Point Blue Report

Bird Monitoring to Inform Meadow Restoration on Sierra National Forest

Final Report to Sierra National Forest

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Conservation science for a healthy planet

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Introduction

Healthy mountain meadows foster biodiversity, reduce downstream flooding, purify water, and store carbon (Hammersmark et al. 2008, Norton et al. 2011, Purdy et al. 2011, Viers et al. 2013, Reed et al. 2020). Unfortunately, a history of exploitation has degraded the hydrologic functions that sustain these benefits in most meadows of the Mountain West, including the Sierra Nevada (Hunsaker et al. 2015). Hydrologic restoration of meadows aims to elevate groundwater levels in the dry season to near the meadow surface, with expected enhancement of the benefits provided by hydrologically functional meadows (Hunsaker et al. 2015, Drew et al. 2016). However, resources are often lacking to evaluate whether restoration objectives for ecosystem services have been met at project sites. Because of the lack of rigorous and long-term evaluation (Ramstead et al. 2012) and sensitivity to variation in ecosystem context and methodology (reviewed by Hunsaker et al. 2015), the effectiveness of meadow restoration in achieving intended objectives is debated (c.f. Hammersmark et al. 2008, Pope et al. 2015). Yet understanding the efficacy of meadow restoration in achieving desired outcomes is critical to maximizing the multiple benefits of restoration (e.g., Dybala et al. 2019). Outcome-based evaluations of meadow restoration are needed to ensure objectives are being met and to guide modifications where needed.

A frequent objective of meadow restoration is to increase the abundances of meadow-dependent bird species following expected increases in habitat quantity and quality (Drew et al. 2016). Meadows have been called the single most important habitat for birds in the Sierra Nevada (Siegel & DeSante 1999), and three bird species listed as Endangered or Threatened by the state of California—Willow Flycatcher (*Empidonax traillii*), Great Gray Owl (*Strix nebulosa*), Greater Sandhill Crane (*Grus canadensis tabida*)—rely on montane meadows (CDFG 1994, Mathewson et al. 2013, Kalinowski et al. 2014). Campos et al. (2020) found that restoring natural water levels in montane riparian meadows with streams improved habitat for some bird species associated with meadows from 1–18 years after

restoration. However, the processes of deposition and erosion that influence riparian meadows and their floodplains are not all applicable to other meadow types. For this reason, bird response to hydrologic restoration of other meadow types is still unknown.

In this study, we collected pre-restoration data on bird abundance and species richness to inform restoration activities on the Sierra National Forest. We compare metrics of abundance and richness to previously established targets of meadow restoration success (Campos et al. 2014). Combined with data collected after restoration, this data will allow us to evaluate the expected outcome of increased abundances of birds following the restoration of hydrologic connectivity for a variety of meadow types.

Methods

We surveyed birds and vegetation at 24 sample locations across 9 meadows on Sierra National Forest slated to receive hydrologic restoration treatments in the near future (Table 1, Figure 1). The meadows covered a large geographic extent and elevation range (Table 1, Figure 1). The meadows ranged in size from 0.7 to 16.6 ac with small contributing watersheds. Upland habitat types adjacent to the meadows was Sierra mixed conifer forest, except for Exchequer Meadow, which was surrounded by red fir forest.

To sample the bird community , surveyors conducted standardized five-minute exact-distance point counts at each sample location (Ralph et al. 1995). With the aid of a rangefinder, the surveyor estimated the exact distance to individual birds at the time of initial detection. We counted from sunrise to within five hours of sunrise, without counting in inclement weather (i.e., precipitation, fog, or high wind). We surveyed each sample location for birds twice from late May through June, the peak of the bird breeding season in the study region.

For vegetation surveys, one surveyor conducted relevé-style vegetation surveys for the area within 50 m of each sample location. The surveyor estimated: the percent cover of large trees (>5 m), small trees (<5 m), shrubs, herbaceous plants, and ground cover; the 50^{th} percentile and 85^{th} percentile

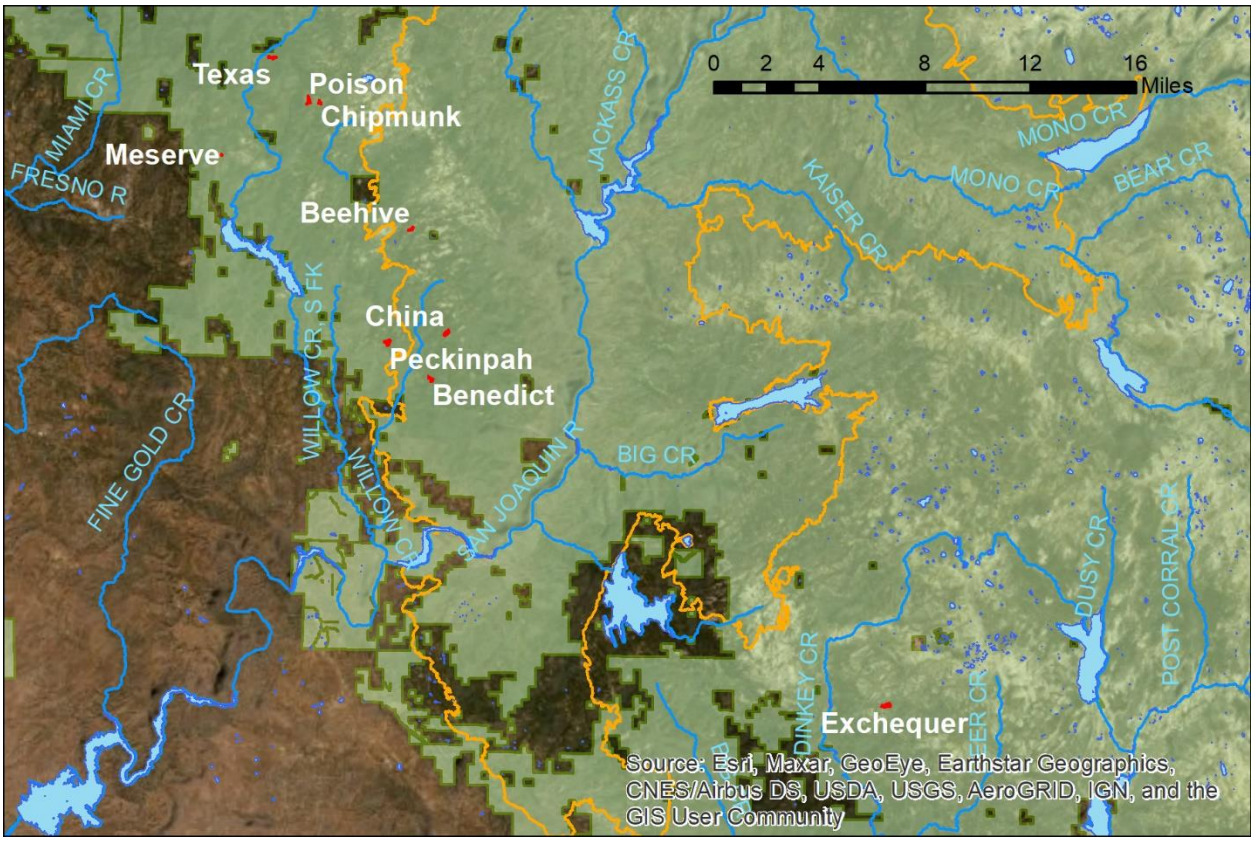

Figure 1. Location of nine meadows (red polygons) surveyed for birds and vegetation in Sierra National Forest (green shaded polygons) and relative to the 2020 Creek Fire boundary (orange line).

