadows, as indicated by plot vegetation (Figure 18). Four meadows had 100% of plots classified as wetland, and at least 78% of plots across all subalpine meadows were wetland. The lowest proportion of wetland plots was in Triple Peak-

South (78%), where 7 of 32 plots were classified as upland. Triple Peak-North had the second lowest proportion of wetland plots (87%), since 6 of the 47 plots were classified as upland.

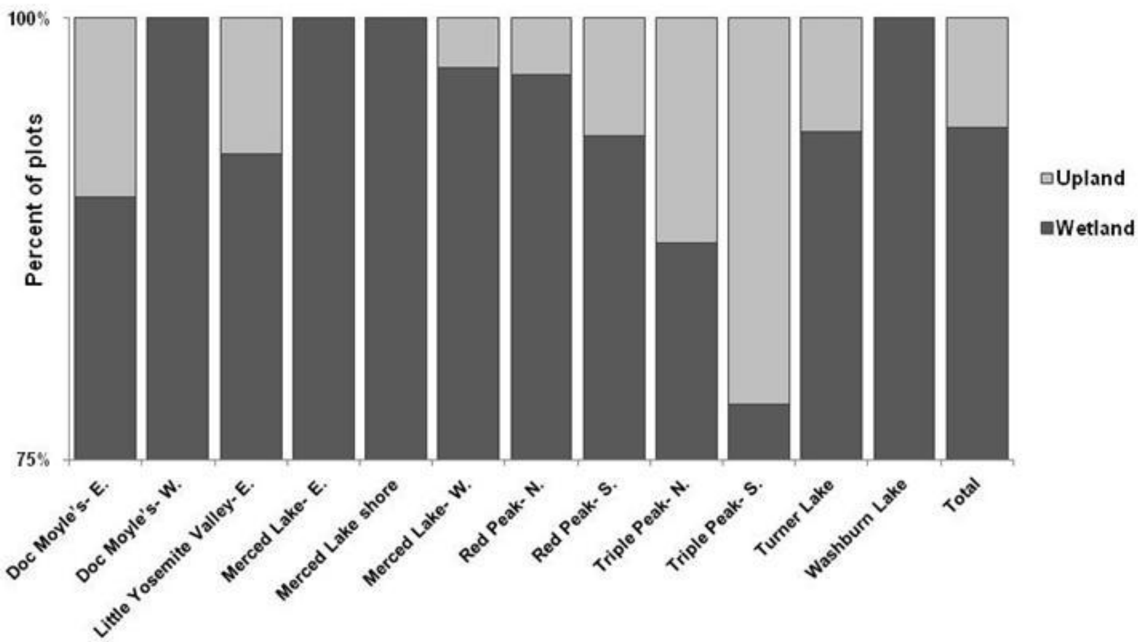

Figure 18. Proportion of plots classified as wetland for subalpine meadows.

Substrate and Bare Ground

Mean cover of bare ground was 11% across subalpine meadows surveyed (Figure 19). Merced Lake-East had the highest mean bare ground (30%), followed by Little Yosemite Valley- East (22%). Merced Lake- West had the lowest bare ground (2%), followed by Red Peak- South (4%) and Merced Lake shore (6%).

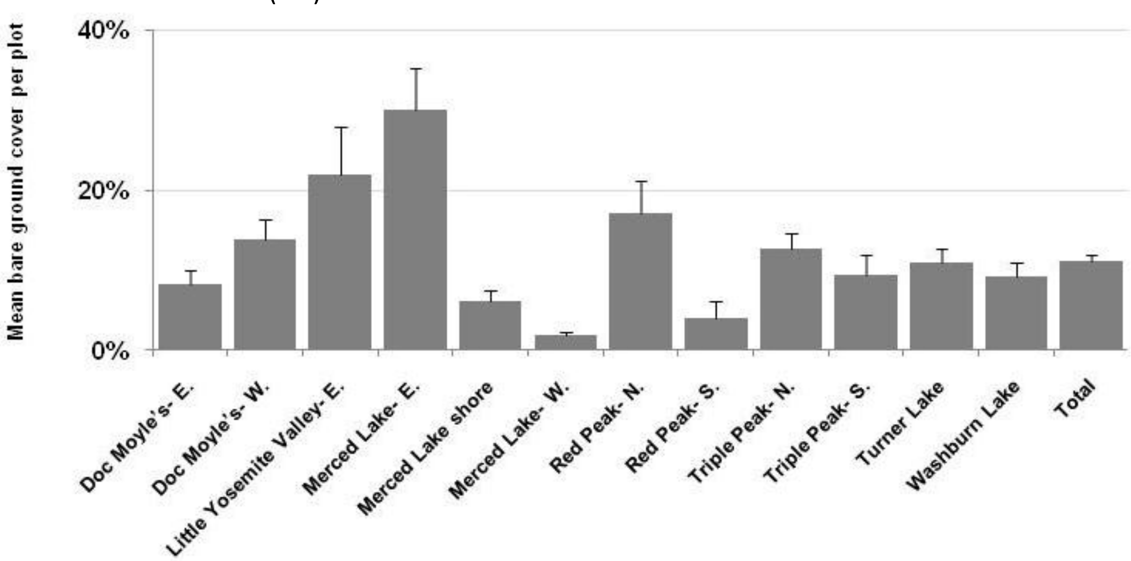

Figure 19. Mean bare ground cover in subalpine meadows with error bars showing standard error.

We also summarized bare ground in terms of the proportion of plots with high levels of bare ground (Figure 20). Merced Lake- West and Red Peak- South had very few plots with high bare ground cover. In contrast, Merced Lake- East had the highest proportion of plots with greater than 35% cover of bare ground, and 73% of plots with greater than 16% cover of bare ground.

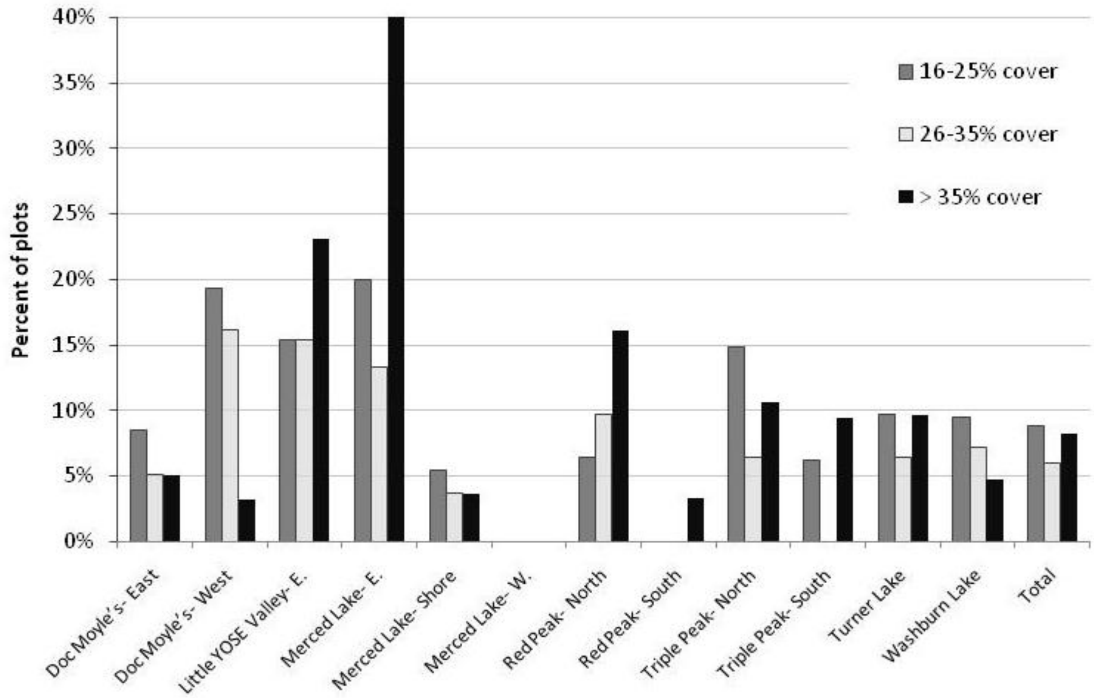

Figure 20. Proportion of plots with high bare ground cover in subalpine meadows.

Litter cover averaged 52% across subalpine meadows surveyed (Figure 21). Doc Moyle's- West and Merced Lake- East had the highest mean litter values (61% and 60%) and Triple Peak- south and Doc Moyle's- East had the lowest values (40% and 43%).

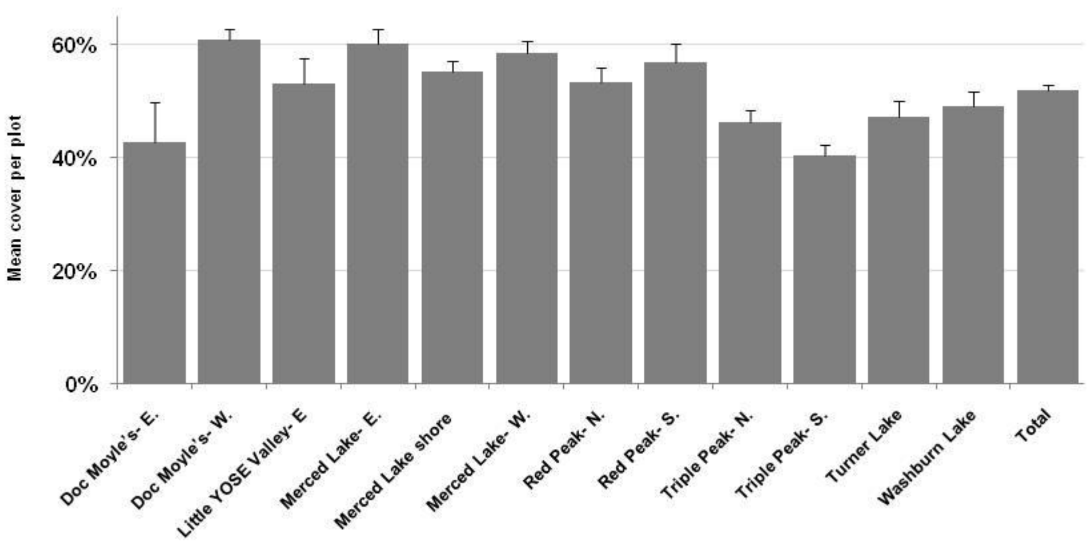

Figure 21. Mean litter cover in subalpine meadows with error bars showing standard error**.**

Mean moss cover varied from 1-5% across subalpine meadows (Figure 22). Little Yosemite Valley-East, Red Peak- North, and Turner Lake averaged 1% cover of moss and Washburn Lake and Triple Peak- North averaged 5%.

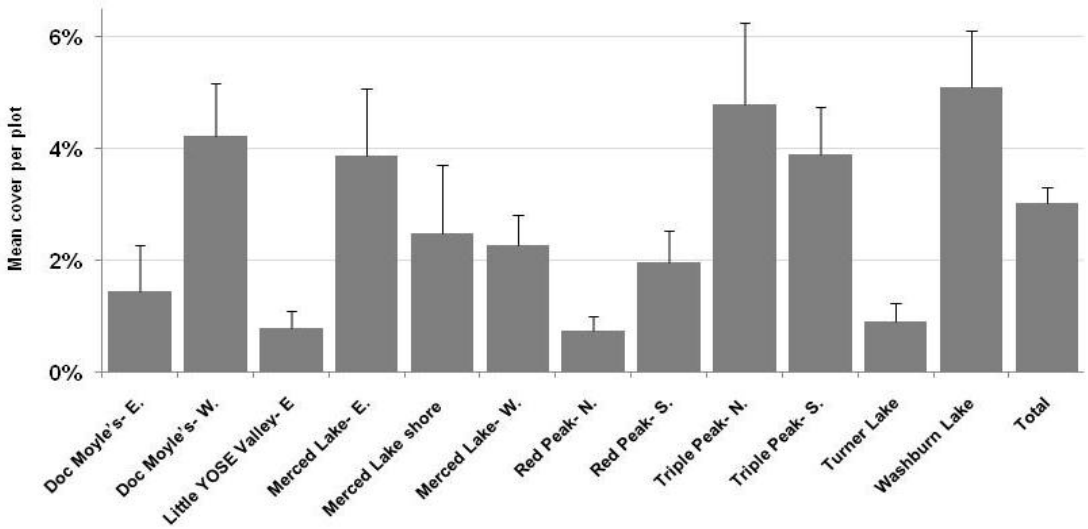

Figure 22. Mean moss cover in subalpine meadows with error bars showing standard error**.**

Disturbance Features

Small mammal burrowing activity was most extensive at Triple Peak- South, where 38% of plots contained small mammal burrows or tailings (Figure 23). Turner Lake and Triple Peak- North also had high extent of burrow evidence (26-27%) relative to the rest of subalpine meadows. Four of the subalpine meadows had no evidence of small mammal burrows in gridpoint plots. Nearly all plots with burrowing evidence had only trace amounts, except for two plots at Triple Peak- South with 15-25% burrow cover and two plots at Turner Lake with 6-10% burrow cover.

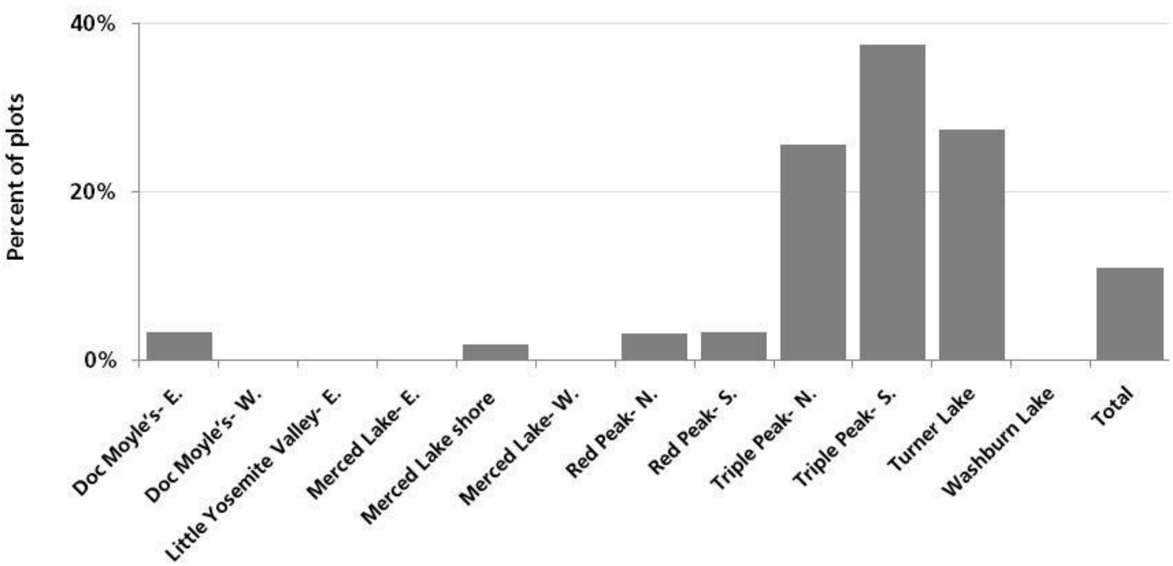

Figure 23. Small mammal burrowing evidence in subalpine meadows.

Informal trails were not present in any subalpine gridpoint plots, and most subalpine meadows did not have informal trailing or areas mapped as bare ground (Table 10). Merced Lake- Shore had the most informal trails, with approximately 1.6 km of trails mapped. Bare ground was greatest at Washburn Lake, where nearly 3% of the meadow was mapped as bare. Merced Lake- Shore had nearly 1% of bare ground mapped in the meadow, and the rest of the sites had either no bare ground, or bare ground was unable to be mapped due to site inundation at the time of data collection (Little Yosemite Valley- West and Merced Lake- East.)

Table 10. Informal trails and bare ground areas in subalpine meadows, including informal trails within 50m of each meadow. Bare ground from informal trails was not included in mapped bare areas. "*"indicates site was largely inundated at time of survey, so detection of informal trails or bare ground areas may not have been possible.

Meadow Name	Informal trails (total length in meters)	Trails per meadow area (m/ m^2)	Bare area mapped(m^2)	%Meadow mapped as bare
Doc Moyle's- West	205.8	<0.001		
Doc Moyle's- East	60.6	<0.001	33.8	<.001%
Little YOSE Valley- W*				
Little YOSE Valley- E				
Merced Lake- Shore	1637.5	0.10	278.6	0.8%
Merced Lake- West				
Merced Lake- East*	144.0	0.02		
Red Peak- North				
Red Peak- South				
Triple Peak- North				
Triple Peak- South				
Turner Lake			57.6	0.1%
Washburn Lake	144.2	0.005	796.9	2.8%

Gridpoint plot data indicates that pack stock impacts were absent or uncommon in most subalpine meadows with the exception of Merced Lake- East, which had 76% of plots with impacts (Figure 24). The impacts observed in Merced Lake - East plots were nearly all hoofpunching and grazed vegetation. Doc Moyle's- West had the second highest levels of impacts, also mainly hoofpunching and grazed vegetation (27% of plots). Scattered hoofpunches were found in 5% of plots at Washburn Lake and Merced Lake- shore, and in 3% of plots at Doc Moyle's- east. A few scattered manure piles occurred in plots at Turner Lake, Washburn Lake, Doc Moyle's- West, and Triple Peak- South.

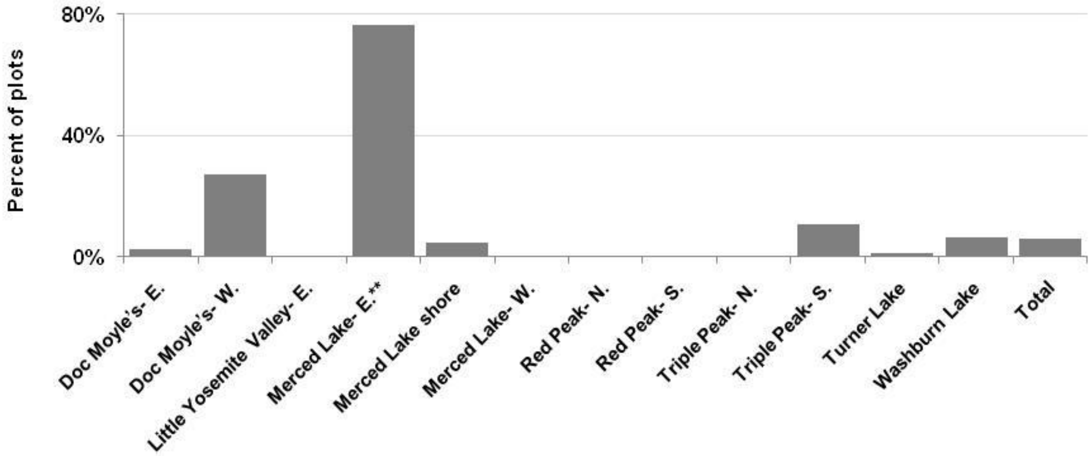

Figure 24. Stock impacts in gridpoint plots in subalpine meadows. **Merced Lake- East was revisited in September 2010 and 100% of the meadow contained stock impacts at that time.

Table 11 summarizes stock impacts mapped outside gridpoint plots. All categories of impacts were present at Merced Lake- East, as well as the greatest areas of trampling and grazed vegetation. The data presented for Merced Lake-East are from the early-season survey (July 10th) When this meadow was revisited in September, 100% of the meadow area was trampled and grazed. Doc Moyle's- West had the second-highest amounts of pack stock impact overall, and impacts that appeared to be from recent use. The adjoining meadow (Doc Moyle's- East) had only a few dried manure piles which appeared to be from previous years. Most of the manure mapped at Washburn Lake was near the stock camp on the meadow boundary, and it all appeared old.

Table 11. Stock impacts mapped outside gridpoint plots in subalpine meadows, including features mapped within 50m outside meadow boundary. "*" indicates meadows that were inundated at the time of sampling, making impact features more difficult to detect.

Meadow Name	Trampled area (m2)	Hoofpunch points	Grazed area (m2)	Grazed points	Manure points	Roll pits
Doc Moyle's- West	478	21	60	8	19	
Doc Moyle's- East					3	
Little YOSE Valley- W*						
Little YOSE Valley- E						
Merced Lake- Shore		3				
Merced Lake- West						
Merced Lake- East*	5075	2	666	2	86	1
Red Peak- North						
Red Peak- South						
Triple Peak- North						
Triple Peak- South						
Turner Lake					1	
Washburn Lake		3			23	

Stream Assessments (subalpine meadows)

General condition metrics (Table 12) show excellent overall ecological conditions as calculated by the analysis spreadsheet from Burton et al. (2011). Excessive bank erosion and heavy trampling were documented at few sites and the most severely eroded areas were usually concentrated at stream crossings. Streambank vegetation was mainly mesic and hydric and exhibited high biodiversity and rooting strength.

Ecological succession of plant species is at or near climax (potential natural community), suggesting that recent ecological disturbances have been minimal. Vegetation biomass and plant diversity indices were all very high. Wetland condition ratings were high to very high. Winward stability ratings were high at all but one site, indicating lower rooting strength of greenline vegetation at Doc Moyle's-West.

Table 12. General condition metrics calculated from MIM data for subalpine streams. See Data Analysis section for explanation of condition ratings (PNC, low, mid, high, very high).

Site Name	Ecological Status Rating	Wetland Rating	Winward Stability Rating	Vegetation Biomass Index	Plant Diversity Index
Doc Moyle's- West	99 (PNC)	84 (High)	6.36 (Mid)	71 (Very High)	7.1 (Very High)
Triple Peak- South	99 (PNC)	93 (Very High)	7.02 (High)	70 (Very High)	8.1 (Very High)
Turner Lake	100 (PNC)	77 (High)	7.82 (High)	74 (Very High)	7.0 (Very High)
Red Peak- North	100 (PNC)	92 (Very High)	7.34 (High)	76 (Very High)	6.6 (Very High)

Streambank erosion for most sites was minimal, although all types of bank erosion features (slough, slump, and fracture) were present at each site. Streams at most sites had well- covered banks, and only one site had bank alteration (Doc Moyle's- West). Erosion was highest for Triple Peak-South, where 36% of the stream survey reach was actively eroding (Table 13). Headcut erosion was present at most sites but was of low to moderate severity. Most headcuts were small (1 to 2 cubic meters); the largest headcuts were at Doc Moyle's- West but were only of moderate severity.

Table 13. Geomorphological condition and erosion feature metrics from MIM stream surveys. *Headcut severity is based on length, width, and depth of headcut.

Site Name	Number of Plots	Altered (% of plots)	Covered (% of plots)	Active Erosion (%plots)	# Headcuts	Headcut Severity*
Doc Moyle's- West	82	9%	99%	12%	3	Moderate
Triple Peak- South	82	0	85%	36%	8	Low
Turner Lake	81	0	92%	10%	8	Low
Red Peak- North	80	0	93%	1%	None	None

The greenline was composed of mainly hydric species at all sites (Table 14). Woody species composed only 6-20% of stream survey reaches and were primarily rhizomatous species (Table 15). Doc Moyle's-West had both the lowest amount of woody species, and lowest proportion of rhizomatous woody species. Proportion of forb vegetation varied at each site but were generally present at less than a third of the survey plots.

Table 14. Greenline composition of streambanks from MIM stream surveys.

Site Name	Woody (% of plots)	Rhizomatous Woody (% of woody species)	Forbs (% of plots)	Hydric (% of plots)	Hydric Herbaceous (% of hydric species)
Doc Moyle's- West	6%	75%	16%	90%	84%
Triple Peak Fork- South	8%	100%	33%	86%	79%
Turner Lake	20%	100%	32%	82%	67%
Red Peak Fork- North	16%	93%	25%	75%	66%

Woody species were present at all sites but never in abundance (Table 15). Dominant woody species included willows (primarily *Salix eastwoodii* (mountain willow) and *Salix orestera* (Sierra willow), the subshrub *Vaccinium caespitosum* (dwarf bilberry)* and shrub *Vaccinium uliginosum* (Western blueberry). Most woody species provided little or no shade for the stream channel.

Table 15. Woody species data for survey sites in the Merced River Corridor.

Site Name	Woody Species Present	Plots with Woody Species	Rhizomatous Woody Species (% of Woody Species)	Age Class of Non-Rhizomatous Woody Species		Mean Woody Use	Shade Index
				Seedlings /Young	Mature		
Doc Moyle's-West	*Vaccinium uliginosum, Pinus contorta*	6%	75%	40%	0	11%	0.0
Triple Peak-South	*Kalmia polifolia, Salix eastwoodii, Salix orestera, Vaccinium caespitosum*	8%	100%	0	0	11%	0.0
Turner Lake	*Kalmia polifolia, Salix arctica Salix eastwoodii, Salix orestera, Vaccinium caespitosum*	20%	100%	0	0	10%	0.1
Red Peak-North	*Kalmia polifolia, Pinus contorta, Salix orestera, Vaccinium caespitosum, Vaccinium uliginosum*	16%	93%	67%	33%	10%	0.0

Substrate at each site varied widely ranging from very fine gravel to large cobble with incidences of large boulders at some sites (2-128 mm). Substrate was generally dominated by varying sizes of gravel (2-64mm), as shown in Figures 25a,b. Doc Moyle's-West had the highest percentage of fine substrate materials, and Red Peak-North had mainly larger cobble.

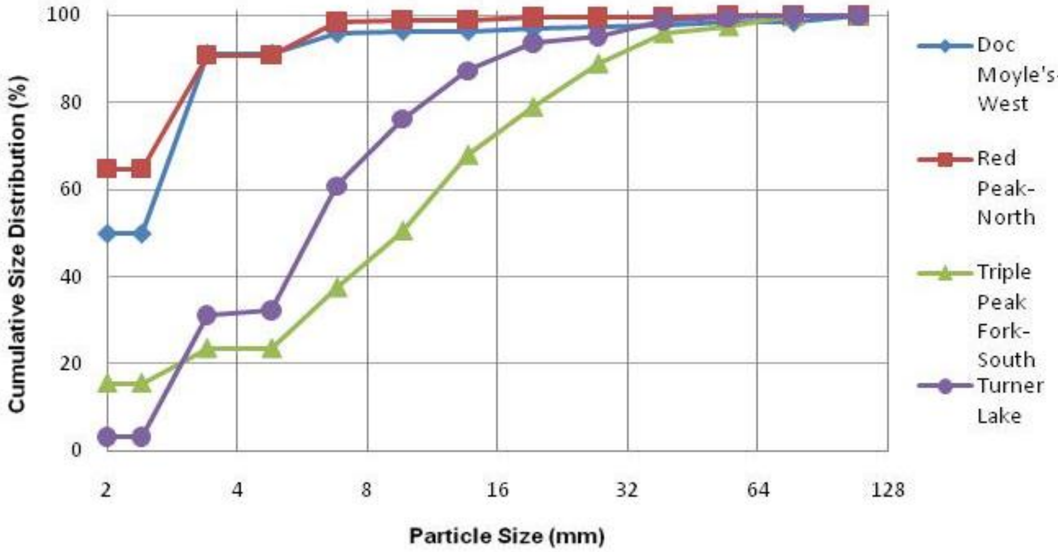

Figure 25a. Substrate particle size distributions for MIM stream survey sites.

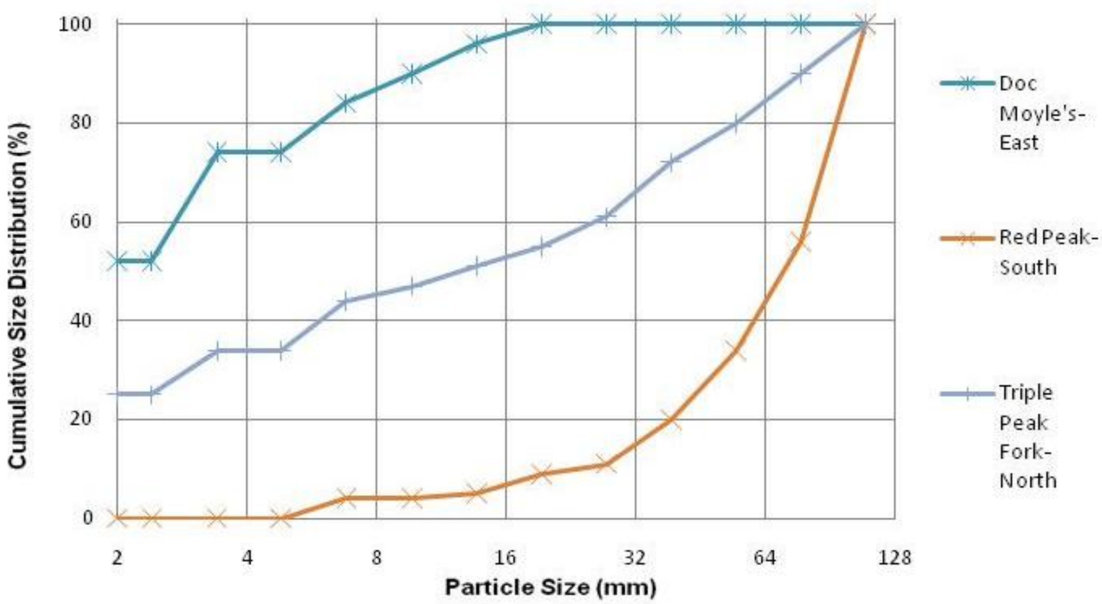

Figure 25b. Substrate particle size distributions for rapid assessment stream survey sites.

Mean stream widths at each site varied from 2 to 18 meters (Figures 26a,b). Measurements were based on a sample size of 80 for MIM surveys and 10 for rapid assessments surveys, which contributed to the wide variation in mean stream widths for rapid assessment sites. Headwater stream reaches (Red Peak and Triple Peak Forks, including Turner Lake) generally had narrower stream channels (greenline widths) and less variation in stream width measurements. Stream reaches that had larger meander bends generally showed a greater amount of variation in stream width measurements taken (Both Doc Moyle sites and Triple Peak Fork-North). Doc Moyle's-West had the widest stream channel width (18m) and the greatest amount of variation of stream width measurements for all sites surveyed. Several width measurements were above 30m at Doc Moyle's-West. We observed and recorded a measurable "sedge line" establishing below the greenline at Doc Moyle's- West. Because this sedge line was located below the scour line, it could not be considered the greenline. The presence of such a sedge line may indicate that the greenline at this site is narrowing over time (see Discussion section).

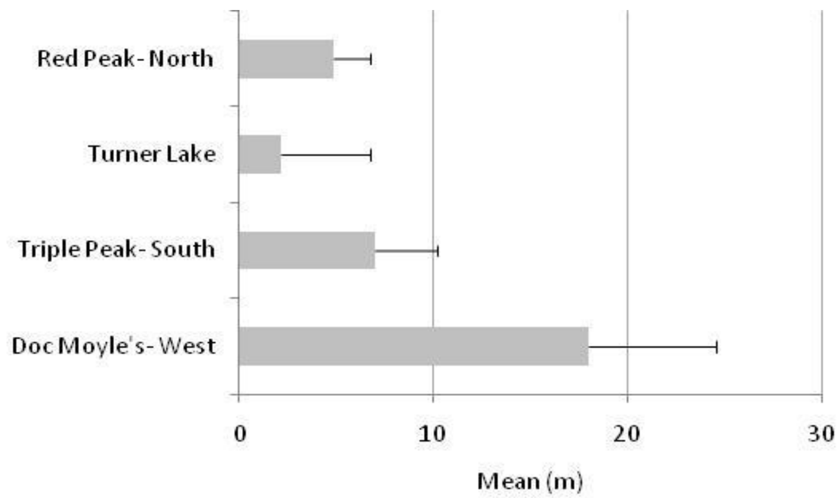

Figure 26a. Mean greenline to greenline widths for MIM stream survey sites.

