CONCLUSIONS

Detecting vegetation change over time periods beyond seasons and decades is an important component to our collective understanding of vegetation dynamics in upper elevation systems. Anthropogenic and natural drivers act upon mountain communities at varying temporal scales and thus it behooves us to continually refine and test detection methodologies and hypotheses of interaction.

Through visual interpretation of change from repeat-photography triplets, five vegetation change trends were identified in and around the Tuolumne Meadows area. By comparing historic photos (c1900 and c1985) to photos captured in 2008, the following five trends were detected: 1) Krummholz stands beyond the tree line exhibited increases in individual height (67%) and stand density (55%); 2) Within forest stands at the tree line, stand density and coverage increased (90%) and there was a noticeable upslope movement of the tree line from c1900 to 2008 (75%); 3) There was evidence of meadow invasion by trees (63%), in some cases substantial new growth; 4) Large stands of forest in the sub-alpine vegetation zone showed evidence of decreased forest clearings and increased stand density (63%); 5) On and around domes and on rocky slopes, the number of individuals as well as the health and density of branches of individual trees has increased (76%). Additionally, areas of large-scale tree die-off were identified (7%).

An increase in height and density of Krummholz formations suggests changes in weather patterns and climate shifts though the sample size of photo triplets were small. The growth visible within this data set mirrors Krummholz response to increased annual

average temperature changes and a lengthening of the growing season (Hättenschwiler and Körner 1995; Grace *et al.* 2002; Roush *et al.* 2007; Beckage *et al.* 2008). Growth of trees at upper elevations is primarily restricted or encouraged by temperature and precipitation and thus future monitoring of vegetation growth and climate conditions in these areas is encouraged.

In and around the Tuolumne Meadows area, tree invasion into meadows was apparent and visibly substantial in 63 percent of the photo triplets studied. Previous studies have noted that the combination or interaction of cyclical precipitation increases and/or the removal of intensive livestock grazing in subalpine meadows as the cause(s) of noted tree invasion. Cyclical multi-year increases in precipitation have resulted in punctuated tree growth, particularly at meadow edges over the last century (Vale 1987). These periods of intense tree growth and establishment of new saplings was previously not possible when large herds of domestic grazers were a presence on the landscape. Livestock grazing was removed from meadows in the National Park in the 1920's and many attribute the advance of the treeline in the later 20th century into these meadows as a direct result (Franklin *et al.* 1971; Dunwiddie 1977; Bahre and Bradbury 1978; Vankat and Major 1978; Vale 1987; Taylor 1990; Miller and Halpern 1998). This study identified areas of tree invasion and suggests further research of local history and conditions is necessary to conclude causality of local tree invasion.

Across the study area forest stand density at the treeline and meadow edges, as well as on domes and rocky slopes, was seen to have increased while forest clearings

have been reduced. Recent studies attribute forest stand density increases to a combination of reduced cyclical fire patterns, a history of logging and human influence on the landscape, and precipitation and temperature increase trends. In the study area it has been the policy of the National Park Service to suppress fires since the turn of the century through the 1970's and 80's. Sub-alpine landscapes void of fire returns result in a denser forest, reduced species diversity and increased stand homogeneity, increased susceptibility to pests and disease, and increased probability of larger, more widespread, and more intense fires.

In the mid 1980's, Vale (1987) found that while there was clear evidence of increased forest stand density, invasion of trees into meadows, increased Krummholz formation growth, and increased density of forest patches over the previous ~80 years, he found no conclusive evidence of upslope treeline movement. The results of this study conclude that there has been an upslope growth trend at the treeline over the last century visible from the photo sets. This departure from Vale (1987) mirrors findings of similar studies of the last two decades across the Sierra Nevada and American West and is likely considering the qualitative nature of photo-analysis. Repeat-photography analysis can vary based on the judgment and experience of the reviewer(s). Vale's findings and analysis were not available for each photo set and thus his summary results are the only permanent record of his original analysis. It is important that analysis of photos remain consistent across the entire data set and ideally repeat-photography review(s) should be conducted by the same person across all data. The inclusion of analysis results for each

