

Supplemental Material

Table A.1 UTM (Universal Transverse Mercator) coordinates of study sites in Grand Teton National Park and Bridger-Teton National Forest, WY (NAD 1983 UTM Zone 12N) with meadow size (ha) and elevation (m) provided for each site. Occupancy data for *Parnassius clodius* is included for each study site collected mid June – late July 2012 (Present = *Parnassius clodius* present, Absent = *Parnassius clodius* absent). Sites were considered occupied if at least one butterfly was verified to be present in at least one of the presence-absence butterfly surveys; sites were considered to be unoccupied if no butterflies were observed across all presence-absence surveys

Site	GPS Location	Elevation (m)	Meadow Size (ha)	<i>P. clodius</i> Occupancy
AMK Ranch	528713 4865045	2080	3	Present
AMK Road	529077 4864934	2094	4	Present
Antelope Flats	529470 4835784	2069	135	Absent
Buffalo Fork	549358 4855639	2132	115	Present
Cow Lake 1	535004 4851840	2080	157	Absent
Cow Lake 2	532269 4851812	2099	261	Absent
Cygnets Pond	530146 4861081	2086	20	Present
Elk Ranch 2	541592 4849795	2095	300	Absent
Grand View 1	535627 4861193	2225	1	Present
Grand View 2	535609 4861415	2285	1	Present
Grand View Trailhead	535142 4860599	2146	9	Present
Lozier Hill East	538775 4856609	2091	8	Present
Lozier Hill West	537747 4856522	2043	26	Absent
Lupine Meadow	521129 4843032	2063	92	Present

North Jenny Lake	522388 4848251	2107	52	Absent
Pilgrim Creek	533718 4862533	2117	65	Present
Surprise Lake Meadow	520001 4841263	2105	6	Present
Timbered Island	522115 4842890	2062	284	Present
Two Ocean Lake Road 2	540030 4860396	2119	9	Absent

Table A.2 UTM (Universal Transverse Mercator) coordinates of study sites in Grand Teton National Park and Bridger-Teton National Forest, WY (NAD 1983 UTM Zone 12N) with meadow size (ha) and elevation (m) provided for each site. Occupancy data for *Parnassius clodius* is included for each study site collected mid June – late July 2013 (Present = *Parnassius clodius* present, Absent = *Parnassius clodius* absent). Sites were considered occupied if at least one butterfly was verified to be present in at least one of the presence-absence butterfly surveys; sites were considered to be unoccupied if no butterflies were observed across all presence-absence surveys

Site	GPS Location	Elevation (m)	Meadow Size (ha)	<i>P. clodius</i> Occupancy
AMK Ranch	528713 4865045	2080	3	Present
AMK Road	529077 4864934	2094	4	Present
Antelope Flats	529470 4835784	2069	135	Absent
Bearpaw Lake Intersection	521838 4852775	2110	1	Present
Bearpaw Lake Trail	522079 4849388	2114	4	Present
Buffalo Fork	549358 4855639	2132	115	Present
Christian Pond	534432 4858912	2104	21	Absent
Climbers Ranch	521577 4838973	2043	14	Present
Cow Lake 1	535004 4851840	2080	157	Absent
Cow Lake 2	532269 4851812	2099	261	Absent
Cygnets Pond	530146 4861081	2086	20	Present
Death Canyon Phelps Lake Jct.	515719 4833590	2068	4	Present
Death Canyon Ranger Cabin	513571 4834713	2401	1	Present
Dump Road	530523 4861790	2090	9	Present
Elk Ranch 1	540261 4850850	2079	40	Absent

Elk Ranch 2	541592 4849795	2095	300	Absent
Grand View 1	535627 4861193	2225	1	Present
Grand View 2	535609 4861415	2285	1	Present
Grand View Trailhead	535142 4860599	2146	9	Present
Hidden Falls Trail	521439 4843954	2080	1	Present
Lozier Hill East	538775 4856609	2091	8	Present
Lozier Hill West	537747 4856522	2043	26	Absent
Lupine Meadow	521129 4843032	2063	92	Present
Mt. Moran Turnout	528887 4850207	2104	1307	Absent
North Jenny Lake	522388 4848251	2107	52	Present
Paintbrush Canyon Trail	521072 4849468	2138	1	Present
Pilgrim Creek	533718 4862533	2117	65	Present
Pilgrim Creek East	533942 4861337	2110	85	Present
Shadow Mountain Hairpin	532852 4838189	2411	25	Present
Sound of Music	533257 4839554	2491	25	Present
String Lake Trailhead	521728 4848059	2102	1	Present
Surprise Lake Meadow	520001 4841263	2105	6	Present
Surprise Lake Trail 1	520818 4841498	2123	2	Present
Surprise Lake Trail 2	520745 4841270	2058	2	Present
Taggart Lake Trailhead	521361 4837657	2006	16	Present
Timbered Island	522115 4842890	2062	284	Present