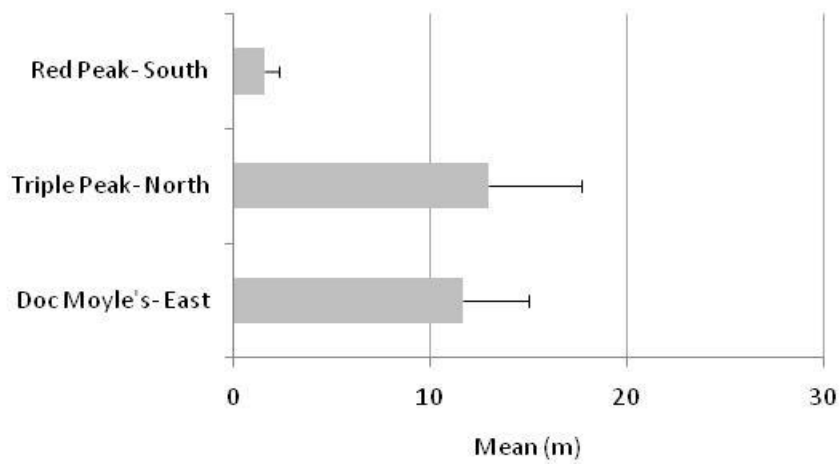

Figure 26b. Mean greenline to greenline widths for rapid assessment stream survey sites.

Alpine Meadows (Above 9,600 Feet in Elevation)

Coarse composition and vegetation

Meadows above 9,600 feet were generally steeper than their subalpine meadow counterparts, with slopes ranging up to 15-20 degrees. The mean slope across the 22 alpine meadows surveyed was 6 degrees. Alpine meadows were also rockier and appeared to have thinner soils than subalpine meadows. Total rock cover (bedrock, boulders, and gravel) averaged 14% across all alpine meadows, with the highest values in meadows M4 andT3 (Table 16). Bare ground estimates were generally low (1-5%), but 6 meadows had 10% or greater cover of bare ground (L4, L5, M2, R2, R7). Subshrub cover was higher in alpine meadows compared with subalpine meadows, with a mean value of 22% across all meadows. Trees and tree seedlings were generally a small component of alpine meadows, although meadows L3, R8, T3 and T9 had 10% or greater estimated cover of trees or tree seedlings.

Table 16. Coarse composition of alpine meadows. Values are rough estimates of relative cover for each category, (total 100% for each meadow). Dominant categories for each meadow are bolded.

	Lyell Fork						Red Peak Fork					Merced Peak Fork				Triple Peak Fork							Mean
	L3	L4	L5	L6	L7	L8	R2	R5	R6	R7	R8	M1	M2	M3	M4	T3	T4	T5	T6	T8	T9	T10	
Herbaceous vegetation	**33**	**33**	**28**	**15**	**20**	**50**	**30**	15	**20**	**19**	**59**	**25**	**25**	**35**	**30**	**21**	15	**25**	**24**	15	**15**	15	26
Subshrub	15	10	13	**15**	10	20	2	**25**	**40**	**21**	5	**20**	15	**30**	15	**21**	**38**	**29**	20	**40**	**35**	**50**	22
Shrub	1	4	8	**30**	**25**	1	10	4	0	0	1	1	1	1	0	2	1	2	1	1	1	1	4
Tree seedlings	4	0	2	0	0	1	1	1	2	1	8	1	6	0	0	2	2	6	0	5	10	5	3
Trees	6	1	1	0	0	1	1	2	1	0	2	1	1	0	0	8	1	1	0	2	5	2	2
Bare ground	3	15	10	5	5	3	**22**	12	3	10	5	5	10	7	3	4	5	4	5	5	1	5	7
Wood	1	0	0	0	0	0	1	4	1	0	1	1	1	0	0	1	1	1	0	1	0	1	1
Litter	**20**	**20**	19	10	15	17	**26**	**31**	18	**40**	20	**24**	**30**	18	**18**	8	**20**	15	**25**	9	10	5	19
Moss	2	1	4	10	15	2	1	1	7	1	1	3	5	2	5	2	3	1	3	1	2	1	3
Bedrock	0	1	3	0	1	1	0	1	0	1	0	2	1	0	0	**14**	3	2	15	5	10	5	3
Boulders	10	5	5	5	5	1	3	2	1	2	1	10	5	2	**19**	8	5	3	5	5	5	5	5
Rocks	5	10	5	10	5	3	0	2	3	3	0	8	2	4	5	8	5	12	2	5	5	5	5
Gravel	0	0	1	0	0	0	0	0	2	0	0	2	1	1	0	1	1	1	1	5	0	2	1
Ponds	0	0	1	0	0	2	3	0	4	2	1	0	1	0	5	2	2	1	0	1	2	1	1

Communities of *Calamagrostis breweri* (Brewer's reed grass), alone and in combination with *Aster alpigenus* (alpine aster) or *Vaccinium caespitosum* (dwarf bilberry), were the most common communities across alpine meadows (Table 17). Communities of subshrubs *Phyllodoce breweri* (mountain heather) and *Vaccinium caespitosum* were also common, as were large patches of *Salix orestera* (Sierra willow) in some meadows, particularly in the Lyell Fork. *Pinus contorta* (lodgepole pine) seedlings were abundant in meadow R8. "Other" communities made up a high proportion of the vegetation, averaging 28% of vegetation across all alpine meadows. "Other" communities encompassed 32 species that were common but were not among the 4 most dominant plant communities. No non-native species were found in alpine meadows. The special status (rare) sedge *Carex fissuricola* (cleft sedge) was common in two meadows (L3 and L5). A list of all plant communities and common species documented in alpine meadows is located in Appendix D.

Table 17. Alpine meadow vegetation composition for the 4 most dominant communities at each site. Values are rough estimates of relative cover for each community, (total 100% for each meadow). Dominant communities for each meadow are bolded.

	Lyell Fork						**Merced Peak Fork**				**Red Peak Fork**					**Triple Peak Fork**							**Mean**
	L3	L4	L5	L6	L7	L8	M1	M2	M3	M4	R2	R5	R6	R7	R8	T3	T4	T5	T6	T8	T9	T10	
Aster alpigenus	15						8				15			7									2
Calamagrostis breweri	**30**	**40**	**51**		**45**	**35**	**40**	**45**		17	8	**75**	25	**40**	10	**34**	20	15	**35**	**85**	**30**	**55**	**33**
Carex filifolia	20																			10			1
Carex nigricans									25				5		5	13	10						3
Carex spectabilis			6	7		10			10	25								7	12				4
Carex subnigricans		18																					1
Carex vesicaria-utriculata												5			30								2
Cassiope mertensiana																					15	20	2
Castilleja parviflora							20																1
Deschampsia cespitosa											**40**												2
Eriophorum criniger							12	20					10	13		13							3
Juncus parryi		8																					0
Kalmia polifolia										8													0
Phyllodoce breweri		7	10										25	15			15		10		20	15	5
Pinus contorta															**35**								2
Ptilagrostis kingii				3		25		10	10	25					20			8	7		5		5
Salix orestera			15	**45**	20						10	7											4
Senecio scorzonella	10				5																		1
Vaccinium caespitosum				25					20								**30**	**30**					5
Other	**25**	27	18	20	**30**	**30**	20	25	**35**	25	27	13	**35**	**25**	**35**	**40**	**25**	**40**	**36**	5	30	10	**26**

Perennial streams and headcuts

Fifteen of the 22 alpine meadows in this study had at least one perennial stream channel. Small ephemeral drainage channels were common but not formally documented in this study. Most perennial streams were approximately 1-2m wide, 25-50cm deep, and flowing with “moderate” speed. There was high variability between alpine meadows in terms of the composition of the channel substrate and streambank cover (Table 18). Channel substrate in most alpine meadows was composed of material that would be resistant to movement during high flow- either bedrock, boulders, or rocks. Gravel made up a small proportion of most channel substrates. Only meadow R8 had a high proportion (90%) of fine sediment in the channel bottom.

Herbaceous vegetation was the dominant category of streambank composition across most alpine meadows, with the exception of meadows L6 and L7 that had higher proportions of shrubs, and meadows M3 and T9 that had higher proportions of subshrubs or rock. Highly erodible components such as gravel and bare soil were absent or nearly absent from streambank composition. Fracturing or sloughing of bank material was nearly absent from alpine streams.

Nine of the 15 alpine meadows with a perennial stream had headcuts present along the stream. Usually only 1-2 headcuts were present per stream, but meadows T8 and M2 had 5 and 6 headcuts, respectively. R6, T10 and T8 were the only alpine meadows with headcuts separate from the stream channels (see R6 photo illustration in Appendix A). Meadow R6 had 2 headcuts, meadow T10 had 4 headcuts and meadow T8 had 5 headcuts.

Table 18. Perennial stream channel bottom and streambank composition for alpine meadows. Only alpine meadows with perennial streams are listed in this table. Composition values are visual estimates of percent cover made after surveying the entire length of meadow stream. “t”= trace amount, blank spaces indicate zeros.

		Lyell Fork				Red Peak		Merced Peak Fork			Triple Peak Fork						Mean
		L5	L6	L7	L8	R6	R8	M1	M2	M3	T3	T4	T5	T6	T9	T10	
Channel bottom composition	Bedrock	30		5		20		10	5		50	1	40	35	70	80	23
	Boulders	30	40	10		70		48	25	10	20	15	15	44		10	22
	Rocks	15	30	80	52	10		30	45	30	15	50	25	10	20	5	28
	Cobble	20	30	5	48		10	10	21	60	9	29	10	5	5	5	18
	Gravel	5			2			2	3		5	4	5	3	2		2
	Fine Sediment						90		1		1	1	5	3	3		7
Streambank composition	Trees (>2m tall)						2		t		2		t		10		1
	Trees (<2m tall)	1					1				3		2				0
	Shrubs (willow)	20	70	40	2		1	t	1	t	8	t	5	t		t	10
	Subshrubs	20		5	5		2	8	15	35	24	15	10	25	40	10	14
	Herbaceous veg.	20	20	20	93	100	89	61	59	15	26	50	39	40	20	10	44
	Bedrock			10				10	5		21	t	25	15	30	80	13
	Boulders	20	10	5			5	15	20	35	8	5	15	15			10
	Cobble	7		5						15	2	5	1				2
	Rocks	10		15				5	t		4	25	2	5			4
	Bare Soil	2		t				1	t		2		1				0
	Gravel																0

Rating criteria, other features and impacts

Rating score totals ranged from 2 to 22 across alpine meadows (Table 19), with higher scores indicating higher levels of impact and/or potential vulnerability to impact. Meadows from the Red Peak Fork and Triple Peak Fork had the highest total scores, mainly due to the presence of formal trails within the meadows. No trails were present in any Lyell Fork and Merced Peak Fork meadows. Meadow T10 had the highest score (22), due to high ratings from trail impacts and headcut formation along the stream. Meadow T8 had the second-highest score (19) due to rutted and braided trail sections in the meadow. Two Red Peak Fork meadows (R6 and R7) had scores of 18, due to formal trails in the meadows, and meadow R8 scored 18 due to headcuts and incised sections of stream.

No stock impacts or informal trails were observed in any alpine meadow, although a stock camp is located approximately ½ mile west of meadow T8. Two alpine meadows had small areas of bare ground mapped. Meadow T4 had a total of 180m^2 mapped as bare, and meadow T6 had a total of 61m^2 mapped as bare. Eight of the alpine meadows had small mammal burrowing activity noted, with only one (T8) having more than trace amounts. Wildlife sightings included Sierra Nevada yellow-legged frogs in the ponds of three alpine meadows, and pikas in the talus adjacent to ten alpine meadows. Three alpine meadows had dry areas of hummocky topography (similar in appearance to mima mounds), including meadow T4, that had an estimated 30% of hummocky area. Sphagnum mounds were noted in six of the alpine meadows, and fen indicator species (mainly *Eriophorum criniger*, fringed bullrush) were noted in 11 alpine meadows; however, only one meadow (T9) had areas described as truly fen or fen-like.

Table 19. Rating scores for vulnerability and impacts of alpine meadows. Higher scores indicate higher levels of impact or vulnerability. Blanks are synonymous with "N/A", or not applicable. "HC" is abbreviation for headcut.

	Lyell Fork Meadows						**Red Peak Fork**					**Merced Peak Fork**				**Triple Peak Fork Meadows**							**Mean**
	L	**L**	**L**	**L6**	**L**	**L**	**R2**	**R**	**R**	**R**	**R**	**M**	**M**	**M**	**M**	**T**	**T**	**T**	**T**	**T**	**T**	**T**	
Slope rating	2	1	3	2	2	2	2	2	2	1	1	3	2	2	1	3	2	3	2	1	2	2	2
Trail extent	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	2	0	1	0
Trail level				0	0				2	3										4		2	1
Trail incision				0	0				2	2										3		3	3
Trail incision				0	0				2	3										3		3	3
Human	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0
Pack stock	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0
Fen indicators	0	0	0	0	0	1	1	0	1	1	0	1	1	0	0	1	1	0	0	1	1	1	1
Conifer	2	0	0	0	0	0	0	2	0	0	2	0	1	0	0	2	0	2	0	1	2	1	1
Bare ground	1	2	2	1	1	1	3	2	1	2	1	1	2	2	1	1	1	1	1	2	0	1	1
Streambank			1	1	1	1			1	1	1	1	1			1	1	1	1		1	1	1
Lakeshore	1					0		1	1	1			1										1
Bank/ shore	0		0	0	0	0		0	1	0	0	0	0			0	0	0	0		0	0	0
Stream HC			0	0	1	0			0	0	2	0	0			0	1	1	0		0	1	0
Stream HC			0	0	1	0			0	0	2	0	0			0	1	1	0		0	1	0
Stream HC			0	0	1	0			0	0	1	0	0			0	2	3	0		0	3	1
Stream			0	0	0	0			0	0	3	0	0			0	0	0	0		0	0	0
Stream			0	0	0	0			0	0	3	0	0			0	0	0	0		0	0	0
Stream			0	0	0	0			0	0	0	0	0			1	0	0	0		0	0	0
TOTALS	**7**	**3**	**6**	**4**	**7**	**5**	**6**	**8**	**18**	**1**	**1**	**6**	**8**	**4**	**2**	**9**	**9**	**1**	**4**	**1**	**6**	**2**	**9**

Discussion

Yosemite Valley Meadows

Graminoid (grass, sedge, and rush) species dominated Yosemite Valley meadow vegetation, with mean graminoid cover two to three times higher than forb cover across all meadows. Turf-forming, native graminoids are considered a healthy component of meadow vegetation because, in part, they create dense sods with soil-stabilizing, rhizomatous roots. (Cooper et al. 2006, unpublished report). In 5 of the 6 meadows surveyed, tree seedlings were present in more than 10% of plots, illustrating that the tree encroachment documented since 1870 (Gibbens and Heady 1964) continues. The extent of tree seedlings was highest in El Capitan and Stoneman Meadows (32% of plots contained seedlings), indicating that nearly 1/3 of meadow area in El Capitan and Stoneman has some degree of tree encroachment. El Capitan and Stoneman meadows had the lowest proportion of wetland area of Yosemite Valley meadows (60-61% of plots classified as wetland). As tree seedlings will not survive long periods of soil inundation (Koxlowski 1997), this suggests a connection between extent of perennially wet soils and tree encroachment in Yosemite Valley meadows.

Sedge communities of *Carex senta* (rough sedge) and *Carex lanuginosa* (woolly sedge) were the most common plant communities across Yosemite Valley Meadows with the exception of El Capitan, Stoneman and Sentinel. Communities of the non-native grass *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) dominated El Capitan and Stoneman vegetation, and the native grass *Leymus triticoides* (beardless wildrye) was most common in Sentinel. Non-native species were common across all Yosemite Valley meadows, with the highest extent of non-natives in Stoneman and El Capitan (92-96% of plots containing non-natives). Stoneman also had the greatest proportion of plots with higher density infestations (25-75% cover of non-natives per plot). Stoneman and El Capitan had the lowest extent of wetland area, suggesting a connection between the extent of non-native species currently occupying Yosemite Valley meadows and the extent of wetland in Yosemite Valley. Our data indicate that for the meadows surveyed, mean cover of non-native plants was lower in saturated and inundated soils (by a factor of 2 to 7) compared with moist to dry soils.

Studies have found that *Poa pratensis* ssp. *pratensis* outcompetes native meadow species such as *Deschampsia cespitosa* (tufted hairgrass) when soil moisture is reduced (Martin and Chambers 2001, Kluse and Allen-Diaz 2005). In addition, most non-native plants prefer the central part of the moisture gradient (Rejmanek 1989). While there are non-native plants in California that commonly invade wetlands, our findings suggest that non-native plants currently in Yosemite Valley meadows may not compete well with native plants in wet soils. There are exceptions, such as *Holcus lanatus* (velvet grass) that is already present in Yosemite Valley and tolerates soil inundation better than many non-native species (Thomsen et al. 2006). Early detection and eradication of non-native wetland plants are tools to mitigate invasion of wetland areas. However, species distribution is strongly linked to water table depths in meadows (Dwire et al. 2006), so maintaining meadow water tables to promote areas of wet soil may be key to sustaining native meadow vegetation composition (Kluse and Allen-Diaz 2005).

Bare ground cover differed by approximately 11% on average across all meadows. Bridalveil had the lowest mean bare ground (2%), and Cook's and Leidig had the highest (13%). Higher levels of bare ground in Cooks and Leidig appeared to be from natural causes. These two meadows had many areas that were inundated at the time of the survey, and may have had high cover of bare ground because litter cover was washed away or sediment was deposited by flooding. "Ephemeral pond" was most commonly noted as the cause for bare ground in Cook's and Leidig, as well as "undisturbed", which field staff often recorded for bare ground in areas of inundation.

Bare ground from small mammal disturbance was most common in the drier meadows (El Capitan and Stoneman), likely because burrowing activity would not be possible in inundated areas where small mammals would drown. In addition, spring runoff can wash away evidence of small mammal activity. Cooper et al. (2006, unpublished report) suggest a connection between small mammal disturbance and conifer encroachment in subalpine meadows, and Berlow et al. (2002) found that sagebrush establishment in meadows was related to gopher disturbance. Small mammal disturbance could be related to the higher levels of tree encroachment seen in El Capitan and Stoneman, but further studies would be needed to establish this connection.

Not surprisingly, bare ground from informal trails was highest in El Capitan, Sentinel and Bridalveil that had 15-19% of plots with informal trails. Stoneman and Cook's had the lowest extent of informal trails, likely due to the presence of elevated boardwalks that concentrate visitor foot traffic, discouraging visitors from venturing cross country through the meadows and mitigating trampling effects. Current information on the status of informal trails in Yosemite Valley meadows, the monitoring of informal trails and their use as an indicator for management can be found in Newburger et al. (2011). An investigation of correlations between informal trails in Yosemite Valley Meadows and ecological data from our study can be found in Leung et al. (2011).

Subalpine Meadows

Graminoids dominated subalpine meadow vegetation, exhibiting 3-25 times the cover of forbs in most meadows (Merced Lake sites, Doc Moyle's sites, Little Yosemite Valley- East, Washburn Lake, and Red Peak- North.) This may be a healthy sign since turf-forming native graminoids create dense sods that stabilize soil and deposit organic matter (Cooper et al. 2006, unpublished report). *Carex vesicaria-utriculata* (bladder sedge) was the most common plant community, dominating most subalpine meadows in the Lyell Fork (Doc Moyle's) and below. *C. vesicaria* and *C. utriculata* are obligate wetland species[14] that typically occur in saturated or inundated meadow soils (Ratliff 1982). The strong presence of this community indicates that meadows at Doc Moyle's, Washburn Lake, Merced Lake and Little Yosemite Valley are wet longer into the growing season compared with other meadows. Some of these meadows may be better classified as marshes (D. Cooper,

[14] From USDA Plants website http://plants.usda.gov/java/profile?symbol=CAVEV2, 3/10/11.

personal communication). In contrast, dry sedge communities of *Carex filifolia* (shorthair sedge) were common in Triple Peak Fork meadows (including Turner Lake), indicating drier conditions there.

Subshrub cover was higher in the remaining meadows (Red Peak Fork meadows and Triple Peak Fork meadows including Turner Lake), with the native *Vaccinium caespitosum* (dwarf bilberry) being the most common subshrub. Conifer seedlings were most extensive in Triple Peak Fork meadows and Red Peak- South. Since 45% of plots at Triple Peak- North and Turner Lake contained seedlings, we may infer that nearly half the meadow at those sites had some degree of conifer encroachment. While the subshrubs *Vaccinium caespitosum* (dwarf bilberry) and *Kalmia polifolia* (alpine laurel) are classified as wetland plants[15], we have observed that they grow in drier areas of subalpine meadows. Our preliminary findings suggest that areas dominated by subshrubs in subalpine meadows may have drier conditions that allow conifer establishment. Cooper et al. (2006, unpublished report) found more conifer seedlings in communities dominated by *Vaccinium caespitosum* in Tuolumne Meadows, however, further studies are needed to support the hypothesis that subshrub areas in subalpine meadows suggest drier conditions.

Vegetation cover ranged from 49-60% across all meadows on average, with the exception of Merced Lake- East (32%) and Little Yosemite Valley- East (41%). Species composition in Little Yosemite Valley- East may help explain the lower-than-average vegetation cover at this site. Nearly 1/3 of the vegetation in Little Yosemite Valley- East was dominated by *Juncus balticus* (Baltic rush), *Eleocharis quinqueflora* (fewflower spikerush) and *E. palustris* (common spikerush) that appear to have naturally low vegetative cover (anecdotal observations). Communities of these species were absent from other subalpine meadows, and their dominance in Little Yosemite Valley- East lowered the mean vegetation cover for this site.

In contrast, Merced Lake- East was dominated by the hardy obligate wetland species *Carex vesicaria- utriculata* (bladder sedge). This community was the most common vegetation community across all subalpine meadows in this survey, but mean vegetation cover was 8-25% lower in Merced Lake- East compared with other *Carex vesicaria-utriculata* meadows[16]. Merced Lake- East had the highest levels of pack stock use of any site in this study[17]. Higher intensities of grazing can lead to reduced productivity and decreased vegetation cover in common subalpine meadow communities (Stohlgren et al. 1989, Olson-Rutz et al. 1996, Cole et al. 2004). Trampling by pack stock also decreases vegetation cover (Cole 1987). It seems likely that pack stock use contributes to lower vegetation cover at Merced Lake- East. It is worth noting that previously grazed meadows at Merced Lake that were closed to stock use in the 1990's (Mark Fincher, personal communication)

[15] *Vaccinium caespitosum* rating is FACW and *Kalmia polifolia* rating is OBL per the regional wetland species indicator lists at http://plants.usda.gov/wetinfo.html and/or http://www.fws.gov/nwi/Plants/list88.html

[16] Meadows dominated by *Carex vesicaria-utriculata* included Merced Lake- West, Merced Lake- Shore, Washburn Lake, Doc Moyle's- East and Doc Moyle's- West

[17] Merced Lake- East stock use averaged 169 stock nights over 7 years, whereas other sites averaged 8-19 stock nights

seemed to recover well, displaying similar vegetation cover to other subalpine meadows and no obvious evidence of residual pack stock effects. Photo 5 compares the conditions observed in *Carex vesicaria-utriculata* communities at Merced Lake- East (grazed) and Merced Lake- West (closed to grazing) in July 2010.

Photo 5. Comparison of Carex vesicaria-utriculata (bladder sedge) communities at Merced Lake-East, a grazed meadow (left photo) and Merced Lake- West, a meadow closed to grazing in the 1990's (right photo). NPS photos, July 2010.

The number of common and dominant species found during plot collection differed greatly among the Merced Lake meadows. Three species were detected in plots at Merced Lake- East (where most plots had only *Carex vesicaria-utriculata* present), compared with 19 species at Merced Lake-West and 21 species at Merced Lake- Shore. Merced Lake- East has the highest pack stock use of the meadows in this study, and grazing has been shown to decrease species richness in nutrient-poor environments (Proulx and Mazumder 1998). Huston (1979) also predicts lower species diversity with high levels of disturbance. *Carex utriculata* is a hardy wetland species that can be used in restoration of grazed riparian areas (Sarr and Dudley 2008), so it may be one of the only meadow species resilient enough to withstand current disturbance levels at Merced Lake- East.

Non-native plants were only found in lower-elevation subalpine meadows (Little Yosemite Valley, Echo Valley, Merced Lake- East, Washburn Lake). These meadows share more upper montane than subalpine characteristics, and this may influence the success of non-native species. In addition, the highest abundance and diversity of non-native species was in Little Yosemite Valley, which has the highest visitor use. Gridpoint plots documented *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) at Little Yosemite Valley- East, and non-native species absent from other subalpine meadow plots. *Poa pratensis* ssp. *pratensis* can outcompete native meadow species such as *Deschampsia cespitosa* (tufted hairgrass) when soil moisture is reduced (Martin and Chambers 2001, Kluse and Allen-Diaz 2005). Maintaining meadow hydrology to promote areas of wet soil may help sustain native meadow vegetation composition (Kluse and Allen-Diaz 2005).

Additional surveys outside gridpoint plots in 2010 detected other non-native species in or adjacent to meadows. Scattered individuals of *Cirsium vulgare* (bull thistle) were mapped near the meadows at Little Yosemite Valley, Merced Lake- East, and in Echo Valley (Hartman and Johnson 2011, unpublished report). *Verbascum thapsus* (common mullein) and *Tragopogon dubius* (yellow salsify) were also detected in Little Yosemite Valley in 2010, and one *Taraxacum officinale* (dandelion) was found at Washburn Lake. Of these species, the only one targeted as high priority for control in Yosemite is *Cirsium vulgare*. Non-native species were not observed in any meadow or adjacent areas in the Merced corridor above Washburn Lake.

Previous invasive plant surveys (2006-2009) by the Yosemite Wilderness Restoration Crew detected populations of *Holcus lanatus* (velvetgrass, a high-priority species for control), *Lactuca serriola* (prickly lettuce), *Phleum pretense* (timothy), and *Taraxacum offinale* (dandelion) at Little Yosemite Valley. Populations were controlled with hand-pulling where feasible, but early detection and further control efforts are needed to stop the spread of non-native plants into wilderness areas (Hartman and Johnson 2011, unpublished report).

Average bare ground per plot varied by 28% across all meadows, with Merced Lake- East having the highest levels (30%) and Little Yosemite Valley- East having the second-highest (22%). Other meadows were close to or lower than the 11% average across all subalpine meadows. The vegetation communities of Yosemite Valley- East may provide some explanation for the higher bare ground levels at this site. As with vegetation cover, *Juncus balticus* (baltic rush) and *Eleocharis palustris* and *E. quinqueflora* (spikerush) are dominant species at this site and appear naturally sparse (anecdotal observations). They have low vegetative cover and do not produce much litter cover when they die back, possibly causing more bare ground in these communities. In addition, flooding from spring runoff at this site likely removes much of the surface litter each year. Little Yosemite Valley- East had large inundated areas at the time of survey.

Merced Lake- East, however, was a near-monoculture of *Carex vesicaria-utriculata* (bladder sedge), the most common community across subalpine meadows in this study. One would assume that mean bare ground levels at Merced Lake- East would be similar to the other meadows where *Carex vesicaria-utriculata* was dominant, but instead Merced Lake- East had mean bare ground levels that were 16-22% higher. Other studies have shown that grazing and trampling impacts from pack stock in subalpine meadows cause increases in bare ground (Cole 1987, Cole et al. 2004). Merced Lake- East has received consistently high pack stock use in recent years (average 169 stock nights over 7 years), so pack stock use may contribute to higher levels of bare ground at this site. The other sites at Merced Lake that were closed to grazing in the 1990's (Mark Fincher, personal communication) had similar levels of bare ground compared to the other subalpine meadows. In fact, Merced Lake- West had the lowest mean bare ground per plot of all subalpine meadows in the study.

Mapped bare ground areas were highest at Washburn Lake (comprising 3% of meadow area). Observations of the bare areas at this site suggest that most are from deposition of alluvial material and other saturated areas lacked an obvious explanation. Merced Lake- Shore had bare areas mapped (1% of meadow area) that appeared to be caused by visitor use near the meadow's edge. Other subalpine meadows had little to no bare ground areas mapped.

Small mammal burrowing was absent or nearly absent from the subalpine meadows in this survey, except for the Triple Peak Fork meadows (including Turner Lake). These meadows had 26-38% of plots with burrowing evidence. These meadows were also the meadows with a higher proportion of subshrubs and low proportion of hydric communities like *Carex vesicaria-utriculata* (bladder sedge). Small mammal burrows are not expected in frequently inundated areas, since the burrows would flood at high water. However, Red Peak- South had a high proportion of subshrubs, low proportion of hydric vegetation and low extent of small mammal burrows. We cannot suggest an obvious explanation for this finding.

No formal trails were present in any of the subalpine meadows surveyed. Informal trails were absent from gridpoint plots but were mapped at five subalpine sites. At sites with pack stock use, we could not differentiate between human and equine trailing (Doc Moyle's sites and Washburn Lake). However, Merced Lake- Shore has no overnight stock use and a high concentration of people at the adjacent High Sierra Camp, so the nearly 2km of informal trail segments between the formal trail, High Sierra Camp and lake are likely human-caused. Likewise, at Merced Lake- East where stock are turned out for grazing and visitor use is low, the 0.5km of informal trails leading into the meadow are equine-caused. Many more equine trails were mapped throughout the forest adjacent to Merced Lake-East. This area is riddled with downed logs, making travel difficult for pack stock. Sections were cut out from these downed logs to enable stock to reach the meadow for grazing, causing the formation of many informal trails leading to the meadow from various points along the formal trail.

Gridpoint plots and GPS mapping detected stock impacts in all but five subalpine meadows in this study. Most meadows had few impacts, but Merced Lake-East had 76% of plots with impacts in early July. When the meadow was revisited in September, all of the meadow was grazed and trampled, and a new roll pit was observed. This amount of impact was not surprising, since annual stock use at Merced Lake- East has ranged from 96-410 stock nights since 2007 (per records kept by the Wilderness Office at Yosemite). Other meadows in this study received 0-33 stock nights in those years. Although stock are turned out into the approximately 225 hectare wooded area east of the Merced Lake Ranger Station, most of the area is impassable to stock because it is choked with deadfall. Trampling impacts have become concentrated along the informal trails where logs are cut and in the small (0.6 hectare) meadow where forage is more abundant (see Appendix F, Photo F-6b).

Scattered hoofpunches and/or manure that appeared to be from previous years were mapped in five subalpine meadows with no recorded 2010 stock use (Washburn Lake, Triple Peak, Merced Lake- Shore, Triple Peak- South, and Turner Lake). Doc Moyle's- west had higher amounts of grazing, hoofpunches and trampling, all of which were fresh impacts. Wilderness Office records showed only 6 stock nights for Doc Moyle's in 2010 (and 0 in 2009), so the impacts were likely caused by the low levels of 2010 use. The scattered hoofpunches at Merced Lake- Shore were surprising, since stock are not turned out there to graze, but these impacts could be caused by day use such as stock led to the lake for watering, picnicking, or sight-seeing. Stock impacts at Turner

Lake were also unexpected, since this site is more than ¼ mile off trail (and therefore not legal for stock use), but it is likely some private parties use the site since the terrain is not impassable to stock (Mark Fincher, personal communication).