Table 2. Sample size, sample dates, and elevations for nine meadows surveyed in Sierra National Forest.

Meadow	Sample Locations	Bird Survey Dates		Vegetation Survey Date	Elevation (feet)
		2020	2021		
Beehive	2	6/12, 6/24	5/27, 6/11	7/3/2020	6,510
Benedict	3	6/12, 6/24	5/27, 6/11	7/4/2020	5,630
China	3	6/12, 6/24	5/27, 6/11	7/4/2020	6,060
Chipmunk	2	6/11, 6/26	5/28, 6/12	7/3/2020	6,730
Exchequer	4	6/09, 6/22	6/13, 6/16	7/1/2020	7,280
Meserve	1	6/10, 6/25	5/28, 6/12	7/3/2020	4,400
Peckinpah	3	6/10, 6/25	5/27, 6/11	7/3/2020	5,620
Poison	3	6/11, 6/26	5/28, 6/12	7/2/2020	6,680
Texas	3	6/11, 6/26	5/28, 6/12	7/2/2020	5,370

heights of vegetation in each of these cover categories; and the relative cover of each species of large tree, small tree, and shrub. When the 50-m plot overlapped wetland (meadow and riparian) and upland (non-meadow and non-riparian) habitat (23 of 24 sample locations), we collected this data for the wetland and upland habitat types separately. The surveyor also noted any signs of cattle grazing and beaver occupancy.

We limited our analysis of the bird data to a subset of focal species selected *a priori*. A focal species group is likely to provide a better measure of the health of meadow habitat than using all species combined (Chase and Geupel 2005). We used the 13 meadow focal species identified by Campos et al. (2014): Wilson's Snipe (*Gallinago delicata*), Red-breasted Sapsucker (*Sphyrapicus ruber*), Calliope Hummingbird (*Selasphorus calliope*), Willow Flycatcher (*Empidonax traillii*), Swainson's Thrush (*Catharus ustulatus*), Warbling Vireo (*Vireo gilvus*), Wilson's Warbler (*Cardellina pusilla*), Yellow Warbler (*Setophaga petechia*), MacGillivray's Warbler (*Geothlypis tolmiei*), Song Sparrow (*Melospiza melodia*), Lincoln's Sparrow (*Melospiza lincolnii*), Mountain West White-crowned Sparrow (*Zonotrichia leucophrys oriantha*), and Black-headed Grosbeak (*Pheucticus melanocephalus*). This suite of focal species reach their greatest breeding density in montane meadow and riparian habitat in the Sierra Nevada, are appropriately sampled by passive point count methods, and we expected them to respond positively to habitat conditions created by the restoration of meadow form and function, specifically: (a) floodplain inundates at a <2 year interval; (b) water table within the rooting zone of meadow plants for growing season, including some flooded or perennially saturated areas in oxbows or other depressional areas; (c) vigorous herbaceous layer dominated by native meadow graminoid species; (d) riparian shrubs with active recruitment; and € riparian deciduous trees.

For bird data analysis we used naïve point count detections within 50 m of the observer, uncorrected for detection probability, thus abundance metrics herein represent indices rather than true densities (Johnson 2008). These indices reflect the mean number of individuals and mean number of

species detected per point per visit. Abundance and richness estimates from all points within a meadow were averaged across visits and years to produce the estimates of abundance and richness. This allowed for comparisons between meadows consisting of different numbers of sample locations. The Creek Fire, which burned around three of the meadows in fall 2020, did not appear to affect meadow bird abundances in a consistent manner relative to unburned meadows, so we felt comfortable averaging across years. Our calculations do not provide a measure of the total number of individuals or species for an individual meadow. We compared meadow-scale estimates of naïve focal species richness to previously established targets for restoration success (Campos et al. 2014).

We used the vegetation data to summarize structural attributes of bird habitat in each meadow as indicators of bird habitat quality to help interpret bird abundances. For each meadow, for both wetland and upland habitat, we calculated the average percent cover of all shrubs, aspen, riparian deciduous shrubs (RDS), small and large conifers, herbaceous vegetation, sedges and rushes, forbs, grasses, and bare ground. We also summarized the median shrub height and the richness of wetland shrubs, which were those with a wetland indicator status of facultative, facultative wetland, and obligate wetland in both the wetland and upland habitats, as classified on the CalFlora website (calflora.org).

Results

We detected eight focal species on our bird surveys (Table 2, Figure 2). Focal species detections were comprised largely of Lincoln's Sparrow (46%), with Warbling Vireo (21%) and MacGillivray's Warbler the next most common (14%; Table 2). Focal species richness ranged from 0.5 focal species per point per visit at Meserve Meadow, where only one focal species was detected over both visits, to 1.8 focal species per point per visit at Benedict Meadow where we detected five focal species over both visits (Figure 2). All but one meadow fell short of the focal species richness target for high quality bird habitat of 2 focal species per point per visit (Campos et al. 2014; Figure 2).

Table 2. Number of detections of each focal species within 50 m of the surveyor over four survey visits in 2020 and 2021. Focal species without a detection are not listed.

	Beehive		Benedict		China		Chipmunk		Exchequer		Meserve		Peckinpah		Poison		Texas		
Species	20	21	20	21	20	21	20	21	20	21	20	21	20	21	20	21	20	21	Totals
Black-headed Grosbeak	0	0	1	4	0	1	0	0	0	0	0	2	0	0	0	0	0	0	8
Lincoln's Sparrow	1	2	9	4	6	3	3	0	5	5	0	0	9	8	5	6	5	2	73
MacGillivray's Warbler	0	0	2	6	1	1	1	1	1	1	0	0	0	1	2	4	0	1	22
Red-breasted Sapsucker	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Song Sparrow	0	0	0	0	0	0	0	0	2	0	0	0	4	4	0	2	0	1	13
Warbling Vireo	1	4	1	2	3	3	1	2	1	0	1	0	0	2	2	3	4	3	33
Wilson's Warbler	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
Yellow Warbler	0	1	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	1	5
Totals	2	7	14	18	10	8	6	5	9	6	1	2	13	16	9	15	9	8	158