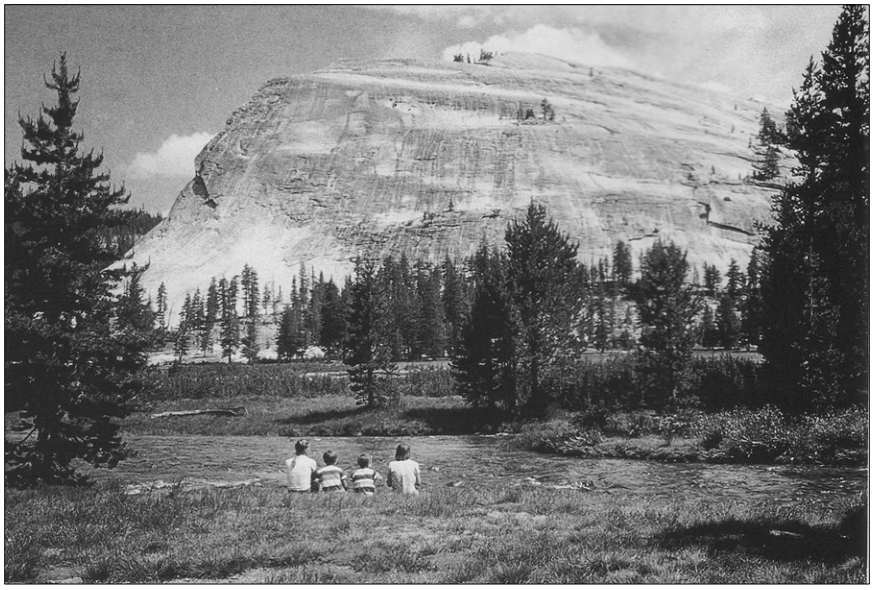
photo triplet from this study are meant to encourage further review with the hope that a marriage of qualitative/quantitative methods in the future could possibly reduce analysis inconsistencies and increase certainty of conclusions.

Repeat-photography has become less expensive and more easily repeatable as digital technologies have expanded. In Yosemite and the Central Sierra Nevada, repeat analysis and long term monitoring are necessary and indispensible tools to resource and conservation managers. The methods discussed and utilized, along with project results will provide the basis for continued monitoring of alpine and sub-alpine forest systems in Central Sierra Nevada Range. Armed with over 100 years of qualitative data, future monitoring projects could and should utilize the photographic sites located in this study. By expanding the meta-data available for each photo site, including date, time, Lat/Long location, and optics specific data, precise data collection can continue into the future. The addition of snow patch and large scale forest die-offs visible in this photo set could be included in future monitoring of the area.

Questions remains whether species found in upper elevation systems can/will keep pace with rapid anthropogenic and natural driven changes (Bartlein 1997; Hansen *et al.* 2001). Will mountain tops indeed become quickly disappearing 'islands' for terrestrial vegetation? What will the long term effects of current and future climate cycling, pest/disease prevalence, and fire cycling have on upper elevation systems? Development of future vegetation management policies depends on continued monitoring of meadows, tree lines, and forest stands.

It is hoped that increased accuracy of repeat-photography sites, made available through this project, would aid additional research in this region. Examples of possible tangential studies include post fire succession monitoring, alpine glacier and snowpack studies, sequential ground truthing for aerial and remote sensing projects, and forest and meadow dynamics investigations. Future projects could utilize the photograph triplets from this study to their own ends.

International consensus suggests rapid climate change in the coming century, especially in mountain systems (IPCC 2007). The integration of change detection methods, both quantitative and qualitative, is necessary if our knowledge of fragile mountain systems is to expand (Marston 2008). Monitoring systems must be in place to expand the temporal scale of study to cover future affects of climate change and/or unknown/unpredictable disturbance events. Repeat-photography has the potential to fill many gaps left vacant in change detection methodologies. True long term monitoring of vegetation at upper elevations of the Sierra Nevada will require decades and centuries of further study.



T. Vale & family,
on the banks of the Tuolumne River across
from Lembert Dome, c1985.

N.Wasserman, August 2008

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Appendix A. Repeat-photography site locations