Subalpine Meadow Streams

All 2010 sites surveyed (using both MIM and rapid assessment protocols) indicated that the streams are generally in very good and near-natural condition, and general condition metrics show excellent overall ecological conditions. Wetland conditions, ecological status (successional status), vegetation biomass, and plant diversity indices were rated high to very high for all sites. Streambank stability ratings were rated mid to high, suggesting somewhat limited rooting strength of greenline vegetation at some sites. Erosion features were minimal for all sites surveyed, with the exception of one site (Triple Peak- South, see below). Streambank alteration from pack stock use was recorded for only one site (Doc Moyle's West, see below). Because reference sites were not established for condition comparison, only condition ratings and (Tables 7a, 7b) could be drawn upon to assess current site conditions. Sites with lower condition ratings (in comparison to other sites surveyed) and/or other areas of special concern are discussed below.

Doc Moyle's-West had recreational impacts of potential concern. Direct pack stock impacts (such as bank alteration, grazed vegetation and heavily eroded stream crossings) were severe in localized areas, warranting future monitoring of metrics such as greenline width and headcut severity. The stream channel at Doc Moyle's- West was the widest among all sites surveyed, with a mean width of 18 meters. A widened stream channel could be due to channel instability caused by historical high-impact grazing (Powell et al. 2000). This site had high levels of pack stock use until the last few decades (Mark Fincher, personal communication), so channel widening in response to pack stock impacts may have occurred. However, the lower benches of sedges at this site (see "future greenline", Photo 6) could indicate a healing mechanism for the stream channel to return to a narrower state. In the absence of information on the condition of this channel during the decades of high stock use at this site, it is difficult to determine the cause of its seemingly unnatural width. Long term monitoring of Doc Moyle's- West using MIM would be valuable in evaluating trends at this site.

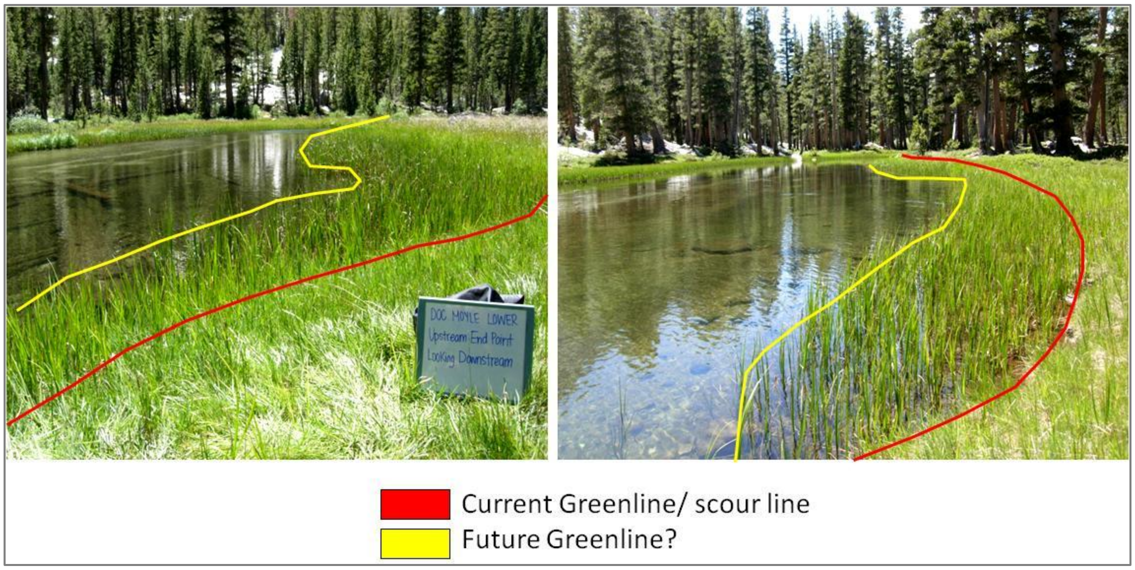

Photo 6. Streambanks at Doc Moyles- West showing current scour line and lower bench vegetated with sedges that appears to be developing a new greenline. NPS photos, August 2010.

Turner Lake had distinctive ecosystem indicators and lower condition ratings compared with other Merced corridor sites. The presence of fen indicators species suggest that it may be a distinctive wetland system sensitive to visitor use. Fen indicators observed included sphagnum moss (often peat-forming) along the streambanks and *Eriophorum cringer* (fringed cottongrass). The site appeared to be a patterned fen wetland, considered a rare ecosystem type in the Sierra (D. Taylor, personal communication). Since the hydrologic regime of fens is usually wetter than other meadows, the site wetland rating at Turner Lake causes concern since it was the lowest of all sites in the study (77 out of 100). Although the wetland rating for this site is classified as high according to MIM standards (Burton et al. 2011), it may be low for a fen ecosystem and warrants further investigation. However, wetland ratings are driven by the wetland ratings (USDI 1997) of the most dominant species present. The identification of one of the dominant species (*Carex scopulorum)*, is still being examined. If this species, were identified incorrectly, it may affect the wetland rating. Therefore, further investigation of dominant species at Turner Lake may be warranted.

Triple Peak Fork- South had lower condition ratings compared to other Merced corridor sites. Streambanks were highly eroded with active fracturing in 46% of streambank plots. Causes of erosion were not obvious, although many deer hoof prints and dung in the meadow and along the bank were evident. The geology of this site may be influencing streambank erosion. This meadow occurs in a narrow valley between steeply-sided granite walls that could produce high lateral flow velocities from the valley walls during peak runoff periods. The stream channel is composed of bedrock overlain by cobble, and the banks have a relatively thin soil layer on top of the bedrock. We hypothesize that water infiltration at the base of the soil horizon may be blocked by the bedrock, and this causes sheet flow to pool and flow laterally toward the stream. The force of this lateral flow may increase streambank sloughing. Whatever the cause(s), these streambanks are highly eroded and therefore likely sensitive to disturbance.

Red Peak Fork- North had lower condition ratings compared with other Merced Corridor sites. The stream channel had a high percentage (97%) of fine substrate with a median particle size of 2 mm. A high percentage of fines may be the result of erosion inputs to the stream channel from weakened streambanks during floods (Bohn 1986). Erosion inputs typically result in a wider, shallower stream channel profile (Bohn 1986). Changes to stream channels (caused by increased fines and stream widening) can be detrimental to biota because suitability of the aquatic habitat is reduced through restriction of living spaces of substrate-dwelling organisms and limiting oxygen transfer to incubating eggs (Powell et al. 2000). However, the channel relatively narrow (average 4.83 m wide) and the was 93% stable, suggesting that stream widening due to erosion inputs is not occurring. We hypothesize that the fine substrate material is due to natural processes and may have been deposited from Red Devil Lake, located just upstream.

Red Peak Fork- South had distinctive ecosystem indicators that may be contribute to site vulnerability. Spaghnum moss was noted along the streambank surveyed, which is a potential fen indicator. Furthermore, overview photos taken of the area show that the area may be a patterned fen (Appendix F, Photo F-10c).

Alpine Meadows

Alpine data collection differed from subalpine and Valley data collection in the use of rapid assessment methods and rating criteria rather than gridpoint plots. This approach maximized efficiency and the number of sites visited. Because rapid assessment data were based on cover estimates for entire meadow areas (ranging in size from 0.2 to 22 hectares), they were not intended to be as precise as the data collected from 5x5m gridpoint plots in subalpine and Valley meadows. However, they provided some quantitative measure of meadow conditions and a basis for comparing coarse attributes across meadows. Rating criteria provided a way to quantify impacts and vulnerabilities, as well as identify sites where follow-up investigation may be warranted.

The alpine meadows in this study were rockier and had thinner soils than subalpine meadows, and the proportion of subshrubs appeared to be higher than subalpine sites. Conifer encroachment is likely limited by elevational constraints in alpine environments, although four alpine meadows in this study did have an estimated 10% cover of trees or seedlings. Meadow species more characteristic of alpine elevations were common, such as *Carex nigricans* (black sedge), *Cassiope mertensiana* (white heather), *Phyllodoce breweri* (mountain heather), and *Salix arctica* (alpine willow). No non-native species were found in alpine meadows.

We assessed the condition of perennial streams in fifteen alpine meadows. All streams but one (meadow R6 in the Red Peak Fork) appeared resistant to erosion, with channels composed of bedrock and various sizes of rock and streambanks well-armored with vegetation and rock. Approximately 90% of the R6 stream channel had a fine sediment bottom that is easily affected by flood events and provides less favorable habitat for substrate-dwelling invertebrates (Powel et al. 2000). The streambank in R6 was also entirely lined with herbaceous vegetation, which is less resistant to erosion than streambanks with more robust-rooted vegetation (shrubs and subshrubs) or rock. Although naturally-occurring, these factors may contribute a greater vulnerability to disturbance at this site.

Small headcuts emanating from stream channels were common in alpine meadows (at 9 of 15 sites with perennial streams), while headcuts separate from streams (i.e. meadow headcuts) were less common (3 sites). Sites with meadow headcuts all had formal trails in them (T8, and T10 in the Triple Peak Fork, and R6 in the Red Peak Fork), with the highest total number of headcuts at T8 meadow. Erosion features such as headcuts and gully erosion are evidence of stream channel instability (Brooks et al. 2003).

Rating criteria generally resulted in meadows with formal trails having the highest scores, due to rating of trail condition and impacts in the trail corridor (T10, T9, R6 and R7). These meadows may be more vulnerable to impact, since they are easily accessed by visitors and pack stock. Trails can also affect the meadows through interruption of sheet flow, channeling runoff, changes in sediment dynamics, and changes in the amount and timing of ground and surface water available for plants (Loheide et al. 2008). The sections of braided and rutted trail in meadow T10 (Photo 7) may be altering local hydrologic processes in this meadow.

Photo 7. Braided and rutted trail segment in alpine meadow T10. NPS photos, August 2010.

By their very nature, alpine meadows are more vulnerable to disturbance and slower to recover than their lower elevation counterparts (Billings 1973). This may be due, in part, to their lower productivity. Ratliff et al. (1987) compared vegetation production (in lbs/acre) for different meadow types at several elevation intervals in the Sierra Nevada and found that biomass produced by meadows at 11,000 feet is approximately half the production of meadows at 9,000 feet. This implies that recovery would be slower at alpine elevations, since it relies on vegetation growth and deposition of organic matter.

Caveats and Further Analyses

This report presents information based on initial analyses of the data collected for condition assessments of meadows in the Merced corridor. Initial data exploration suggests further analysis that could be informative, if time and funding become available. Statistical analyses of gridpoint data would support and add significance to our findings (J. Holmquist, personal communication). Soil studies would augment wetland information in Yosemite Valley meadows, as past hydrologic alteration affected vegetation composition (D. Cooper, personal communication). Weixelman (2008, unpublished report) uses a system of scoring the ecological condition of meadows based on species composition. This system classifies species into functional groups according to traits such as life history, wetland rating, rooting characteristics, life form and nitrogen fixing capability. Based on the species composition of a meadow, a ranking of high, moderate, or low ecological condition is determined. With some methods adaption, the Weixelman (2008, unpublished report) model could further interpret our gridpoint plot in order to obtain additional information on the ecological condition of meadows in the Merced River corridor.

Subalpine stream surveys, using the interagency peer-reviewed MIM monitoring protocol, have proven effective at summarizing study site conditions using ecological ratings. However, MIM was designed for areas that see higher grazing levels than are typical of Yosemite meadows. Stream survey metric rating classifications could be adapted to reflect the pristine conditions relevant to management of a national park. Additional sites would reflect a wider variety of conditions, from high use to reference sites, and represent overall condition of subalpine meadow streams in the park. Addition of an aquatic invertebrate monitoring component would enhance the effectiveness of the MIM stream survey protocol by providing an improved indication of water quality and ecological condition (Herbst 2004).

This study builds on an existing set of gridpoint plot, stock impacts, and stream conditions data from the Tuolumne watershed that has been growing since 2008. Previously, meadows and streams were usually targeted for study because of pack stock use levels and concern over impacts. However, in order to provide context and a basis for comparing conditions among meadows and streams, data from reference sites is needed. Reference condition is defined as the condition representative of a group of minimally disturbed sites organized by selected physical, chemical, and biological characteristics (Reynoldson 1997). A reference site is one that is considered in good condition for the same channel type in similar geology and watershed (Prichard et al. 1998). Reference data derived from the establishment and monitoring of reference sites are helpful in understanding watershed health and riparian-wetland condition (DeBano and Schmidt 1989). A sufficient body of reference meadows and stream reaches has not yet been established in Yosemite. Initial meadow references were examined in the Tuolumne watershed, but they would be improved by the addition of more pristine sites.

Conclusion/ Considerations

The size of meadows in Yosemite Valley has decreased substantially from 745 acres (302 ha) in the mid-1880's to the current estimated 269 acres (109 ha), representing a 64% decrease in meadow extent. This study assessed the condition of remaining meadows in Yosemite Valley, focusing on measures of meadow integrity. Aside from the reduction in overall meadow extent, conifer encroachment and non-native plant invasion are key issues reflected in the new data. Both issues are linked to water table level, a key driver of meadow integrity. Informal trailing is another key issue that affects the ecological integrity and scenic beauty of Valley meadows, and appears to be mitigated in some areas by the use of boardwalks and other restoration activities. Actions to protect and enhance Yosemite Valley meadows in the Merced River corridor may include restoration of portions of historic meadows and enhancing the integrity of remaining meadows. Both routes would require restoration of hydrologic processes that are fundamental to meadow integrity.

Pack stock impacts or vulnerability to impact rose to the forefront of subalpine meadow considerations. Issues highlighted in Ballenger et al. (2011) including the level of use, timing of use, and suitability for use are all applicable to meadows in this study. Timing and suitability for use are particularly relevant since many Merced River corridor meadows have wet soils with vegetation composed of hydric sedge species. Most meadows in the Merced River corridor showed little to no stock impacts, with the exception of Merced Lake- East, which had widespread impacts including trampling, grazed vegetation, roll pits and manure throughout the meadow by the second week of July.

Merced Lake- East exhibited lower vegetation cover and higher bare ground levels than two nearby meadows with the same dominant plant species, Merced Lake- West and Merced Lake- shore. These two meadows were grazed until the 1990s, when the National Park Service halted the practice due to concern over meadow conditions. In reference to these two meadows, Sharsmith (1961) reported "their regenerative tendencies are losing ground, and deterioration is increasing". From our study, it appears that Merced Lake- Shore and Merced Lake- West have recovered from previous stock impacts, and could potentially be used for comparison of conditions in monitoring Merced Lake- East.

Doc Moyle's- West may also be recovering from previous high levels of pack stock use. Heavy use of this site as a pack camp in the mid 20th century has declined to low levels of use in the last few decades. Doc Moyle's- West is a wet meadow; trampling and soil shearing of streambanks is known to be more severe in wet areas (Vallentine 1990), and this can lead to channel widening (Powell et al. 2000). Stock impacts may have contributed to the wide channel we observed during streambank assessments. The sedges currently growing in the channel may indicate a trend toward streambank recovery, although long-term monitoring is needed for confirmation. If these trends are real, this indicates vulnerability of this meadow to pack stock trampling impacts.

Extensive informal trails were documented at two subalpine sites- Merced Lake- Shore and Merced Lake- East. Yosemite is currently using informal trails as an indicator to monitor visitor impacts to meadows (Newburger et al. 2011), so these methods are applicable to the Merced Lake sites.

In general, alpine meadows displayed little to no impacts from visitors or pack stock, with the exception of formal trails in some Red Peak and Triple Peak Forks meadows. Some sections of trail were braided and rutted, which may exacerbate impacts to hydrologic processes in these meadows. Although pack stock impacts were mainly noted in formal trail corridors, a stock camp occurs within ¼ mile of T8 meadow in the Triple Peak Fork, so there is potential for grazing and trampling impacts in this meadow. Due to the lower productivity and slower recovery of alpine meadows, effects of pack stock use could be more severe in this zone.

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Appendix A. Photos of Select Mapped Features and Impacts

Features defined in Table 3 (Methods)

		
Photo A-1. Roll pit, Merced Lake- East.	**Photo A-2. Dried pack stock manure, R7**	**Photo A-3. Headcuts (2), R6**
		
Photo A-4. Hoofpunches, Echo Valley	**Photo A-5. Bare ground and hoofprints, Merced Lake- shore**	**Photo A-6. Stock camp, Doc Moyle's- W.**
		
Photo A-7. Trampled area, Merced Lake- East	**Photo A-8. Informal trail, Merced Lake- shore**	**Photo A-9. Bare ground, T4**

Appendix B. Plant Communities Recorded in Gridpoint Plots

Values entered are proportion of plots (percentage) of each community at each meadow.
"*" denotes non-native species.

Table B-1. Plant Communities recorded in Yosemite Valley meadows gridpoint surveys.

Growth habit	Plant association	Bridalveil	Cook's	El Cap	Leidig	Sentinel	Stoneman	Total
Forb	**Forb Total**	**8.0%**	**10.0%**	**4.9%**	**2.4%**	**1.6%**	**1.0%**	**4.5%**
	Artemisia douglasiana			0.6%	2.4%	0.8%		0.8%
	Euthamia occidentalis		3.1%					0.5%
	Heracleum lanatum		3.9%					0.6%
	Iris missouriensis			3.3%				0.8%
	Solidago canadensis var. *elongata*	8.0%	0.8%	1.1%		0.8%		1.3%
	Sparganium angustifolium		0.8%					0.1%
	Typha latifolia		0.8%					0.1%
	Unknown forb		0.8%				1.0%	0.3%
Grass	**Grass Total**	**20.0%**	**17.7%**	**61.2%**	**42.4%**	**57.3%**	**62.4%**	**45.5%**
	Agrostis pallens		0.8%					0.1%
	*Agrostis stolonifera**		2.3%		0.6%			0.5%
	Bromus hordeaceus- Bromus diandrus**			1.1%	0.6%			0.4%
	Bromus inermis ssp. *inermis**		1.5%			0.8%	10.9%	1.8%
	*Bromus japonicus**			1.6%	1.8%	1.6%	1.0%	1.2%
	*Bromus tectorum**			1.1%	1.2%			0.5%
	Calamagrostis canadensis		2.3%	6.0%	1.2%	0.8%	5.9%	3.0%
	Deschampsia danthonioides				1.8%			0.4%
	Elymus glaucus		2.3%					0.4%
	Festuca occidentalis			14.2%		0.8%	5.0%	4.1%
	Leymus triticoides	9.3%	7.7%	2.2%	18.2%	41.1%	3.0%	13.5%
	Poa pratensis ssp. *pratensis**	10.7%	0.8%	35.0%	17.0%	12.1%	36.6%	19.7%
Rush	**Rush Total**	**1.3%**	**0.8%**	**4.4%**			**2.0%**	**1.5%**
	Juncus balticus	1.3%		4.4%				1.2%
	Juncus occidentalis						1.0%	0.1%
	Juncus orthophyllus		0.8%					0.1%
	Juncus sp.						1.0%	0.1%
Sedge	**Sedge Total**	**70.7%**	**63.9%**	**16.9%**	**55.2%**	**39.5%**	**34.7%**	**44.0%**
	Carex angustata		0.8%	0.6%		0.8%	2.0%	0.6%
	Carex athrostachya				1.8%		1.0%	0.5%
	Carex douglasii				1.8%			0.4%
	Carex feta			1.1%	2.4%		1.0%	0.9%
	Carex integra			1.6%				0.4%
	Carex lanuginosa	1.3%	11.5%	0.6%	28.5%	16.9%	2.0%	11.2%
	Carex mariposana						1.0%	0.1%
	Carex praegracilis			2.2%	0.6%		7.9%	1.7%
	Carex senta	58.7%	39.2%	7.7%	6.1%	12.9%	13.9%	19.2%
	Carex senta & Carex lanuginosa	9.3%	6.2%	0.6%	0.6%	5.7%	4.0%	3.6%
	Carex utriculata-vesicaria		5.4%	0.6%	9.1%	1.6%	1.0%	3.3%
	Carex ssp. (vegetative)	1.3%		2.2%	4.2%	1.6%	1.0%	1.9%
	Other Carex		0.8%					0.1%
Shrub	**Shrub Total**		**2.3%**	**0.6%**				**0.5%**
	Rhododendron occidentale		0.8%	0.6%				0.3%
	*Rubus armeniacus**		1.5%					0.3%
Fern & Fern Allies	**Fern & Fern Allies Total**		**5.4%**	**12.0%**		**1.6%**		**4.0%**
	Pteridium aquilinum var. *pubescens*		5.4%	12.0%		1.6%		4.0%

Table B-2. Plant Communities recorded in subalpine meadows gridpoint surveys.

Special status (rare) species are in bold type.

Life Form	Plant association	Doc Moyle's-East	Doc Moyle's-West	LYV- East	LYV- West	Merced Lake-East	Merced Lake - shore	Merced Lake-West	Red Peak-North	Red Peak-South	Triple Peak-North	Triple Peak-South	Turner Lake	Washburn Lake	Total
	Forb Total		**3%**							**2%**	**5%**		**10%**		**2%**
	Aster alpigenus		3%							2%	3%		7%		2%
Forb	*Senecio scorzonella*										2%		3%		1%
	Grass total	**30%**	**30%**	**18%**	**15%**		**34%**	**3%**	**24%**	**16%**	**28%**	**41%**	**21%**	**10%**	**21%**
	Calamagrostis breweri/Aster alpigenus	8%	6%						8%	2%	10%	14%	18%		6%
	Calamagrostis canadensis	1%	3%	12%	8%		2%				3%			1%	2%
	Danthonia intermedia	3%									7%	3%			1%
	Deschampsia cespitosa	5%	21%		8%		8%	3%	3%	2%	3%	5%		9%	5%
	Deschampsia cespitosa/ Carex utriculata-vesicaria						23%								3%
	Glyceria elata						2%								0%
	Muhlenbergia filiformis								5%						0%
	Poa pratensis ssp. *pratensis*			6%											0%
Grass	*Ptilagrostis kingii*	12%							8%	13%	5%	19%	3%		5%
	Rush total			**12%**				**3%**							**1%**
	Juncus balticus			12%											1%
Rush	*Juncus macrandrus*							3%							0%
	Sedge total	**53%**	**61%**	**47%**	**69%**	**100**	**53%**	**92%**	**46%**	**11%**	**13%**	**30%**	**17%**	**51%**	**43%**
	Carex douglasii												3%		0%
	Carex filifolia										12%	14%	4%		3%
	Carex filifolia/Vaccinium caespitosum										2%	5%			1%
	Carex fissuricola									2%					0%
	Carex integra	1%													0%
	Carex lenticularis	1%								2%					0%
	Carex nigricans												1%		0%
	Carex nigricans/Kalmia polifolia												1%		0%
	Carex scopulorum	4%											1%		1%
	Carex spectabilis									2%			4%		1%
	Carex subnigricans											3%			0%
	Carex utriculata-vesicaria	43%	61%	24%	69%	100	50%	78%	46%	2%		8%		38%	32%
	Carex utriculata-vesicaria/Carex lenticularis	1%					3%							13%	2%
	Eleocharis palustris			18%											1%
	Eleocharis quinqueflora	1%		6%											0%
	Eriophorum criniger									4%			1%		1%
Sedge	*Scirpus microcarpus*							14%							1%
	Shrub total	**1%**					**5%**		**3%**	**20%**	**2%**		**3%**	**8%**	**4%**
	Salix lemmonii						2%								0%
	Salix lucida sp. *lasiandra*													8%	1%
	Salix orestera	1%							3%	18%					2%
	Salix spp.						3%			2%	2%				1%
Shrub	**Subshrub total**								**14%**	**31%**	**40%**	**19%**	**46%**		**15%**
	Kalmia polifolia									4%			3%		1%
	Vaccinium caespitosum								3%	5%	3%	3%			1%
Sub-shrub	*Vaccinium caespitosum/ Aster alpigenus*									4%	2%				1%

Life Form	Plant association	Doc Moyle's- East	Doc Moyle's- West	LYV- East	LYV- West	Merced Lake- East	Merced Lake - shore	Merced Lake- West	Red Peak- North	Red Peak- South	Triple Peak- North	Triple Peak- South	Turner Lake	Washburn Lake	Total
	Vaccinium caespitosum/ Calamagrostis breweri								8%	13%	33%	16%	30%		10%
	Vaccinium caespitosum/ Kalmia polifolia												11%		1%
	Vaccinium caespitosum/ Ptilagrostis kingii								3%	5%					1%
Tree	*Pinus contorta/ Vaccinium caespitosum*	7%									2%		3%		1%

Appendix C. Plant Species Recorded in Gridpoint Plots and Subalpine Meadow Stream Surveys

"*" denotes non-native species. Special status (rare) species are in bold type.

Table C-1. Plant species recorded in Yosemite Valley gridpoint surveys.

Plant Species	Bridalveil	Cook's	El Capitan	Leidig	Sentinel	Stoneman
Achillea millefolium	x	x	x		x	x
Achnatherum occidentale			x			x
Achnatherum sp.			x	x		x
Agastache urticifolia	x				x	
*Agrostis gigantea**				x		x
Agrostis pallens		x				
Agrostis scabra				x		
Agrostis sp.			x			
*Agrostis stolonifera**		x	x	x		x
Alisma plantago-aquatica		x				x
Alopecurus aequalis		x				
Apocynum cannabinum	x		x	x	x	x
Artemisia douglasiana	x	x	x	x	x	
Artemisia dracunculus	x	x	x	x	x	
Artemisia ludoviciana		x		x		
Asclepias sp.			x			
Asclepias speciosa		x	x		x	x
Asteraceae						x
Bromus carinatus		x	x	x		x
*Bromus diandrus**				x	x	
*Bromus hordeaceus**		x	x			
Bromus inermis ssp.*inermis**		x			x	x
*Bromus japonicus**			x	x	x	x
Bromus sp.*					x	
*Bromus tectorum**	x	x	x	x	x	x
Bulbostylis capillaris						x
Calamagrostis canadensis	x	x	x	x	x	x
Carex angustata		x	x	x		x
Carex athrostachya				x		x
Carex aurea						x
Carex buxbaumii		x	x			x
Carex douglasii			x	x	x	
Carex feta	x	x	x	x	x	x
Carex hoodii			x			x
Carex integra			x			
Carex lanuginosa	x	x	x	x	x	x
Carex lenticularis var. *lipocarpa*					x	
Carex mariposana	x					x
Carex nebrascensis		x				
Carex praegracilis	x	x	x	x		x
Carex senta	x	x	x	x	x	x
Carex sp.	x	x	x	x	x	x
Carex utriculata		x		x	x	x
Carex vesicaria		x	x	x	x	x
Carex, vegetative (likely *C. lanuginosa*)	x	x		x	x	
Carex, vegetative (unknown ID)	x	x	x	x	x	x
*Chenopodium album**	x		x		x	
*Cirsium vulgare**		x	x	x	x	x
Clarkia rhomboidea				x		
Claytonia parviflora			x	x	x	
Conyza canadensis		x		x	x	
*Dactylis glomerata**						x
Deschampsia danthonioides				x	x	
Descurainia sp.					x	
Dodecatheon jeffreyi		x				

Plant Species	**Bridalveil**	**Cook's**	**El Capitan**	**Leidig**	**Sentinel**	**Stoneman**
Eleocharis obtusa var. *engelmannii*				x		
Eleocharis sp.		x				
Elymus glaucus		x	x			x
Elymus trachycaulus ssp. *trachycaulus*	x	x		x	x	
Epilobium glaberrimum				x		
Epilobium sp.		x				
Equisetum arvense		x				x
Equisetum hyemale var. *affine*					x	
Equisetum laevigatum		x		x	x	x
*Erigeron strigosus**		x				
Euthamia occidentalis	x	x		x	x	
Festuca idahoensis			x	x		x
Festuca occidentalis			x		x	
Festuca sp.			x			x
Fragaria vesca		x				x
Fragaria virginiana						x
Galium aparine		x				
Gayophytum diffusum ssp. *parviflorum*		x		x		
Geranium carolinianum				x	x	
Geranium sp.*			x			
Gilia capitata				x		
Helenium bigelovii		x				x
Heracleum lanatum		x			x	x
*Holcus lanatus**	x	x		x		
Hypericum anagalloides		x				
*Hypericum perforatum**		x				x
Iris missouriensis	x	x	x	x		
Juncus balticus	x	x	x	x	x	x
Juncus effusus		x	x			
Juncus effusus var. *exiguus*		x				
Juncus effusus var. *pacificus*				x		
Juncus mertensianus			x			
Juncus nevadensis			x			
Juncus occidentalis						x
Juncus orthophyllus				x		x
Juncus oxymeris		x				
Juncus sp.	x	x	x	x		x
*Lactuca serriola**	x	x	x	x	x	
Lepidium virginicum					x	
Lessingia leptoclada			x	x	x	x
Leymus triticoides	x	x	x	x	x	x
Linanthus ciliatus						x
Lotus oblongifolius var. *oblongifolius*	x	x	x		x	x
Lotus pinnatus				x		
Lotus purshianus var. *purshianus*	x		x	x	x	
Lupinus bicolor				x		
Lupinus latifolius	x					x
Lupinus lepidus var. *sellulus*				x		
Lupinus sp.				x		
Luzula orestera						x
Mentha arvensis		x		x		x
*Mentha spicata**					x	
Mimulus moschatus			x			
Muhlenbergia richardsonis	x		x	x		x
Muhlenbergia rigens		x	x			x
Oxypolis occidentalis	x					
Panicum acuminatum var. *acuminatum*			x	x		
Panicum sp.	x					
Parthenocissus vitacea		x				
Penstemon rydbergii var. *oreocharis*			x	x	x	
Perideridia parishii	x					

Plant Species	Bridalveil	Cook's	El Capitan	Leidig	Sentinel	Stoneman
*Phleum pratense**			x	x		
Pinus ponderosa	x		x			
Plagiobothrys torrei						x
*Plantago lanceolata**			x			
*Poa bulbosa**			x	x	x	x
Poa pratensis ssp. *pratensis**	x	x	x	x	x	x
*Polygonum arenastrum**	x	x	x			
Polygonum bistortoides		x				
*Polygonum persicaria**				x		
Potentilla glandulosa			x			
Prunus virginiana var. *demissa*		x				
Pteridium aquilinum var. *pubescens*		x	x	x	x	x
Quercus kelloggii			x			
Ranunculus flammula		x				
Rhododendron occidentale		x	x			
*Robinia pseudoacacia**		x				
Rorippa curvisiliqua			x	x		x
Rosa californica						x
Rosa sp.		x				
Rosa woodsii var. *ultramontana*				x		
*Rubus armeniacus**		x	x			
*Rubus laciniatus**		x				
Rubus leucodermis		x				x
Rubus parviflorus	x					
Rudbeckia hirta var. *pulcherrima**			x			x
*Rumex acetosella**	x		x	x	x	x
*Rumex crispus**		x		x	x	
Salix lemmonii				x		
Salix lucida sp. *lasiandra*				x		
Sambucus mexicana		x				
*Scirpus cyperinus**		x				
Scirpus microcarpus	x	x		x	x	
*Sisymbrium altissimm**	x			x	x	
Smilacina racemosa					x	
Smilacina stellata			x			
Solidago californica	x	x	x			x
Solidago canadensis var. *elongata*	x	x	x	x	x	x
Sparganium angustifolium		x				
Stachys albens	x	x	x	x	x	x
*Stellaria media**			x			
*Taraxacum officinale**			x	x		x
Torreyochloa pallida var. *pauciflora*		x				
*Tragopogon dubius**	x	x	x	x	x	x
Trifolium microcephalum			x			
Trifolium monanthum			x			
*Trifolium repens**		x				
Trifolium sp.			x			
Trifolium variegatum					x	
Typha latifolia		x		x		
Unknown		x			x	
*Verbascum thapsus**	x	x	x	x	x	x
Veronica scutellata		x				
Vulpia microstachys			x	x	x	
*Vulpia myuros**		x			x	
Wyethia angustifolia						x
Total number of species	**43**	**85**	**76**	**77**	**60**	**69**

Table C-2. Plant species recorded in subalpine meadow gridpoint plots and stream surveys.