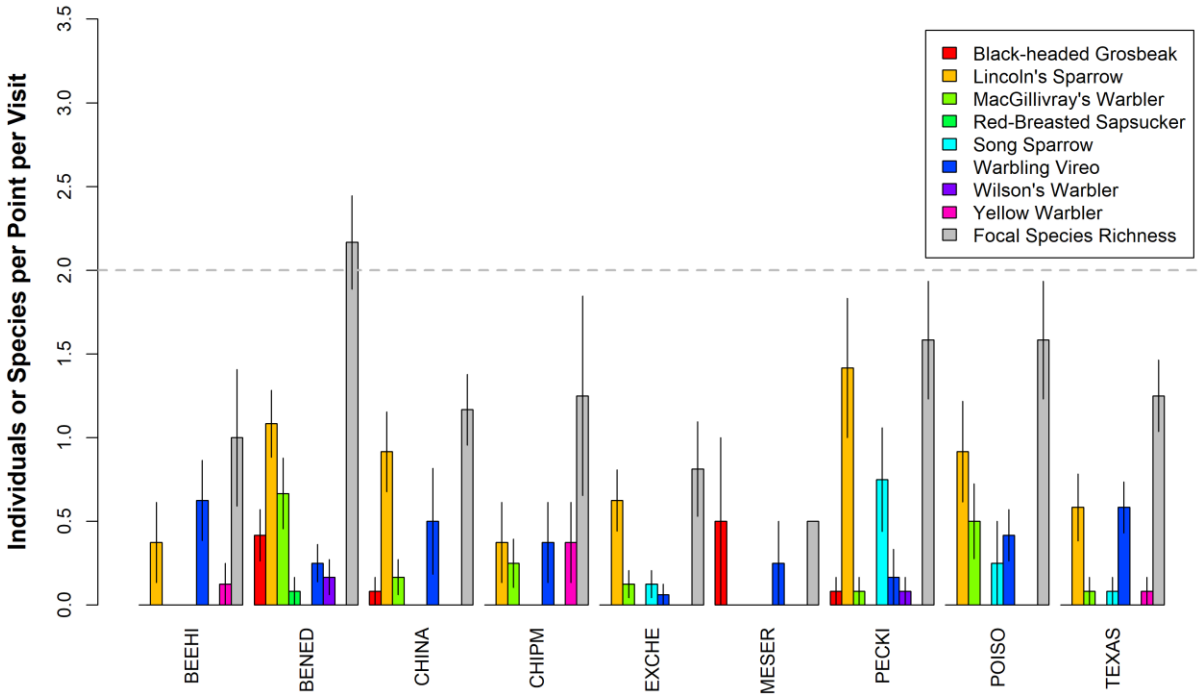

Figure 3. Indices of abundance and richness of bird focal species across 9 meadows on Sierra NF in summer of 2020. Vertical bars represent standard error. Dashed horizontal gray line is the target focal species richness (gray bars) for high quality bird habitat (Campos et al. 2014).

Vegetation in the meadows (wetland habitat) was characterized as herbaceous-dominated with generally low percent cover of deciduous shrubs (Table 3). Herbaceous cover dipped below 90% at only one meadow, Exchequer, at 88% (Table 3). The sedge and rush component of the herbaceous cover

ranged from 10 – 72% (Table 3). Bareground values were less than 2% at all the meadows except Meserve at 10% (Table 3). Large conifer cover was less than 5% at all the meadows except Exchequer and Beehive, at 13% and 7%, respectively (Table 3). Small conifer cover ranged 0.5 – 4.9%, with values at Benedict, Texas, and Exchequer at or above 4% (Table 3). All but two of the meadows had less than 5% cover of riparian deciduous shrubs, with Benedict and Exchequer each at 13 – 14% (Table 3). Shrub height averaged less than 2 m at all the meadows except Benedict and China. Richness of wetland shrubs ranged 0 – 3.3 species per point (Table 3). Vegetation in the uplands adjacent to the meadows also supported wetland-associated vegetation, including aspen and riparian shrubs (Table 3). For seven of the meadows, the cover and richness of riparian deciduous and wetland shrubs was equivalent or, in most cases, higher, in the uplands around the meadow than the wetlands within meadow (Table 3).

Table 3. Vegetation measurements at each meadow averaged over all sample locations in each meadow. Cover values are percent cover and are relative to the habitat (wetland/upland). Values from wetland habitat are shaded gray to help with readability of the table. RDS = Riparian Deciduous Shrub. Herb = Herbaceous cover (sum of grass, forb, and sedge/rush covers).

Meadow	Habitat	% of Sample Area	Large Conifer Cover	Small Conifer Cover	Aspen Cover	Shrub Cover	Willow Cover	Wtlnd Shrub Rich	RDS Cover	Medn Shrub Height	Herb Cover	Grass Cover	Forb Cover	Sedge Rush Cover	Bare Ground Cover
Beehive	upland	50	48.8	20.0	1.3	7.5	0.0	0.0	0.3	0.8	4.0	1.5	2.5	0.0	2.5
	wetland	50	7.4	4.9	0.1	3.5	0.0	0.5	2.5	0.8	100.0	35.0	35.0	30.0	0.0
Benedict	upland	57	31.7	8.2	0.0	28.3	4.2	3.0	20.1	2.0	25.0	0.0	25.0	0.0	8.3
	wetland	43	3.3	2.3	0.0	13.3	2.6	3.3	13.3	3.0	100.0	21.7	41.7	36.7	0.0
China	upland	42	51.3	12.8	0.7	13.3	1.0	0.7	4.0	1.7	13.3	2.3	11.0	0.0	5.0
	wetland	58	3.5	2.7	1.5	5.0	3.3	0.7	5.0	4.0	98.3	30.0	58.3	10.0	0.3
Chipmunk	upland	48	37.5	7.5	0.0	35.0	1.8	1.5	5.5	1.0	4.0	0.5	3.5	0.0	5.0
	wetland	53	0.0	0.5	0.0	2.0	0.0	0.5	1.0	1.0	100.0	17.5	35.0	47.5	0.0
Exchequer	upland	33	52.5	14.5	0.0	5.5	0.0	0.0	0.2	0.9	5.3	0.8	4.5	0.0	10.0
	wetland	68	13.3	3.8	0.0	15.0	4.9	1.8	13.9	1.1	88.0	43.0	25.0	20.0	1.7
Meserve	upland	10	30.0	7.5	0.0	20.0	0.0	1.0	2.0	1.0	25.0	10.0	15.0	0.0	10.0
	wetland	90	1.0	0.5	0.0	5.0	1.0	1.0	3.0	1.0	90.0	50.0	15.0	25.0	10.0
Peckinpah	upland	30	26.3	7.3	0.0	10.0	0.3	1.5	6.1	1.0	52.5	27.5	25.0	0.0	20.0
	wetland	80	2.0	2.0	0.0	1.0	0.2	0.0	0.7	1.5	100.0	48.3	23.3	28.3	0.0
Poison	upland	43	40.0	6.7	0.0	13.3	0.2	1.3	8.0	1.0	2.7	0.0	2.7	0.0	6.0
	wetland	57	0.0	0.3	0.0	4.0	0.0	0.7	2.0	0.7	100.0	11.7	16.7	71.7	0.0
Texas	upland	40	43.3	23.1	0.0	13.3	0.0	0.7	6.5	0.8	16.7	3.3	13.3	0.0	1.7
	wetland	60	1.3	4.3	0.0	3.3	0.7	0.7	3.1	0.9	96.3	38.3	14.0	44.0	0.3