Appendix A. Repeat-photography site locations

Photo #	Label	Area	Latitude	Longitude	Elevation (m)	GPS Accuracy (m)	Direction (east=0°)	Date	Time
1	1-V01-US3142	Tioga Pass	N37°56.271'	W119°14.006'	2985	10	270	8/2/2008	9:15am
2	2-V02-US3119	Tioga Pass	N37°56.280'	W119°14.104'	2953	6	260°	8/2/2008	9am
3	3-V03-US3137	Tioga Pass	N37°55.815'	W119°14.691'	3009	10	160	7/12/2008	10:50am
4	4-V04-US3135	Tioga Pass	N37°55.601'	W119°14.761'	3024	5	170	7/12/2008	11:15am
5	5-V05-US3131	Tioga Pass	N37°55.108'	W119°15.308'	2976	4	330	7/12/2008	11:45am
8	8-V08-US3116	Tioga Pass	N37°53.787'	W119°15.389'	2992	10	0	8/2/2008	2:30pm
9	9-V09-US2129	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	80	8/2/2008	12:10pm
10	10-V10-US2120	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	30°	8/2/2008	12:10pm
11	11-V11-US2121	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	10	8/2/2008	12:10pm
12	12-V12-US2122	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	300	8/2/2008	12:10pm
13	13-V13-US2123	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	270	8/2/2008	12:10pm
14	14-V14-US2124	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	230	8/2/2008	12:10pm
15	15-V15-US2125	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	210	8/2/2008	12:10pm
16	16-V16-US2126	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	190	8/2/2008	12:10pm
17	17-V17-US2127	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	130	8/2/2008	12:10pm
18	18-V18-US2128	Gaylor Lake	N37°53.843'	W119°16.467'	3257	3	0	8/2/2008	12:10pm
19	19-V19-US2092	Parker Pass	N37°50.423'	W119°12.369'	3393	3	340	7/14/2008	12:00pm
20	20-V20-US2094	Parker Pass	N37°50.723'	W119°12.520'	3462	6	290	7/14/2008	11:41am
22	22-V22-US2098	Lyell Canyon	N37°50.573'	W119°17.163'	2687	10	280	8/9/2008	12:30pm
24	24-V24-US2164	Tuolumne Meadows	N37°53.031'	W119°20.713'	2854	3	210°	8/10/2008	2:20pm
25	25-V25-US2165	Tuolumne Meadows	N37°52.953'	W119°20.738'	2858	3	240°	8/10/2008	2:30pm
26	26-V26-US3111	Tuolumne Meadows	N37°52.717'	W119°21.798'	2627	6	20	8/8/2008	3pm
27	27-V27-US2155	Tuolumne Meadows	N37°52.418'	W119°22.885'	2636	2	180	7/26/2008	2pm
28	28-V28-US3105	Pothole Dome	N37°52.614'	W119°23.687'	2622	7	30°	7/26/2008	2:15pm
29	29-V29-US3123	Pothole Dome	N37°52.653'	W119°23.711'	2616	11	170	7/10/2008	10:10am
30	30-V30-US2037	Pothole Dome	N37°52.641'	W119°23.558'	2621	3	195°	7/10/2008	11:10am
31	31-V31-US3127	Pothole Dome	N37°52.708'	W119°23.680'	2634	3	300	7/10/2008	10:50am
32	32-V32-US2135	Tioga Road	N37°53.104'	W119°24.337'	2776	2	320	8/3/2008	2:15pm
33	33-V33-US2136	Tioga Road	N37°53.113'	W119°24.331'	2776	3	10	8/3/2008	2:45pm
34	34-V34-US2137	Tioga Road	N37°53.119'	W119°24.361'	2778	2	320°	8/3/2008	2:30pm
35	35-V35-US2138	Tioga Road	N37°53.122'	W119°24.380'	2784	2	100	8/3/2008	2:30pm
36	36-V36-US0782a	Tuolumne Meadows	N37°53.053'	W119°22.702'	2619	6	200°	8/8/2008	1pm
38	38-V37-US2133-LOWER	Glen Aulin	N37°54.413'	W119°25.846'	2663	9	30	7/27/2008	9:10am
40	40-V38-US2132	Glen Aulin	N37°54.413'	W119°25.846'	2663	9	70	7/27/2008	9:10am
41	41-V39-US2131	Glen Aulin	N37°54.413'	W119°25.846'	2663	9	80	7/27/2008	9:10am
42	42-V40-US2160	Young Lakes	N37°53.894'	W119°22.980'	2729	8	270°	8/8/2008	1:20pm
44	44-V42-US2157	Cathedral Lake	N37°51.691'	W119°25.169'	2990	5	30°	8/3/2008	12:30pm
45	45-V43-US3141	Tenaya Lake	N37°50.258'	W119°27.294'	2533	-	0	8/1/2008	2:45pm
46	46-V44-US3118	Tenaya Lake	N37°50.169'	W119°27.402'	2535	8	10	8/1/2008	2:30pm
47	47-V45-US2189	Tenaya Lake	N37°49.723'	W119°28.053'	2489	5	40	8/1/2008	2:10pm
48	48-VBK-77	Tenaya Lake	N37°49.650'	W119°28.051'	2493	6	100	8/1/2008	1pm
49	49-V47-US2188	May Lake	N37°49.219'	W119°29.376'	2807	3	40°	8/4/2008	11:45am

Appendix A Repeat-photography site locations (cont.)