"x"= recorded in gridpoint plots, "0" = recorded in stream surveys, "*" denotes non-native species, special status (rare) species are in bold type

Plant species	Doc Moyle's-East	Doc Moyle's-West	LYV- East	LYV- West	Merced Lake-Shore	Merced Lake-West	Merced Lake-East	Red Pk.-North	Red Peak-South	Triple Peak-North	Triple Peak-South	Turner Lake	Washburn Lake
Achillea millifolium			x										
Agrostis scabra					x								x
Allium validum						x							
Antennaria media		0									x		
Antennaria sp.	X,0									x	x	x	
Arnica sp.								0					
Aster alpigenus	X,0	X, 0						x	X,0	X,0	X,0	X,0	
Aster occidentalis					x								
Aster sp.					x			0					
Bromus sp.									0				
Calamagrostis breweri	x	X, 0						X,0	x	X,0	X,0	X,0	
Calamagrostis canadensis	x	X, 0	x		x	x				X,0	0		x
Carex aqualitis											0		
Carex athrostachya			x										
Carex douglasii												x	
Carex filifolia								0		x	x	x	
Carex fissuricola	X,0	0							x	X,0	0		
Carex illota		x						x					
Carex integra	x	x											
Carex lenticularis var. *lipocarpa*		0				x						0	
Carex lenticularis	x				x	x	x	X,0	x	0	0	x	x
Carex leporinella					x								
Carex nigricans								x	x			X,0	
Carex rossii									x	x			
Carex scopulorum	X,0	X, 0				x			0			X,0	x
Carex sp.	X,0	X, 0						X,0		x	X,0	0	
Carex spectabilis								x	X,0	x		X,0	
Carex subnigricans	x	0							0		X,0	0	
Carex utriculata-vesicaria	X,0	X, 0	x	x	x	x	x	X,0	x		x		x
Castilleja lemmonii	X,0									0	0		
Castilleja parviflora									X,0			X,0	
Danthonia intermedia	x	X			x				x	X,0	x		
Deschampsia cespitosa	X,0	X, 0		x	x	x	x	X,0	X,0	X,0	X,0	x	x
Eleocharis acicularis			x										
Dodecatheon alpinum		0											
Eleocharis palustris			x										
Eleocharis quinqueflora	x	x	x	x				x	x			x	
Epilobium sp.												0	
Equisetum hyemale					x								
Eriophorum criniger									x			X,0	
Galium trifidum						x							
Gentiana newberryi	x	X, 0						0	x	x	X,0	X,0	
Gentianopsis holopetala										0			
Glyceria elata					x	x							
Helenium bigelovii					x								
Horkelia fusca										x	x		
Hypericum anagalloides						x							
Juncus balticus			x										
Juncus drummondii												x	
Juncus macrandrus						x							
Juncus mertensianus								X,0	0				
Juncus oxymeris					x								
Juncus parryi								0	x			X,0	
Juncus sp.						x		0					
Kalmia polifolia		0						x	X,0	x	X,0	X,0	
Lonicera cauriana										0			
Lotus oblongifolius var. *oblongifolius*						x							
Ledum glandulosum		0								0			
Lupinus covillei										0		x	
Lupinus sp.													
Lupinus lepidus										X,0			x
Lupinus polyphyllus													
Luzula orestera	x											x	

Plant species	Doc Moyle's-East	Doc Moyle's-West	LYV- East	LYV- West	Merced Lake-Shore	Merced Lake-West	Merced Lake-East	Red Pk.-North	Red Peak-South	Triple Peak-North	Triple Peak-South	Turner Lake	Washburn Lake
Mimulus primuloides var. *primuloides*	X,0							X,0	x	x	0	x	
Muhlenbergia filiformis	x	x	x			x		x		x		X,0	
Muhlenbergia richardsonis		x	x			x					0		
Pedicularis attolens								X,0	X,0	0		X,0	
Penstemon heterodoxus var.												x	
Perideridia bolanderi	x	x			x								
Perideridia parishii		0			x					0			
Phalacroseris bolanderi			x	x									
Phleum alpinum										x		X,0	
Phyllodoce breweri									x			x	
Pinus contorta	0				x			0	x	X,0		x	
Poa fendleriana					x								
Poa pratensis ssp. *pratensis**			x										
Poa secunda										x			
Polygonum bistortoides						x		0	X,0	X,0	X,0	X,0	
Potentilla flabellifolia	0	0						X,0	X,0	x	0	0	
Potentilla gracilis								0		0	x		
Ptilagrostis kingii	X,0	0			x			x	X,0	x	X,0	X,0	
Ranunculus alismifolius			x	x	x							x	
Salix arctica												X,0	
Salix eastwoodiae	0									X,0	0	0	
Salix lemmonii	X,0												
Salix lucida sp. *lasiandra*					x								
Salix orestera	x	0						X,0	X,0	0	0	X,0	
Salix planifolia	0	0											
Salix sp.	x												
Scirpus clementis	x								x			x	
Scirpus microcarpus						x							
Senecio pauciflora	0												
Senecio scorzonella	x							x	x	X,0	X,0	x	
Senecio sp.	x												
Senecio triangularis									0			0	
Symphyotrichum spathulatum			x										
Unknown forb										x			
*Taraxacum officinale**													
Trisetum spicatum	0								0	0		0	
Unknown graminoid			x										x
Vaccinium caespitosum	x							X,0	X,0	X,0	X,0	X,0	
Vaccinium uliginosum ssp. *occidentale*	x	X, 0						0		X,0			
Veratrum californicum var. *californicum*						x							
Veronica peregrina			x										
Veronic wormskskjoldii												0	
Viola makloskeyi		0			x	x					0	0	x
Total number of species	**29**	**16**	**16**	**5**	**21**	**19**	**3**	**20**	**27**	**28**	**18**	**34**	**9**

Appendix D. Plant Communities and Common Species of Alpine Meadows (from rapid assessment surveys)

Numbers are a visual estimate of percent of vegetation (totals 100% for each meadow). “x” indicates species that were common but not one of 4 most dominant communities. Special status (rare) plants are in bold type.

	--------Lyell Fork Meadows---------						Merced Peak Fork				Red Peak Fork Meadows					---------Triple Peak Fork Meadows--------						
Plant community or species	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**M1**	**M2**	**M3**	**M4**	**R2**	**R5**	**R6**	**R7**	**R8**	**T3**	**T4**	**T5**	**T6**	**T8**	**T9**	**T10**
Antennaria sp.					x	x			x	x						x	x		x	x		x
Aster alpigenus	15	x	x				8		x		15			7		x			x			
Athyrum alpestre																			x			
Calamagrostis breweri				x	5	15			x							13						
Calamagrostis breweri- Aster alpigenus								15		x		15			5			15		25		5
Calamagrostis breweri/ Vaccinium caespitosum	30	40	51		40	20	40	30			8	60	25	40	5	21	20			60	30	50
Calamagrostis breweri/ Vaccinium caespitosum-Kalmia polifolia										17									35			
Carex filifolia	20																			10		x
Carex fissuricola	x		x																			
Carex nigricans				x	x	x	x	x	25	x			5		5	13	10	x	x			x
Carex scopulorum																			x			x
Carex spectabilis		x	6	7	x	10	x	x	10	25						x	x	7	12	x	x	x
Carex subnigricans		18	x																			
Carex vesicaria-utriculata												5			30							x
Cassiope mertensiana									x							x		x	x		15	20
Castilleja lemmonii										x						x						
Castilleja parviflora				x		x	20	x								x	x	x			x	x
Danthonia intermedia			x					x		x							x					
Deschampsia cespitosa								x			40									x	x	x
Dodecatheon alpinum																			x			
Eleocharis quinqueflora			x														x				x	x
Eriophorum criniger			x			x	12	20					10	13		13	x		x			
Gentiana newberryi		x		x					x	x						x	x	x	x			x
Juncus drummondii																x		x	x			x
Juncus mertensianus									x							x	x	x	x			
Juncus parryi	x	8			x	x		x	x	x						x	x	x	x	x	x	

Plant community or species	L3	L4	L5	L6	L7	L8	M1	M2	M3	M4	R2	R5	R6	R7	R8	T3	T4	T5	T6	T8	T9	T10
Kalmia polifolia			x				x	x	x	8						x		x				x
Ledum glandulosum																	x	x				
Lupinus lepidus var. *lobbii*																				x		
Luzula orestera																			x			
Muhlenbergia filiformis																x	x					
Pedicularis attollens									x							x	x				x	x
Perederidia parishii	x																					
Phleum alpinum										x								x				
Phyllodoce breweri	x	7	10		x	x	x	10		x			25	15		x	15		10		20	15
Pinus albicaulis																				x		
Pinus contorta	x						x	x								x	x	x		x	x	x
Poa secunda																		x				
Poa sp.																			x			
Polygonum bistortoides																x		x			x	x
Potentilla flabellifolia										x						x					x	
Potentilla sp.																	x	x	x			
Ptilagrostis kingii		x	x	3	x	25	x	x	10	25					20			8	7		5	x
Salix arctica			x						x									x		x	x	x
Salix orestera	x	x	15	45	20	x		x	x		10	7				x	x	x	x	x	x	x
Scirpus clementis			x	x		x	x	x	x													x
Senecio scorzonella	10		x	x	5	x		x								x	x	x		x	x	x
Senecio triangularis			x																			
Trisetum spicatum																x				x		
Tsuga mertensiana																x						
Vaccinium caespitosum				25					20													
Vaccinium caespitosum/ Calamagrostis breweri- Aster alpigenus																		30				
Vaccinium cespitosum- Kalmia polofolia																	30					
Vaccinium uliginosum																x	x					
Veratrum californicum	x					x				x							x	x	x			

Appendix E. Site Details for Yosemite Valley Meadows

In alphabetical order by meadow name

Ahwahnee Meadow

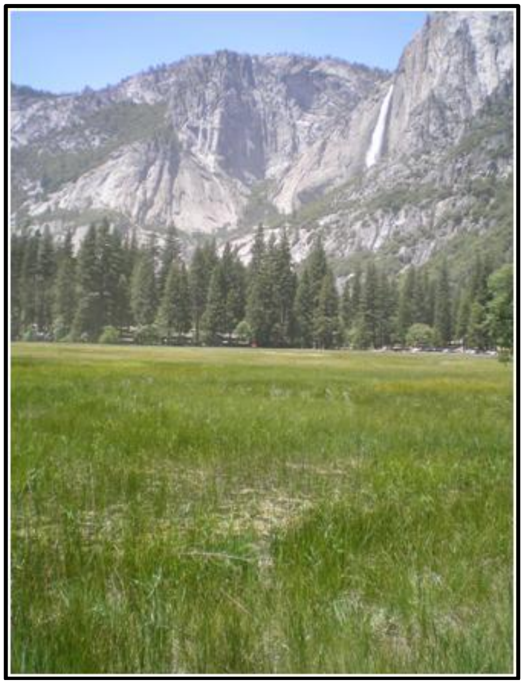


Photo E-1a. Ahwahnee Meadow, looking northwest (left photo).

Photo E-1b. Informal Trail in Ahwahnee Meadow , looking northwest (right photo).

Photo E-1c. Large bare ground area at Ahwahnee Road bus stop, Ahwahnee Meadow, looking east.

Ahwahnee Meadow is located in the eastern portion of Yosemite Valley, west of the Ahwahnee Hotel, between Ahwahnee Road and Northside Drive. The meadow is 11.8 hectares in size, and the elevation at the site is 4,000 feet (see Photo E-1, Map E-1a).

We did not conduct gridpoint sampling throughout the entire meadow, and instead collected ten plots in a north-south transect (Map E-1). *Agrostis stolonifera* (creeping bent grass) and *Carex senta* (rough sedge) were the dominant meadow plant communities in gridpoint plots. Less dominant native plants included *Artemesia douglasiana* (mugwort), *Leymus triticoides* (beardless wildrye), and *Muhlenbergia rigens* (deer grass).

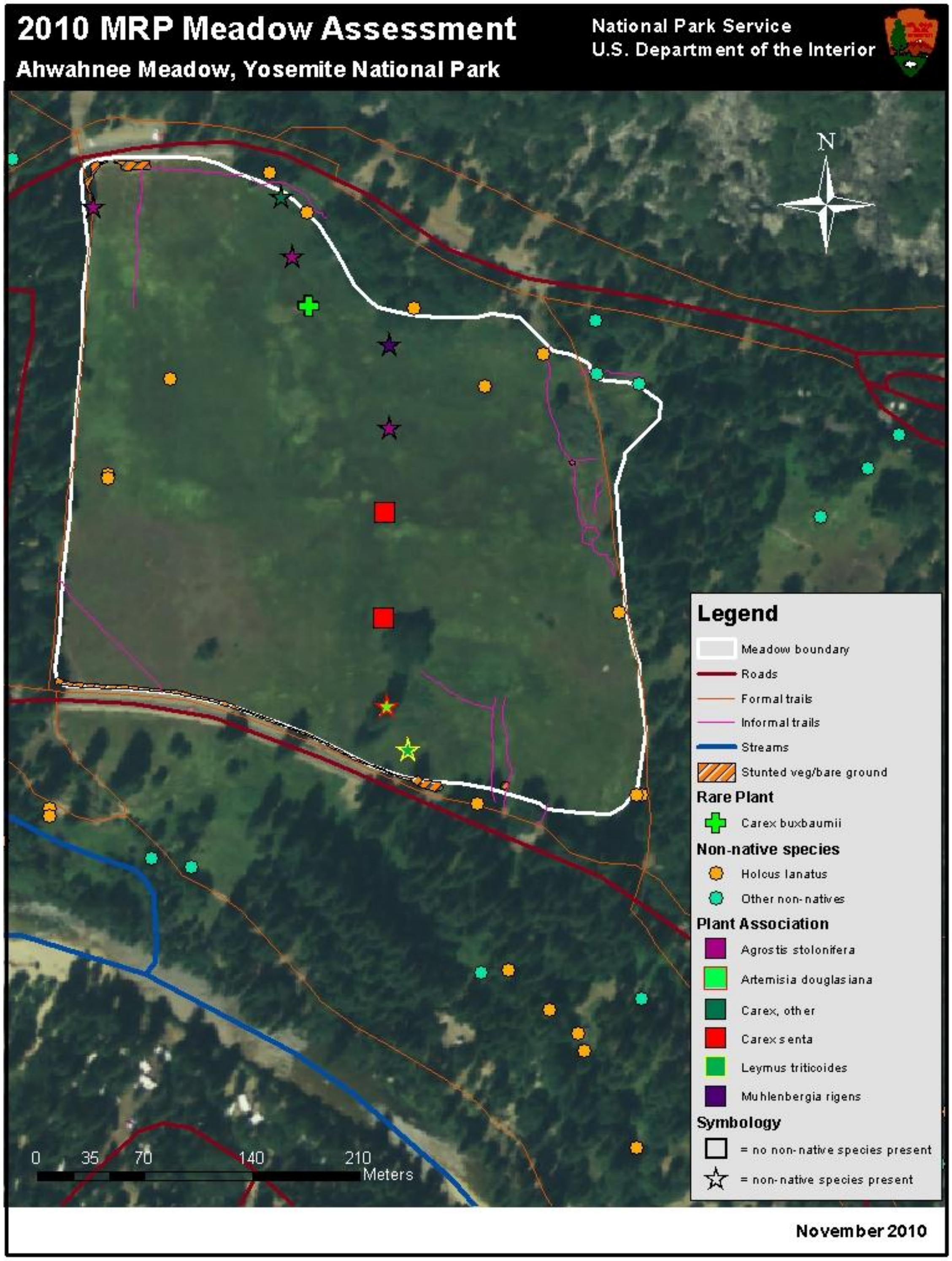
The most common non-native species were *Agrostis stolonifera* (creeping bent grass) and *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass), both found in 4 out of 10 plots. Additional non-native species present included *Holcus lanatus* (velvet grass), *Hypericum perforatum* (St. John's wort), *Bromus diandrus* (ripgut brome), *Bromus secalinus* (rye brome), and *Rumex acetosella* (sheep sorrel). The rare sedge *Carex buxbaumii* (Buxbaum's sedge) was found in one plot.

Informal trails were abundant at this site (Photo E-1b,) with 697m of informal trails mapped in 2010 (Newburger et al. 2011, in prep.).

<u>Meadow History</u>: Ahwahnee meadow was part of the Lamon homestead claim of 1859, the first homestead claim in Yosemite Valley. Lamon had two to three cabins on site including one at the site of the Ahwahnee hotel. Later, Aaron Harris managed the site as a ranch known as the Royal Arch Farm, leasing it from the Commissioners from 1876 to 1886. The meadow was plowed each season for grazing and farming. After Harris left, the eastern portion was given to Kenney and Associates who plowed and sowed grain for his pack stock. The meadow was plowed and sown for hay several times between 1910 and 1914 (Ernst 1943).

<u>Meadow Infrastructure</u>: Remnant ditches from agricultural era remain. Meadow areas south of the road have much higher water tables than those north of Ahwahnee, and they remain wet for longer periods of time (Cooper 2008, unpublished report).

<u>Meadow Observations</u>: There is a large raised area (comprising approximately 15% of the meadow) located in the southwestern portion of the meadow. The area has a visibly high cover of bare ground (Map E-1). This meadow area is considerably dry in comparison with the northeastern meadow area, which is consistently saturated to inundated. There is also a large, bare ground area adjacent to the Ahwahnee Road bus stop, on the northwestern edge of the meadow (Photo E-1c).



Map E-1. Aerial photo map of Ahwahnee Meadow showing plant communities (plots), and other features.

Bridalveil Meadow

Photo E-2a. Bridalveil Meadow, looking west.

Photo E-2b. Bridalveil Meadow, looking east.

Photo E-2c. Historic conditions in Bridalveil Meadow, possibly taken in 1896 by Joseph LeConte (left). **Photo. E-2d. Recent Bridalveil Meadow photo showing less willow** and riparian shrubs (right).

Bridalveil Meadow is located in the western portion of Yosemite Valley, east of Pohono Bridge and Fern Springs (Photos E-2a,b Map E-2, Map 4). The meadow is located adjacent to the Merced River, along Southside Drive. The meadow is 5.6 hectares in size, and the elevation at the site is 3,920 feet.

Forty-three plant species were documented in eighty-one gridpoint plots at Bridalveil Meadow. The dominant native meadow plant communities were the sedges *Carex senta* (rough sedge) and *Carex lanuginosa* (woolly sedge), (Map E-2). Tree seedlings were present in 11% of plots.

Non-native species were present in 51% of plots, but no plots had greater than 25% cover of non-native species. *Poa pratensis* ssp. *pratensis* (non-native Kentucky bluegrass) was a sub-dominant meadow species present in 49% of plots, and comprised 8% of plant communities (Table E-1). *Rubus armeniacus* (Himalayan blackberry) was mapped on the north and eastern edges of the meadow (Yosemite Parkwide Weeds Database, accessed 11/30/2010).

Table E-1. Non-native plant species in Bridalveil Meadow gridpoint plots.

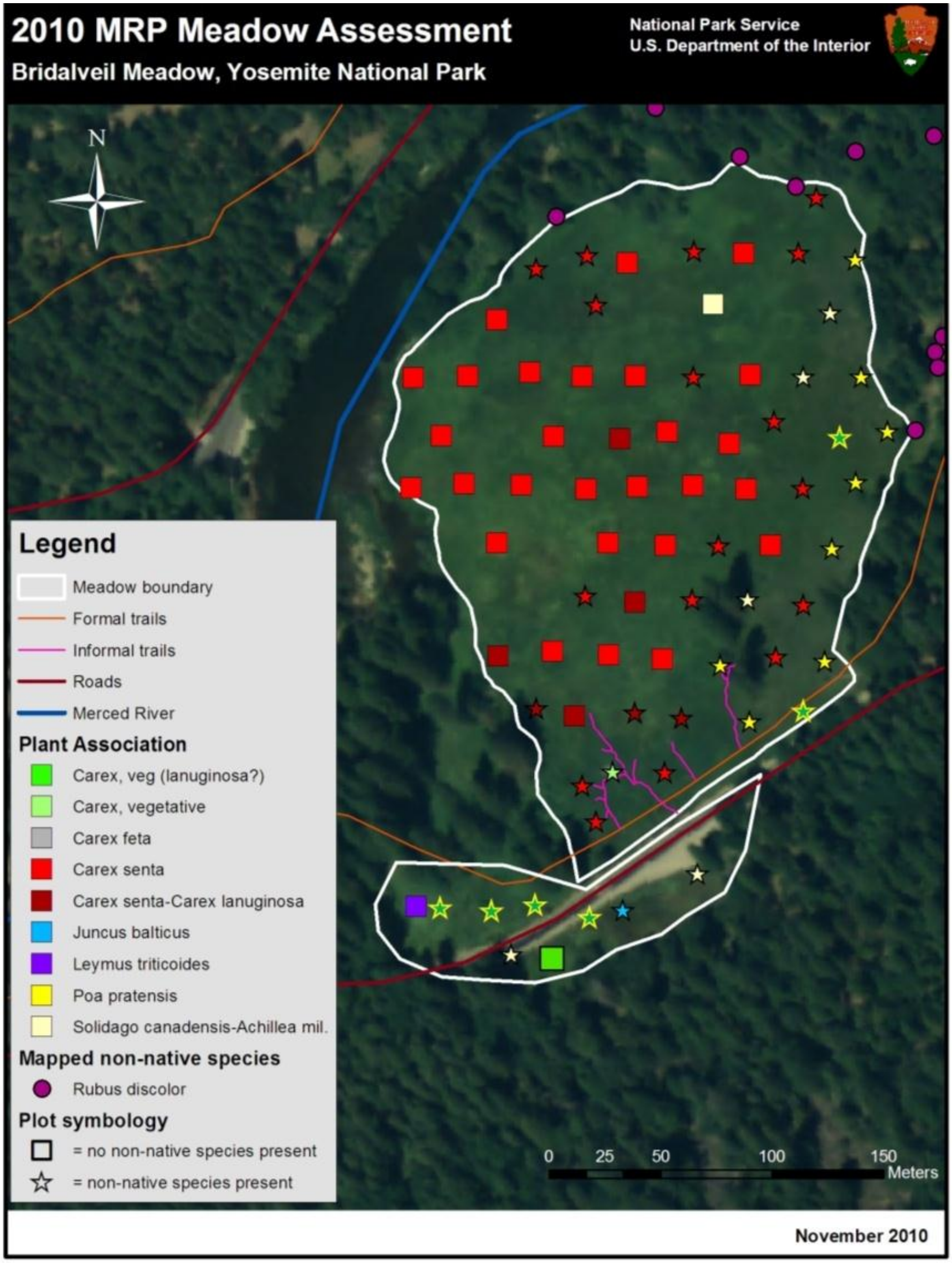
Non-native species	% of plots where present
Bromus tectorum	1%
Chenopodium album	1%
Holcus lanatus	1%
Lactuca serriola	3%
Panicum sp.	1%
Poa pratensis ssp. *pratensis*	49%
Polygonum arenastrum	1%
Rumex acetosella	3%
Sisymbrium altissimum	1%
Tragopogon dubius	3%
Verbascum thapsus	1%

Informal trails were found in 15% of Bridalveil plots, and 188m of informal trails were mapped in Bridalveil meadow (Newburger et al. 2011, in prep.).

Meadow History: Bridalveil Meadow was often used as a first campsite for weary travelers before roads were established into Yosemite Valley. The Mariposa Battalion camped here in 1851. In the late 1880s, this area was used as pasture for the saddle train business of Kenney and Associates. There is no record of the meadow being plowed, though at one time, the meadow was covered with willows and other shrubs (Photo E-2c,d). An early superintendent may have ordered this clearing to improve forage. Bridalveil Meadow was the site of an historic meeting between John Muir and President Theodore Roosevelt (http://www.nps.gov/yose/historyculture/muir-influences.htm).

Meadow Infrastructure: No infrastructure is located within Bridalveil Meadow, however, this meadow is bisected from east to west by a paved road. Remnants of an old borrow pit and dump site are located just southeast of the meadow adjacent to Southside Drive. The Valley Loop Trail also intersects the southeastern portion of the meadow near the plaque dedicated to Dr. Lafayette Houghton Bunnell. There is also a man-made drainage area located adjacent to the western boundary of the meadow (Eagan, S. 1994).

Meadow Observations: The western portion of the meadow was saturated to inundated in the third week of June, 2010.



Map E-2. Aerial photo map of Bridalveil Meadow showing plant communities (plots) and other features.

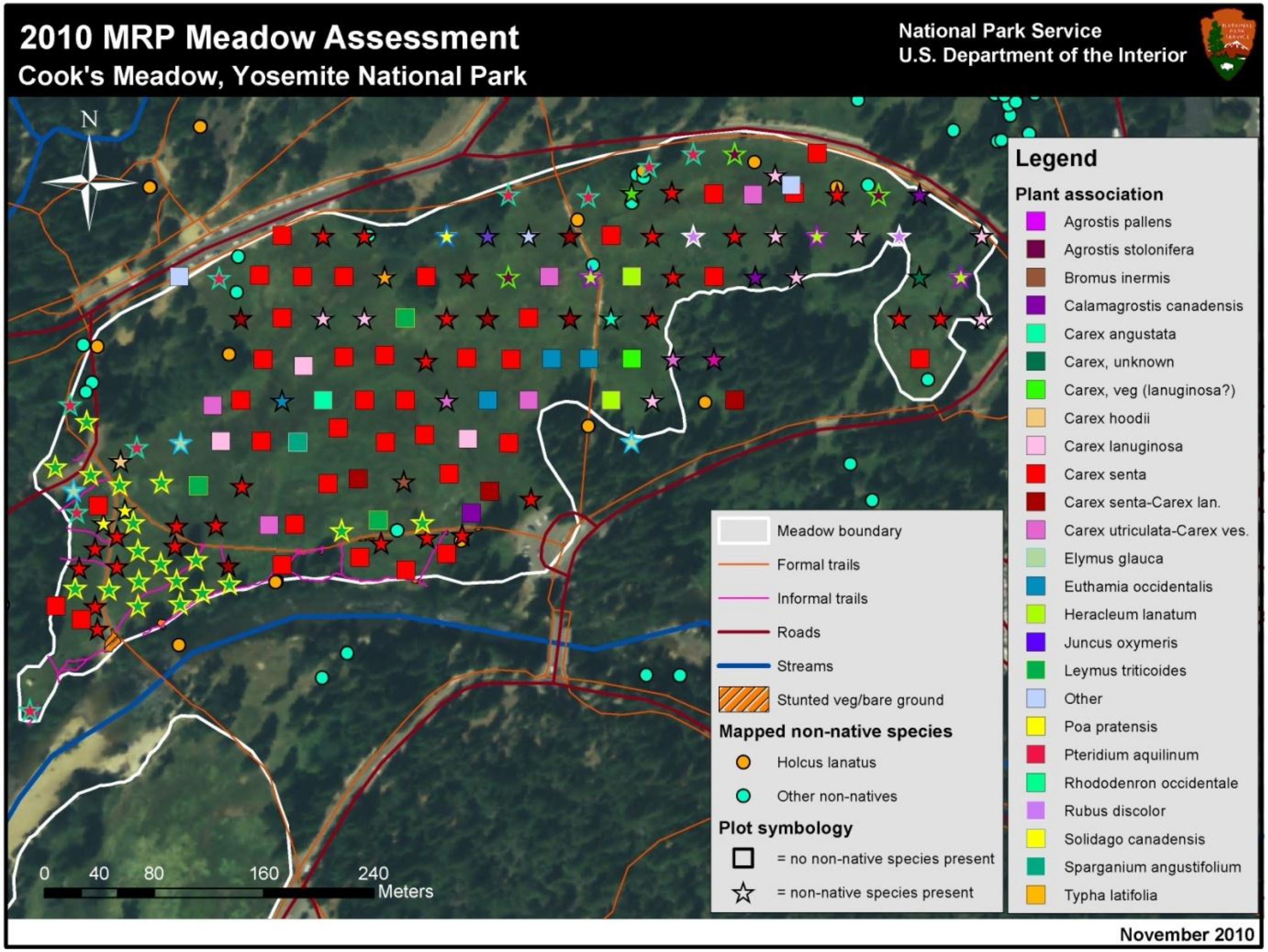
Cook's Meadow


Photo E-3a. Cook's Meadow, looking west.


Photo E-3b. Cook's Meadow, looking east.

Cook's Meadow is located in the eastern portion of Yosemite Valley, northwest of Sentinel Bridge (Photo E-3a, Map E-3). The meadow is located adjacent to the Merced River, along Northside Drive. The meadow is 13.6 hectares in size, and the elevation at the site is 3,960 feet.

Eighty-five plant species were documented in gridpoint plots at Cook's Meadow. The dominant meadow plant communities were *Carex senta* (rough sedge) and *Carex lanuginosa* (woolly sedge). *Leymus triticoides* (beardless wildrye) was also common, comprising 8% of plant communities (Map E-3). Tree seedlings were present in 14% of plots.



Map E-3a. Aerial photo map of Cook's Meadow showing plant communities (plots) and other features.

Non-native species were present in 60% of Cook's meadow plots; 9% of plots had greater than 25% cover of non-native species and 6% of plots had greater than 50% cover of non-native species. The most common non-native species was *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass), present in 27% of plots, followed by *Agrostis stolonifera* (creeping bent grass) in 15% of plots, *Rubus armeniacus* (Himalayan blackberry) in 12% of plots, and *Hypericum perforatum* (St. John's wort) in 11% of plots (Table E-2). *Holcus lanatus* (velvet grass) was mapped in on the edges of Cook's meadow (Yosemite Parkwide Weeds Database, accessed 11/30/2010). The rare sedge *Carex buxbaumii* (Buxbaum's sedge) was found in 4 plots in Cooks meadow. Yellow pond-lily (*Nuphar lutea* ssp. *polysepala*) is found in the deepest pond (Photo E-3c)

Table E-2. Non-native plant species in Cook's Meadow gridpoint plots.

Non-native species	%Plots where present
Agrostis stolonifera	15%
Bromus inermis ssp. *inermis*	2%
Bromus hordeaceus	1%
Bromus tectorum	2%
Cirsium vulgare	8%
Holcus lanatus	5%
Hypericum perforatum	11%
Lactuca serriola	1%
Poa pratensis ssp. *pratensis*	27%
Polygonum arenastrum	1%
Robinia sp.	1%
Rubus armeniacus	12%
Rubus laciniatus	1%
Scirpus cyperinus	3%
Tragopogon dubius	2%
Trifolium repens	1%
Verbascum thapsus	1%
Vulpia myuros	1%

Informal trails were found in 5% of Cook's meadow plots, and 967m of informal trails were mapped (Newburger et al. 2011, in prep.).

Meadow History: Cook's Meadow, also known as the Former Elk Paddock Meadow, was used for pasturage of the dairy herd that supplied early hotels from 1888 to 1913. It was fenced during these years, and a barn stood in the southwestern corner of the meadow. The meadow remained unfenced from 1913 until 1921, when elk were moved into a fenced area of the meadow from outside the park. The elk were removed in 1933. In 1942, a large effort to remove encroaching conifers took place. (Ernst 1943).

Meadow infrastructure: A sewer line, roads, paved trails, culverts, ditches, and channeled streambeds altered the surface and groundwater hydrology of the meadow throughout time (Eagan 1994). In 1998, a large ecological restoration effort took place to fill artificial drainage ditches and outlets, remove abandoned roadbed fill material, replace paved trails with elevated boardwalks, install additional culverts under roads, and remove exotic species(Niederer 2007, unpublished report). The sewer line was replaced outside of the meadow in 2010, with the exception of a small portion of the line in the west part of the meadow.

