FIRE RESPONSE OF *AQUILEGIA LARAMIENSIS* (LARAMIE COLUMBINE) AND STATUS REPORT UPDATE, SOUTHEASTERN WYOMING

Prepared for the Medicine Bow National Forest
and the Bureau of Land Management -
Wyoming State Office, Rawlins and Casper Field Offices

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ABSTRACT

This study was conducted to evaluate the effects of fire on *Aquilegia laramiensis* (Laramie columbine), comparing 2014 tallies with estimates made in 2003 and 2004 surveys, following the 2012 wildfires that burned up to 17 (32%) of all known populations. Vegetation data were also collected at surveyed sites to evaluate the effects of fire on the species' habitat. Additional populations outside of burn areas were surveyed, including old burn settings and unburned settings, to provide context. We determined that the species is resilient to fire, surviving at all burned sites except for one population that was extirpated under atypical conditions. Trend results point to net decline of species' numbers in burned settings, whether they burned in 2002 or 2012. Decline was also present at some level in unburned settings. There were cases of major declines in all settings, for which explanations are not available unless they were susceptible to the drought conditions that lead up to the major 2012 fire events. A combination of factors rather than one single factor such as fire may account for overall trends. Most plants appeared healthy despite high associated plant density at new and old burn sites, suggesting *A. laramiensis* can survive fire and compete with other vegetation over the long term.

ACKNOWLEDGEMENTS

This study reflects on *Aquilegia laramiensis* field surveys in 2003, 2004 and 2009 by Hollis Marriott and Dennis Horning, their reports, and their expertise. Dennis Horning also provided much helpful information and field assistance in relocating an occurrence in 2014. Map preparation and data entry was provided by Joy Handley (Wyoming Natural Diversity Database; WYNDD), and vegetation sampling data were entered by Landon Eastman. The use of the Rocky Mountain Herbarium and the expertise of Ronald Hartman and B. E. Nelson are acknowledged with gratitude. Permission to study Department of State Trust Lands was secured through Brenda Davis. This project would not have been possible without the interest and support of Frank Blomquist, Bureau of Land Management (BLM) Rawlins Field Office, and Katie Haynes, Medicine Bow National Forest. It was conducted under two simultaneous challenge cost-shares of WYNDD with both the BLM, and with the U.S. Forest Service.

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Cover: *Aquilegia laramiensis* by Bonnie Heidel

TABLE OF CONTENTS

APPENDIX

FIGURES AND TABLES

INTRODUCTION

Aquilegia laramiensis (Laramie columbine) is a sensitive species known only from the Laramie Range in Wyoming, including the Laramie Peak unit of Medicine Bow National Forest and BLM lands. Wildfires have been extensive in the Laramie Range over the past decade, most notably in the Arapaho Fire and other fires of 2012 that burned up to 32% of known *A. laramiensis* occurrences (17 of 52) in crown fires spanning over 100,000 acres. This study addresses survival of *A. laramiensis* and vegetation changes in occupied and adjoining habitat, including spread of non-native species such as *Bromus tectorum* (cheatgrass) and *Carduus nutans* (musk thistle).

The fire response of *Aquilegia laramiensis* was identified as a possible management issue for the species in past reports (Marriott and Horning 2004a):

> "There has been concern that fire could damage or extirpate *Aquilegia laramiensis* populations, by direct burning as well as removal of shade. Based on observations in 2003, it appears that fire is not a threat to the columbine in most cases. Most populations, and all of the larger ones, occur on large rock outcrops with little tree cover and little fuel in general. Shading usually is provided by aspect and topographic position rather than tree cover. Laramie columbine apparently can tolerate nearby fire in some cases. It was found in several areas where in 2002 fire had come quite close to microsites where the columbine was growing. However, without baseline information for comparison, it is impossible to confidently assess the species' tolerance of fire."

This statement reflects earlier ones in the Medicine Bow National Forest Revised Land and Resource Management Plan (USDA Forest Service 2003) that stated:

> "Laramie columbine occurs within forested lands where there were frequent fire returns historically. In this area, the fire regimes have been significantly altered from their historical range through fire suppression. …Under an extreme wildfire event, the rugged, rocky cliffs may not provide protection from wildfire effects."

A conceptual model for evaluating fire effects on plant species and habitats is provided by Baker (2009) who separated the biological from physical effects, on the species and its habitat, over three different time periods.

1. Immediate fire effects (during the fire or within minutes),
2. Reorganization/recovery (days, months, years after fire), and
3. Long-term adjustment (multiyear systemic change)

This study was conducted to evaluate the short-term effects of fire on *Aquilegia laramiensis,* i.e., "reorganization/recovery", comparing 2014 tallies with estimates made in 2002 and 2003 surveys. Vegetation data was also collected at burned and unburned sites to evaluate the short-term effects of fire on the species' habitat. A schematic diagram for evaluating fire effects and structuring the first part of this report is represented by Figure 1.