Discussion

Across the nine meadows we surveyed on Sierra NF, the habitat value for meadow bird focal species ranged from poor (Meserve) to good (Benedict), with all but one meadow, Benedict, falling short of our target for high quality bird habitat (Campos et al. 2014). Hydrologic restoration has the potential to improve habitat quality for meadow birds at some or all of these meadows (Campos et al. 2020), though the degree to which hydrologic restoration improves bird habitat in meadow types other than riparian meadow (see Weixelman et al. 2011) is not yet known. Hydrologic restoration alone, however, will likely not achieve the restoration targets for meadow birds at the meadows under the target; additional restoration and management actions focused on vegetation are needed.

The cover and height of wetland deciduous shrubs was insufficient to support a high abundance and richness of meadow birds at most of the meadows. The cover and height of wetland deciduous shrubs and trees are a primary driver of habitat quality for most meadow-dependent bird species (Campos et al. 2014, 2020; Loffland et al. 2014). At all nine meadows the cover of wetland shrubs was well below the 40% cover that maximizes the abundance and richness of focal species (Campos et al. 2014). The average height of wetland shrubs should be at least 2 m to optimize bird density. Restoration and management actions to increase the cover and heights of wetland deciduous shrubs, especially willows, and deciduous trees in and on the edges of the meadow would improve bird habitat at all of the meadows in this study.

Conifer encroachment at our sample locations in the nine meadows did not approach levels that would impact habitat quality for most focal species, except at Exchequer. At Exchequer, conifer cover in the meadow approached 20%, values high enough to impact abundance of many focal species (Campos et al. 2014). This may help explain the lower than expected abundance of focal species despite having the highest cover of riparian shrubs of the nine meadows. If hydrologic restoration does not kill and

preclude future recruitment for the vast majority of the encroaching conifers at Exchequer, additional actions to remove the trees would improve habitat quality for birds.

Herbaceous cover is an important component of habitat quality for some focal species, such as Lincoln's and Song sparrows, which nest close to or on the ground, often in thick graminoid cover (Arcese et al. 2002). The cover of herbaceous vegetation at most of the meadows was sufficient to support relatively high densities of Lincoln's Sparrow. The species was absent from Meserve meadow, likely below the elevation range of this species. Interestingly, Lincoln's Sparrow and Song Sparrow were both most abundant in Peckinpaw, a mid-elevation meadow with high herbaceous cover but low shrub cover. Hydrologic restoration should increase the vigor and abundance of sedges in the meadows where herbaceous cover was lower (e.g. Exchequer), which would benefit these species. Additional actions to increase herbaceous cover and height in portions of the meadow could further improve conditions for these species.

Lastly, the size and position of a meadow in its watershed can help inform which focal species to prioritize management for. The most abundant species in the meadows we surveyed, Lincoln's Sparrow, Warbling Vireo, and MacGillivray's Warbler, are all species that reach their highest abundance in meadows with smaller contributing watersheds with lower surface flow (Campos et al. 2014, 2020). The low abundance and absence of Wilson's Warbler and Calliope Hummingbird respectively, who also tend to be more abundant in meadows with smaller watersheds, reflects the lack of suitable habitat for species requiring riparian deciduous shrubs. The small size of the meadows and their watersheds in this study makes them much less suitable for Willow Flycatcher (Loffland et al. 2014), which are often the focus of management in meadows in the Sierra Nevada. In these small meadows, where conditions may not always be conducive to riparian shrub proliferation, restoration practitioners should consider revegetation of the meadow edge/ecotone where important resources such as riparian shrubs and

flowering plants may contribute to habitat suitability for meadow species that require more than herbaceous cover.

Recommendations to Improve Restoration Outcomes for Birds

- Revegetation with willows and other riparian shrubs in high-density clumps would jump-start the colonization and growth of crucial structural components of meadow bird habitat. In grazed meadows, clumped plantings should be protected with temporary exclusion fencing to allow the plants to grow above the browse height of cattle and deer.
- Consider revegetating with a diversity of meadow plants that meet the diverse needs of meadow birds, including nesting structure, fruiting resources, and nectar resources. Point Blue's Meadow Planting Palette can help guide the selection of species for revegetation (Vernon et al. 2020).
- Applying long-term land management that is compatible with the development and retention of dense patches of deciduous shrubs and trees (20-40% of the meadow area), with continued recruitment, will be important to reaching and sustaining restoration targets for meadow birds.
- The early years after hydrologic restoration are a sensitive period for meadows. Consider resting recently restored meadows in active grazing allotments to reduce impacts to soil and vegetation. If cattle grazing continues to be a long-term use within the meadow, consider developing an adaptive management and monitoring plan with triggers for management actions to guide cattle grazing in direct response to site conditions and restoration targets (e.g., bird density, vegetation cover).

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Appendix A. Sample Locations

Table A1. Sample location coordinates. Datum WGS 84.

Point	Latitude	Longitude
BEEHI01	37.32868886	-119.4475693
BEEHI02	37.32799115	-119.4496587
BENED01	37.24717991	-119.4328080
BENED02	37.24669454	-119.4305288
BENED03	37.24501873	-119.4313847
CHINA01	37.27090679	-119.4234156
CHINA02	37.27211318	-119.4217358
CHINA03	37.27363911	-119.4205311
CHIPM01	37.39629555	-119.5124180
CHIPM02	37.39780756	-119.5136566
EXCHE01	37.07214444	-119.1165723
EXCHE02	37.07225926	-119.1143241
EXCHE03	37.07360090	-119.1127041
EXCHE04	37.07251909	-119.1108834
MESER01	37.36667522	-119.5796186
PECKI01	37.26519981	-119.4619145
PECKI02	37.26693859	-119.4612669
PECKI03	37.26624962	-119.4637752
POISO01	37.39643127	-119.5214738
POISO02	37.39816483	-119.5208377
POISO03	37.39992070	-119.5213426
TEXAS01	37.42099794	-119.5485502
TEXAS02	37.42083839	-119.5462994
TEXAS03	37.42120341	-119.5440860

Appendix B. Representative Photos

Figure B1. Representative conditions at Beehive Meadow: heavily grazed herbaceous vegetation and lack of riparian deciduous shrub cover.

Figure B2. Representative conditions at Benedict Meadow: thick and tall herbaceous vegetation, tall riparian deciduous shrubs in the foreground and distance.