Photo #	Label	Area	Latitude	Longitude	Elevation (m)	GPS Accuracy (m)	Direction (east=0°)	Date	Time
50	50-V48-US3161	May Lake	N37°50.817'	W119°30.637'	3308	4	190	8/4/2008	9:45pm
51	51-V49-US2073A	Cathedral Lake	N37°50.565'	W119°25.038'	2918	4	180	8/3/2008	10am
52	52-V50-US2202	Cathedral Lake	N37°50.417'	W119°24.970'	2933	7	270	8/3/2008	10:30am
54	54-V52-US2063	Elizabeth Lake	N37°50.809'	W119°22.348'	2898	7	210°	8/9/2008	9:30am
56	56-V54-US2059	Vogelsang	N37°48.472'	W119°19.596'	3152	4	20°	7/25/2008	11:32am
57	57-V55-US2058	Vogelsang	N37°48.476'	W119°19.593'	3152	3	240°	7/25/2008	11:20am
58	58-V56-US2067	Vogelsang	N37°48.240'	W119°20.894'	3158	6	210°	7/25/2008	2:50pm
59	59-V57-US2069	Vogelsang	N37°47.811'	W119°20.639'	3097	4	300	7/25/2008	10:23am
60	60-V58-US2080	Vogelsang	N37°47.645'	W119°19.197'	3361	3	170	7/25/2008	12:50pm
61	61-V59-US2177	Vogelsang	N37°46.774'	W119°22.882'	2856	10	260	7/25/2008	9am
62	62-VBK-01	Tuolumne Meadows	N37°53.037'	W119°22.758'	2609	9	210°	8/8/2008	12:30pm
63	63-VBK-03	Pothole Dome	N37°52.619'	W119°23.680'	2621	3	120	7/10/2008	10am
64	64-VBK-04	Tioga Road	N37°52.708'	W119°24.729'	2655	7	230°	8/1/2008	4:30pm
65	65-VBK-06	Tioga Road	N37°51.821'	W119°26.034'	2644	4	290	8/1/2008	3:30pm
66	66-VBK-07	May Lake	N37°49.338'	W119°29.462'	2746	6	90	8/4/2008	12pm
67	67-VBK-09	Tuolumne Meadows	N37°52.757'	W119°21.306'	2625	2	210°	8/10/2008	3:11pm
68	68-VBK-10	Parker Pass	N37°52.184'	W119°14.298'	3023	10	110	7/14/2008	1:50pm
71	71-VBK-15	Parker Pass	N37°50.807'	W119°13.112'	3324	7	280	7/14/2008	11:05am
72	72-VBK-18	Glen Aulin	N37°53.792'	W119°24.264'	2591	3	130	7/26/2008	4pm
74	74-VBK-21B	Tenaya Lake	N37°48.940'	W119°29.332'	2588	6	20	8/1/2008	11:50am
75	75-VBK-21C	Tenaya Lake	N37°48.943'	W119°29.343'	2594	3	20	8/1/2008	11:50am
76	76-VBK-21D	Tenaya Lake	N37°48.912'	W119°29.281'	2618	16	20	8/1/2008	11:50am
78	78-VBK-23	Tuolumne Meadows	N37°53.181'	W119°23.180'	2614	4	270	8/8/2008	2pm
79	79-VBK-26	May Lake	N37°50.709'	W119°29.483'	2855	18	180	8/4/2008	8:30am
81	81-VBK-29	Tenaya Lake	N37°49.616'	W119°28.336'	2503	2	90	8/1/2008	1:30pm
82	82-VBK-32	Glen Aulin	N37°54.240'	W119°24.929'	2502	5	130	7/27/2008	10:40am
83	83-VBK-38	Cathedral Lake	N37°50.695'	W119°24.762'	2906	6	80	8/3/2008	11:00am
85	85-VBK-41	Glen Aulin	N37°53.361'	W119°23.409'	2597	7	90	7/26/2008	3:20pm
89	89-VBK-57	Mono Pass	N37°56.283'	W119°15.610'	2982	7	300	8/2/2008	10:30am
90	90-VBK-60	Young Lakes	N37°53.836'	W119°22.930'	2691	5	270	8/8/2008	1:25pm
91	91-VBK-62	Tioga Pass	N37°56.950'	W119°13.474'	2779	12	70	8/2/2008	8:50am
92	92-VBK-63	Tuolumne Meadows	N37°52.721'	W119°22.005'	2621	7	300	8/8/2008	11:45am
93	93-VBK-65	Tenaya Lake	N37°50.091'	W119°27.086'	2491	4	110	8/1/2008	2:45pm
94	94-VBK-66	Sunrise	N37°47.558'	W119°25.680'	2860	4	90	8/10/2008	10:50am
96	96-VBK-72A	Tenaya Lake	N37°48.728'	W119°29.013'	2566	3	70	8/1/2008	12:30pm
97	97-VBK-73	Tioga Pass RS	N37°54.677'	W119°15.481'	3030	-	230	8/2/2008	11:00am
98	98-VBK-74	Tenaya Lake	N37°50.180'	W119°27.193'	2488	8	170	8/1/2008	3:15pm
99	99-VBK-75	Tenaya Lake	N37°49.562'	W119°28.075'	2529	20	30	8/1/2008	12:50pm
100	100-VBK-76	Tenaya Lake	N37°49.649'	W119°28.049'	2488	6	200	8/1/2008	1pm
101	101-VBK-78	Tenaya Lake	N37°49.657'	W119°28.085'	2495	4	300	8/1/2008	1:15pm
102	102-VBK-79	Tenaya Lake	N37°49.650'	W119°28.091'	2495	5	60°	8/1/2008	1:25pm