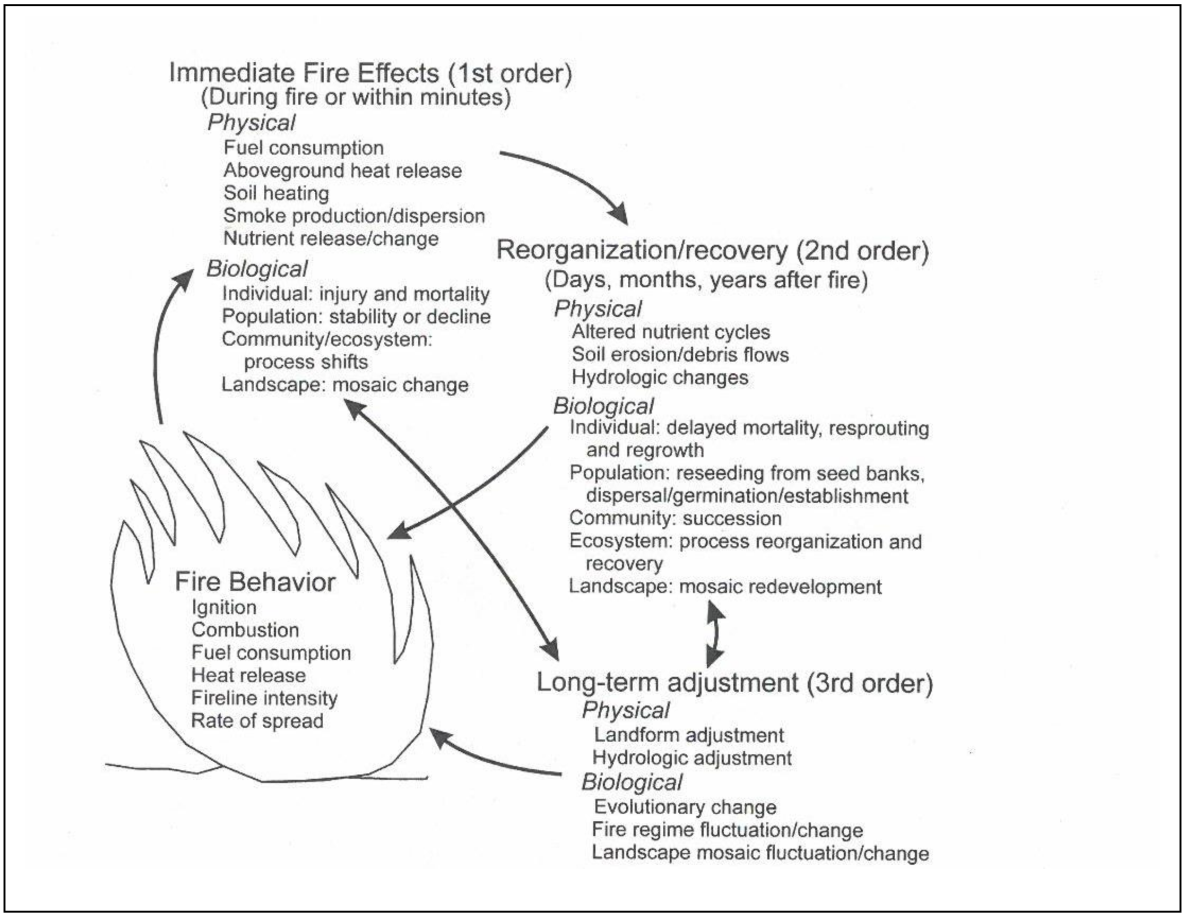


Figure 1. Fire effects on the physical and biological environment [of plant species].
From: Baker (2009)

Understanding the response of *Aquilegia laramiensis* to fire has bearing on species' status and management practices given the frequency of wildfire in the Laramie Range. Any future BLM and Forest Service management actions, such as weed spraying and prescribed burning, will require detailed knowledge of *A. laramiensis* population locations and trends for species conservation. This study provides a framework for species' management and status review.

In addition to gauging fire response, the secondary goals of this study are to compile and update status information on *Aquilegia laramiensis* and to refine population mapping. The location of a couple occurrence records were imprecise, based on collections, and they were mapped in detail in 2014 surveys.

STUDY AREA

Aquilegia laramiensis (Laramie columbine) is endemic to the Laramie Mountains of Albany and Converse counties in southeastern Wyoming. The Laramie Range is part of the Rocky Mountain cordillera and extends approximately 225 km (140 mi) from north-central Colorado to just southeast of Douglas, Wyoming. *Aquilegia laramiensis* occurrences are centered near Laramie Peak and the irregularly-shaped outline of the Laramie Peak unit (Douglas District) of Medicine Bow National Forest (MBNF) in the northern portion of this range, with a one outlying population found south of the main concentration area in the vicinity of Ragged Top Mountain. The Laramie Peak unit (MBNF) covers an area of 72,874 ha (180,000 ac), with mountains and foothills that also contain very large areas of other public and private lands, including extensive BLM-administered lands of the BLM Casper and BLM Rawlins Field Offices (Figure 2).