Meadow Observations: A fen, a sensitive wetland habitat that often supports a high diversity of flora and fauna, may be present near the east end of the meadow. Roadside parking is expanding directly north of the area. Actions that change water supply to the area could impact the area.

There was a meadow of sixty acres near Cook's old hotel. It was covered with verdure, and here and thee clumps of wild rose bushes broke the monotony of the greensward. A romantic path wound through and cross the meadow and was a favorite walk for visitors. The Yosemite ranchers looked with covetous eyes upon this fertile spot…They cleared the land, burned the rose bushes, plowed the meadow and sowed it with grain to make hay. They destroyed the walk and fenced the public out with barbed wire.
San Francisco Daily Examiner, 1888

There is a larger number of species of plants within this district than probably can be found anywhere else on the continent. Professor Torrey, who has given the correct botanical names to several hundred plants of California, states that on the space of a few acres of meadow land he found about 300 species, and that within the sight of trail usually traveled by visitors at least 600 may be observed, most of them being small and delicate flowering plants. (These plants have been destroyed by the Commission and the Saddle Train Company.)
San Francisco Daily Examiner, 1889

Photo E-3c. Yellow pond-lily (*Nuphar lutea* ssp. *polysepala*) in Cook's Meadow.

El Capitan Meadow

Photo E-4a. El Capitan Meadow, looking south.

Photo E-4b. El Capitan Meadow, looking north.

El Capitan Meadow is located in the western portion of Yosemite Valley, just south of El Capitan (Photos E-4a,b, Map E-4 and Map 4). The meadow is adjacent to the Merced River, along Northside Drive. The meadow is 19.6 hectares in size, and the elevation at the site is 3,953 feet.

Gridpoint plots documented 76 plant species in El Capitan Meadow. Dominant native plant communities were *Festuca occidentalis* (western fescue) and *Calamagrostis canadensis* (blue-joint grass), comprising 14% and 6% of plots, respectively (Map E-4). The native fern *Pteridium aquilinum* (brackenfern) was more common in El Capitan than any other meadow. The rare sedge *Carex buxbaumii* (Buxbaum's sedge) was found in one plot in El Capitan Meadow. Tree seedlings were present in 32% of plots.

Non-native species were present in 96% of plots, and 12% of plots had greater than 25% cover of non-native plants. The most common non-native was *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) present in 91% of plots, followed by *Tragopogon dubius* (goat's beard) in 15% of plots (Table E-3). *Rubus armeniacus* (Himalayan blackberry) was mapped at many points in the western half of El Capitan, and across the river (Yosemite Parkwide Weeds Database, accessed 11/30/2010). Birds can easily transport *Rubus* seeds from across the river to El Capitan meadow.

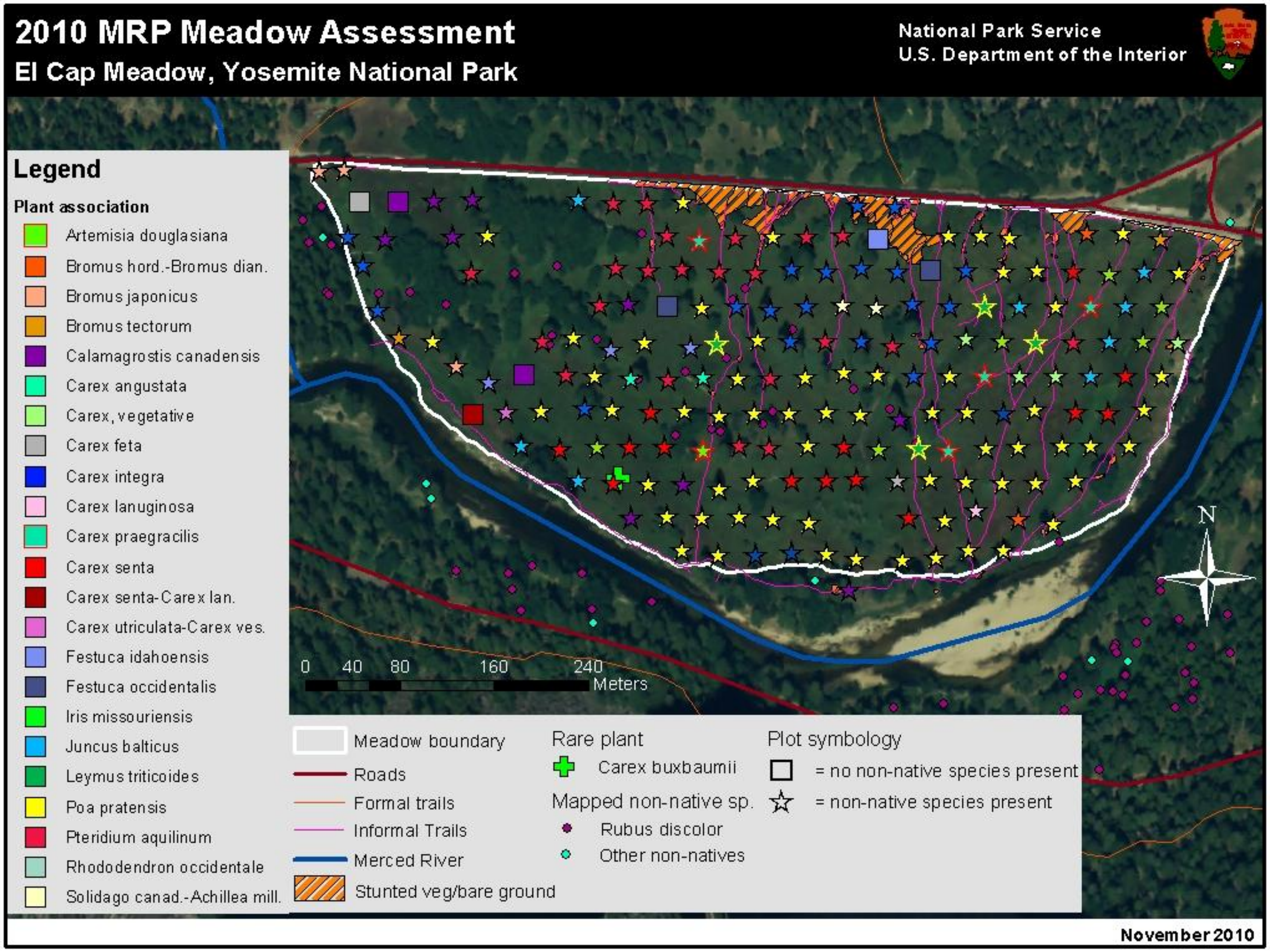
Informal trails were found in 19% of El Capitan meadow plots, and 4135m of informal trails were mapped (Newburger et al. 2011).

> *Your[Yosemite Valley] meadows must be sown with a good mixture of the hardy grasses grown for hay such as Phleum pratense (timothy), Poa trivialis, Poa pratensis (Kentucky blue grass), Avena pubescens (oat grass).*
>
> Report of State Engineer
> Wm. Ham. Hall. 1881

Table E-3. Non-native plant species in El Capitan Meadow gridpoint plots.

Non-native species	%plots present
Agrostis stolonifera	1%
Bromus hordeaceus	1%
Bromus japonicus	2%
Bromus tectorum	3%
Chenopodium album	1%
Cirsium vulgare	1%
Geranium sp.	1%
Lactuca serriola	1%
Plantago lanceolata	2%
Poa bulbosa	2%
Poa pratensis ssp. *pratensis*	91%
Polygonum arenastrum	1%
Rudbeckia hirta var. *pulcherrima*	1%
Rubus armeniacus	1%
Rumex acetosella	6%
Stellaria media	1%
Taraxacum officinale	1%
Tragopogon dubius	15%
Verbascum thapsus	1%

Meadow History: El Capitan Meadow served as a pasture off and on at least since the late 1870s for the Washburn Brothers and their stage and saddle business. Galen Clark blasted the moraine just downstream of the meadow in 1879 to reduce extensive overbank flooding of the river in the meadow. Kenney and Associates farmed the meadows soon after the moraine was blasted – 20 acres were plowed and sown with *Phleum pratense* (timothy grass). A hay shed was mapped on early maps in eastern portion of the meadow. John Degnan kept a dairy herd in the meadow from 1889 to 1921. The milking shed was located east of the present El Capitan Bridge Road. The North Road across the meadow was raised to prevent flooding in 1922. The Civilian Conservation Corps removed encroaching forest trees between the meadow and the base of the cliffs in 1933-1935 to open views of El Capitan. Over 9,000 pines were removed. They returned in 1942 to remove 2,756 more trees. Emil Ernst documented tens of thousands of one- to four- year old conifer seedlings the meadow in 1943 (Ernst 1943).



Map E-4. Aerial photo map of El Capitan Meadow showing plant communities (plots) and other features.

Meadow Infrastructure Notes: There are several drainage ditches located in the El Capitan meadow, two of which run perpendicular to Northside Drive (Eagan 1994).

Meadow Observations: During the time of survey, we noted meadow patches dominated by both non-native and native pioneering annual grass species; *Vulpia microstachys* (small fescue) and *Deschampsia danthoniodes* (annual hairgrass). We hypothesize that these meadow patches may be degraded picnic areas and El Capitan viewing locations.

Leidig Meadow

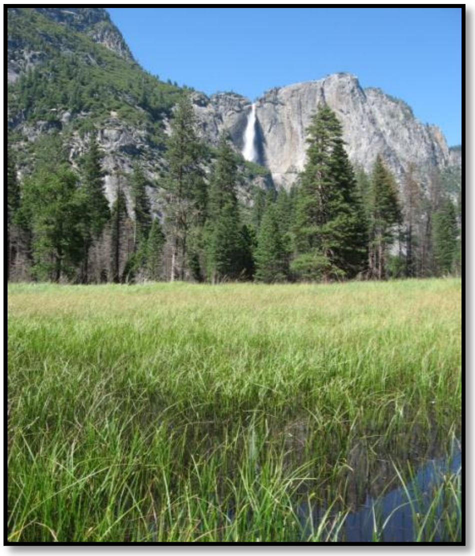


Photo E-5a. Leidig Meadow, looking northeast. Photo E-5b. Leidig Meadow, looking east.

Leidig Meadow is located in the eastern portion of Yosemite Valley, just south of El Capitan. The meadow is located adjacent to the Merced River, along Northside Drive. The meadow is 19.6 hectares in size, and the elevation at the site is 3,953 feet (see Photos E-5a,b, Map E-5, Map 4).

We documented 77 plant species in Leidig Meadow gridpoint plots. The dominant meadow plant community was *Carex lanuginosa* (woolly sedge), comprising 29% of plots. Other common communities were native *Leymus triticoides* (beardless wildrye), comprising 18% of plots and non-native *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass), comprising 17% of plots. Low-lying, saturated areas of *Carex vesicaria-utriculata* (bladder/inflated sedge) comprised 9% of plots. Leidig was the only Yosemite Valley meadow with no tree seedlings found in gridpoint plots.

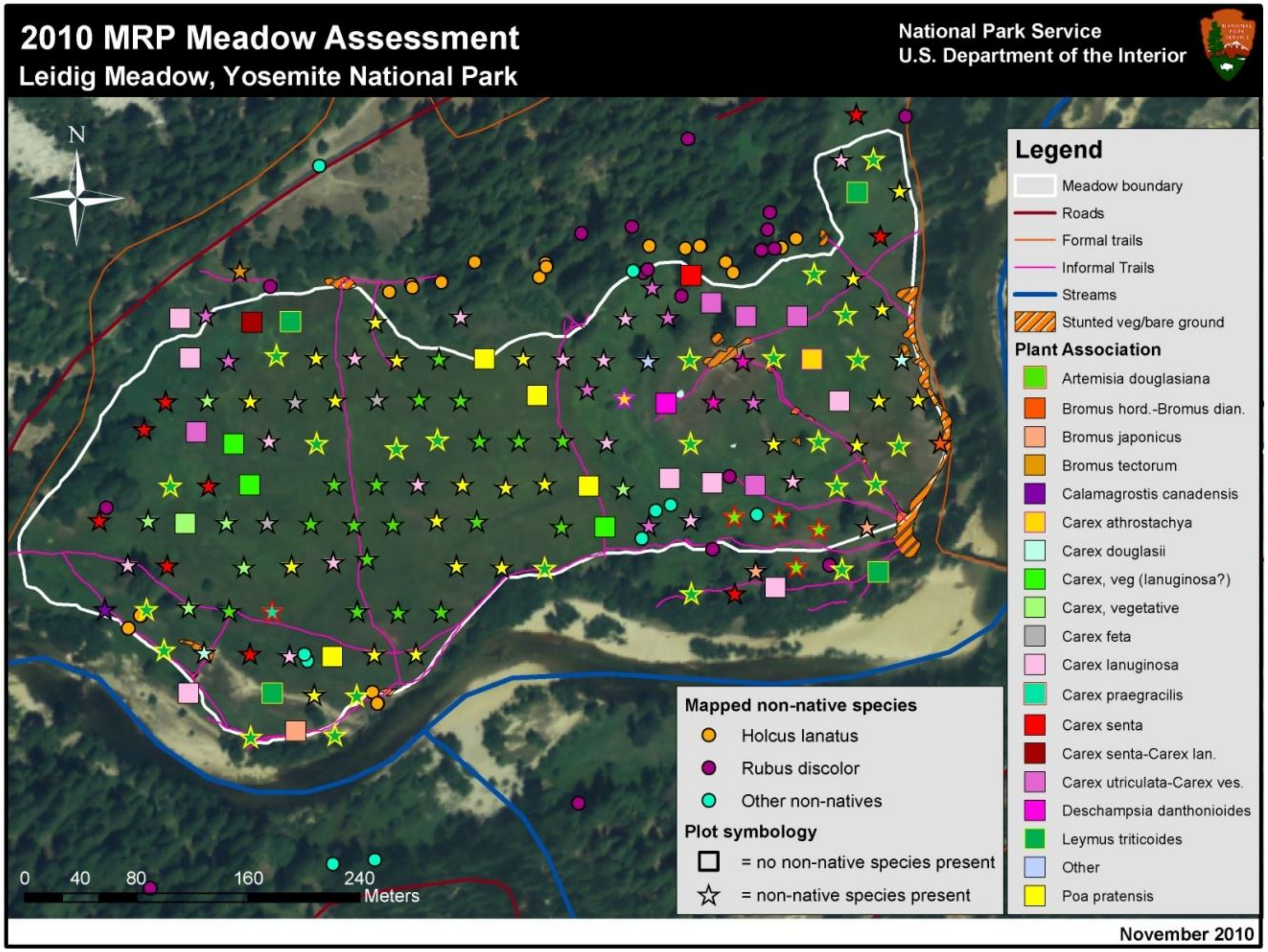
Non-native species were present in 80% of plots, and 13% of plots had greater than 25% cover of non-native plants. The most common non-native was *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) present in 64% of plots, followed by *Bromus japonicus* (Japanese chess) and Rumex acetosella (sheep sorrel), both of which comprised 10% of plots each (Table E-4). The non-natives *Rubus armeniacus* (Himalyan blackberry) and *Holcus lanatus* (velvet grass) were mapped at several locations in Leidig meadow, and outside the meadow along its northern edge. (Yosemite Parkwide Weeds Database, accessed 11/30/2010). Informal trails were found in 12% of Leidig plots, and 2159m of informal trails were mapped in this meadow (Newburger et al. 2011, in prep.).

<u>Meadow History:</u> Leidig Meadow was plowed and sown with *Phleum pratense* (timothy grass) for forage in 1887, then wheat in 1888. It may have been plowed and sown more often. The meadow was highly desired for grazing by early settlers, and it was one of the last to retain domestic animal grazing in Yosemite Valley. An oval race track was constructed in the meadow in 1929 as part of the festivities for the Indian Field Days gathering (Ernst 1941). Rubble check dams were built along the river to discourage

overbank flooding between 1890 and 1915. In 1919, the meadow was the site of a rustic aircraft landing strip.

Table E-4. Non-native plant species in Leidig Meadow gridpoint plots.

Non-native species	**%Plots present**
Agrostis gigantea	1%
Agrostis stolonifera	2%
Bromus diandrus	2%
Bromus japonicus	10%
Bromus tectorum	3%
Cirsium vulgare	5%
Holcus lanatus	1%
Lactuca serriola	1%
Phleum pratense	2%
Poa bulbosa	5%
Poa pratensis ssp. *pratensis*	64%
Polygonum persicaria	1%
Rumex acetosella	10%
Rumex crispus	1%
Sisymbrium altissimm	3%
Taraxacum officinale	2%
Tragopogon dubius	6%
Verbascum thapsus	1%



Map E-5. Aerial photo map of Leidig meadow showing plant communities (plots) and other features.

Meadow Infrastructure: The southern portion of the meadow contained remnant riprap structures. These rock barriers were once used to influence the river channel along the riverbank, but are now located within the meadow itself (Eagan 1994). Adjacent to the eastern meadow boundary, a paved bicycle path runs from north to south, and remnants of an old bridge abutment are located just east of the bicycle path adjacent to the Merced River.

Meadow Observations: During the time of survey, we noted numerous non-native annual grasses and high amounts of disturbed, bare ground in the southern and eastern meadow edges. A denuded area near the “John Muir Tree” was noted as having high amounts of compacted bare ground and disturbed areas dominated by both native and non-native pioneering annual grasses such as *Deschampsia danthoniodes* (annual hairgrass) and *Vulpia microstachys* (small fescue). The western portion of the meadow had two parallel ditches that ran from west to east into an oxbow in eastern meadow. These ditches appeared to be man-made, apparently for the purpose of draining the meadow.

Sentinel Meadow


Photo E-6a. Sentinel Meadow, looking east.


Photo E-6b. Sentinel Meadow, looking north.

Sentinel Meadow is located in the eastern portion of Yosemite Valley, just north of Sentinel Rock. The meadow is located adjacent to the Merced River, along Southside Drive. The meadow is 13.0 hectares in size, and the elevation at the site is 3,965 feet (see Photos E-6a,b, Map E-6, Map 4).

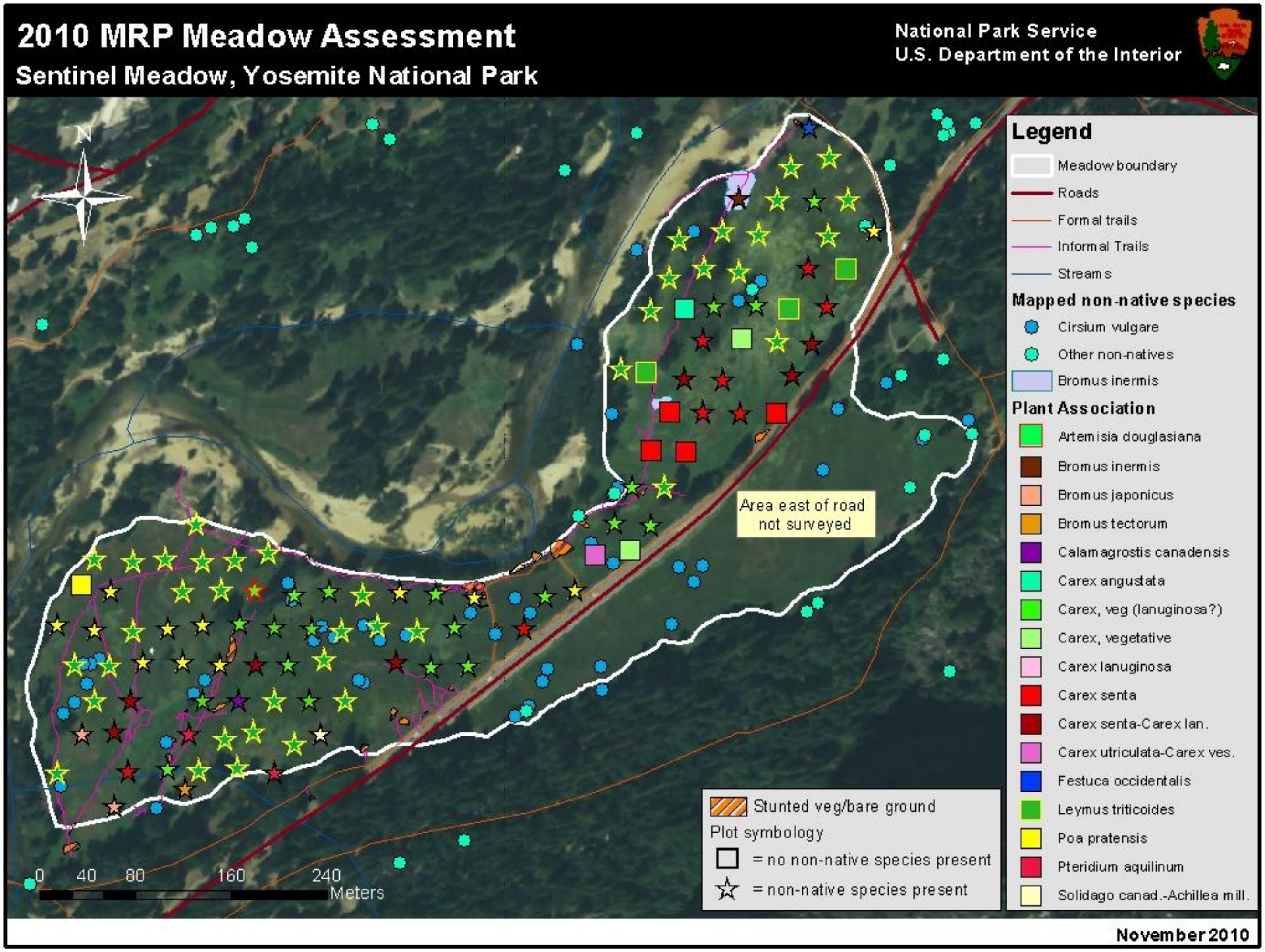
We documented 60 plant species in Sentinel Meadow gridpoint plots. The dominant community was the native grass *Leymus triticoides* (beardless wildrye) comprising 41% of plots (Map E-6). Other common communities were the native sedges *Carex senta* (rough sedge) and *Carex lanuginosa* (woolly sedge), together comprising 36% of plots. Tree seedlings were found in 2% of gridpoint plots in Sentinel Meadow.

Non-native species were present in 90% of plots, and 12% of plots had greater than 25% cover of non-native plants. The most common non-native was *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) present in 78% of plots, followed by *Bromus japonicus* (Japanese chess) and *Bromus tectorum* (cheat grass), present in 7% and 5% of plots, respectively (Table E-5). The non-native *Cirsium vulgare* (bull thistle) was mapped in and adjacent to Sentinel meadow. (Yosemite Parkwide Weeds Database, accessed 11/30/2010).

Table E-5. Non-native plant species in Sentinel Meadow gridpoint plots.

Non-native species	% of plots present
Bromus diandrus	1%
Bromus inermis ssp. *inermis*	2%
Bromus japonicus	7%
Bromus tectorum	5%
Chenopodium album	1%
Cirsium vulgare	7%
Lactuca serriola	7%
Mentha spicata	1%
Poa bulbosa	2%
Poa pratensis ssp. *pratensis*	78%
Rumex acetosella	2%
Rumex crispus	1%
Sisymbrium altissimm	2%
Tragopogon dubius	7%
Verbascum thapsus	2%
Vulpia myuros	1%

Informal trails were found in 16% of Sentinel meadow plots, and 2264m of informal trails were mapped in the western portion of the meadow (Newburger et al. 2011, in prep.).



Map E-6. Aerial photo map of Sentinel Meadow showing plant communities (plots) and other features.

Meadow History Notes: Sentinel Meadow was used for pasturing stock and dairy animals since the earliest pioneers arrived in Yosemite Valley. A boardwalk, the Cosmopolitan Walk, was built in 1870 to allow a straight passage across the meadow in 1870 during the wet spring months. The boardwalk ran in the approximate alignment of the present Northside Drive (Ernst 1943).

Meadow Infrastructure: This meadow is bisected from east to west by a paved road, as well as by a series of connecting boardwalks that run north to south from Southside Drive and west to east along the Merced River. Remnant infrastructure is located in the southern portion of the meadow including an old culvert and a rock wall that was once used to raise an old roadbed (Eagan 1994). The northern meadow portion is fenced along the paved path that runs parallel with Southside Drive. A paved bicycle path runs from north to south adjacent to the eastern meadow boundary.

Meadow Observations: During the time of survey, we noted many ephemeral drainages throughout the meadow. Non-native annual grasses were dominant in a portion of the eastern meadow near the “Old Yosemite Village” site.

Stoneman Meadow

Photo E-7a. Stoneman Meadow, looking west. **Photo E-7b. Road bisecting Stoneman Meadow.**

Photos E-7c,d. Highly invasive non-native Bromus inermis ssp. inermis (Smooth brome). Planted in close proximity to Stoneman Meadow, this invasive grass spread into the meadow, out-competing diverse native vegetation.

Stoneman Meadow is located in the eastern portion of Yosemite Valley, east of Stoneman Bridge and north of Curry Village. The meadow is located adjacent to the Merced River, along Southside Drive. The meadow is 6.8 hectares in size, and the elevation at the site is 4,000 feet (see Photos E-7a,b, Map E-7, Map 4).

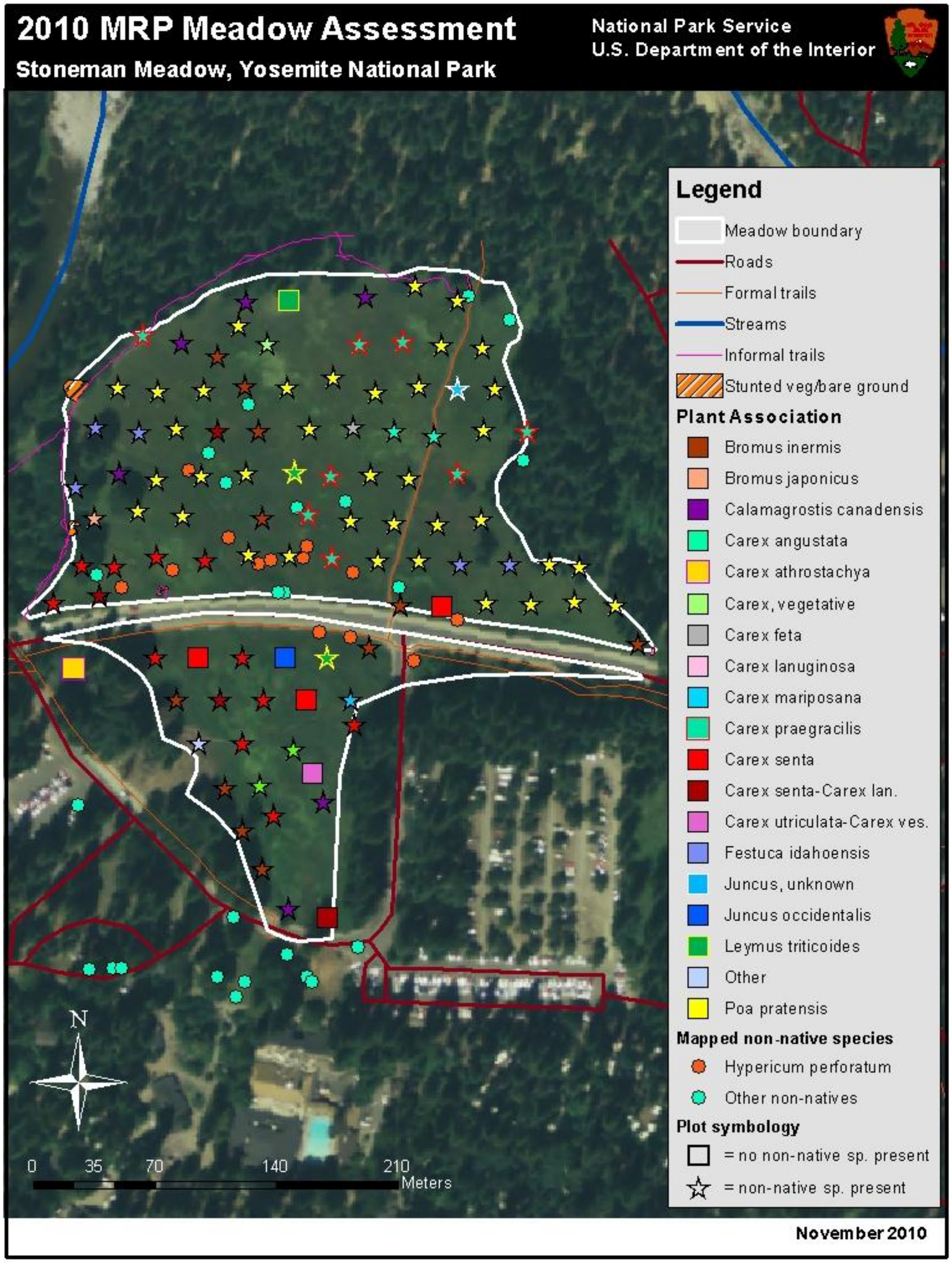
We documented 69 plant species in Stoneman Meadow gridpoint plots. The dominant meadow plant communities were non-native grasses *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass), comprising 37% of plots and *Bromus inermis* ssp. *inermis* (smooth brome), comprising 11% of plots (Table E-7). Also common were the native sedges *Carex senta* (rough sedge) and *Carex praegracilis* (clustered field sedge) which comprised 14% and 8% of plots, respectively. Tree seedlings were found in 32% of plots.

Non-native species were present in 92% of plots, and Stoneman Meadow had the highest proportion of plots with greater than 25% cover of non-natives. (29% of plots had greater than 25% cover of non-natives, 7% of plots had greater than 50% cover of non-natives, and 4% of plots had greater than 75% cover of non-natives.) The most common non-native was *Poa pratensis* ssp. *pratensis* (Kentucky bluegrass) present in 78% of plots (Table E-6), followed by *Cirsium vulgare* (bull thistle) in 25% of plots, *Tragopogon dubius* (goat's beard) in 15% of plots, and *Bromus inermis* ssp. *inermis* (smooth brome) in 13% of plots (Table E-6). The non-native *Hypericum perforatum* (St. John's wort) was mapped throughout Stoneman meadow, with the highest concentrations near the paved road. (Yosemite Parkwide Weeds Database, accessed 11/30/2010). The rare sedge *Carex buxbaumii* (Buxbaum's sedge) was found in 5 plots of Stoneman Meadow, south of the paved road.

Table E6. Non-native plant species in Stoneman Meadow gridpoint plots.

Non-native species	%Plots present
Agrostis gigantea	1%
Agrostis stolonifera	5%
Bromus inermis ssp. *inermis*	13%
Bromus japonicus	2%
Bromus tectorum	3%
Cirsium vulgare	25%
Dactylis glomerata	1%
Hypericum perforatum	6%
Poa bulbosa	1%
Poa pratensis ssp. *pratensis*	78%
Rudbeckia hirta var. *pulcherrima*	12%
Rumex acetosella	2%
Taraxacum officinale	3%
Tragopogon dubius	15%
Verbascum thapsus	1%

Informal trails were found in 3% of Stoneman meadow plots, which was the lowest level of trailing among all Valley meadows. A 167m length of social trail was mapped in the western portion of Stoneman meadow (Newburger et al. 2011, in prep.).



Map. E-7. Aerial photo map of Stoneman Meadow showing plant communities (plots) and other features.

Meadow History: James Lamon planted an orchard in the southeast portion of Stoneman Meadow in 1860. The orchard occupied about one-sixth of the meadow in 1943. The remaining portion of the meadow was cleared and plowed in 1887. Ernst notes that Stoneman Meadow is a vestige of meadow-like conditions which covered almost the entire upper (eastern) end of Yosemite Valley (Ernst 1943).