Appendix B. 2008 photograph and camera meta-data

All 2008 photographs were captured with a Nikon D60 DSLR and Nikon Nikkor 18-135mm (f/3.5-5.6G) DX lens in JPEG format (RBG, 3872x2592px, 300ppi).

Appendix B. 2008 photograph and camera meta-data

Photo #	Label	Area	*f* / stop	Shutter Speed	Focal length (35mm equivalent)	ISO
1	1-V01-US3142	Tioga Pass	5.6	1/500	30mm	200
2	2-V02-US3119	Tioga Pass	5.6	1/1250	27mm	200
3	3-V03-US3137	Tioga Pass	5.6	1/1000	39mm	200
4	4-V04-US3135	Tioga Pass	13.0	1/200	27mm	200
5	5-V05-US3131	Tioga Pass	5.6	1/1000	33mm	200
8	8-V08-US3116	Tioga Pass	5.6	1/500	27mm	200
9	9-V09-US2129	Gaylor Lake	5.6	1/1600	33mm	200
10	10-V10-US2120	Gaylor Lake	5.6	1/1250	30mm	200
11	11-V11-US2121	Gaylor Lake	5.6	1/800	27mm	200
12	12-V12-US2122	Gaylor Lake	5.6	1/1250	27mm	200
13	13-V13-US2123	Gaylor Lake	5.6	1/1250	30mm	200
14	14-V14-US2124	Gaylor Lake	5.6	1/1000	30mm	200
15	15-V15-US2125	Gaylor Lake	5.6	1/1250	36mm	200
16	16-V16-US2126	Gaylor Lake	18.0	1/100	30mm	200
17	17-V17-US2127	Gaylor Lake	5.6	1/2500	30mm	200
18	18-V18-US2128	Gaylor Lake	5.6	1/3200	33mm	200
19	19-V19-US2092	Parker Pass	5.6	1/1250	36mm	200
20	20-V20-US2094	Parker Pass	5.6	1/3200	30mm	200
22	22-V22-US2098	Lyell Canyon	5.6	1/1250	36mm	200
24	24-V24-US2164	Tuolumne Meadows	5.6	1/640	30mm	200
25	25-V25-US2165	Tuolumne Meadows	5.6	1/640	27mm	200
26	26-V26-US3111	Tuolumne Meadows	5.6	1/500	27mm	200
27	27-V27-US2155	Tuolumne Meadows	5.6	1/640	33mm	200
28	28-V28-US3105	Pothole Dome	5.6	1/640	42mm	200
29	29-V29-US3123	Pothole Dome	5.6	1/640	30mm	200
30	30-V30-US2037	Pothole Dome	5.6	1/1000	39mm	200
31	31-V31-US3127	Pothole Dome	5.6	1/640	33mm	200
32	32-V32-US2135	Tioga Road	5.6	1/1250	27mm	200
33	33-V33-US2136	Tioga Road	5.6	1/2500	27mm	200
34	34-V34-US2137	Tioga Road	5.6	1/1600	33mm	200
35	35-V35-US2138	Tioga Road	5.6	1/1600	30mm	200
36	36-V36-US0782a	Tuolumne Meadows	5.6	1/800	27mm	200
38	38-V37-US2133-LOWER	Glen Aulin	5.6	1/2000	33mm	200
40	40-V38-US2132	Glen Aulin	5.6	1/4000	33mm	200
41	41-V39-US2131	Glen Aulin	18.0	1/125	33mm	200
42	42-V40-US2160	Young Lakes	5.6	1/200	27mm	200
44	44-V42-US2157	Cathedral Lake	5.6	1/1000	27mm	200
45	45-V43-US3141	Tenaya Lake	18.0	1/80	36mm	200
46	46-V44-US3118	Tenaya Lake	5.6	1/1600	36mm	200
47	47-V45-US2189	Tenaya Lake	18.0	1/100	33mm	200
48	48-VBK-77	Tenaya Lake	5.6	1/640	30mm	200
49	49-V47-US2188	May Lake	5.6	1/1250	27mm	200

Appendix B. 2008 photograph and camera meta-data (cont.)