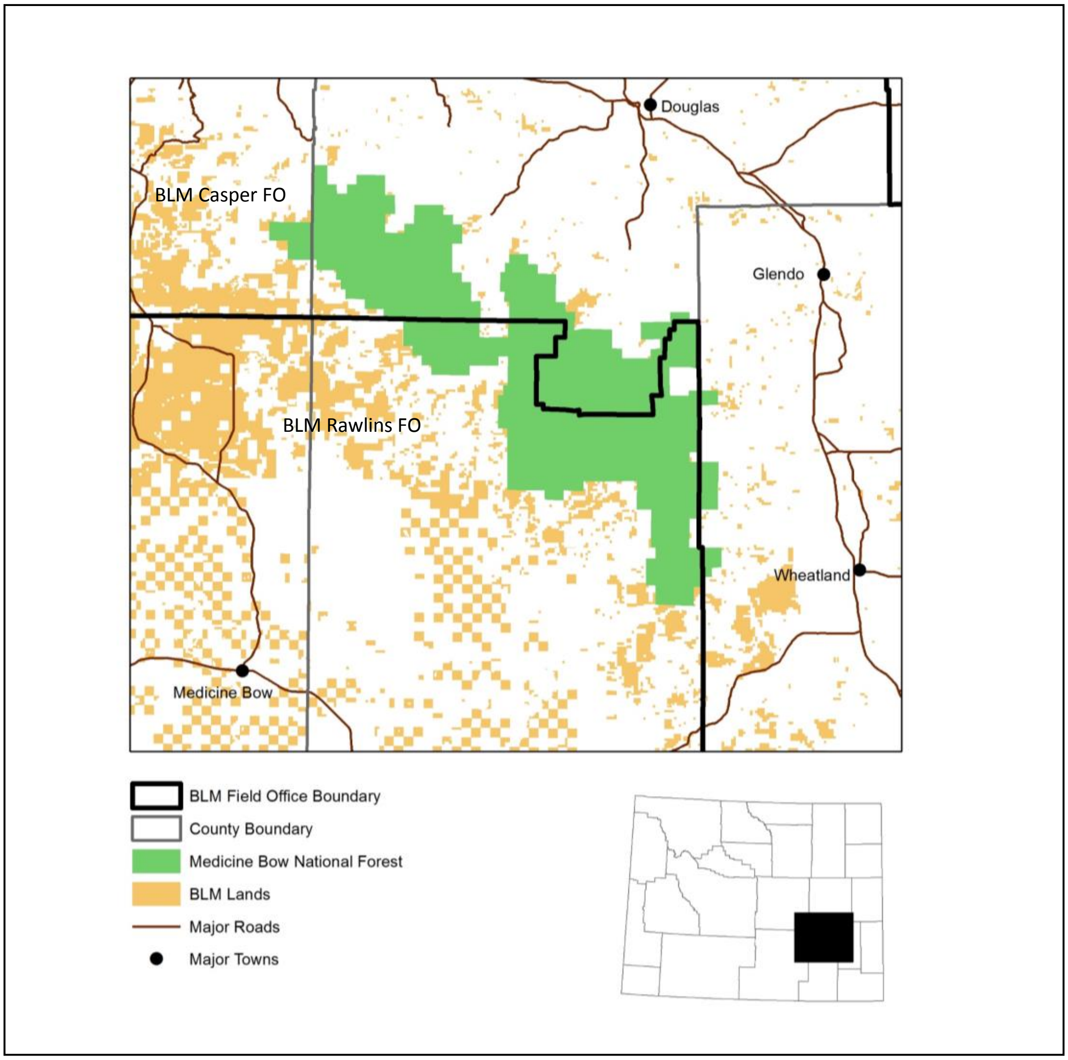


Figure 2. Study area of *Aquilegia laramiensis* (Laramie columbine) fire response, northern Laramie Range

The northern Laramie Range has vegetation types comprised of Ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*) and Rocky Mountain juniper (*Juniperus scopulorum*)(von Ahlefeldt and Speas 1996; in Dillon et al. 2005). A MBNF land cover map shows that lodgepole pine (*Pinus ponderosa*) is also extensive (Dillon et al. 2005). Shrublands and grasslands are also common (Dillon et al. 2005).

Elevation ranges from less than 1,585-3,132 m (5,200 ft - 10,274 ft), with mean annual temperature of 7 °C (45 F) and a maximum recorded range of -40 °C (-40 °F) to 43 °C (109.4 °F) (Martner 1986). Severe droughts, as well as extended wet periods, have been present in southeastern Wyoming over the last 500 years (Gray et al. 2004).

There have been five major fires (greater than 1,000 ha) in the northern Laramie Range since 2000, taking place in 2002 and 2012. During July 2012, the Arapaho Fire burned extensively throughout the area of Laramie Peak, including the watersheds of Cottonwood Creek, Arapaho Creek, Bear Creek, Friend Creek, and the North Laramie River. Total area burned was 39,706 ha (98,115 acres) (InciWeb Incident Information System 2015). Other recent fire activity in the area includes the 3,437 ha (8,492 acres) Cow Camp fire, which occurred in early June 2012 (InciWeb Incident Information System 2015). The 2012 fires burned a total of 45,354 ha, over three times greater an area than the 2002 fires, which burned a total of 13,450 ha (Table 1). The Arapaho Fire of 2012 burned 39,706 ha, over five times greater an area than that of any other northern Laramie Range fire since 2000. The fires of this century are represented in Figure 3 and Table 1, based on the Fire History Geodatabase (1930-2014) provided by MBNF and cross-checked with BLM fire records. Accompanying the shapefile is background information. Conditions during July 2012 when the fires burned were classified as severe drought by the US Drought Monitor. Drought conditions persisted until August 2013 (US Drought Monitor 2015). The extent of fires in any given year is largely a function of fire conditions and secondarily of fire frequency. The frequency of fire starting by lightning in the Laramie Peak unit averages over 400/year (Dillon et al. 2005). Fire frequency and extent would also be likely to be influenced by drought conditions, though not necessarily by mountain pine beetle outbreaks (Knight et al. 2014).