Meadow Infrastructure: There are several surface features that appear to drain ground water from the meadow (Cooper 2008, unpublished report). Cooper (2008) surmised that tree invasion in Stoneman Meadow is likely due to hydrologic alterations, as little conifer invasion occurs in the unimpacted portions of the meadow. This meadow is bisected from east to west by a paved road. An informal trail in the eastern portion of the meadow (running north to south) was rehabilitated and changed to an elevated boardwalk in 1987.

Bromus inermis ssp. *inermis* (smooth brome) was planted in Curry Village landscaping approximately 15 years ago. This non-native invasive grass spread to completely circles the south portion of Stoneman Meadow and invade large portions of the north meadow (Photo E-7c,d). This grass has the potential to outcompete native meadow vegetation. During the time of survey, we noted a ditch that runs through the southern part of meadow from west to east and appears to aid in draining the meadow.

Alteration of Hydrologic Processes: Stoneman Meadow is sustained by ground water from Valley walls that moves from the south to north toward the river (Cooper 2008, unpublished report). Southside Drive bisects the meadow, creating a southern and a northern meadow. The northern meadow has a lower elevation, lower water table (in relation to ground surface), lower ratio of wetland to upland plants, higher cover of non-native plants, and lower cover of sedges. Social trails and ditches were removed in early 1990s as part of a restoration project (Cooper 2008, unpublished report). Cooper (2008) notes four constructed surface water diversions that drain groundwater. While three of the four diversions are adjacent to the road, they appear to be related to historic ditches which drained the meadow. These diversions may cause the drastic decrease in ground water elevation adjacent to the road ((Cooper 2008, unpublished report). The road may impact water movement from south to north and elevate the water table south of the road and lower the water level north of the road (Cooper 2008, unpublished report). Hydric features in meadow soils suggest that soils were formed under long-duration periods of saturation during the growing season for an extended period of time, from the near-present to several hundred years in the past (Cooper 2008, unpublished report).

Appendix F. Site Details for Subalpine Meadows

In alphabetical order by meadow name.

Doc Moyle's- East Meadow

Photo F-1a. *Carex vesicaria* in Doc Moyle's- East. **Photo F-1b. Bare ground area in Doc Moyle's- East.**

Photo F-1c. Lyell Fork in Doc Moyle's- East.

Doc Moyle's- East Meadow is located in the eastern section of the park along the Lyell Fork of the Merced River, east of Washburn Lake and north of Mt. Ansel Adams. The Doc Moyle's meadow complex is composed of two meadows that are separated by the rocky, forested confluence of Hutchings Creek entering from the north (see Photos F-1a,b, Map F-1, Map 6). This site is the upper (eastern-most) meadow of the Doc Moyle's complex and is located about one mile east of the formal trail.

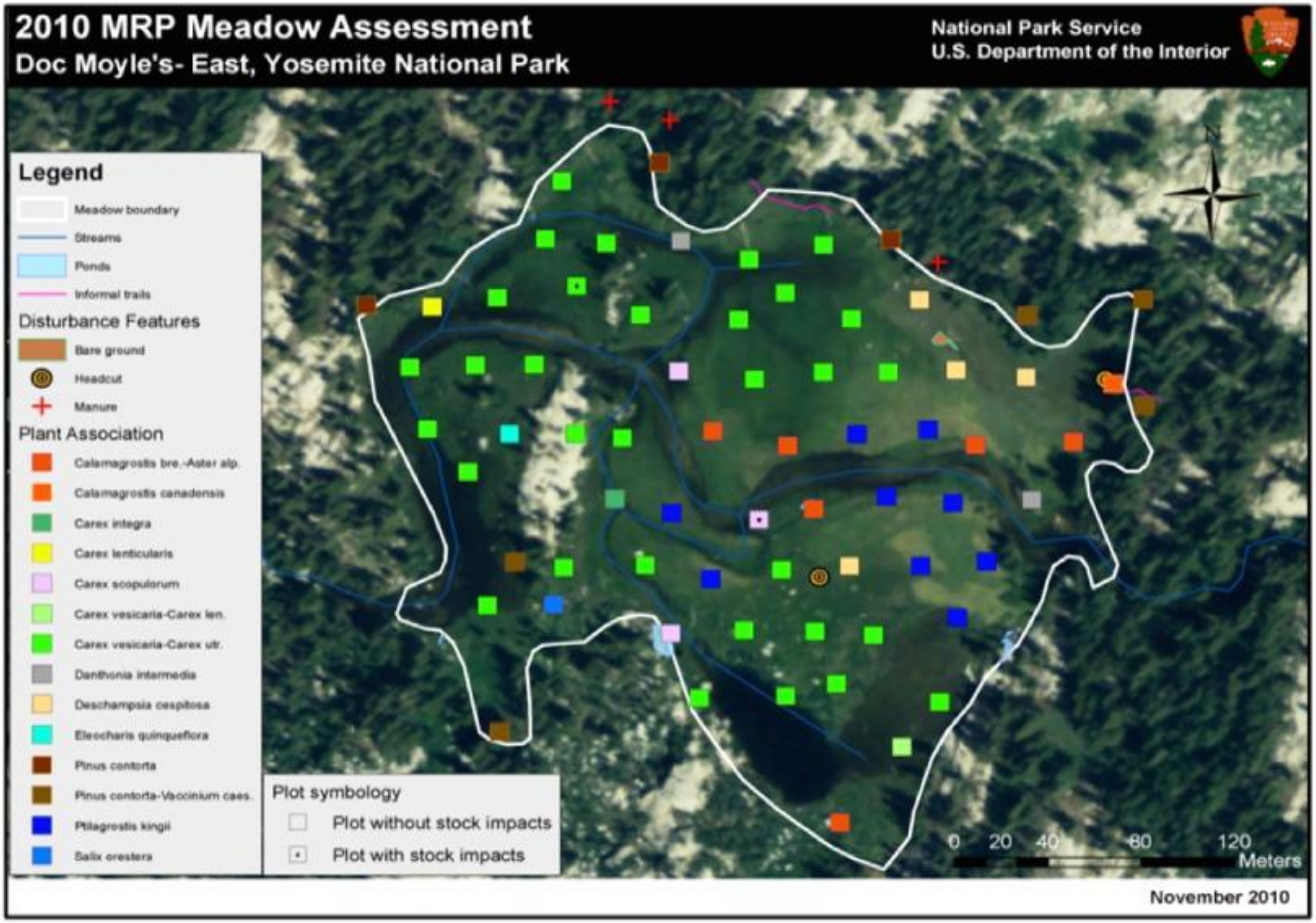
Doc Moyle's- East is 6.6 hectares in size, and the elevation is 9,334 feet. The dominant meadow plant community in gridpoint plots was the hydric species *Carex vesicaria-C. utriculata* (bladder sedge), and *Ptilagrostis kingii* (Sierra rice grass) dominated some drier areas. The dominant streambank communities were *Carex scopulorum* (mountain sedge) and *Deschampsia cespitosa* (tufted hairgrass).

This meadow was very wet in mid-August. We noted sphagnum moss along the southwestern corner of the meadow. Tree seedlings were present in 5% of plots.

Minimal stock use evidence (camps, residual manure and hoof prints) and informal trails were present near this site (Map F-1). In the mid-1900s, private pack stock parties frequently used Doc Moyle's meadow but use has decreased dramatically over the past several decades (M. Fincher, personal communication). Impacts are more likely at Doc Moyle's- West, adjacent to the stock camp. Historic data show that mean annual pack stock use for the Doc Moyle area from 1946 to 1954 was high compared to other Merced River tributary areas surveyed. 229 stock nights were reported for the area over the 8 year period (NPS 1960).

Doc Moyle's- East Stream Survey (Rapid Assessment)
We conducted a short MIM survey of only 10 plots for this stream reach as time did not permit a full MIM survey. We followed MIM protocol methods, including DMA selection and plot spacing. We later converted these data to a more standardized rapid assessment protocol.

Graminoids dominated greenline vegetation (primarily *Carex scopulorum* and *Deschampsia cespitosa*). 20% of plots contained willows (*Salix planifolia* and *Salix orestera*), of which 33% were browsed. Active erosion was uncommon along the bank (one of ten plots). Bank vegetative cover was high, but data may have been influenced by high water at the time of survey causing us to read plots above the scour line (Photo F-1c). Substrate was primarily gravel and fine sediment with 80% fine material (less than 6 mm). The stream channel width was 12.5 m, which was the second widest of all study streams.



Map F-1. Aerial photo of Doc Moyle's-East showing plant communities (plots) and other features.

Doc Moyle's- West Meadow

Photo F-2a. Lyell Fork in Doc Moyle's- West.

Photo F-2b. Inundated area in Doc Moyle's- West.

Doc Moyle's- West is located in the eastern section of the park along the Lyell Fork of the Merced River. It is east of Washburn Lake, north of Mt. Ansel Adams, and about one mile east and upriver from of the formal trail. The area known as Doc Moyle's was historically grazed by pack stock and consists of two large meadows at the upstream end of a relatively narrow river canyon. The Lyell Fork flows from east to west through the canyon. The eastern and western meadows are separated by Hutchings Creek, which flows into the Lyell Fork from the north. Doc Moyle's- West is the first of the two meadows that travelers reach when arriving from the formal trail, and is closest to the main stock camp. It likely receives heavier use than Doc Moyle's- East (see Photos F-2a,b, Map F-2, Map 6).

The meadow is 2.8 hectares in size, and the meadow elevation is 9,305 feet. The dominant meadow plant community in gridpoint plots was *Carex vesicaria* (bladder sedge). The dominant streambank communities were *Carex vesicaria* and *Deschampsia cespitosa* (tufted hair grass), both of which are hydric species. This meadow was extremely wet in mid-August. Tree seedlings were present in 13% of plots.

Doc Moyle's- West had areas of concentrated impacts on the north side of the river including hoofpunching, trampled areas, manure, grazed vegetation and the stock camp adjacent to the meadow and stream (Map F-2). This site was the only study stream with bank impacts (hoofpunching) from pack stock. Only six stock use nights were reported for Doc Moyle's Meadow (both east and west) in the 2010 season, suggesting that these impacts occurred with low levels of use. Wilderness permit data for years 2004 to 2010 showed fluctuations in annual use, with a total of 58 nights for the entire period and several years with no use reported. Historic data show that mean annual pack stock use for the Doc Moyle area from 1946 to 1954 was high compared to other Merced River tributary areas surveyed. 229 stock nights were reported for the area over the 8 year period (NPS 1960). Until the mid-1900s, Doc Moyle's meadow was frequently used by private pack stock parties related to the Moyle family, but popularity has decreased in recent decades (M. Fincher, personal communication). The well-established camp near the stream is considered Doc Moyle's historic camp.

Along much of the stream reach, the stream channel had lower terraces of sedges below the greenline (streambank). This could be an indication of recovery from previous stock use disturbances, and could be a healing mechanism for the stream channel to return to a narrower state. In the absence of information on the condition of this channel during the decades of high stock use at this site, it is difficult to determine the cause of its seemingly unnatural width (see Photo 6, Discussion).

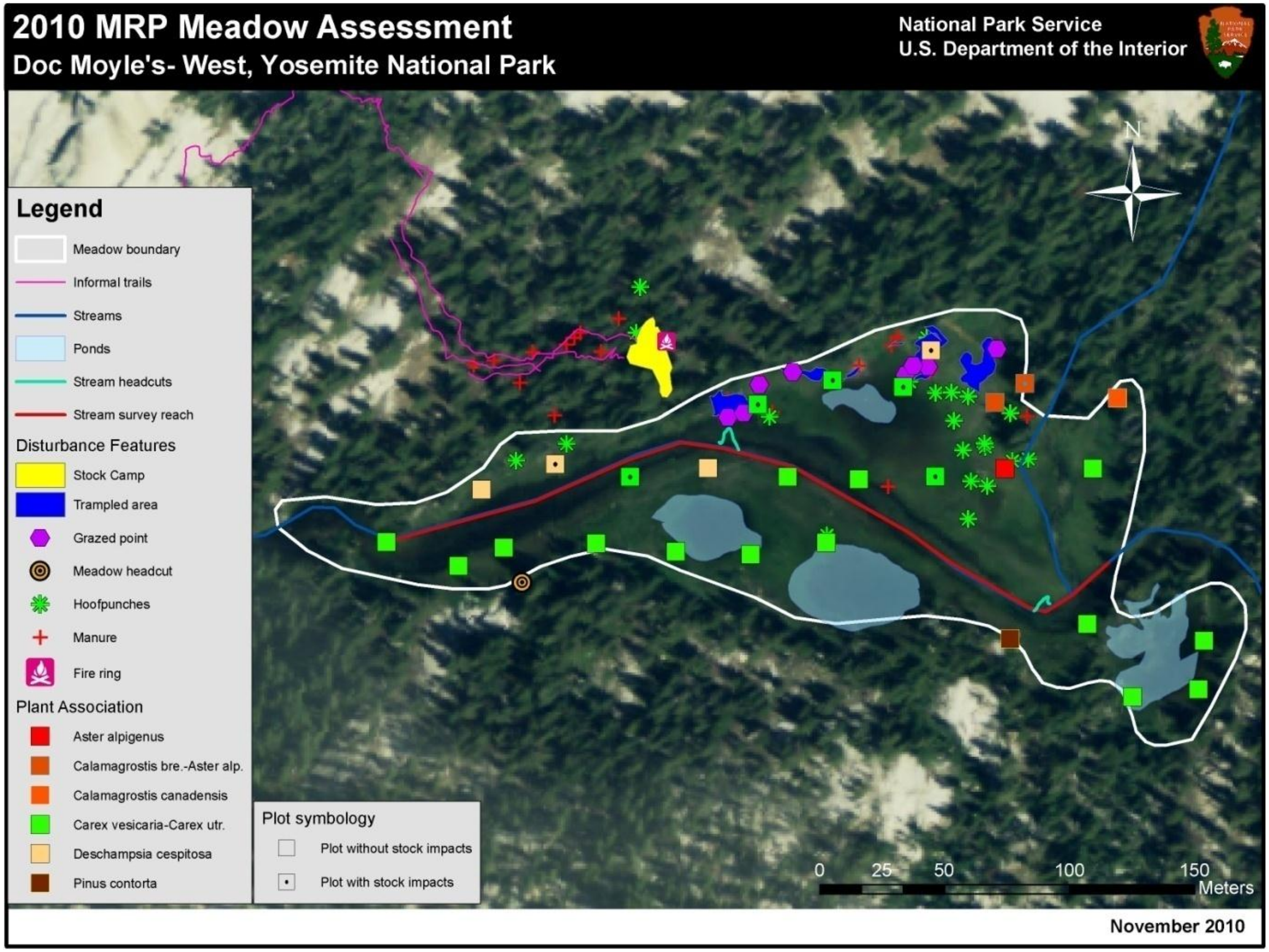
Doc Moyle's- West Stream Survey (MIM): Doc Moyle's- West had a high ecological status rating (99 of 100), indicating potential natural condition. This condition rating denotes that ecological succession may have reached successional climax and recent ecological disturbances at this site may have been minimal (Burton et al. 2011). The wetland rating for this site was the second lowest in comparison with other sites surveyed (84 of 100). The plant diversity index was high (7.1 of 10). The Winward Stability rating (an indication of greenline vegetation rooting strength) was the second lowest of all sites surveyed. Because rooting strength is correlated with streambank stability, the streambank at this site may be sensitive to erosion (See Table 12 and 13 in Results section for more information).

MIM survey showed streambank alterations (hoofpunches) from pack stock at 9% of plots. Bank vegetative cover was very high (99%), but these data were possibly influenced by the high waterline at the time of survey (thus inundating the bank that would typically be surveyed). Active erosion was recorded for 12% of the survey plots, which was second lowest for all sites. Several types of erosion features were recorded, including a total of three headcuts that were of low to moderate severity. Although headcut abundance was second lowest among all sites, headcut severity was the highest among all sites surveyed (See Table 13 in Results section for more information).

There were 23 greenline plant species present, and greenline vegetation composition showed the highest percentage of hydric and hydric herbaceous species (90% and 84%, respectively) among all study streams. Hydric herbaceous species were primarily sedges. The percentage of forbs was the lowest for all MIM sites surveyed (16%). The woody species presence was the lowest of all MIM sites surveyed. 75% of the woody species were rhizomatous. These woody species included willow (primarily *Salix planifolia* and *Salix orestera*) and flowering shrubs (primarily *Vaccinium caespitosum*). Woody species use was very low (see Tables 14 and 15 in Results section).

The substrate at Doc Moyle's- West consisted of the most fine materials (<2mm) of all sites surveyed. Fine materials made up 91% of the substrate at the site, and the median particle size was sand at 2.5 mm. The substrate was primarily sand and silt with very few particles greater than 8 mm in size.

The greenline to greenline width (18m) was wider than all other sites surveyed. The wide stream channel could be due to channel instability related to high levels of grazing (Powell et al. 2000). Doc Moyle's had high levels of pack stock use in the mid 20th century (M. Fincher, personal communication). Long term monitoring of Doc Moyle's- West would help to evaluate the trend in site conditions.



Map F-2. Aerial photo map of Doc Moyle's-West showing plant communities (plots) and other features.

Echo Valley Meadows


Photo F-3a. Downed logs in Echo Valley


Photo F-3b. Meadow area in Echo Valley

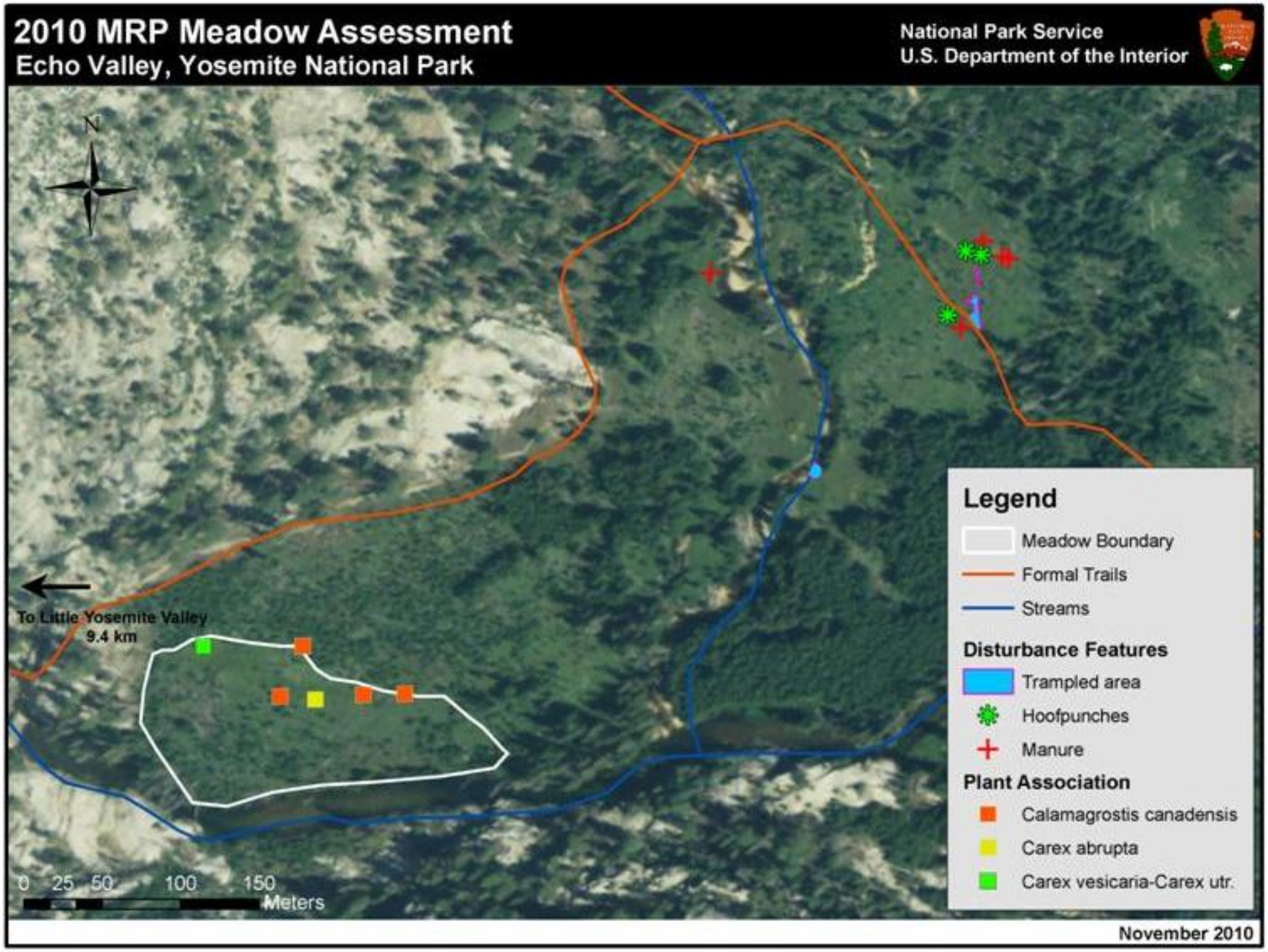

Photo F-3c. Echo Creek stream channel in Echo Valley

Echo Valley is located along Echo Creek, about 3 miles west of Merced Lake, and is bounded on its south end by the Merced River. The meadow elevation is approximately 7,000 feet. This valley has a mosaic of meadow-like openings that are likely related to a fire that burned through the area in the 1980s. This fire killed most of the trees, thereby raising the water table and creating temporary meadows. Debris from burned trees, stumps and deadfall is common in many meadow areas of Echo Valley. The stream contains abundant woody debris related to the fire. Conifer regeneration is thick and forms doghair thickets in many places (see Photos F-3a,b, Map F-3, Map 5).

Because of Echo Valley's meadow-like photosignature in aerial photos (MapF-3), it was included in our survey for subalpine meadows. However, only one area in the southwest portion of the valley fit our definition for meadow, due to extensive deadfall and regenerating conifer thickets. We collected minimal gridpoint plot data (6 plots) in this wet meadow opening (approximately 1.6 ha in size). The dominant plant community of this small meadow was *Calamagrostis canadensis* (blue-joint grass). Other meadow-like openings were noted throughout the valley, but most of these were drier and had thin, sandy soils and little organic matter in the soil. Scattered *Cirsium vulgare* (bull thistle) plants were the only non-native species found in the area.

Echo Valley was not suitable for stream monitoring (MIM) by the criteria in Burton et al. (2011), and only descriptive information was collected at the site. MIM guidelines require that the only significant disturbance be pack stock use; the influence of the burn disturbance would likely confuse analysis.

Although records from Yosemite's Wilderness Office report some pack stock use nearly every year, we were not able to locate a stock camp in the area. Many areas were not navigable due to extensive deadfall and impenetrable thickets of pine regeneration. We surveyed most of the valley that was accessible to pack stock, and minimal impacts (manure and scattered hoofpunches) were observed, mainly near the trail corridor (Map F-3). Until natural processes reduce deadfall and more meadow openings become accessible, the area seems inhospitable for stock grazing and unlikely to support much stock use in the near future. Historic data show that mean annual pack stock use for the Echo Valley/ Merced Lake area from 1946 to 1954 was high when compared with other Merced River corridor areas surveyed, as 882 stock nights were reported for the area over the 8-year period (NPS 1960).



Map F-3. Aerial photo map of Echo Valley showing plant communities (plots), and other features.

Little Yosemite Valley- East Meadow

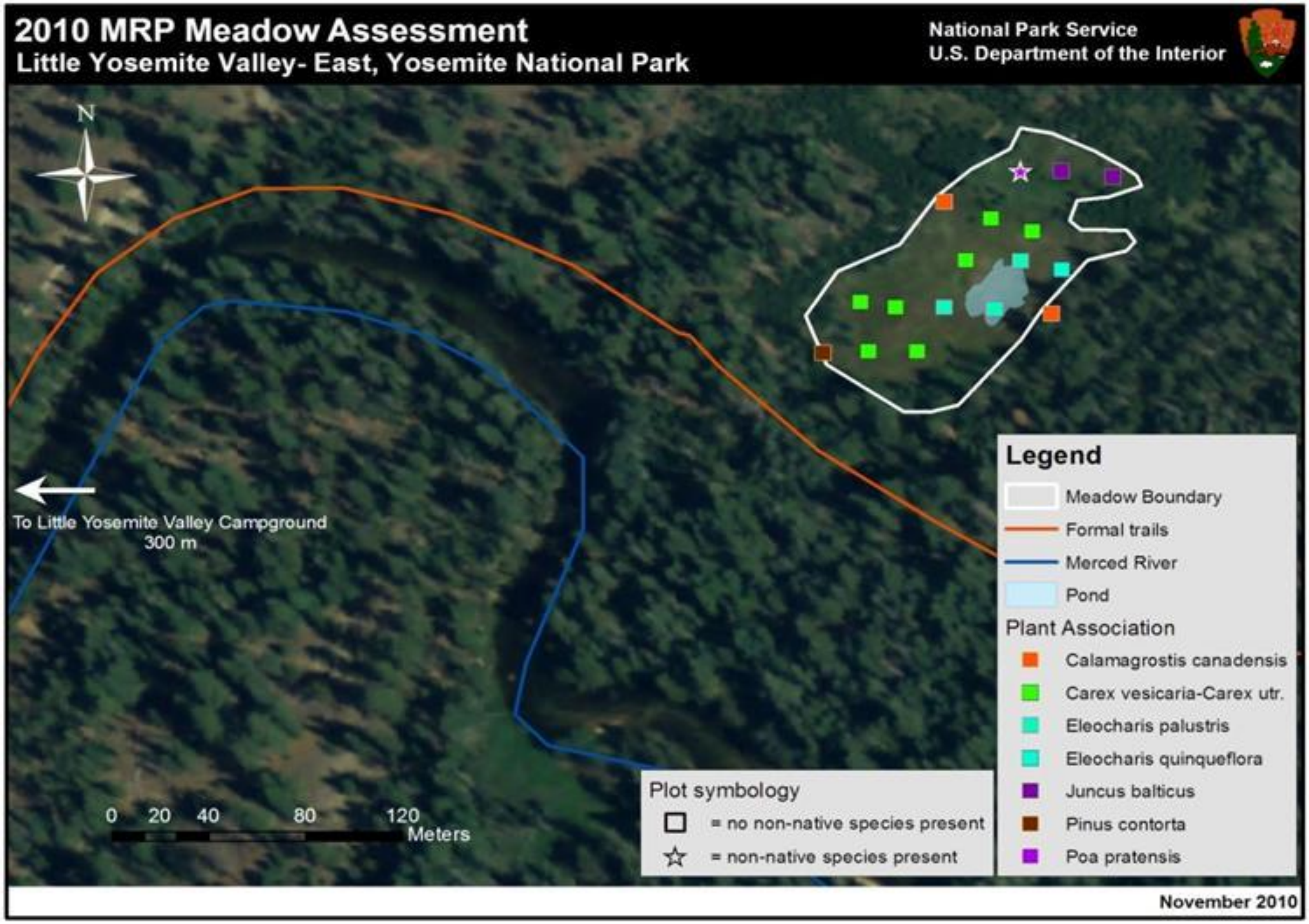
Photo F-4. Meadow at Little Yosemite Valley-East

Little Yosemite Valley-East Meadow is located along the main stem of the Merced River, 5 miles southeast of Yosemite Valley, and about 9 miles west of Merced Lake. The Little Yosemite Valley area receives high amounts of visitor use, as it is located along the route to Half Dome and encompasses a backpacker's camp and ranger station. The small meadow (0.9 ha in size) is located 300m east of Little Yosemite Valley campground, at an elevation of 6,120 feet (see Photos F-4a,b, Map F-4, Map 6).

The meadow was very wet at the time of survey, with most of the southern portion saturated and/or inundated. There was a large pond located in the center of the meadow (Map F-4). Large vernal areas with carpets of low-growing forb species (such as *Veronica peregrina*) were noted at this site. The dominant plant communities were *Carex vesicaria* (bladder sedge) and two species of *Eleocharis* (spikerush), *E. palustris* and *E. quinqueflora*. The non-native grass *Poa pratensis* ssp. *pratensis* was dominant in one plot, and found mainly in the northern, drier part of the meadow. No tree seedlings were found in gridpoint plots. The site was not suitable for streambank survey as there was no stream channel in the meadow.

Invasive plant surveys in 2006-2010 detected populations of *Holcus lanatus* (velvetgrass), *Cirsium vulgare* (bull thistle), *Verbascum thapsus* (common mullein), *Tragopogon dubius* (yellow salsify) *Lactuca serriola* (prickly lettuce), *Phleum pretense* (timothy), and *Taraxacum offinale* (dandelion) outside the meadows in Little Yosemite Valley. Hand-pulling was used to control non-native plant populations.

No recreational impacts were visible in the meadow from foot traffic or pack stock. Overnight stock use of the meadows is not allowed, and most visitors appear to recreate on the beach-like banks of the Merced River just south of the trail in Little Yosemite Valley. However, historic data show that mean annual pack stock use for Little Yosemite Valley in the years 1946 to 1954 was the highest of all sites in this study, as 1,878 stock nights were reported for the area over the 8 year period (NPS 1960).



Map F-4. Aerial photo map of Little Yosemite Valley-East showing plant communities (plots) and other features.

Little Yosemite Valley- West Meadow

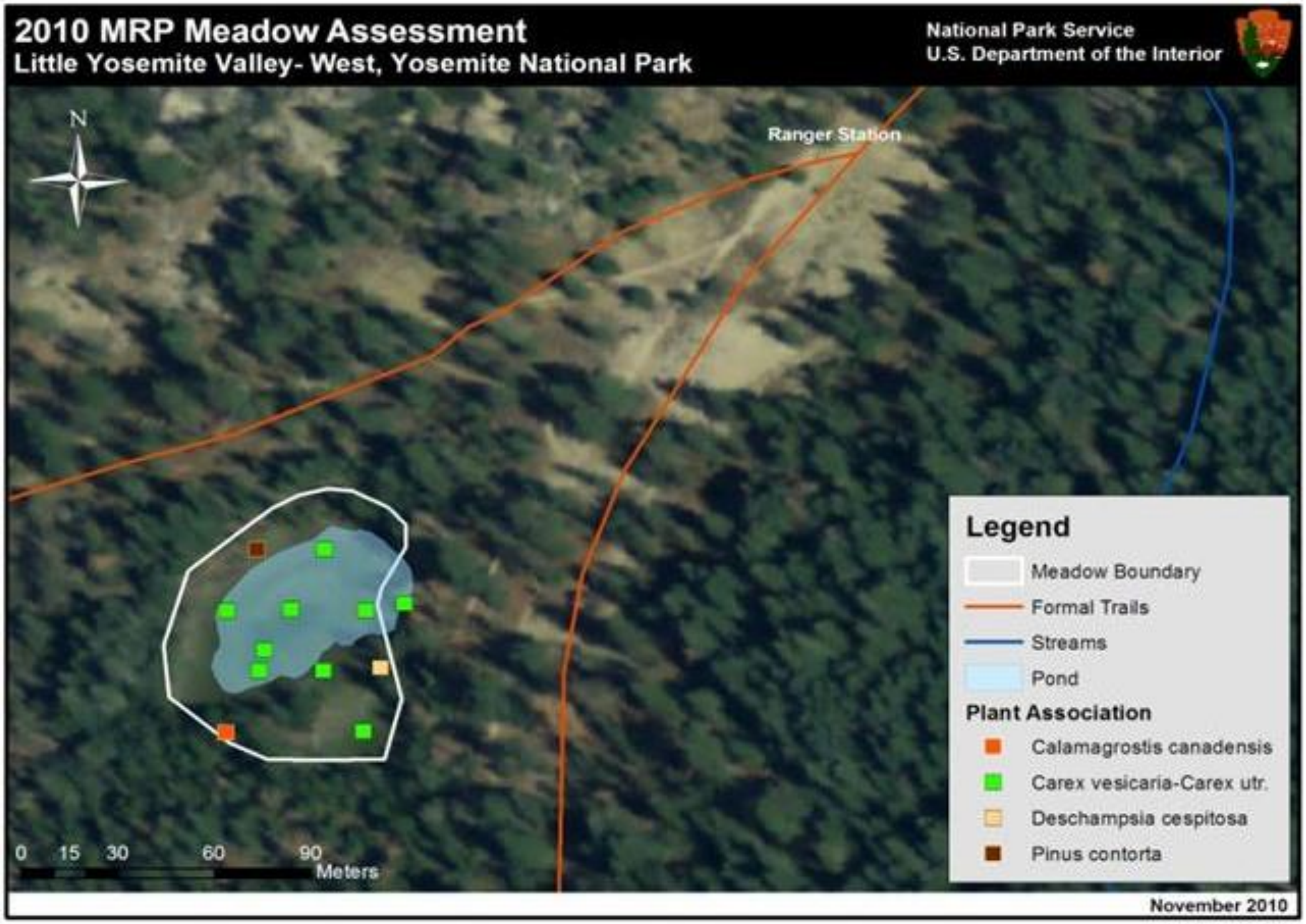
Photo F-5a. Inundation at Little Yosemite Valley-W. **Photo F-5b. Meadow, Little Yosemite Valley-W.**

Little Yosemite Valley-West Meadow is located along the main stem of the Merced River, 5 miles southeast of Yosemite Valley, and about 10 miles west of Merced Lake. The Little Yosemite Valley area receives high amounts of visitor use, as it is located along the route to Half Dome and also encompasses a backpacker's camp and ranger station. This small meadow (0.5 hectares in size) is located just west of the composting toilet and just southwest of the ranger station. The elevation is 6,120 feet (see Photos F-5a,b,Map F-5, Map 6).