Two Ocean Lake Road 1	540926 4858405	2107	50	Absent
Two Ocean Lake Road 2	540030 4860396	2119	9	Present
Wilderness Road 1	544237 4864715	2147	6	Present
Wilderness Road 2	543598 4864076	2144	10	Present
Wilderness Road 3	542182 4861987	2125	30	Present

Table A.3 List of vegetation categories used in the vegetation analysis^a. Indented regular font items include vegetation data collected in the field that were combined into 14 numbered items in bold for analysis purposes

1. Bare ground
2. Litter
3. Graminoids
4. Buckwheat family (Polygonaceae)* – sulphur flower buckwheat (<i>Eriogonum umbellatum</i> var. <i>dichrocephalum</i>); Buckwheat family (Polygonaceae) – sulphur flower buckwheat (<i>Eriogonum umbellatum</i> var. <i>umbellatum</i>); Buckwheat family (Polygonaceae)
5. Arrow-leaved balsamroot (<i>Balsamorhiza sagittata</i>); Aster family (Asteraceae)**
6. Secondary forb nectar sources** – groundsel (<i>Senecio</i> spp.); Aster family (Asteraceae) – sticky geranium (<i>Geranium viscosissimum</i>); Geranium family (Geraniaceae) – nettle-leaved giant-hyssop (<i>Agastache urticifolia</i>); Mint family (Lamiaceae) – spreading dogbane (<i>Apocynum androsaemifolium</i>); Dogbane family (Apocynaceae) – purple and yellow flowering asters; Aster family (Asteraceae)
7. Secondary woody shrub nectar sources** – snowbrush ceanothus (<i>Ceanothus velutinus</i>); Buckthorn family (Rhamnaceae) – common snowberry (<i>Symphoricarpos albus</i>); Honeysuckle family (Caprifoliaceae) – birch-leaved spiraea (<i>Spiraea betulifolia</i>); Rose family (Rosaceae)
8. Stonecrop (<i>Sedum</i> spp.); Stonecrop family (Crassulaceae)
9. Low sagebrush (<i>Artemisia arbuscula</i>); Aster family (Asteraceae)
10. Big sagebrush (<i>Artemisia tridentata</i>); Aster family (Asteraceae)
11. Lupine (<i>Lupinus</i> spp.); Pea family (Fabaceae/Leguminosae)
12. Asteraceae family (non-nectar sources for <i>Parnassius</i> species) – thistle (<i>Carduus</i> spp.); Aster family (Asteraceae) – common yarrow (<i>Achillea millefolium</i>); Aster family (Asteraceae) – nodding microseris (<i>Microseris nutans</i>); Aster family (Asteraceae) – orange agoseris (<i>Agoseris aurantiaca</i>); Aster family (Asteraceae) – hawksbeard (<i>Crepis</i> spp.); Aster family (Asteraceae) – goldenrod (<i>Solidago</i> spp.); Aster family (Asteraceae) – pussytoes (<i>Antennaria</i> spp.); Aster family (Asteraceae)