Photo #	Label	Area	*f* / stop	Shutter Speed	Focal length (35mm equivalent)	ISO
50	50-V48-US3161	May Lake	5.6	1/3200	33mm	200
51	51-V49-US2073A	Cathedral Lake	5.6	1/400	30mm	200
52	52-V50-US2202	Cathedral Lake	5.6	1/640	33mm	200
54	54-V52-US2063	Elizabeth Lake	5.6	1/800	27mm	200
56	56-V54-US2059	Vogelsang	5.6	1/640	39mm	200
57	57-V55-US2058	Vogelsang	5.6	1/800	39mm	200
58	58-V56-US2067	Vogelsang	5.6	1/1250	46mm	200
59	59-V57-US2069	Vogelsang	5.6	1/640	33mm	200
60	60-V58-US2080	Vogelsang	5.6	1/1250	36mm	200
61	61-V59-US2177	Vogelsang	5.6	1/640	42mm	200
62	62-VBK-01	Tuolumne Meadows	5.6	1/1000	27mm	200
63	63-VBK-03	Pothole Dome	5.6	1/800	36mm	200
64	64-VBK-04	Tioga Road	5.6	1/1000	36mm	200
65	65-VBK-06	Tioga Road	5.6	1/1250	36mm	200
66	66-VBK-07	May Lake	5.6	1/2000	33mm	200
67	67-VBK-09	Tuolumne Meadows	5.6	1/800	39mm	200
68	68-VBK-10	Parker Pass	5.6	1/125	27mm	200
71	71-VBK-15	Parker Pass	5.6	1/1000	39mm	200
72	72-VBK-18	Glen Aulin	5.6	1/1600	39mm	200
74	74-VBK-21B	Tenaya Lake	5.6	1/500	27mm	200
75	75-VBK-21C	Tenaya Lake	5.6	1/500	27mm	200
76	76-VBK-21D	Tenaya Lake	5.6	1/320	42mm	200
78	78-VBK-23	Tuolumne Meadows	18.0	1/100	33mm	200
79	79-VBK-26	May Lake	5.6	1/2500	30mm	200
81	81-VBK-29	Tenaya Lake	5.6	1/1600	36mm	200
82	82-VBK-32	Glen Aulin	5.6	1/1000	46mm	200
83	83-VBK-38	Cathedral Lake	5.6	1/500	30mm	200
85	85-VBK-41	Glen Aulin	5.6	1/1000	27mm	200
89	89-VBK-57	Mono Pass	5.6	1/640	36mm	200
90	90-VBK-60	Young Lakes	18.0	1/100	27mm	200
91	91-VBK-62	Tioga Pass	5.6	1/400	30mm	200
92	92-VBK-63	Tuolumne Meadows	5.6	1/640	27mm	200
93	93-VBK-65	Tenaya Lake	5.6	1/800	27mm	200
94	94-VBK-66	Sunrise	5.6	1/400	27mm	200
96	96-VBK-72A	Tenaya Lake	5.6	1/1000	46mm	200
97	97-VBK-73	Tioga Pass RS	5.6	1/3200	36mm	200
98	98-VBK-74	Tenaya Lake	5.6	1/800	30mm	200
99	99-VBK-75	Tenaya Lake	5.6	1/500	33mm	200
100	100-VBK-76	Tenaya Lake	5.6	1/400	30mm	200
101	101-VBK-78	Tenaya Lake	5.6	1/1000	27mm	200
102	102-VBK-79	Tenaya Lake	5.6	1/1250	30mm	200

Appendix C. Historic photograph meta-data

In Table:

[1] Vale, T. (1987). "Vegetation Change and Park Purposes in the High Elevations of Yosemite National Park, California." Annals of the Association of American Geographers 77(1): p1-18.

[2] Vale, T. and G. Vale (1994). Time and the Tuolumne Landscape: Continuity and Change in the Yosemite High Country. Salt Lake City, UT, University of Utah Press.