Figure B3. Representative conditions at China Meadow: thick herbaceous vegetation and wetland deciduous shrubs at the meadow edge.

Figure B4. Representative conditions at Chipmunk Meadow: thick herbaceous vegetation, small patches of wetland deciduous shrubs at the meadow edge, and lack of wetland shrubs in the meadow interior.

Appendix C. Relevé Protocol

separate attachment

POINT BLUE SIERRA MEADOW POINT COUNT VEGETATION PROTOCOL

(modified by Brent Campos, June 30, 2020 for Sierra NF Meadows)

All data is collected within a circle of 50-meter radius centered on the point count station.

Header and Habitat Information

Transect: The four-letter code of the point count transect (e.g., GUCR)

Point: The point number of the point count along the transect (e.g, 11).

Date: The date you are collecting the data.

Observers: The three-letter initials for all observers aiding in data collection.

Aspect: The direction of the slope given in degrees (the direction a drop water would flow if poured onto the point). Declination on compasses should be set to 0°. If slope is ≤6°, "ALL" (all aspects) is an equally valid entry for this field.

Slope: Use a clinometer on your compass to measure the average slope of the plot with 90° being vertical and 0° being flat. A 45° slope is a 1:1 slope and is about as steep as you can walk up.

Hab1: Classification for the primary (majority) habitat present in the plot. If the primary habitat is a meadow, record the hydrogeomorhpic type according to the Weixelman et al. key. If it is not a meadow, record the CWHR habitat type (e.g. aspen [ASP], montane riparian [MRI], Sierra mixed conifer [SMC], lodgepole [LPN]). For degraded meadows, do your best to classify the historic meadow boundaries. Codes for hydrogeomorphic types: basin peatland (BPTM), mound peatland (MPTM), discharge slope peatland (DPTM), depressional seasonal (DPSM), depressional perennial (DPPM), lacustrine fringe (LAFM), dry (DRYM), discharge slope (DISM), riparian low gradient (RLGM), riparian middle gradient (RMGM), riparian high gradient (RHGM), subsurface low gradient (SLGM), subsurface middle gradient (SMGM), subsurface high gradient (SHGM). <u>More general hydrogeomorhpic type options include: peatland (PEAT), depressional (DEPR), riparian (RIPA), and subsurface (SUBS).</u>

Hab1%: Estimate of the percentage of the plot occupied by habitat 1.

Hab2: Classification for the secondary habitat present in the plot, if the primary habitat is <100% of the plot. If the secondary habitat is a meadow, record the hydrogeomorhpic type according to the Weixelman key. If it is not a meadow, record the CWHR habitat type.

[**Note**: If you suspect you have multiple meadow types in the plot but it is unclear where the boundaries are, do your best to roughly estimate the percentages. If you are at a complete less, use the broader categories of dry meadow and wet meadow, but be sure to add comments in the notes].

Hab2%: Estimate of the percentage of the plot occupied by habitat 2.

Hab3: Classification for the tertiary habitat present in the plot, if the primary and secondary habitats are < 100% of the plot. If the tertiary habitat is a meadow, record the hydrogeomorhpic type according to the Weixelman key. If it is not a meadow, record the CWHR habitat type.

Hab3%: Estimate of the percentage of the plot occupied by habitat 3.

Plot in uplands: Percentage of the plot classified as upland habitat. That is, the percentage of the plot that is not a meadow type or montane riparian corridor (which are "wetlands" for the purposes of this data).

Form for wet-lands/uplands: If your plot has a meadow component, you will collect the data on this form separately for the wetland and upland habitat types. If your plot has no meadow component, do not separate out the wetland and upland habitat types. Circle what part (wetlands, uplands, or both) of the plot you

are collecting data for on this side of the form. If separating wetlands and uplands, collect the data for the uplands part of the plot on the backside of the same form as the wetlands, indicating the appropriate page number on the bottom right. For the uplands side, just fill in the transect, point, and observer in the header information and do not collect data past the Ground Cover section.

Percent cover relative to: You have two options for the calculation of percent cover of the four main vegetation strata in first table. The first option is to calculate percent cover estimates for each side of the form relative to just the area that is wetland or upland. In other words, if one-quarter of your plot is uplands with 60% tree cover and three-quarters of the plot is wetlands with 5% tree cover, the percent cover for the tree layer you would record in percent cover fields for the uplands habitat would be 60%. The second option is to calculate percent cover estimates for each side of the form relative to the entire plot area, rather than the area of the plot that is wetland or upland. In other words, using the example above, the percent cover for the tree layer for the uplands habitat side of the form would be calculated as 60% × 0.25 = 15%. The second option is helpful if you are used to doing releves at a 50-m scale and have visual filters for what 1% or 5% of a 50-m radius circle looks like. Indicate your calculation method by circling percent cover relative to "habitat type" (first option) or "entire plot" (second option) for the first and second options, respectively.

Photos: Take photos in all four magnetic cardinal directions from the center of the plot. On the corner of a piece of paper, your datasheet, or a whiteboard, write the transect, point number, and direction of the photo. Hold this photo label up in the corner of the photo at arm's length away from the camera when taking each photo. Check the box once photos have been taken in all four magnetic cardinal directions. When you return from the field, upload the photos to a work computer and rename them as in the following format: transect.point number_direction.photo file type. For example: WSLA.7_E.jpeg

Cover Layers

The vegetation within the plot is divided up into layers: Tree, Tree Shrub, Real Shrub, and Ground Cover. For each layer estimate the percentage of the plot covered by all *live* vegetation in that layer. Live vegetation includes live leaves and branches holding live leaves. Note that the maximum cover is 100% for each of these categories, but that is rarely achieved. The sum of the total percent cover for all the layers can be over or less than 100%.

Tree Layer: The tree layer is composed of all trees on the plot that are >5 m tall. Tree species include the conifers, aspen, cottonwood, black oak, etc.

Tree Shrub Layer: The tree shrub layer is composed of all trees that are less than 5 meters tall.

Real Shrub Layer: The real shrub layer is composed of true shrub species (regardless of height) as well as a few shrubby trees that rarely get above 5 meters tall (e.g. Pacific dogwood, scrub oak). If in doubt about whether a species is a tree or a shrub, add it to the shrub layer. Record the total cover of these shrubs ≥0.5 m tall.

Herbaceous

Layer: The herbaceous layer is a subset of the ground cover layer. It includes all non-woody vegetation (grasses, sedges, forbs, etc.), regardless of height, as well as shrubs, and shrub-like species *Ceanothus prostratus, Synthocarpus mollis, Chamaebatia foliolosa,* and *Arcostophylus nevadensis* that rarely get over 0.5 m tall and do not have structure for shrub-nesting birds to nest in. Juncos, which are ground nesters, will nest in these ground cover species but Fox Sparrows or Yellow Warblers, which are shrub nesters, would almost never use this to nest in. Herbaceous coverage is the total percent of the plot covered in herbaceous layer species. A plant species that is NOT a tree or real shrub species is in this layer. (see the Ground Cover section for more information)

Height Bounds

Low: An estimate of the average height of the bottom quartile of heights for the lowest living foliage in that layer. This is done for the tree layer only. In other words, of the lowest 25% of living tree branches in the plot, what is the average height? If this estimate is >1 m, estimate to the nearest meter, or to the nearest 0.1 m if <1m.