13. Miscellaneous forbs (non-nectar sources for *Parnassius* species)

- Lily family (Liliaceae)
- cinquefoil (*Potentilla* spp.); Rose family (Rosaceae)
- *phacelia* (*Phacelia* spp.); Waterleaf family (Hydrophyllaceae)
- ballhead sandwort (*Arenaria congesta*); Pink family (Caryophyllaceae)
- Parsley/Carrot family (Apiaceae)
- common harebell (*Campanula rotundifolia*); Campanula family (Campanulaceae)
- blue flax (*Linum lewisii*); Flax family (Linaceae)
- paintbrush (*Castilleja* spp.); Figwort family (Scrophylariaceae)
- common toadflax (*Linaria vulgaris*); Figwort family (Scrophylariaceae)
- wild rose (*Rosa woodsii*); Rose family (Rosaceae)
- wild strawberry (*Fragaria virginiana*); Rose family (Rosaceae)
- prairie smoke (*Geum triflorum*); Rose family (Rosaceae)
- scarlet gilia (*Ipomopsis aggregata*); Phlox Family (Polemoniaceae)
- larkspur (*Delphinium* spp.); Buttercup Family (Ranunculaceae)
- showy-green gentian (*Frasera speciosa*); Gentian family (Gentianaceae)
- common peppergrass (*Lepidium densiflorum*); Mustard family (Brassicaceae)
- northern bedstraw (*Galium boreale*); Madder family (Rubiaceae)

14. Miscellaneous woody shrubs (non-nectar sources for *Parnassius* species)

- western serviceberry (*Amelanchier alnifolia*); Rose family (Rosaceae)
- choke cherry (*Prunus virginiana*); Rose family (Rosaceae)
- creeping Oregon grape (*Mahonia repens*); Barberry family (Berberidaceae)
- willow (*Salix* spp.); Willow family (Salicaceae)
- shrubby cinquefoil (*Pentaphylloides floribunda*); Rose family (Rosaceae)

* indicates main nectar source of *P. clodius*

** indicates secondary nectar source of *P. clodius*

^aVegetation was grouped using the following criteria: predominant nectar source (Polygonaceae family that include *E. umbellatum* var. *dichrocephalum* and *Eriogonum umbellatum* var. *umbellatum*) was listed individually. Plants utilized less frequently as nectar sources were categorized as secondary forb nectar sources and secondary woody shrub nectar sources. Non-nectar sources were categorized into Asteraceae family, miscellaneous forbs, and miscellaneous woody shrubs. *Sedum* spp., the host plant of *Parnassius smintheus*, was listed individually. Bare ground, litter, graminoids, *Lupinus* spp., and the sagebrush species *Artemisia arbuscula* and *Artemisia tridentata* were considered major habitat variables and were therefore grouped separately

Table A.4 *Parnassius clodius* presence-absence surveys (n = 19) conducted in Grand Teton National and Bridger-Teton National Forest, WY from mid June – late July 2012

Site	Visit 1 Obs 1	Visit 1 Obs 2	Visit 2 Obs 1	Visit 2 Obs 2
AMK Ranch	1	1	-	-
AMK Road	1	1	1	1
Antelope Flats	0	0	-	-
Buffalo Fork	0	0	1	1
Cow Lake 1	0	0	-	-
Cow Lake 2	0	0	-	-
Cygnets Pond	0	0	1	1
Elk Ranch 2	0	0	-	-
Grand View 1	1	1	-	-
Grand View 2	1	1	-	-
Grand View Trailhead	1	1	-	-
Lozier Hill East	0	1	-	-
Lozier Hill West	0	0	-	-
Lupine Meadow	1	1	-	-
North Jenny Lake	0	0	0	0
Pilgrim Creek	1	1	1	1
Surprise Lake Meadow	1	1	-	-
Timbered Island	0	1	0	0
Two Ocean Lake Road 2	0	0	-	-

Table A.5 Grand Teton National Park and Bridger-Teton National Forest, WY study sites that were occupied by *Parnassius clodius* (n = 32) during 2013 surveys. Four presence-absence butterfly surveys were conducted at each study site^a. The total number of butterflies observed per survey and the total number of *Parnassius clodius* butterflies summed across four surveys are provided for each study site

Site	Visit 1 Obs 1	Visit 1 Obs 2	Visit 2 Obs 1	Visit 2 Obs 2	Total butterflies across 4 surveys
AMK Ranch	0	0	1	0	1
AMK Road	9	7	6	6	28
Bearpaw Lake Intersection	1	0	0	0	1
Bearpaw Lake Trail	0	1	1	1	3
Buffalo Fork	1	2	0	1	4
Climbers Ranch	1	1	1	0	3
Cygnnet Pond	1	3	0	0	4
Death Caynon Phelps Lake Jct.	3	0	0	0	3
Death Canyon Ranger Cabin	3	-	-	-	3
Dump Road	2	3	8	4	17
Grand View 1	8	6	5	7	26
Grand View 2	6	10	4	3	23
Grand View Trailhead	6	7	5	8	26
Hidden Falls Trail	2	0	0	0	2
Lozier Hill East	0	1	0	1	2
Lupine Meadow	5	5	3	8	21
North Jenny Lake	1	2	1	1	5