[3] USGS (2007). "U.S. Geological Survey Photographic Library." Retrieved January,2008, from http://libraryphoto.dr.usgs.gov/.

Appendix C. Historic photograph meta-data

Photo #	Label	Vale (1987) ID[1]	Vale & Vale (1994) ID[2]	Vale Year	USGS ID[3]	USGS Photographer	USGS Year	USGS html
1	1-V01-US3142	01	-	-	3142	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/land/ggk03142.jpg
2	2-V02-US3119	02	69	1984	3119	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/port/ggk03119.jpg
3	3-V03-US3137	03	14	1984	3137	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/port/ggk03137.jpg
4	4-V04-US3135	04	70	1984	3135	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/port/ggk03135.jpg
5	5-V05-US3131	05	16	1984	3131	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/land/ggk03131.jpg
8	8-V08-US3116	08	58	1984	3116	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb053/port/ggk03116.jpg
9	9-V09-US2129	09	53	1984	2129	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02129.jpg
10	10-V10-US2120	10	54	1984	2120	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02120.jpg
11	11-V11-US2121	11	45	1984	2121	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02121.jpg
12	12-V12-US2122	12	46	1984	2122	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02122.jpg
13	13-V13-US2123	13	47	1984	2123	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02123.jpg
14	14-V14-US2124	14	48	1984	2124	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02124.jpg
15	15-V15-US2125	15	49	1984	2125	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02125.jpg
16	16-V16-US2126	16	50	1984	2126	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02126.jpg
17	17-V17-US2127	17	51	1984	2127	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02127.jpg
18	18-V18-US2128	18	52	1984	2128	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02128.jpg
19	19-V19-US2092	19	-	-	2092	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02092.jpg
20	20-V20-US2094	20	24	1984	2094	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02094.jpg
22	22-V22-US2098	22	59	1984	2098	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02098.jpg
24	24-V24-US2164	24	33	1984	2164	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb054/land/ggk02164.jpg
25	25-V25-US2165	25	-	-	2165	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb054/land/ggk02165.jpg
26	26-V26-US3111	26	64	1984	3111	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/port/ggk03111.jpg
27	27-V27-US2155	27	35	1984	2155	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb054/land/ggk02155.jpg
28	28-V28-US3105	28	56	1984	3105	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb022/land/ggk03105.jpg
29	29-V29-US3123	29	68	1984	3123	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb054/land/ggk03123.jpg
30	30-V30-US2037	30	30	1984	2037	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb022/land/ggk02037.jpg
31	31-V31-US3127	31	31	1984	3127	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/port/ggk03127.jpg
32	32-V32-US2135	32	-	-	2135	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02135.jpg
33	33-V33-US2136	33	67	1985	2136	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02136.jpg
34	34-V34-US2137	34	-	-	2137	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02137.jpg
35	35-V35-US2138	35	-	-	2138	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02138.jpg
36	36-V36-US0782a	36	-	-	0782	F.E. Matthes	1936	http://libraryphoto.cr.usgs.gov/htmlorg/lpb026/land/mfe00782.jpg
38	38-V37-US2133-LOWER	37	-	-	2133	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb199/land/ggk02133.jpg
40	40-V38-US2132	38	-	-	2132	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02132.jpg
41	41-V39-US2131	39	-	-	2131	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/land/ggk02131.jpg
42	42-V40-US2160	40	17	1985	2160	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb170/port/ggk02160.jpg
44	44-V42-US2157	42	-	-	2157	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb053/port/ggk02157.jpg
45	45-V43-US3141	43	-	-	3141	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb053/port/ggk03141.jpg
46	46-V44-US3118	44	20	1984	3118	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb054/land/ggk03118.jpg
47	47-V45-US2189	45	-	-	2189	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb170/land/ggk02189.jpg
48	48-VBK-77	46	77	1984	3151	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb054/land/ggk03151.jpg
49	49-V47-US2188	47	61	1984	2188	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb054/land/ggk02188.jpg

Appendix C. Historic photograph meta-data (cont.)