Table 1. Major Northern Laramie Range fires

Major Fire	**Year**	**Extent in ha (ac)**
Arapaho	2012	39,706 (98,115)
Cow Camp	2012	3,436 (8,492)
Hensel	2002	5,920 (14,630
Reese	2002	7,530 (18,608)
Russells Camp	2012	2,212 (5,466)

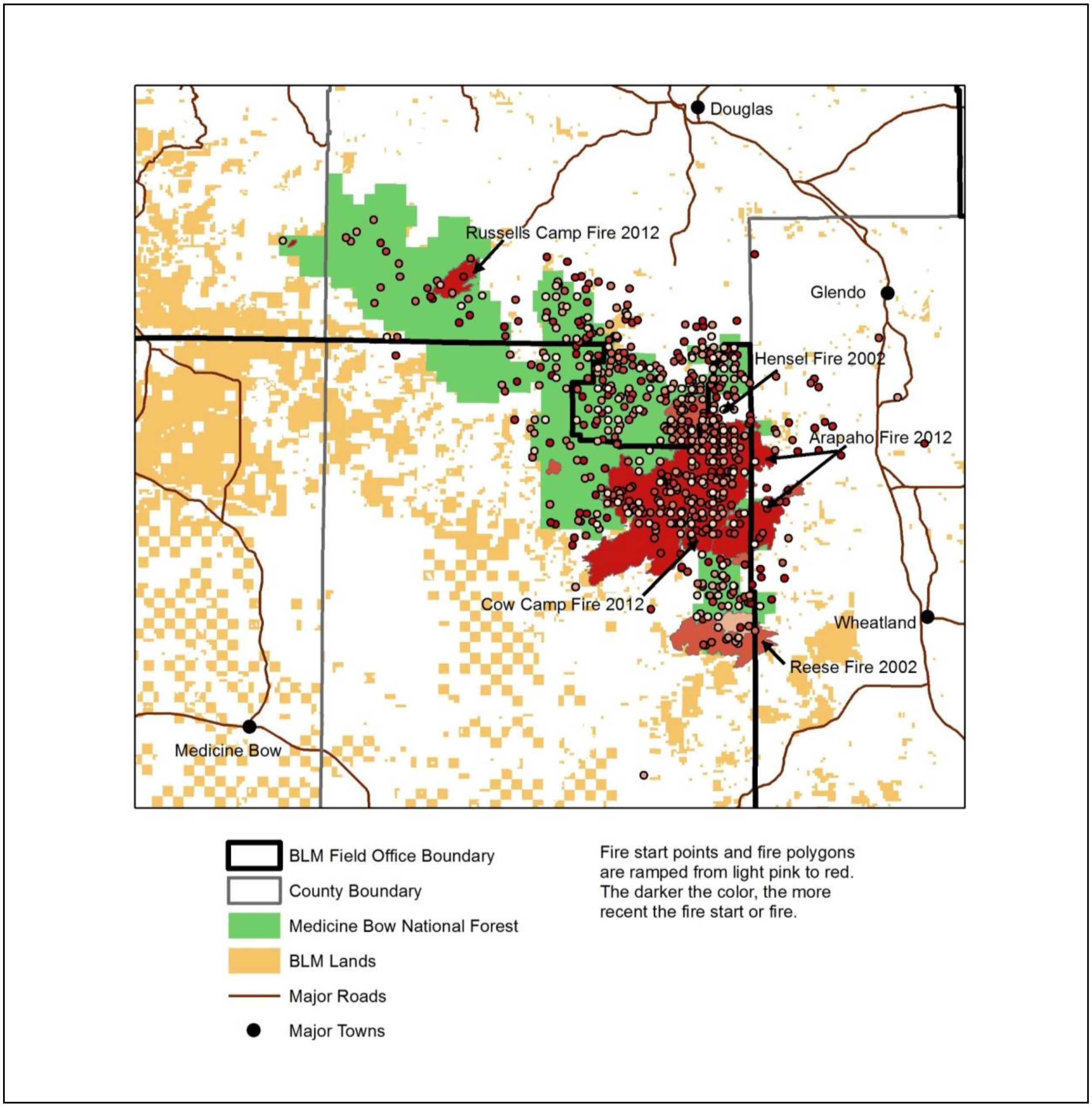


Figure 3. Fire history in the northern Laramie Range

Considerable information on the vegetation and the anthropogenic and natural disturbances affecting it has been compiled for the Laramie Peak unit and other units comprising the MBNF (Dillon et al. 2005) as part of Historic Range of Variability (HRV) analysis. Each of the salient points from HRV analysis for low elevation forests, as pertain to the Laramie Peak unit, are reprinted in their entirety (Table 2), and provide context for understanding recent fire events within prevailing conifer stands, across the landscape, and among aspen (*Populus tremuloides*) in particular.