Low Species: Record the plant species that constitutes the majority of individual plants in the averaged quartile.

Average: An estimate of the average highest point of living foliage on individual plants in each vegetation layer (tree, tree shrub, tree seedling, real shrub, shrub seedling). If this estimate is >1 m, estimate to the nearest meter, or to the nearest 0.1 m if <1m.

Avg Species: Record the plant species that constitutes the majority of individual plants near the average height.

High: An estimate of the average height of the top quartile of heights for all plants in each vegetation layer (tree, tree shrub, real shrub). This is not the height of the absolute tallest outlier in that layer. In other words, of the tallest 25% of trees in the plot, what is the average height? If this estimate is >1 m, estimate to the nearest meter, or to the nearest 0.1 m if <1m.

High Species: Record the plant species that constitutes the majority of individual plants in the top quartile.

Diameter at Breast Height

Avg and Max DBH: Using a DBH tape, measure the diameter of at least three trees at breast height (1.4 m), paying close attention to values relative to the average and maximum diameters of trees on the plot. For trees on a slope or on otherwise greatly uneven ground, stand on the side of the tree with the highest ground when measuring the DBH. Record the species and DBH that represent the majority of the average and maximum DBH values for trees on the plot.

Snags and Logs

Snags are standing dead trees. Snags can have branches and dead leaves or needles, but the tree must appear completely dead. Snags must be tall enough to have a DBH measurement. Anything shorter than that should be considered a stump, and included in the woody debris ground cover estimate. Dead trees that are uprooted but not on the ground, or almost on the ground, are snags. Logs must still have the form of a tree, once they have decomposed into a pile of crumbs they are no longer countable. The DBH of log is measured 1.4 m up from the root end. Record the total number of snags and meters of logs in each of the three categories: >60 cm DBH, 30-60 cm DBH, and 10-30 cm DBH. When filling out the form for upland habitat (or both), simply record the number of logs, rather than meters of logs.

Relative Cover by Species

For each of three layers – T1 (tree layer), TS (tree shrub), and RS (real shrub) – record the proportion (as a percentage) each species comprises of the total cover for that layer. The percentages for the T1, TS, and RS layers should add up to 100% regardless of the percent total cover for that layer. List as many species as can easily be recorded in a timely manner. However, we are interested in all hardwood species, so if they are present in small numbers recording them even if they are less than 5% is worth the effort. Recording the contribution of each tree species is also important, even if there is only one of them. But chasing down that lone shrub off in the corner of the plot is not worth the effort.

Ground Cover

For the ground layer (GD), record the absolute cover of each cover type in the given list. The cover of the herbaceous layer is the sum of grass, forbs, sedge & rush, emergent aquatics (e.g. tules, cattails), and low shrubs (those that rarely get above 0.5 m, as described above). Open water is any water, running or standing, not covered by herbaceous vegetation. Gravel/sand/rock are differentiated by bare ground and soil by the grain size of material. If it is sand or larger, it is classified as gravel/sand/rock. Coarse woody debris (CWD) includes tree boles and large branches. Slash is the smallest type of coarse woody debris. It includes fallen stems and branches that are larger than 1" diameter – i.e. includes small twigs that are part of the same branch. Other fine woody debris that is smaller than 1" diameter, including leaf material, small twigs, and loose needles, are classified as litter. The "other" type of ground cover provides a place for you to record other types of human-made corridors or structures.

Non-vegetation Features

Circle all of the non-vegetation features present in the plot in the four categories: running water, standing water, human-made corridors, and human-made structures.

Last Section, Various Info

Percent of meadow surface: Give the percent of the meadow surface in each of the categories below. The total of these percentages adds to 100%. Standing water under emergent aquatic vegetation counts as standing water. Observers should probe the ground under vegetation with their fingers in multiple (≥5) places throughout the plot to assess soil moisture.

Dry – no moisture content visible or felt in the top 2" of soil; if you were to shovel it, it would be dusty

Moist – moisture visible and felt in the soil, but it is not easily penetrable

Saturated – no standing water, but soil has a visible sheen, is easily penetrable, and water pools around feet when you step on it

Standing – completely covered in water and water has no detectable flow

Moving – completely covered in water and water has detectable flow

~~Distance to channel: Measure the distance from the center of the plot to the largest channel (at least the size of a small brook) within 75 m of the PC center. If there is no stream channel in the meadow, record NA or a dash. If the stream channel is greater than 75 m away, record >75.~~

~~Channel width and height: For the channel identified above, find the nearest run (see Appendix A) to the PC center. At that location, record the width of the channel. For channels less than 3m wide, record to the nearest 0.1m, other record to the nearest 0.5 or 1m. At this same location, measure the height from the channel bottom to the top of the lowest bank at approximately the 25th, 50th and 75th percentile distances~~

~~across the channel. For channels less than 2m deep, record to the nearest 0.1m, other record to the nearest 0.5 or 1m.~~

Distance to upland and CWHR type: Measure the distance the near upland habitat edge using a rangefinder. Record the CWHR type of the upland community.

Signs of beaver: Circle whether you detect lodges, dams, or cut stems in the plot. Circle none if none is detected. Also record the age of the activity. Fresh is this spring or summer season. Old is anything older than that.

Signs of grazing: Circle any signs of grazing in the plot. Circle none if none is detected. Also record the age of the signs. Fresh is this spring or summer season. Old is anything older than that.

Restoration efforts: Indicate whether there have been restoration efforts within 50 m of the plot center. Restoration efforts include check dams, stabilized headcuts, exclosure fencing, plantings (e.g. willow, alder), etc. If there have been restoration efforts, describe it in the notes.

Non-Applicable and Missing Data

If a NUMERIC data field is not applicable, meaning no data can be measured for a numeric data field, write a dash in the field on the datasheet. If a SPECIES data field is not applicable, meaning SPECIES fields associated with non-applicable numeric data fields, write the code NONE in the field on the datasheet. For example, if there is 0% tree cover, low, average, and high tree heights would be "—" and the species would be NONE. When entering data, a numeric data field that has a dash should be left blank in the database and a species data field with NONE should be entered as NONE (NONE is the default value for a species field in the database). In the rare case that you forget to collect data and notice an empty field on your datasheet later in the day after you have left the survey area, notify your supervisor. The data entry code for data not collected is 9999.

Data Entry

All data will be entered into the Microsoft Access database, generally the day it is collected. To enter data, open the form titled "f_meadows_pcveg_DATA_ENTRY" in the window pane on the left side of the screen. Press the Tab key to navigate between fields. Press Control+Tab to navigate between subforms and forms. Press the Space bar to click a yes/no checkbox. Close this form when you are done entering data. To proof data, open the form titled "f_meadows_pcveg_DATA_PROOFING."