The entire meadow was saturated to inundated at the time of the survey (mid-July), and 50% of it appeared pond-like (Map F-5). Many old logs were present in the meadow. The inundated site conditions made data collection difficult, and plant community information was the only metric collected in most gridpoint plots. The dominant plant community was *Carex vesiciaria-utriculata* (bladder sedge). No tree seedlings were present. The site was not suitable for streambank survey since there was no stream channel in the meadow.

Invasive plant surveys in 2006-2010 detected populations of *Holcus lanatus* (velvetgrass), *Cirsium vulgare* (bull thistle), *Verbascum thapsus* (common mullein), *Tragopogon dubius* (yellow salsify) *Lactuca serriola* (prickly lettuce), *Phleum pretense* (timothy), and *Taraxacum offinale* (dandelion) outside the meadows in Little Yosemite Valley. Hand-pulling was used to control non-native plant populations.

No recreational impacts were visible in the meadow from foot traffic or pack stock. Overnight stock use of the meadows is not allowed, and most visitors appear to recreate on the beach-like banks of the Merced River just south of the trail in Little Yosemite Valley. However, historic data show that mean annual pack stock use for Little Yosemite Valley in the years 1946 to 1954 was the highest of all sites in this study, as 1,878 stock nights were reported for the area over the 8 year period (NPS 1960).



Map F-5. Aerial photo map of Little Yosemite Valley-West showing plant communities (plots) and other features.

Merced Lake- East of Ranger Station

Photo F-6a. Wet meadow, Merced Lake-E.

Photo F-6b. Trampled informal trail with cut logs.

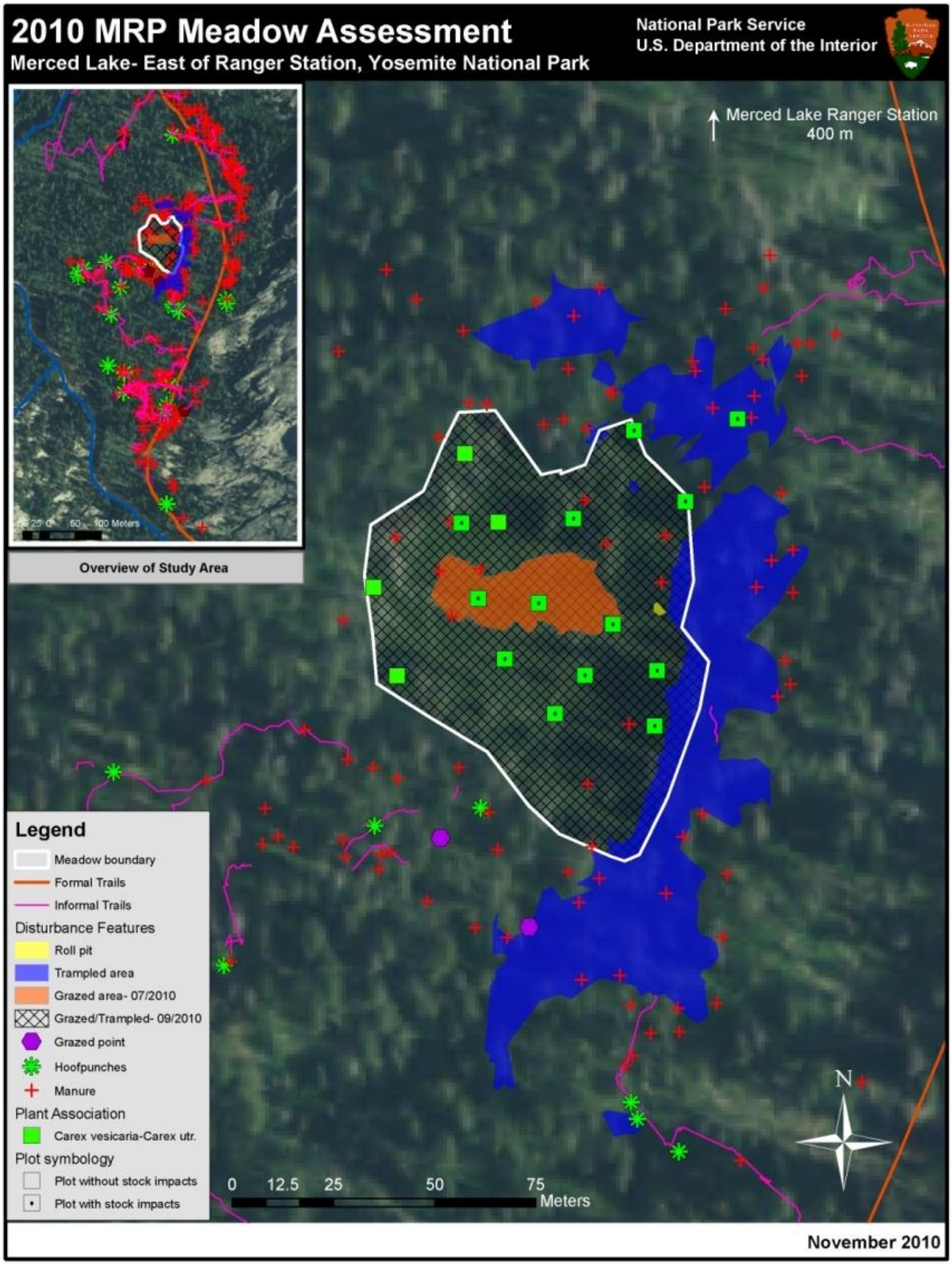
Photo F-6c. Trampled meadow area at Merced Lake-East.

The meadow at Merced Lake- East of the Ranger Station is located approximately 1/4 mile east of the Merced Lake Ranger Station, just south of the formal trail. The meadow is 0.6 hectares in size, and the elevation is 7,307 feet. At the time of survey in mid-July, nearly the entire meadow area was inundated, except for the saturated meadow edges. Spaghnum moss was common in the northern portion of the meadow and along the meadow boundaries, possibly indicating fen conditions (see Photos F-6a, Map F-6, Map 6).

The dominant plant community throughout the meadow was *Carex vesicaria-utriculata* (bladder sedge, Map F-6), and no tree seedlings were found in gridpoint plots. The forested area outside the meadow was dense with deadfall and many snags. A few pockets of mesic herbaceous vegetation were scattered in the largely dry forest understory that surrounds the meadow. We mapped scattered rosettes of *Cirsium vulgare* (bull thistle) in the wooded area outside the meadow, and this was the only non-native species found. The site was not suitable for streambank survey since there is no stream channel in the meadow.

Merced Lake- East receives frequent use by administrative pack stock that support trail crew, backcountry utilities, and other park operations. Sections of logs have been cut out from some of the deadfall, to provide packstock with easier meadow access (Photo F-6b). Impacts are concentrated in the meadow where pack stock prefer to forage. At the time of the first survey in mid-July, grazed vegetation or hoofpunches were present in 76% of plots. Site inundation made it difficult to detect hoofpunching with certainty. We revisited the meadow in mid-September and the entire meadow was trampled, with most vegetation grazed to less than 50% of its ungrazed height (Photo F-6c). There is a large network of informal stock use trails extending from the ranger station to the area adjacent to the meadow, with extensive trampling (hoofpunching) and manure (Map F-6).

Historic data show that mean annual pack stock use for the Merced Lake area in the years 1946 to 1954 was the second highest of all sites in this study, as 1,034 stock nights were reported for the area over the 8 year period (NPS 1960).



Map F-6. Aerial photo map of Merced Lake-East showing plant communities (plots) and other features.

Merced Lake- Shore Meadow

Photo F-7a. Meadow at Merced Lake-Shore (left)

Photo F-7b. Hoofprints in bare ground area at Merced Lake- Shore (right)

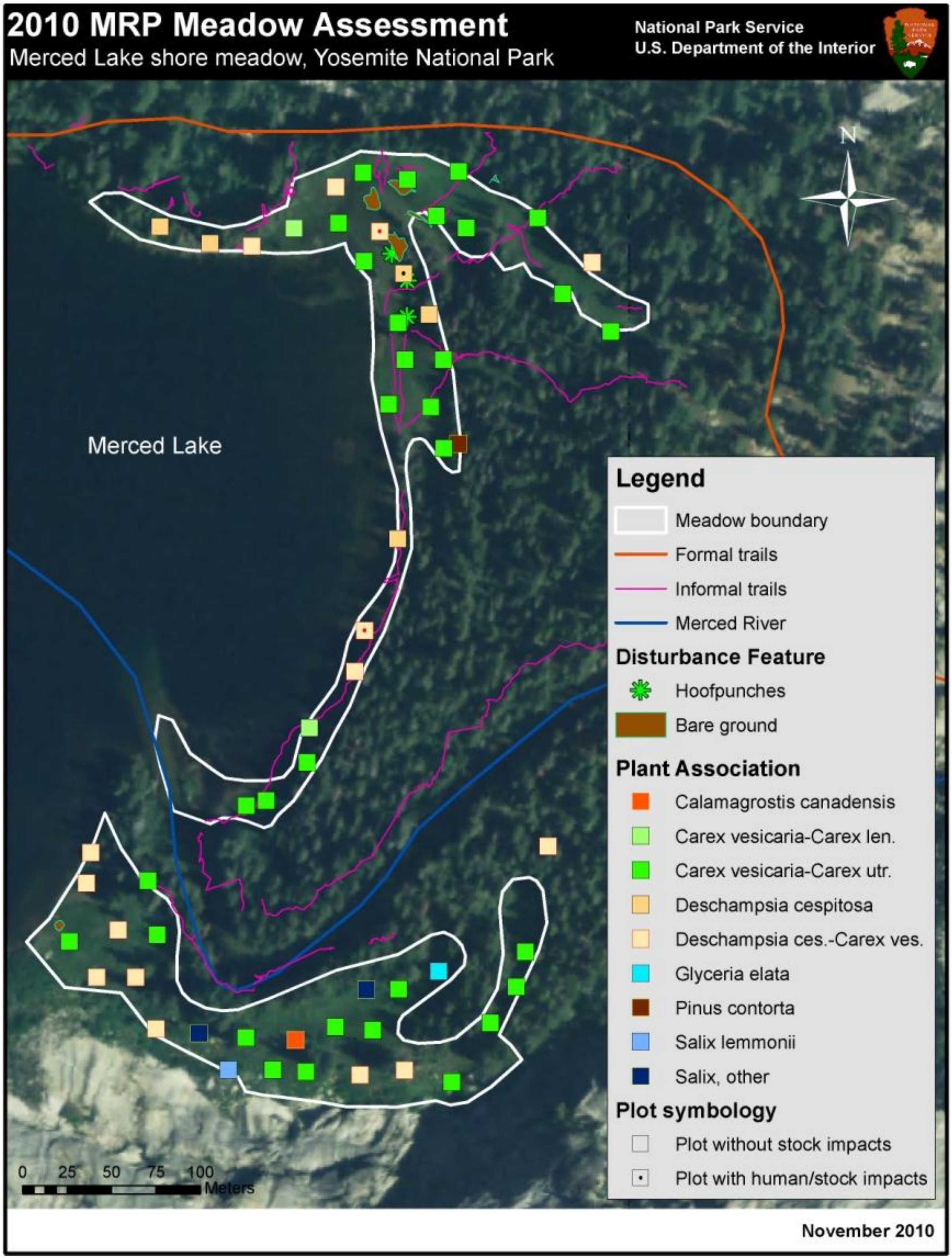
Photo F-7c. Bare ground area at Merced Lake-Shore

Merced Lake-Shore Meadow is located along the eastern shore of Merced Lake, near the High Sierra Camp. The site is composed of two meadows bisected by the Merced River at the inlet. The meadow areas are 1.6 hectares in size combined, and the elevation at the site is 7,202 feet. The meadows are seasonally inundated by high water in the lake and are exposed as the lake recedes during the summer. In 2010, we were not able to survey the site in mid-July due to site inundation, and returned to collect data in mid-September. The site was not suitable for streambank survey because the Merced River inlet stream was forested and not contained by the meadow (see Photos F-7a, Map F-7, Map 6).

The dominant plant communities in gridpoint plots were *Carex vesicaria/utriculata* (bladder/inflated sedge) and *Deschampsia caespitosa* (tufted hairgrass). Tree seedlings were present in 7% of plots.

We mapped numerous informal trails (1.6km in total length) in and adjacent to the meadow (Map F-7), as well as bare ground areas along the meadow edges (Photo F-7c). We found scattered hoofpunches in parts of the meadow (Photo F-7b), likely from day use since overnight grazing is not allowed at Merced Lake. The meadow segment across the river from the High Sierra Camp (south side of the river) was less disturbed and likely receives much lower use.

Historic data show that mean annual pack stock use for the Merced Lake area in the years 1946 to 1954 was the second highest of all sites in this study, as 1,034 stock nights were reported for the area over the 8 year period (NPS 1960).



Map F-7. Aerial photo map of Merced Lakeshore showing plant communities (plots), and other features.

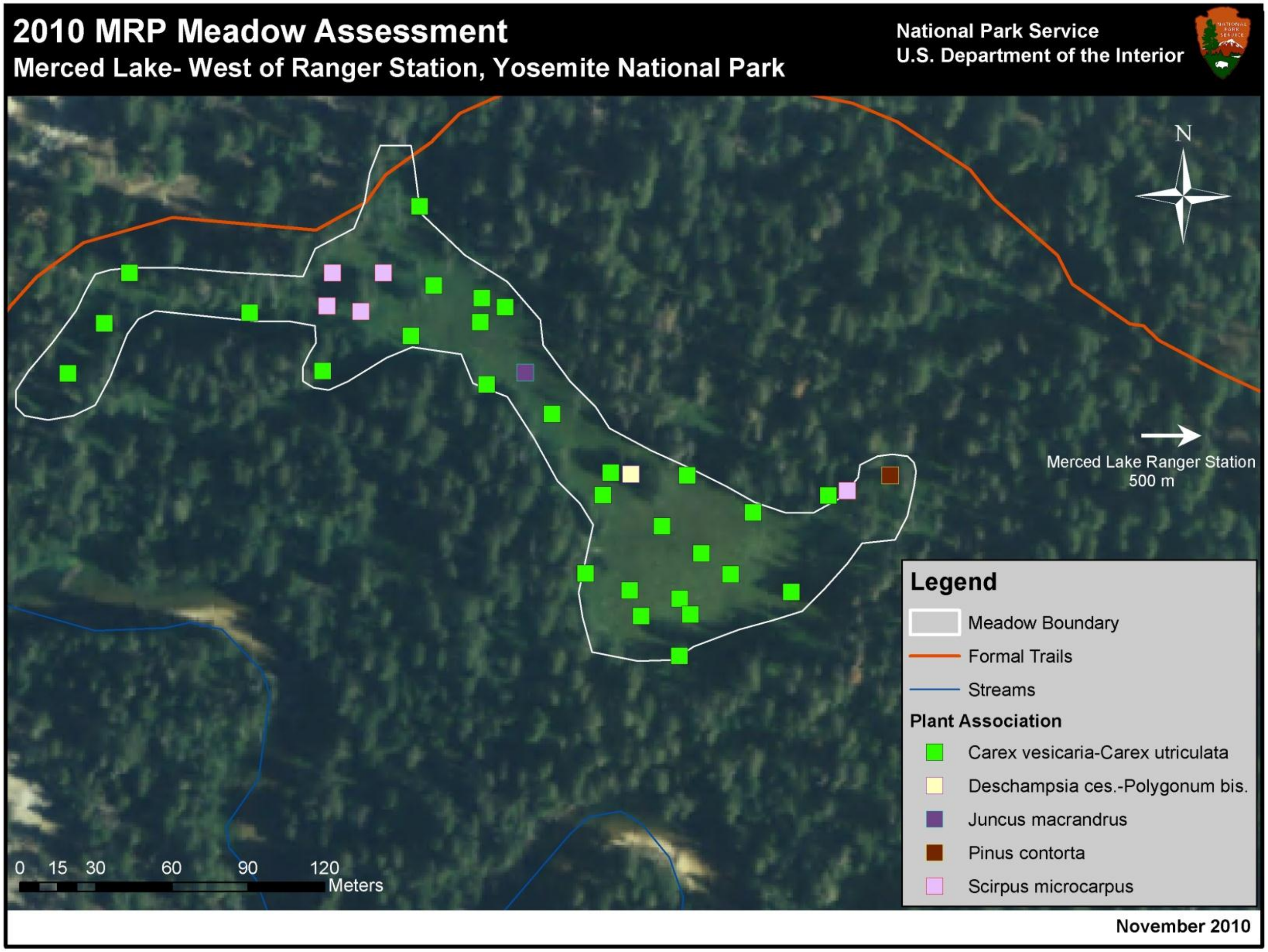
Merced Lake- West of Ranger Station

Photo F-8a. Meadow at Merced Lake-West (left)
Photo F-8b. *Carex vesicaria* Community at Merced Lake-West (right)

The meadow at Merced Lake-West of the Ranger Station is located approximately halfway between Merced Lake and the Merced Lake Ranger Station, at an elevation of 7,267 feet. The meadow is 1.8 hectares in size. During the survey in mid-July, nearly the entire meadow was saturated to inundated, and the substrate was very spongy, with various moss and liverwort species common throughout, which suggests this site may be a fen. A large pond-like area (lacking banks) was noted in the southernmost portion of the meadow, as were active red -winged black bird (*Agelaius phoeniceus*) nests (see Photos F-8a,b Map F-8, Map 6).

The dominant meadow plant communities in gridpoint plots were *Carex vesicaria-utriculata* (bladder sedge), *Deschampsia caespitosa/Polygonum bistortoides* (tufted hairgrass/western bistort), and *Scirpus microcarpus* (panicled bulrush). Fen indicator species were dominant to common in the northern portion of the meadow and included *Carex echinata* (star sedge), *Scirpus microcarpus* (panicled bulrush), and spaghnum moss. The vegetation appeared dense and robust, and bare ground was the lowest of any meadow in the study. Tree seedlings were present in 3% of gridpoint plots. We did not perform a stream survey, since this meadow lacked a stream channel.

At one time, the site received high amounts of administrative stock use to support operations at the Merced Lake High Sierra Camp, but grazing ceased in the early 1990s. Concession stock are now stabled in a nearby corral, where they are given dry feed. There are remnants of an old drift fence located along the southern meadow edge, but otherwise there is no evidence of impacts from past stock use.



Map F-8. Aerial photo map of Merced Lake-West showing plant communities (plots) and other features.

Red Peak- North Meadow

Photos F-9a,b. Meadow at Red Peak-North

Photo F-9c. Upper stream survey endpoint at Red Peak- North

Red Peak Fork- North Meadow is located in the southern section of Yosemite along the Red Peak Fork of the Merced River, downstream (north) of Red Devil Lake and Red Peak Pass. The meadow at this site is bisected by the Red Peak Fork, and composed of a mosaic of mesic to hydric plant communities. Some areas were inundated at the time of survey (end of August). Two ponds and several large stands of willow were located in the meadow, and granite outcrops defined most of the meadow boundary (see Photos F-9a-c, Map F-9, Map 7).

The meadow is 2.2 hectares in size, and the meadow elevation is 9,377 feet. The dominant plant community in both meadow and streambank areas was the obligate wetland species *Carex vesicaria-utriculata* (bladder sedge). Tree seedlings were present in 10% of plots.

This meadow is a remote site approximately ¾ miles from the nearest formal trail, and it likely sees little visitor use. There were no campsites or evidence of any visitor or pack stock disturbance.

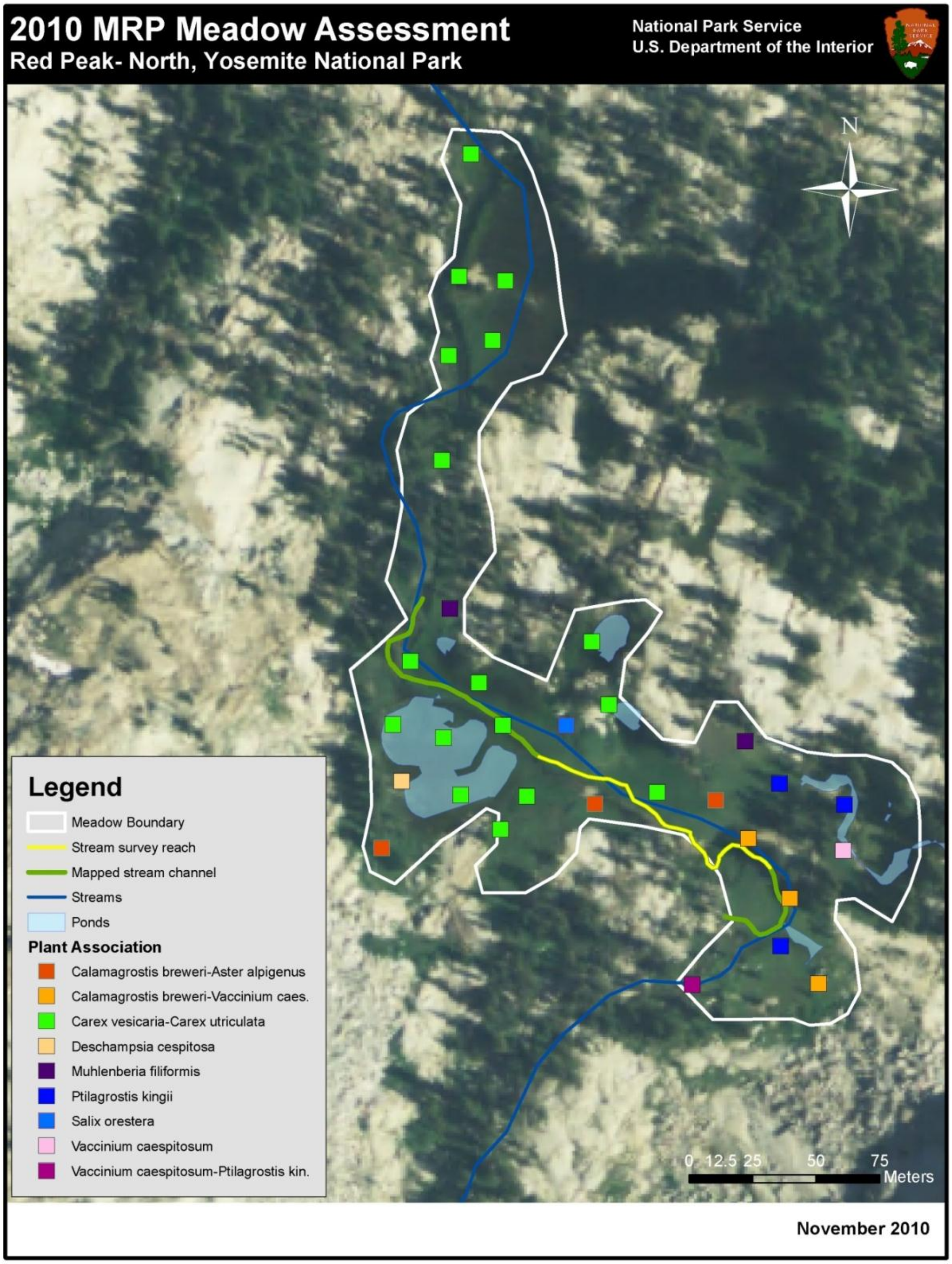
Historic data show that mean annual pack stock use for the Red Peak Pass/Ottoway Lake area in the years 1946 to 1954 was present, but fairly minimal. 31 stock nights were reported for the area over the 8 year period (NPS 1960).

Red Peak-North Stream Survey (MIM)
The ecological status rating for the stream survey was the highest possible (100), indicating that ecological succession at this site has stabilized and that recent ecological disturbances have been minimal. The wetland rating was classified as very high (92), the second highest of all sites surveyed. The plant diversity index was classified as high (6.6 of 10), but was the lowest of the study streams. The rooting strength of greenline vegetation was classified as high (7.3 of 10), and was the second highest of all MIM sites surveyed (see Tables 14 and 15 in the Results section).

Hydric species comprised 75% of greenline vegetation, and of these species, 66% were hydric herbaceous species. These proportions were lower than all other survey sites. Forbs comprised 25% of the greenline, which was the second lowest of all MIM sites surveyed. Woody species presence was the second highest of all sites surveyed (16%). Nearly all woody species were rhizomatous (93% willow). See Table 14 in Results section.

The substrate contained the most fine materials (less than 6 mm) of all sites surveyed, and 97% fine material and a median particle size of coarse sand at 2.0 mm. Only three particles sampled were above 8 mm and the largest was coarse gravel at 64 mm. Mean greenline to greenline width was 4.8 meters, which was close to the average among all streams surveyed.

Active streambank erosion at this site was the lowest of all sites surveyed (7%), with no headcuts present. Historic grazing data (NPS 1960) show that mean annual stock use at Red Peak Fork (both northern and southern survey sites) was 28 nights for the years 1946 to 1954, but recent data show no reported stock use in the years from 2005 to 2010.



Map F-9. Aerial photo map of Red Peak-North, showing plant communities (plots) and other features.

Red Peak- South Meadow


Photos F-10a,b. Meadow at Red Peak-South

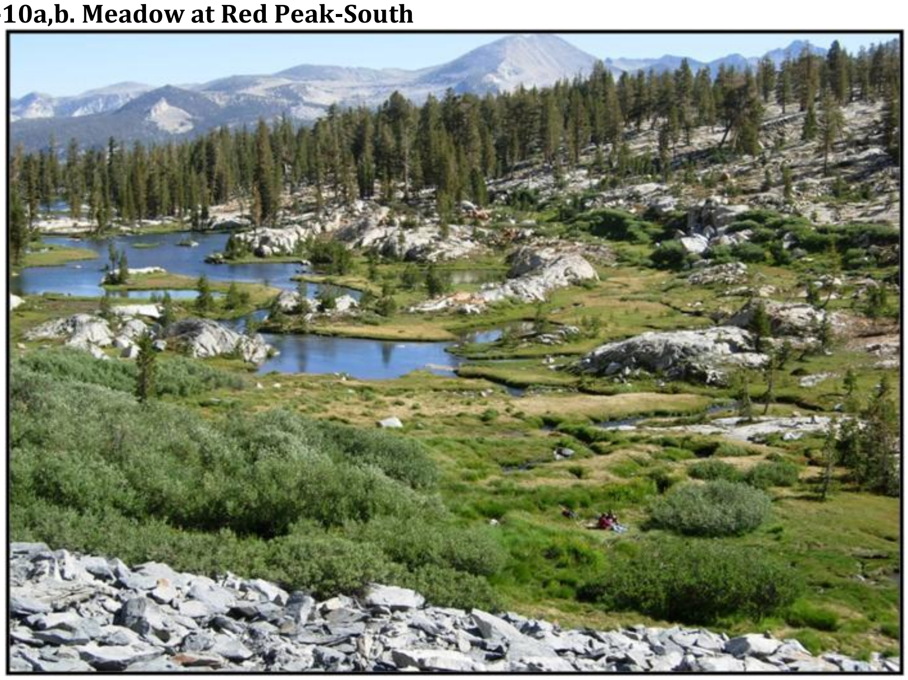


Photo F-10c. Meadow and lake-like stream channel at Red Peak-South. Upper meadow may be patterned fen**.**

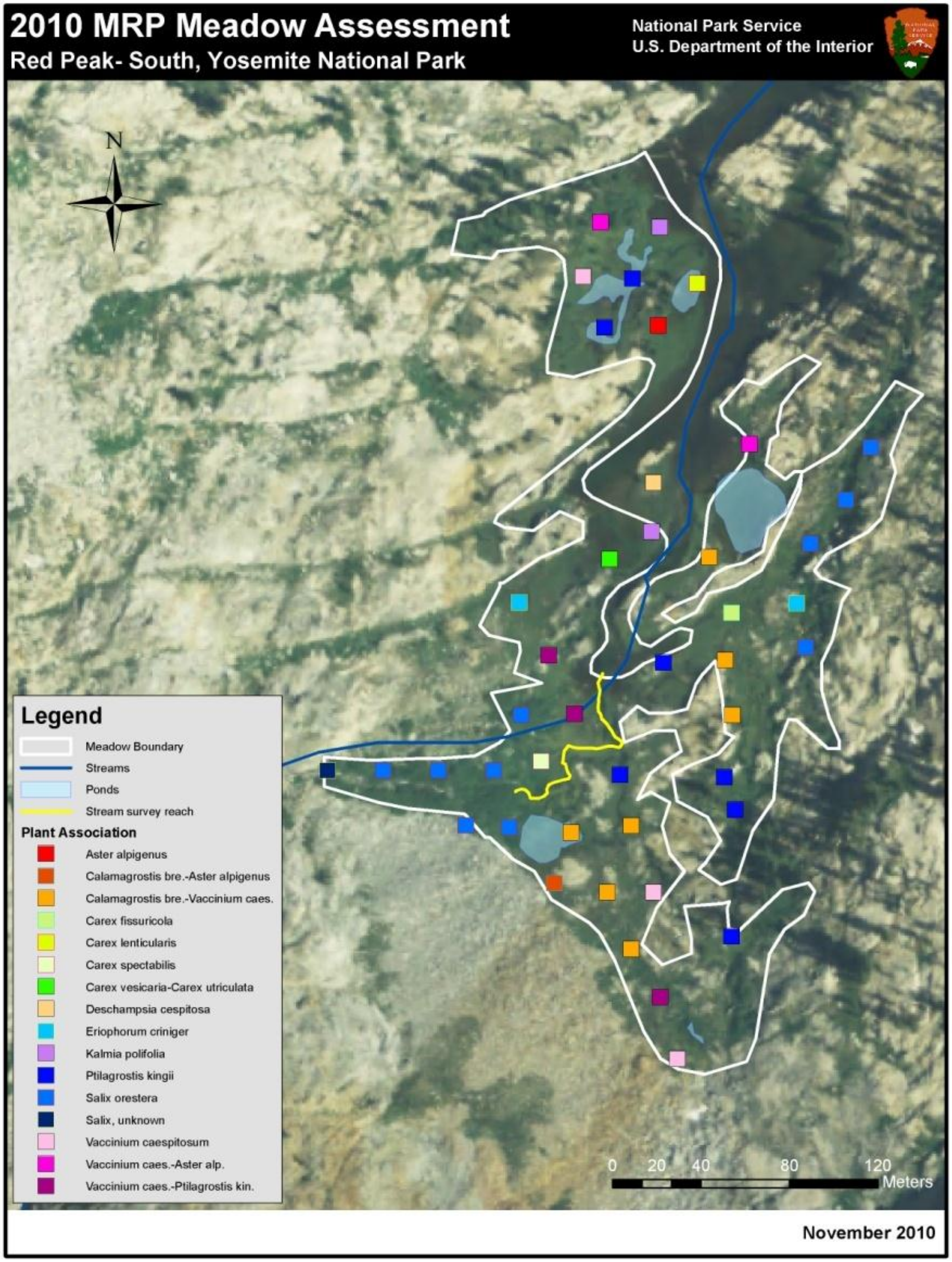
Red Peak Fork- South Meadow is located in the southern section of the park along the Red Peak Fork of the Merced River, just west of Red Devil Lake and north of Red Peak Pass. The meadow is bisected by the upper Red Peak Fork, which is wide and lake-like along much of its length through the meadow. The meadow is 4.1 hectares in size, and the elevation is 9,495 feet (see Photos F-10a-c, Map F-10, Map 7).