Table 2. Historic Range of Variability for low elevation forests (Laramie Peak Unit)

Primary Historic Range of Variability scales in low elevation forests	**Primary Historic Range of Variability vectors**
HRV within stands	Fire suppression, livestock grazing, timber harvesting, and possibly climate change have led to the development of low-elevation forest stands with high densities of young trees, greater canopy cover, and less understory than usually occurred on many sites before 1850 (moderate confidence). Understory composition has also changed (low confidence) and forest floor depth has increased (high confidence).
HRV within stands	By removing large trees and downed wood from the system, wood harvesting has lowered the abundance of snags and coarse woody debris in managed stands of low-elevation forests (moderate confidence). Harvesting in recent decades, where it has occurred, also has led to an increase in sapling density and a reduction in the average diameter of trees, thus creating younger, more uniform-sized stands than existed before harvest (moderate confidence). Much of the harvesting that affected low-elevation forests on the MBNF occurred in the late 1800s and early 1900s.
HRV within stands	Mean fire return intervals have become longer than the HRV at low elevations on drier sites, but fire intensity is probably higher due to the amount and continuity of fuels that have developed in some areas and which could lead to more stand-replacing fires in the future (high confidence).
HRV within stands	White pine blister rust outbreaks exceed the HRV in affected stands, as this disease is not native (high confidence).
HRV across the landscape	Fire suppression, livestock grazing, and the logging of older, more fire resistant trees, where this has occurred at low elevations, probably has increased the amount and continuity of fuels to a point that is above the HRV, leading to potentially more stand-replacing fires than occurred prior to 1850 (moderate confidence). Climate warming may contribute to this trend.
HRV across the landscape	Fire suppression has reduced the level of interspersion of tree stands with grasslands (moderate confidence), and the average tree and sapling density has increased above the HRV (moderate confidence).
HRV within aspen stands in particular	In some aspen stands, grazing by livestock and native ungulates has reduced aspen densities and there has been an increase in the abundance of non-native species in the understory, to the point where such variables are beyond their HRVs (moderate confidence). Some aspen stands now have an understory of conifers, but this successional pattern probably occurred also during the reference period after long periods without fire (moderate confidence).

In summary, the authors hypothesized that on relatively dry sites at low elevations where fire suppression has been effective, the high tree density, sapling density and canopy cover observed when the report was completed were outside their respective range of means during the HRV reference period (moderate confidence). The 2012 fire events since the Dillon et al. (2005) report are consistent with HRV interpretations.

METHODS

A total of 17[1] *Aquilegia laramiensis* occurrences were identified as having locations inside the digitized 2012 fire perimeters or within 50 m of fire ignition points based on species' distribution mapping. These were the top priorities for field studies. A subset of other occurrences outside fire perimeters were also visited for comparison, especially those close to the burn areas. Field work took place from early June to early September 2014 by the authors. The aim was to get meaningful fire response data in the wake of a large fire event as an uncontrolled experiment. At each site, the WYNDD Plant Species of Concern Survey Form was completed, along with a fire response transect form (described below). All sites were photographed, including plants and habitat. Additional observations regarding population status, habitat conditions, invasive plants, and site access were recorded in field journals. A total of 22 occurrences were surveyed in 2014, of which 11 were burned in 2012 fires, two burned in 2002 fires, and 9 were unburned. The three fire status categories are: burned (2012 fires), old burn (2002 fires), and unburned.

Once *Aquilegia laramiensis* plants were relocated, they were tallied. Maps of each occurrence, the associated tallies or estimates, and any prior GPS coordinates were carried into the field, to try revisiting the precise location and extent of the occurrence. Of the 22 sites surveyed in 2014, 17 sites had earlier numeric estimates made in 2002 or 2003 for drawing direct comparisons. We tallied established plants, i.e., plants represented by 1- or more stems arising from a common root crown that were counted as one individual. Individual plants were often easy to distinguish and count, but occasionally grew in denser patches that might possibly represent clusters of plants. A conservative count was taken in these instances. At some occurrences, *A. laramiensis* seedlings were also observed, and counted separately from established plants. These juveniles had one or two true leaf sets that were clearly recognizable as *A. laramiensis* leaves, visible cotyledons, short stature (usually less than 2 cm), and lacked any flowering stems or stem bases from prior years.

The prior *Aquilegia laramiensis* field surveys in 2003, 2004 and 2009 resulted in maps of each occurrence, associated tallies or estimates, and GPS coordinates by Hollis Marriott and Dennis Horning. The aim of these surveys was to better document the distribution of *A. laramiensis* sites throughout large areas of potential habitat in the northern Laramie Range. They did not focus on collecting detailed data on individual populations or thoroughly searching habitat, but rather on targeting large granite outcrops throughout the suspected distributional range to see if *A. laramiensis* was present.

[1] This tally included two vague historic records and two occurrences that were near fire ignition points rather than within a fire polygon perimeter, one of which is on private land. It also included three records that were surveyed in 2014 and in which most or all *Aquilegia laramiensis* habitat was unburned.

Therefore, the present project is a basic trend study, without knowing that the identical area was covered in 2014 with the same survey intensity as in 2003 and 2004. Nevertheless, many of the same large rock outcrop systems were revisited and the original occurrence relocated at the original GPS coordinates. Photographs taken at the time of original surveys were also used. In a few cases, the precise location of original site was unclear or not relocated. There were also instances of searching more habitat or smaller rock outcrops in 2014 near original occurrences and locating additional subpopulations not detected in the earlier studies.