Photo #	Label	Vale (1987) ID[1]	Vale & Vale (1994) ID[2]	Vale Year	USGS ID[3]	USGS Photographer	USGS Year	USGS html
50	50-V48-US3161	48	27	1984	3161	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/port/ggk03161.jpg
51	51-V49-US2073A	49	2	1984	2073a	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb163/land/ggk2073a.jpg
52	52-V50-US2202	50	5	1984	2202	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb170/land/ggk02202.jpg
54	54-V52-US2063	52	37	1984	2063	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb163/port/ggk02063.jpg
56	56-V54-US2059	54	-	-	2059	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb001/land/ggk02059.jpg
57	57-V55-US2058	55	-	-	2058	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb163/port/ggk02058.jpg
58	58-V56-US2067	56	-	-	2067	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb163/land/ggk02067.jpg
59	59-V57-US2069	57	36	1984	2069	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb163/port/ggk02069.jpg
60	60-V58-US2080	58	-	-	2080	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb164/port/ggk02080.jpg
61	61-V59-US2177	59	12	1984	2177	G.K. Gilbert	1903	http://libraryphoto.cr.usgs.gov/htmlorg/lpb170/land/ggk02177.jpg
62	62-VBK-01	-	1	1989	140	R.B. Dole	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb022/land/drb00140.jpg
63	63-VBK-03	-	3	1987	467	F.E. Matthes	1917	http://libraryphoto.cr.usgs.gov/htmlorg/lpb026/land/mfe00467.jpg
64	64-VBK-04	-	4	1987	-	F.C. Calkins	1913	
65	65-VBK-06	-	6	1987	339	F.C. Calkins	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb018/land/cfc00339.jpg
66	66-VBK-07	-	7	1988	3160	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/land/ggk03160.jpg
67	67-VBK-09	-	9	1987	138	R.B. Dole	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb022/land/drb00138.jpg
68	68-VBK-10	-	10	1988	-	F.E. Matthes	1917	
71	71-VBK-15	-	15	1988	-	F.E. Matthes	1917	
72	72-VBK-18	-	18	1987	-	F.C. Calkins	1913	
74	74-VBK-21B	-	21b	1988	354	F.E. Matthes	1917	http://libraryphoto.cr.usgs.gov/htmlorg/lpb025/land/mfe00354.jpg
75	75-VBK-21C	-	21c	1988	354	F.E. Matthes	1917	http://libraryphoto.cr.usgs.gov/htmlorg/lpb025/land/mfe00354.jpg
76	76-VBK-21D	-	21d	1988	354	F.E. Matthes	1917	http://libraryphoto.cr.usgs.gov/htmlorg/lpb025/land/mfe00354.jpg
78	78-VBK-23	-	23	1988	382	F.C. Calkins	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb018/land/cfc00382.jpg
79	79-VBK-26	-	26	1988	-	F.E. Matthes	1914	
81	81-VBK-29	-	29	1988	346	F.E. Matthes	1917	http://libraryphoto.cr.usgs.gov/htmlorg/lpb025/land/mfe00346.jpg
82	82-VBK-32	-	32	1987	416	F.C. Calkins	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb018/land/cfc00416.jpg
83	83-VBK-38	-	38	1987	368	F.C. Calkins	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb018/land/cfc00368.jpg
85	85-VBK-41	-	41	1987	415	F.C. Calkins	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb018/land/cfc00415.jpg
89	89-VBK-57	-	57	1987	-	R.B. Marshall	1898	
90	90-VBK-60	-	60	1987	0351a	C.D. Walcott	1897	http://libraryphoto.cr.usgs.gov/htmlorg/lpb390/land/wcd0351a.jpg
91	91-VBK-62	-	62	1988	-	R.B. Marshall	1909	
92	92-VBK-63	-	63	1988	-	R.B. Dole	1913	
93	93-VBK-65	-	65	1989	-	NPS	c1923	
94	94-VBK-66	-	66	1988	316	F.E. Matthes	1914	http://libraryphoto.cr.usgs.gov/htmlorg/lpb025/land/mfe00316.jpg
96	96-VBK-72A	-	72	1988	348	F.E. Matthes	1917	http://libraryphoto.cr.usgs.gov/htmlorg/lpb025/land/mfe00348.jpg
97	97-VBK-73	-	73	1988	-	NPS	1939	
98	98-VBK-74	-	74	1987	69	R.B. Marshall	1909	http://libraryphoto.cr.usgs.gov/htmlorg/lpb029/port/topa0069.jpg
99	99-VBK-75	-	75	1987	409	F.C. Calkins	1913	http://libraryphoto.cr.usgs.gov/htmlorg/lpb018/land/cfc00409.jpg
100	100-VBK-76	-	76	1988	3150	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/land/ggk03150.jpg
101	101-VBK-78	-	78	1988	3152	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/land/ggk03152.jpg
102	102-VBK-79	-	79	1988	3109	G.K. Gilbert	1907	http://libraryphoto.cr.usgs.gov/htmlorg/lpb176/land/ggk03109.jpg