Paintbrush Canyon Trail	10	-	1	3	14
Pilgrim Creek	11	3	8	4	26
Pilgrim Creek East	2	2	0	1	5
Shadow Mountain Hairpin	1	2	0	1	4
Sound of Music	3	0	2	3	8
String Lake Trailhead	0	0	1	1	2
Surprise Lake Trail 1	1	1	0	1	3
Surprise Lake Trail 2	1	1	1	1	4
Surprise Lake Meadow	13	11	7	4	35
Taggart Lake Trailhead	1	0	0	1	2
Timbered Island	1	1	1	1	4
Two Ocean Lake Road 2	0	0	1	0	1
Wilderness Road 1	9	11	5	7	32
Wilderness Road 2	10	9	2	4	25
Wilderness Road 3	4	2	1	1	8

^a Four presence-absence butterfly surveys were conducted at each study site except for Death Canyon Ranger Cabin (1 survey conducted) and Paintbrush Canyon Trail (3 surveys conducted), where weather conditions limited the number of surveys

Table A.6 Summary statistics comparing habitat variables surveyed using frequency of occurrence sampling techniques for sites with *Parnassius clodius* present (n = 32) versus sites with *Parnassius clodius* absent (n = 9). Vegetation surveys were collected in Grand Teton National Park and Bridger-Teton National Forest, WY during the summer of 2013. Reported are mean values, standard error (SE), and P-values testing evidence of a difference for each vegetation category. Significant P-values obtained from a Kruskal-Wallis non-parametric test ($P < 0.05$) are indicated in bold font

	<i>P. clodius</i> absent		<i>P. clodius</i> present		
Variable	Mean	SE	Mean	SE	P-value
bare ground	1	0.000	0.985	0.007	0.213
litter	1	0.000	0.975	0.014	0.166
graminoids	0.985	0.007	0.945	0.019	0.438
miscellaneous forbs	0.972	0.028	0.950	0.018	0.129
miscellaneous woody shrubs	0.162	0.063	0.252	0.059	0.911
<i>A. arbuscula</i>	0.096	0.088	0.282	0.069	0.154
<i>A. tridentata</i>	0.755	0.084	0.097	0.026	<0.0001
<i>E. umbellatum</i>	0.742	0.064	0.614	0.044	0.170
<i>B. sagittata</i>	0.178	0.062	0.259	0.050	0.472
Asteraceae family	0.487	0.092	0.465	0.053	0.693
<i>Sedum</i> spp.	0.105	0.059	0.074	0.031	0.118
secondary forb nectar sources	0.332	0.072	0.382	0.054	0.752
secondary shrub nectar sources	0.028	0.028	0.112	0.030	0.122
<i>Lupinus</i> spp.	0.443	0.098	0.156	0.030	0.007

Table A.7 Pearson's product-moment correlation coefficients (r) among the seven site covariates used in occupancy modeling. Site covariates were collected using frequency of occurrence vegetation sampling techniques collected in study sites in Grand Teton National Park and Bridger-Teton National Forest, WY ($n = 41$) during the summer of 2013. Bold values indicate there was a significant correlation ($P < 0.05$)

	<i>A. arbuscula</i>	<i>A. tridentata</i>	<i>E. umbellatum</i>	<i>B. sagittata</i>	<i>Sedum</i> spp.	<i>Lupinus</i> spp.	Secondary Nectar
<i>A. arbuscula</i>	1	-0.28	0.41	-0.25	0.48	-0.11	-0.66
<i>A. tridentata</i>	-0.28	1	0.25	0.02	0.08	0.38	-0.18
<i>E. umbellatum</i>	0.41	0.25	1	-0.07	0.25	0.20	-0.54
<i>B. sagittata</i>	-0.25	0.02	-0.07	1	-0.23	0.04	0.18
<i>Sedum</i> spp.	0.48	0.07	0.25	-0.23	1	-0.04	-0.41
<i>Lupinus</i> spp.	-0.11	0.38	0.20	0.04	-0.04	1	-0.19
Secondary Nectar	-0.66	-0.18	-0.54	0.18	-0.41	-0.19	1