To address short-term habitat changes associated with wildfire, a fire response transect protocol was developed to measure burned and live woody vegetation and any associated weed species at *Aquilegia laramiensis* sites. There were 11 vegetation samples in burned settings, three samples in old burn settings (two samples were collected at one occurrence spaced over 0.25 mi apart), and seven unburned samples (two unburned sites were not sampled, and one old burn site had two samples over 0.25 mi apart) for a total of 21 samples (Figure 4, Table 3). Density of live/dead woody species and of invasive species were determined along vegetation transects within occupied habitat within each of the fire status classes (burned, old burn, unburned).

Transects at each sample site were subjectively placed and laid out at two scales and in two directions, to reflect changes in habitat occupied by the species (i.e., microhabitat; hereafter referred to as occupied habitat), and habitat in a zone of influence on the species (hereafter referred to as adjoining habitat; often represented vegetated terrain below outcrop). Specifically, occupied habitat was delimited in a belt transect running 1 m on either side of an *Aquilegia laramiensis* plant (parallel to the slope), and 0.2 m wide (total area = 0.4 m^2). Adjoining habitat was delimited in a belt transect as 15 m downslope from the same *A. laramiensis* plant, perpendicular to the occupied habitat belt transect, for 1 m on both sides (total area = 30 m^2). In each belt transect, the number of stems or clumps of woody and weedy species was recorded by species and diameter class, and placed in the live or dead category. *Bromus tectorum* (cheatgrass) was noted only as present/absent whereas *Cirsium arvense* (Canada thistle) and *Carduus nutans* (musk thistle) stems were counted. It was also noted if soil was burned at the base of the plant, if granite outcrops showed signs of spalling, and if the habitat has partial/complete shade due to aspect, outcrop, or live vegetation. The form used to collect these data is attached as Appendix A.

In addition, a "fire effects summary sheet" was prepared to describe the pattern and severity of burn within sites, and the qualitative observations of the species, the populations, and other vegetation conditions that were not always captured on forms and photographs. Site-specific survey results were used to update occurrence records and populate spreadsheets. GPS coordinates were used to update population maps. Updated location, population size, ranking and viability information has been entered into the WYNDD database to represent the surveyed occurrences and the species.