Dominant meadow plant communities were *Salix orestera* (Sierra willow), *Calamagrostis breweri/Vaccinium caespitosum* (shorthair reedgrass/dwarf bilberry) and *Ptilagrostis kingii* (Sierra rice grass). Tree seedlings were present in 37% of plots, and the meadow appeared drier than most meadows in the study. However, the streambanks were lined with sphagnum moss, often a fen wetland indicator, and photos of the area (Photo F-10c) suggest that it may contain areas of patterned fen (D. Taylor, personal communication). Patterned fens are a rare ecosystem type in the Sierra.

This meadow is a remote site approximately 1/2 mile from the nearest formal trail, so it likely sees little visitor use. There were no nearby campsites or any evidence of visitor or pack stock disturbance. Historic data show that mean annual pack stock use for the Red Peak Pass/Ottoway Lake area in the years 1946 to 1954 was existent, but fairly minimal, as 31 stock nights were reported for the area over the 8 year period (NPS 1960).

Red Peak-South Stream Survey (Rapid Assessment)
Red Peak- South was not suitable for a full MIM survey because it did not fit geomorphologic criteria. The stream gradient was 3% (other sites are 1-2%), the main channel was braided and not well-defined in the upper meadow, and backwatering effects were present other parts of the main channel (creating a lake-like effect).

We conducted a rapid assessment by adapting MIM protocols to collect a subset of full survey data. These data classified the site as being in good condition, with minimal active erosion. Five headcuts were present, but these were small and low in severity. Greenline vegetation was mainly graminoids with some forbs, subshrubs, and shrubs. Substrate was cobble with a median particle size of 90mm, which was the highest of all sites. No fine bed particles (less than 6 mm) were recorded. Mean greenline to greenline width was the narrowest of all sites (1.6 m), which was due to fact that the survey reach was located in narrow braided channels in the upper end of the meadow.



Map F-10. Aerial photo map of Red Peak-South showing plant communities (plots) and other features.

Triple Peak- North Meadow

Photos F-11a,b. Meadow at Triple Peak-North

Photo F-11c. Stream channel bisecting meadow at Triple Peak-North

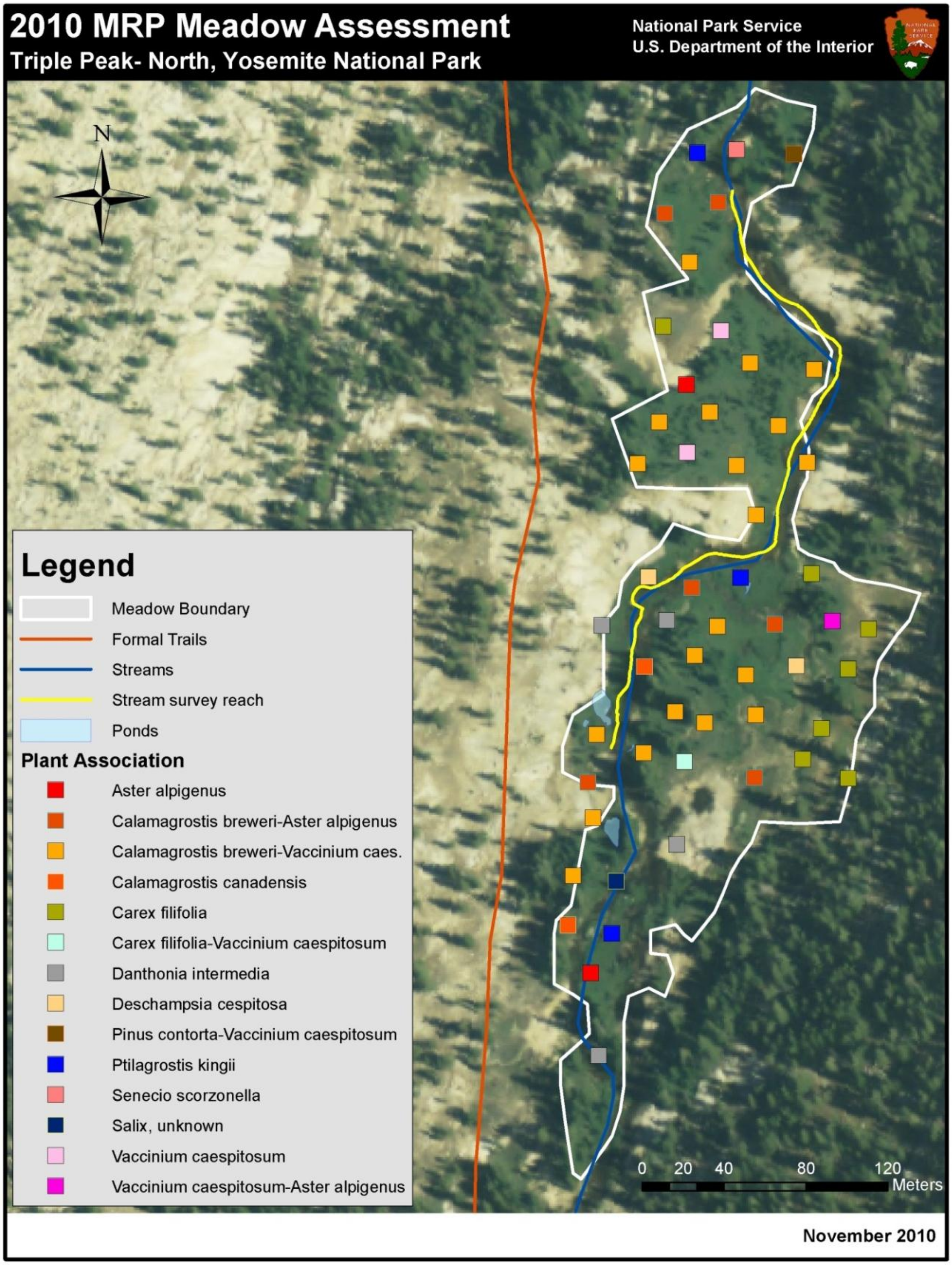
Triple Peak Fork- North Meadow is located in the southern section of Yosemite along the Triple Peak Fork of the Merced River, approximately 3 miles northeast of Red Devil Lake and 2 miles downstream (north) of Turner Lake. The meadow is bisected by the Triple Peak Fork, and the formal trail borders its western edge. The meadow is 3.7 hectares in size, and the elevation at the site is 9,019 feet. This meadow appeared relatively dry when compared with sites outside the Triple Peak Fork, and this was reflected in the vegetation. The dominant meadow plant community was *Calamagrostis breweri/Vaccinium caespitosum* (Brewer's reedgrass/dwarf bilberry), with dry areas of *Carex filifolia* (shorthair sedge) along the southeastern edge. Conifer encroachment was extensive, with 45% of plots containing tree seedlings. This site and Turner Lake had the highest proportion of plots with tree seedlings of any meadow in the study (see Photos F-11a-c, Map F-11, Map 7).

Triple Peak- North is in a remote, little-visited part of Yosemite and although it is close to the formal trail, there was no evidence of visitor or pack stock use. There are no known historical pack stock use data for this area.

Triple Peak Fork-North Stream Survey (Rapid Assessment)
The site was not suitable for MIM due to an inadequate stream channel length vs. width ratio (Burton et al. 2011). Furthermore, the banks were heavily armored with bedrock, which did not meet MIM requirements for an alluvial channel. A MIM rapid survey was performed by collecting an abbreviated set of data from Burton et al. (2011).

Triple Peak- North had more erosion features than any other stream in the study, but features were small to medium in size and severity. Active erosion was estimated at 40%, although streambank vegetative cover appeared to be high. (See discussion section of streambank surveys for more information). Some conifers were present along the banks.

Substrate was mostly bedrock covered in a thin layer of fine sediment with some gravel and cobble. Particle sizes were widely distributed and median particle size was coarse gravel at 16 mm. Percent fines was 41%. Mean greenline to greenline width was 13 m, which was the second widest of all study streams.



Map F-11. Aerial photo map of Triple Peak-North showing plant communities (plots) and other features.

Triple Peak- South Meadow

Photos F-12a,b. Meadow at Triple Peak-South

Photo F-12C. Stream channel bisecting meadow at Triple Peak-South

Triple Peak Fork- South Meadow is located in the southern section of the park along the Triple Peak Fork of the Merced River, approximately 2 miles east of Red Devil Lake and 1.5 miles downstream (north) of Turner Lake. The meadow is bisected by the Triple Peak Fork and is bordered by moderately-sloped and forested canyon walls of granite bedrock (see Photos F-12a-c, Map F-12, Map 7).

The meadow is 2.0 hectares in size, and the elevation at the site is 9,062 feet. This meadow was relatively dry compared with meadows outside the Triple Peak Fork, and this was reflected in the vegetation. The dominant meadow plant communities were *Calamagrostis breweri/Vaccinium caespitosum* (shorthair reedgrass/dwarf bilberry), *Ptilagrostis kingii* (Sierra rice grass), and *Carex filifolia* (short hair sedge). Dominant greenline (streambank) species were more hydric, including *Carex aquatilis* (water sedge), *Deschampsia cespitosa* (tufted hair grass) and *Aster alpigenus* (Alpine aster). Tree seedlings were present in 22% of plots.

Yosemite Wilderness data show no reported stock use at this site in the years 2005 to 2010.
There are no known historical pack stock use data for this area, and no recently reported commercial use, although we found a stock camp nearby. A trail crew camp was located approximately ½ mile from

the site during 2003-2004, and some administrative stock use of Triple Peak- South likely at that time. We found a fire ring on the edge of the meadow (Map F-12), but observed no other recreational impacts.

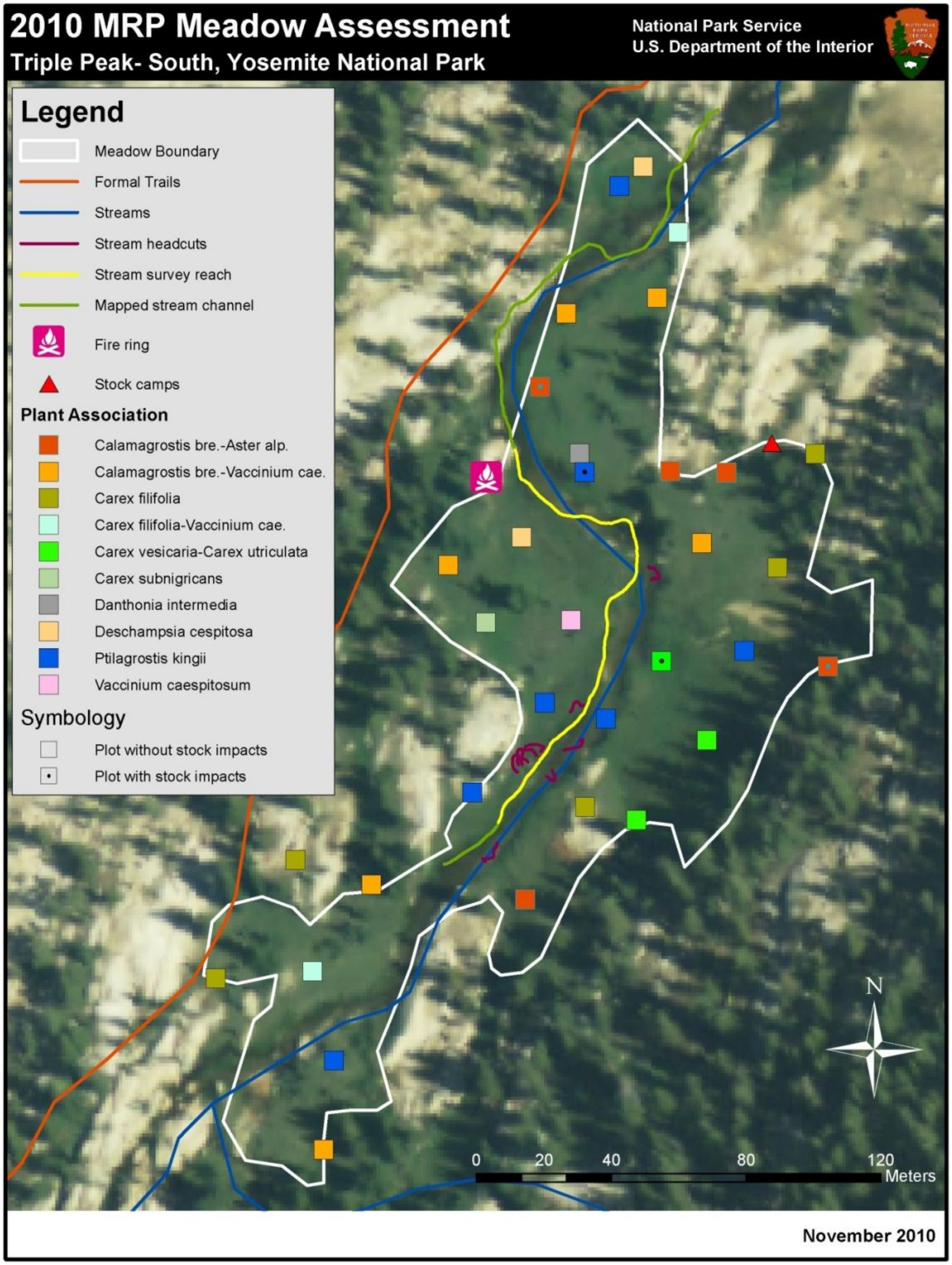
Triple Peak Fork-South Stream Survey (MIM Survey)

Triple Peak-South had a high ecological status rating (99 of 100), indicating potential natural condition (Burton et al. 2011). The wetland rating was the highest of all sites surveyed (93 of 100). The plant diversity index was also the highest of all sites (8.1 of 10), with a total of 22 greenline species present. The rooting strength of greenline vegetation (calculated by the Windward Stability rating) was classified as high (7.0 of 10), although it was the second lowest of all survey streams.

We saw no evidence of pack stock use at this site, although we observed mule deer hoof prints along the streambank. Active streambank erosion was the highest of all study streams, with 36% of plots containing erosional features. The geology of this site may be influencing the rate of streambank erosion (see Discussion section for details). Erosion features included fractures, slumps, sloughs, and headcuts. We recorded 8 headcut features, all of small size and low severity. Streambank vegetative cover was the lowest of all sites surveyed (85%).

Dominant greenline species were the hydric species *Carex aquatilis* (water sedge), *Deschampsia cespitosa* (tufted hair grass) and *Aster alpigenus* (Alpine aster). Hydric species composed 86% of greenline vegetation and 79% of these were hydric herbaceous plants. These proportions were second highest for all MIM survey sites. Forbs composed a third (33%) of the greenline, which was the highest of all MIM sites surveyed. Woody species presence was the second lowest of all MIM sites surveyed (8%). All woody species were rhizomatous and were mainly willows (primarily *Salix eastwoodii*), with some sub-shrubs. Evidence of woody species browsing was minimal (for more details, see Tables 14 and 15).

Substrate was similar to other MIM sites surveyed, with a median particle size of gravel at 11.3 mm, and was primarily gravel with 29% fine material (less than 6 mm). Mean greenline to greenline width was 7m, which is near average among all survey streams.



Map F-12. Aerial photo map of Triple Peak-South showing plant communities (plots) and other features.

Turner Lake Meadow

Photo F-13a. Meadow at Turner Lake, looking north. Photo F-13b. View of meadow, from above lake.

Photos F-13c,d. Triple Peak Fork inlet stream to Turner Lake Turner Lake, bisecting meadow.

Turner Lake Meadowis located in the southern section of the park, just below the headwaters of the Triple Peak Fork of the Merced River and north of Triple Divide Peak. It can reached by a 1-mile hike from the formal trail along the outlet stream or ½ mile hike down from the trail to Isberg Pass. The stream at this site is the inlet to Turner Lake and is located at the eastern side of the lake. The stream channel at this site is very narrow and deep in comparison to other meadow streams surveyed (see Photos F-13a-d, Map F-13, Map 7).

The meadow is 4.2 hectares in size, and the elevation is 9,544 feet. The meadow appeared dry compared with sites outside the Triple Peak Fork, and this was reflected in the vegetation (Photo F-13a). Dominant meadow plant communities were *Calamagrostis breweri/Vaccinium caespitosum* (shorthair reedgrass/dwarf bilberry), and *Calamagrostis breweri/Aster alpigenus (*shorthair reedgrass/alpine aster*)* alliance. The dominant greenline community was the more hydric species *Carex scopulorum* (mountain sedge). Abundant tree seedlings were present along the northwest side of the meadow. Tree seedlings were present in 45% of plots. Turner Lake and Triple Peak- North had the highest proportion of plots with tree seedlings of any meadow in the study.

We found some evidence of pack stock at Turner Lake; there was old manure in the meadow and a stock camp just northeast of the meadow. Pack stock evidence was unexpected, as pack stock travel is not allowed more than ¼ mile off trail. Several campfire rings were located on rocky benches above the outlet stream, but no other visitor impacts were observed in or near the meadow (Map F-13). There are no known historical pack stock use data for this site.

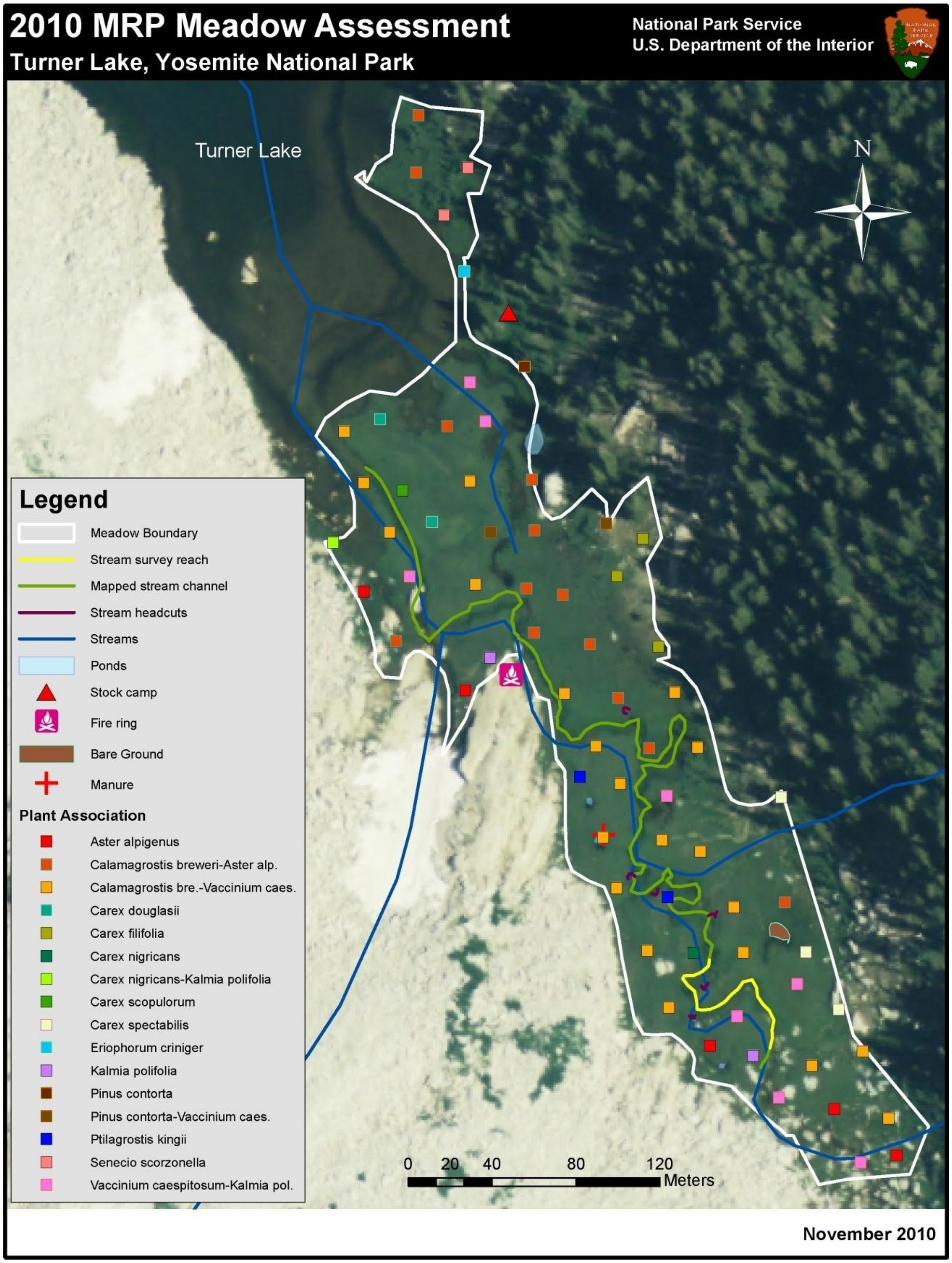
The meadow at Turner Lake may be a patterned fen, which would make it the southernmost fen of its type in North America (D. Taylor, personal communication). Patterned fens consist of a distinctive net-like pattern of low peat ridges (strangs) topped by shrubs, and intervening flarks (low spots occupied by sedge communities or open water pools (Moore and Bellamy 1974). We observed fen indicator species such as sphagnum moss (often peat-forming moss species) along the streambanks and *Eriophorum criniger* (fringed bullrush).

Turner Lake Stream Survey (MIM Survey)

The ecological status rating was the highest possible, at 100, indicating that ecological succession at this site has stabilized and that recent ecological disturbances have been minimal or not existent. The wetland rating was classified as high (77 out of 100) but was the lowest of all sites surveyed. The plant diversity index was classified as high (7.0 of 10), but was the second lowest of all MIM sites surveyed. The rooting strength of greenline vegetation (as calculated by the Windward Stability rating) was classified as high (7.8 of 10), and was the highest of all MIM sites surveyed (see Tables 12 and 13 in the Results section).

There were 28 plant species present along the greenline, with the hydric species *Carex scopulorum* (mountain sedge) most common. Hydric species composed 82% of greenline vegetation and 67% of these were hydric herbaceous, which was the second lowest of all MIM sites. Woody species presence was the highest (20%) of all MIM sites surveyed, and all woody species were rhizomatous and mainly willows (*Salix eastwoodii*) with some sub-shrubs.

Active streambank erosion was moderate to low (17%). We recorded 8 headcut features, all of small size and low severity. Substrate was characterized by fine gravel with a median particle size of 8.0 mm. Percent fines was high (49%) but lacked very fine (sand and silt) particles of 2 mm or less. Only 10% of the particles sampled were above 16 mm (coarse gravel) with none greater than 64 mm (small cobble). Mean greenline to greenline width was 2.1 m, the second narrowest among study streams. Because the survey reach is close to the headwaters of Triple Peak Fork, a narrow stream channel was expected.



Map F-13. Aerial photo map of Turner Lake showing plant communities (plots) and other features.

Washburn Lake Meadow

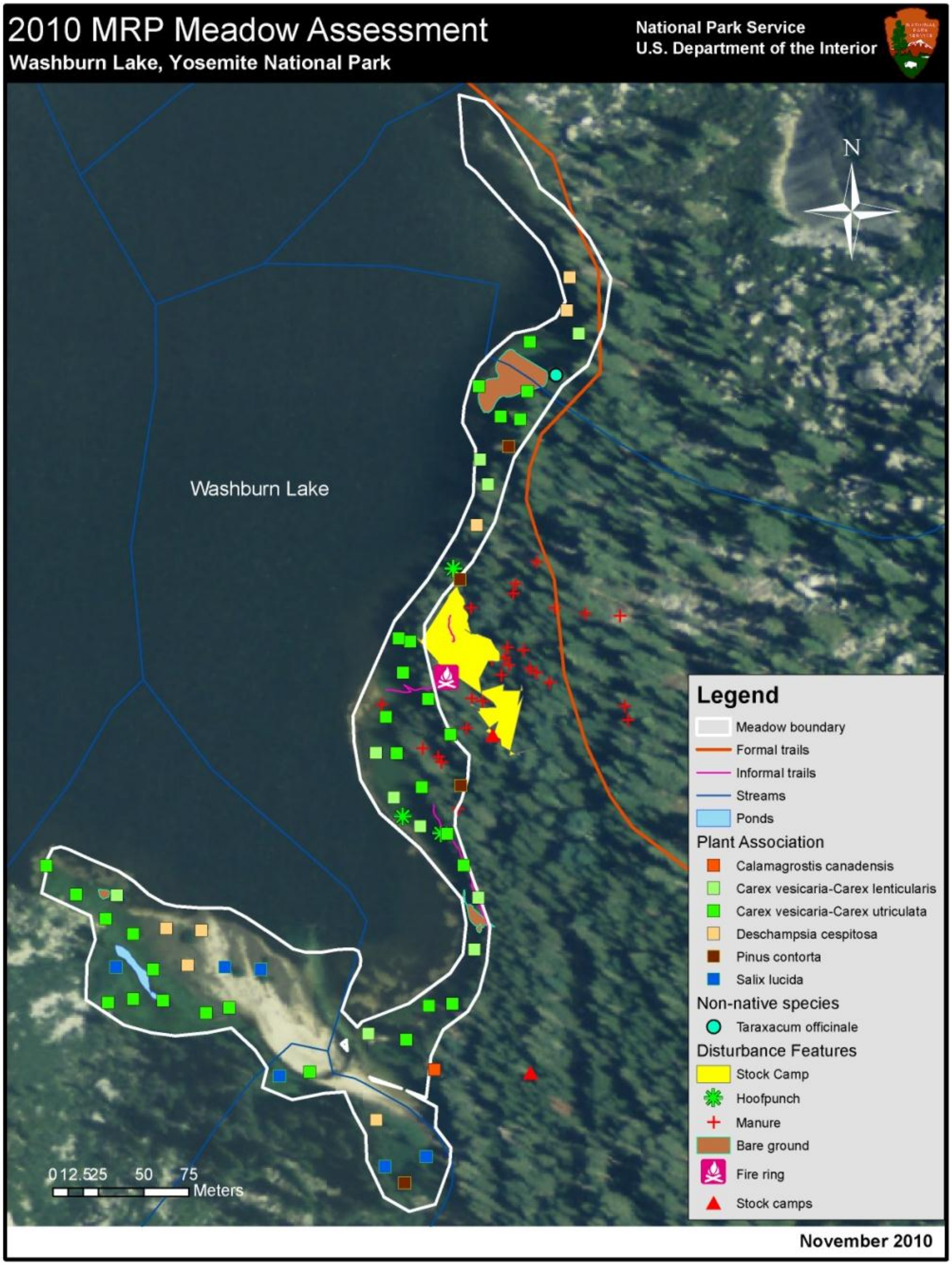
Photo F-14a. Alluvial deposits from one of the inlet streams at Washburn Lake (left)
Photo F-14b. Meadow at Washburn Lake (right)

Washburn Lake Meadow is located about 3 miles southeast of Merced Lake, along the main stem of the Merced River adjacent to the formal trail that leads to Isberg Pass. The meadow wraps around the south and eastern lakeshore, and is seasonally inundated by high water in the lake. As the lake recedes later into the summer season, the meadow is exposed. In 2010, we were not able to survey the site in mid-July due to site inundation, and returned to collect data in mid-September. The site was not suitable for streambank survey because the Merced River inlet stream is largely forested and not contained by the meadow. Another stream draining into the meadow is also forested (see Photos F-14a,b, Map F-14, Map 5).

The meadow is 2.9 hectares in size, and the site elevation is 7,605 feet. The dominant plant community was *Carex vesicaria-utriculata* (bladder sedge). Other common plant communities were *Deschampsia caespitosa* (tufted hairgrass) and *Salix lucida* (shining willow). Thick stands of tall willows dominated portions of meadow west of the inlet stream. Tree seedlings were present in 7% of gridpoint plots. *Taraxacum officinale* (dandelion) was the only non-native plant present (1 rosette).

Visitor use evidence (both human and pack stock) was common in and adjacent to the meadow, which was not surprising since Washburn Lake is a relatively popular destination along a formal trail and easily reached from Merced Lake. We mapped a stock camp and numerous piles of old manure in the forest adjacent to meadow, as well as an informal trail along the meadow edge. We also mapped several areas of old hoofpunches in the meadow that were still distinguishable despite site inundation in the first part of the summer (Map F-14).

Historic data show that mean annual pack stock use for Washburn Lake in the years 1946 to 1954 was existent, but fairly minimal, as 42 stock nights were reported for the area over the 8 year period (NPS 1960).



Map F-14. Aerial photo map of Washburn Lake showing plant communities (plots) and other features.

Appendix G. Photos of Alpine Meadows (grouped by fork)

Photo G-1. L3, Lyell Fork

Photo G-2. L5, Lyell Fork

Photo G-3. L6, Lyell Fork

Photo G-4. L7, Lyell Fork

Photo G-6. L8, Lyell Fork

Photo G-7. M1, Merced Peak Fork

Photo G-8. L4, Lyell Fork

Photo G-9. M2, Merced Peak Fork

Photo G-10. R8, Red Peak Fork

Photo G-11. M3, Merced Peak Fork

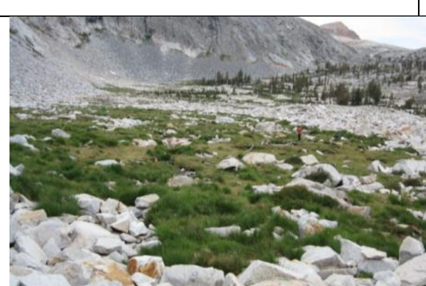


Photo G-12. M4, Merced Peak Fork

Photo G-13. R2, Red Peak Fork

Appendix G. Photos of Alpine Meadows (continued)

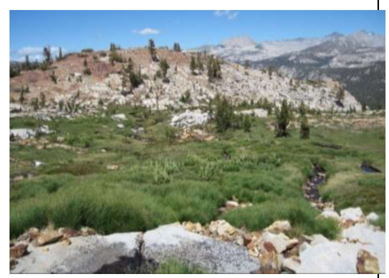
		
Photo G-14. R5, Red Peak Fork	Photo G-15. R6, Red Peak Fork	Photo G-16. R7, Red Peak Fork
		
Photo G-17. T3, Triple Peak Fork	Photo G-18. T4, Triple Peak Fork	Photo G-19. T5, Triple Peak Fork
		
Photo G-20. T6, Triple Peak Fork	Photo G-21. T8, Triple Peak Fork	Photo G-22. T9, Triple Peak Fork

Photo G-23. T10, Triple Peak Fork (shows formal trail bisecting meadow)