Consult your supervisor with data entry questions. If they are not available, feel free to contact Brent Campos at (530) 665-6413 or bcampos@pointblue.org. Notify Brent of any changes you make to the structure (anything other than the data itself) of the database.

Appendix A: Estimating Cover

From the CNPS Releve' protocol (08/23/2007 version)
http://www.dfg.ca.gov/biogeodata/vegcamp/pdfs/CNPS_Releve_Protocol_revised_08-23-07.pdf

Estimating Cover:
There are many ways to estimate cover. Many people who have been in the cover estimation "business" for a long time can do so quickly and confidently without any props and devices. However, to a novice, it may seem incomprehensible and foolhardy to stand in a meadow of 50 different species of plants and systematically be able to list by cover value each one without actually "measuring" them in some way.

Of course, our minds make thousands of estimates of various types every week. We trust that estimating plant cover can be done by anyone with an open mind and an "eye for nature." It's just another technique to learn. It is very helpful to work initially with other people who know and are learning the technique. In such a group setting, typically a set of justifications for each person's estimate is made and a "meeting of the minds" is reached. This consensus approach and the concomitant calibration of each person's internal scales is a very important part of the training for any cover estimate project.

An underlying point to remember is that estimates must provide some level of reliable values that are **within acceptable bounds of accuracy**. If we require an accuracy level that is beyond the realm of possibility, we will soon reject the method for one more quantitative and repeatable. As with any scientific measurement, the requirement for accuracy in the vegetation data is closely related to the accuracy of the information needed to provide a useful summary of it. Put into more immediate perspective - **to allow useful and repeatable analysis of vegetation data, one does not need to estimate down to the exact percent value the cover of a given plant species in a given stand.**

This point relates to two facts: there is inherent variability of species cover in any environment. For example, you would not expect to always have 23% *Pinus ponderosa*, 14% *Calocedrus decurrens*, and 11% *Pinus lambertiana* over an understory of 40% *Chamaebatia foliosa*, 3% *Clarkia unguiculata*, and 5% *Galium bolanderi* to define the Ponderosa pine-Incense cedar/mountain misery/bolander bedstraw plant community. Anyone who has looked at plant composition with a discerning eye can see that plants don't space themselves in an environment by such precise rules. Thus, we can safely estimate the representation of species in a stand by relatively broad cover classes (such as <1%, 1-5 %, 5-25%, etc.) rather than precise percentages.

The data analysis we commonly use to classify vegetation into different associations and series (TWINSPAN and various cluster analysis programs, for example) is likewise forgiving. When analyzed by quantitative mutivariate statistics information on species cover responds to coarse differences in cover and presence and absence of species, but not to subtle percentage point differences. This has been proven time and again through quantitative analysis of vegetation classification. Many of the world's plant ecologists estimate cover rather than measure it precisely. Some of the seminal works in vegetation ecology have been based on cover estimates taken by discerning eyes.

With this as a preamble, below we offer some suggestions on estimating cover that have proven helpful. These are simply "tricks" to facilitate estimation, some work better for different situations. You may come up with other methods of estimation that may seem more intuitive, and are equally reliable in certain settings. All values on the relevé protocol that require a cover estimate, including coarse woody debris and vegetation layer information, may rely on these techniques. Just make the appropriate substitutions (using the vegetation example substitute, bedrock, stone, cobbles, gravel, and litter for vegetation).

Method A: "Squash" all plants into a continuous cover in one corner of the plot
Another way to estimate how much of the plot is covered by a particular species is to mentally group (or "march", or "squash") all members of that species into a corner of the plot and estimate the area they cover.

Then calculate that area as a percentage of the total plot area. This technique works well in herb and shrub dominated plots but is not very useful in areas with trees.

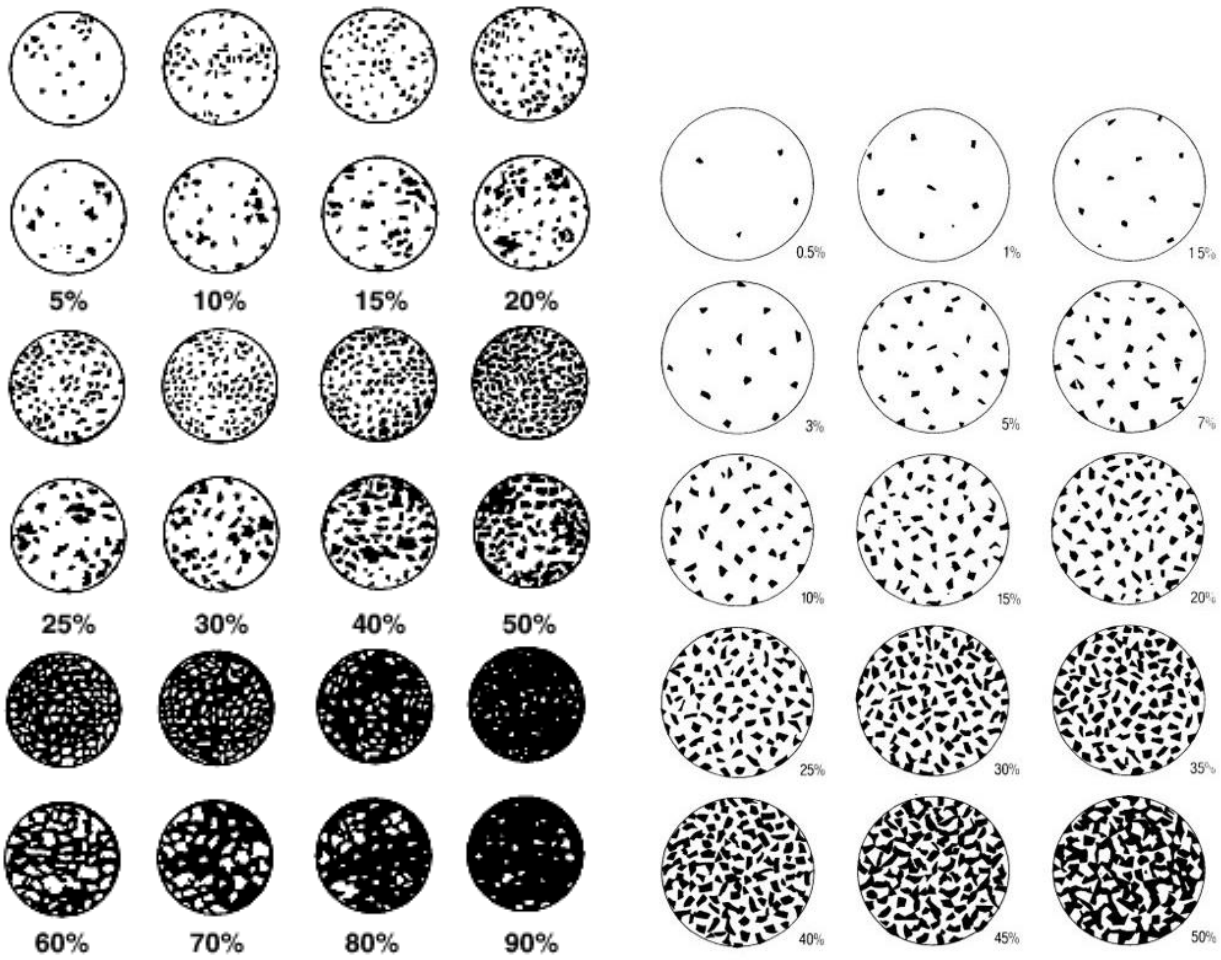
Method B: How to estimate tree cover
Cover estimates of tall trees is one of the most difficult tasks for a beginning relevé sampler. However it is possible to do this with consistency and reliability using the following guidelines.
1. Have regular sized and shaped plots that you can easily subdivide.
2. Estimate average crown spread of each tree species separately by pacing the crown diameter of representative examples of trees of each species and then roughly calculating the crown area of each representative species.
3. Add together the estimated crown area of each individual of each species of tree on the plot for your total cover.