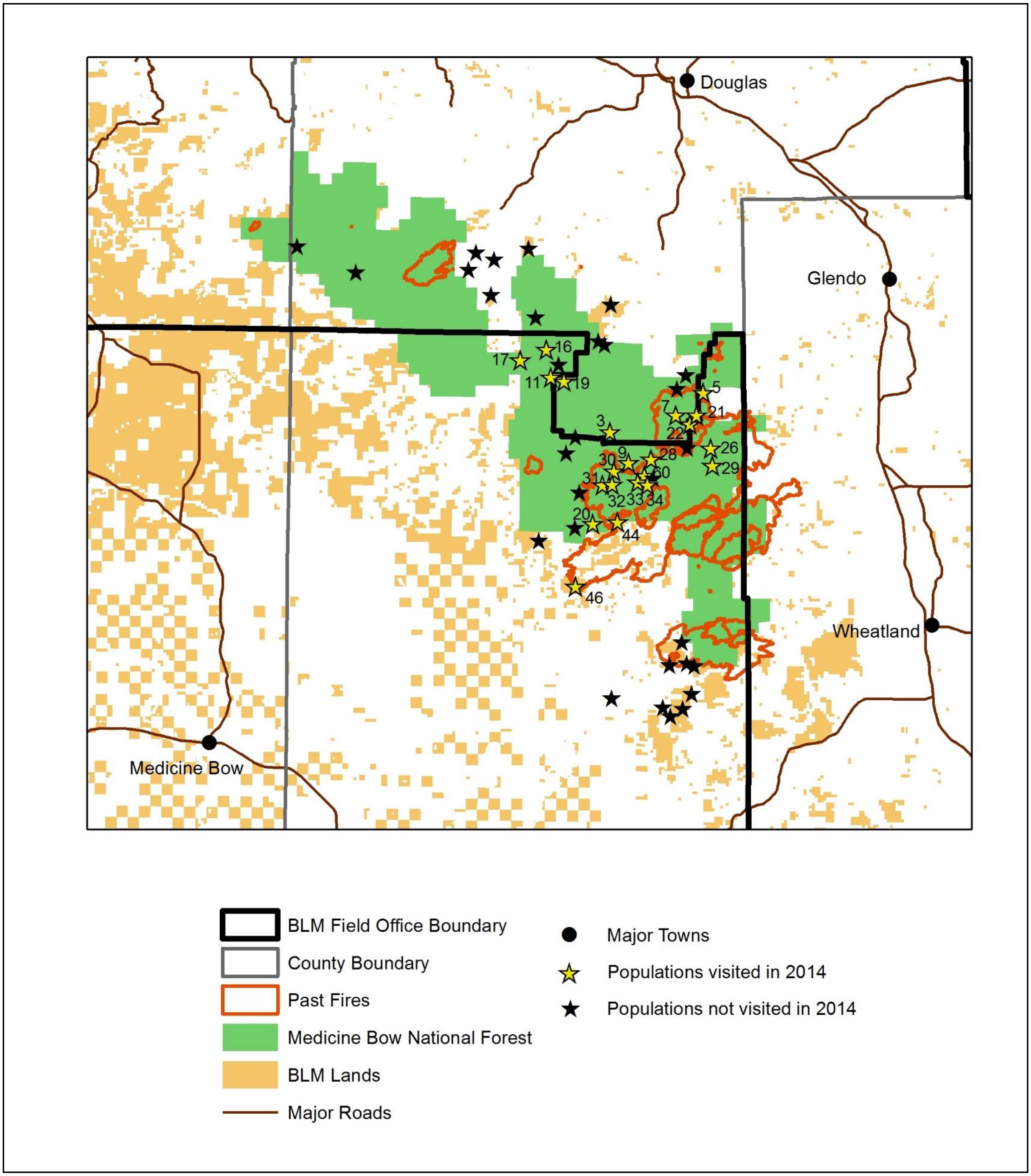


Figure 4. Distribution and 2014 surveys of *Aquilegia laramiensis* (Laramie columbine) in the northern Laramie Range, along with past large fire perimeters.

Table 3. Location information for all occurrences of *Aquilegia laramiensis,* and fire status for those surveyed in 2014[2]

EO No.	Directions	County	USGS topographic map (7.5')	Township-Range Section	Agency	Fire Status [3]	Min. Elev. (ft)	Max. Elev. (ft)	Last Observed Date
(1)	Antelope Basin southeast of Garrett	Albany	Garrett	Merged with EO#046 on Sellers Mtn	BLM		7400		7/9/1900
2	Ragged Top Mountain	Albany	Ragged Top Mountain	017N071W Sec: 15 Note: *017N071W Sec: 16 Note: *017N071W Sec: 21 Note: *017N071W Sec: 22 Note:	State of Wyoming, pvt		7700	8200	2007
3	**Southeast of Buzzard Peak**	**Converse**	**Windy Peak**	**027N072W Sec: 20 Note: NE4 of NW4 of NW4**	**USFS**	**U**	**7300**	**7450**	**8/16/2014**
4	Cottonwood Canyon, at foot of Laramie Peak	Albany	Laramie Peak	026N071W Sec: 07 Note: *026N072W Sec: 01 Note: *026N072W Sec: 02 Note: *026N072W Sec: 03 Note: *026N072W Sec: 10 Note: *026N072W Sec: 11 Note: *026N072W Sec: 12 Note: *026N072W Sec: 13 Note: *026N072W Sec: 14 Note: *027N072W Sec: 35 Note: *027N072W Sec: 36 Note:	USFS		6800		8/04/1895
5	**Ca 3 miles north-northwest of Harris Park**	**Albany, Converse**	**Harris Park**	**027N071W Sec: 02 Note: *027N071W Sec: 03 Note: *027N071W Sec: 04 Note: *028N071W Sec: 26 Note: *028N071W Sec: 27 Note: *028N071W Sec: 28 Note: *028N071W Sec: 33 Note: *028N071W Sec: 34 Note: *028N071W Sec: 35 Note:**	**USFS**	**U**	**6300**	**7050**	**7/7/2014**
6	North of Laramie Peak, off Horseshoe Creek	Converse	Laramie Peak	028N071W Sec: 29 Note: *028N071W Sec: 30 Note: *028N071W Sec: 31 Note: *028N071W Sec: 32 Note: NW4 of NW4?	USFS, private		6250		7/1/1981

[2] Occurrences surveyed in 2014 are bold-faced.

[3] U = Unburned; B = Burned (2012); OB = Old Burn (2002)

EO No.	Directions	County	USGS topographic map (7.5')	Township-Range Section	Agency	Fire Status [3]	Min. Elev. (ft)	Max. Elev. (ft)	Last Observed Date
7	**Ashenfelder Creek and along Harris Park Trail**	**Converse**	**Laramie Peak**	**027N071W Sec: 07 Note: NE4 of NE4 of SE4*027N071W Sec: 08 Note: NW4 of NW4 of SW4, NE4 of NW4**	**USFS**	**U**	**6480**	**6680**	**7/17/2014**
8	South side of Tunnel Road	Albany	Dodge Ranch	023N072W Sec: 19 Note: NE4 of NE4*023N072W Sec: 20 Note:	Private		7140		7/30/1993
9	**Friend Park campground and ridge to north**	**Albany**	**Laramie Peak**	**026N072W Sec: 03 Note: *026N072W Sec: 04 Note: NE4*027N072W Sec: 28 Note: *027N072W Sec: 33 Note: NE4*027N072W Sec: 34 Note: W2 of NW4**	**USFS**	**U**	**7490**	**8520**	**7/10/2014**
10	Northeast slopes of School Section Mountain	Converse	School Section Mountain	029N074W Sec: 16 Note: SW4*029N074W Sec: 17 Note: *029N074W Sec: 21 Note: NE4 of NW4	BLM Casper FO		7600	8200	6/5/2009
11	**La Bonte Creek drainage, Big Bear Canyon**	**Albany, Converse**	**Windy Peak, Toltec, Saddleback Mountain, School Section Mountain**	**028N073W Sec: 20 Note: *028N073W Sec: 21 Note: *028N073W Sec: 28 Note: NW4, SW4 of SW4*028N073W Sec: 29 Note: NE4**	**USFS**	**U**	**7240**	**7840**	**9/7/2014**
12	Deer Creek	Converse	Reno Hill	030N077W Sec: 27 Note: NW4 of SW4	USFS		7530		6/28/2003
14	Box Elder Creek	Converse	Rock Creek, Buck Peak	029N076W Sec: 03 Note: *029N076W Sec: 04 Note: S2*029N076W Sec: 05 Note: *029N076W Sec: 08 Note: *029N076W Sec: 09 Note: *029N076W Sec: 10 Note: *030N076W Sec: 32 Note: *030N076W Sec: 33 Note:	State of Wyoming/ USFS		7900		6/28/2003
15	Upper Curtis Gulch, Peak 8423	Converse	School Section Mountain	029N073W Sec: 30 Note: NE4 of SW4	USFS		8400		7/6/2003
16	**La Bonte Creek near Curtis Gulch**	**Albany**	**School Section Mountain**	**028N073W Sec: 08 Note: NE4 of SW4**	**USFS**	**U**	**7100**		**7/22/2014**
17	**La Bonte Canyon near**	**Albany**	**School Section Mountain**	**028N074W Sec: 13 Note: NW4 of SW4*028N074W Sec: 14 Note: NE4 of SE4**	**USFS**	**U**	**7300**	**7440**	**7/22/2014**