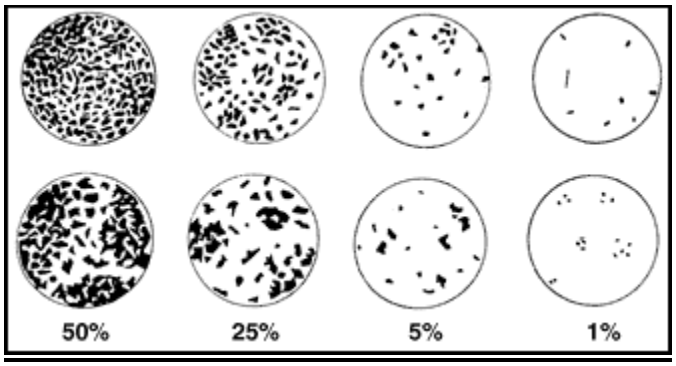
Method C: The process of elimination technique
This method is generally good for estimating cover on sparsely vegetated areas where bare ground, rocks, or cobbles cover more area than vegetation. In such a situation it would be advisable to first estimate how much of the ground is not covered by plants and then subdivide the portion that is covered by plants into rough percentages proportional to the different plant species present. For example, in a desert scrub the total plot not covered by plants may be estimated at 80%. Of the 20% covered by plants, half is desert sunflower (10% cover), a quarter is California buckwheat (5% cover), an eighth brittlebush (2.5% cover), and the rest divided up between 10 species of herbs and small shrubs (all less than 1% cover).

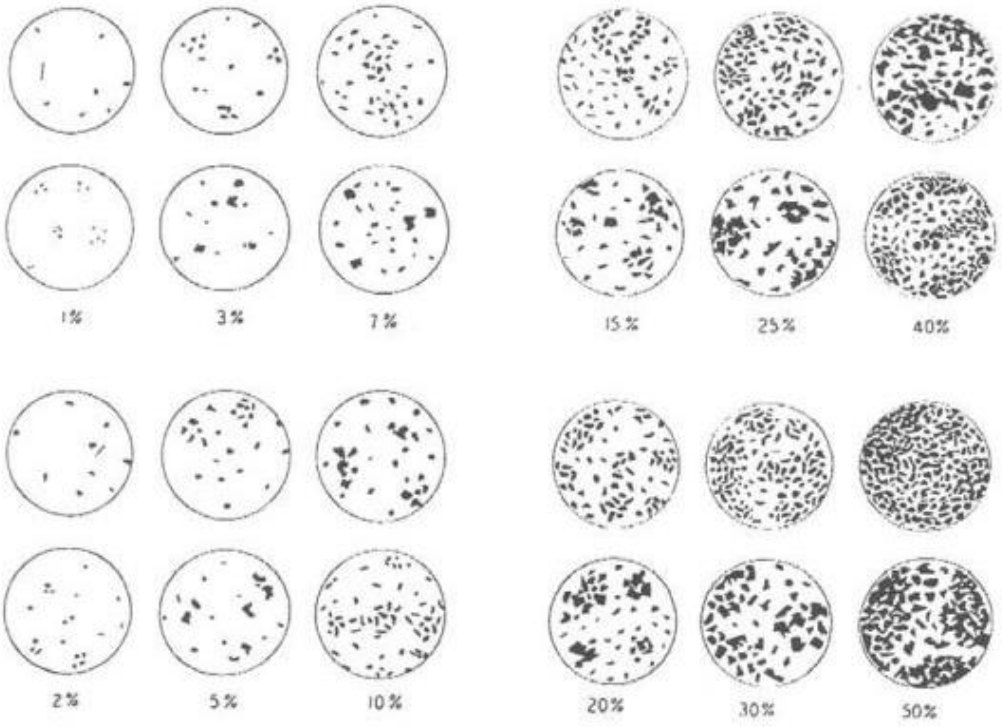
Any of these techniques may be used in combination with one another for a system of checks and balances, or in stands that have characteristics lending themselves for a different technique for each layer of vegetation.

In a relevé, cover estimates, using the techniques described above, are made for each taxon as it is recorded on the species list. Estimates are made for each layer in which the taxon was recorded. For example, if individuals of coast live oak occur in the tree overstory (canopy trees) and tree understory (seedlings and saplings), an estimate is made for each layer, and both should be recorded.

Appendix B: Visualizing Percent Cover



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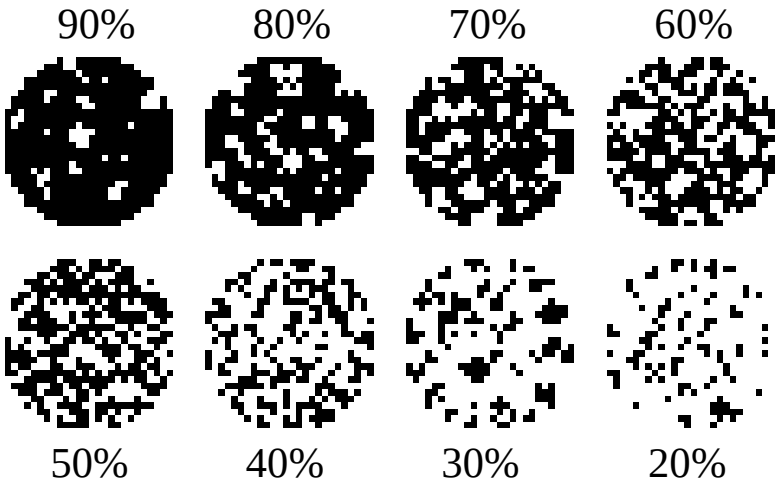
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