EO No.	Directions	County	USGS topographic map (7.5')	Township-Range Section	Agency	Fire Status [3]	Min. Elev. (ft)	Max. Elev. (ft)	Last Observed Date
	Big Bear Canyon								
18	Divide south of La Bonte Canyon	Albany	Saddleback Mountain	028N073W Sec: 21 Note: NW4 of NE4	USFS		8200		7/6/2003
19	**Top of Big Bear Canyon**	**Converse**	**Windy Peak**	**028N073W Sec: 27 Note: NW4 of SW4*028N073W Sec: 28 Note:**	**USFS**	**U**	**8030**	**8080**	**9/7/2014**
20	**Spur of Laramie River near FS Road 671**	**Albany**	**Cow Creek Mountain**	**026N073W Sec: 36 Note: NW4 of SE4, W2 of NE4**	**State of Wyoming**	**U**	**7200**		**8/16/2014**
21	**Along Fall Creek, Black Mountain Road (Forest Service Road 667), and Harris Park Trail**	**Albany, Converse**	**Harris Park**	**027N071W Sec: 04 Note: *027N071W Sec: 09 Note: *027N071W Sec: 10 Note: SW4 of NW4**	**USFS**	**OB**	**6800**	**7240**	**7/15/2014**
22	**Black Mountain summit**	**Albany, Converse**	**Harris Park, Laramie Peak**	**027N071W Sec: 16 Note: NW4 of SW4*027N071W Sec: 17 Note:**	**State of Wyoming/ USFS**	**OB**	**7830**	**7960**	**7/14/2014**
23	Windy Peak	Albany, Converse	Windy Peak	027N073W Sec: 22 Note: NW4 of SE4*027N073W Sec: 23 Note: NW4 of SW4	USFS		7800	8960	7/12/2003
24	Ridge east of Indian Peak	Albany	Cow Creek Mountain	026N073W Sec: 35 Note: NW4 of SW4	USFS		7800		7/5/2003
25	Ridge east of Haystack Peaks, west of Cottonwood Creek	Albany	Laramie Peak	027N071W Sec: 29 Note: NE4 of SE4	USFS		6900		6/22/2003
26	**FS Rd 683, north-northwest of Albany Peak**	**Albany**	**Harris Park**	**027N071W Sec: 26 Note: NW4 of SW4*027N071W Sec: 27 Note:**	**USFS**	**B**	**6440**	**6850**	**6/25/2014**
27	Ridge northeast of Grouse Creek	Albany	Windy Peak	027N073W Sec: 27 Note: *027N073W Sec: 34 Note: NW4 of NW4	USFS		8000	8100	7/5/2003
28	**Summit of Laramie Peak**	**Albany**	**Laramie Peak**	**027N072W Sec: 35 Note: NE4 of SE4**	**USFS**	**B**	**10000**	**10200**	**7/10/2014**

EO No.	Directions	County	USGS topographic map (7.5’)	Township-Range Section	Agency	Fire Status [3]	Min. Elev. (ft)	Max. Elev. (ft)	Last Observed Date
29	**Albany Peak**	**Albany**	**Harris Park**	**026N071W Sec: 02 Note: NW4 of NW4*027N071W Sec: 35 Note: SW4 of SW4**	**USFS**	**B**	**7140**	**7340**	**6/25/2014**
30	**Between upper forks Friend Creek**	**Albany**	**Cow Creek Mountain, Windy Peak**	**026N072W Sec: 05 Note: NW4 of SE4**	**USFS**	**B**	**7640**	**7900**	**6/29/2014**
31	**Bull Gap/Jack Squirrel Peak**	**Albany**	**Cow Creek Mountain**	**026N072W Sec: 07 Note: NE4 of SE4 of SW4**	**USFS**	**B**	**7540**	**7600**	**6/19/2014**
32	**Round Mountain**	**Albany**	**Cow Creek Mountain**	**026N072W Sec: 08 Note: SE4 of SW4**	**USFS**	**B**	**7550**	**7750**	**6/20/2014**
33	**Upper Arapaho Creek**	**Albany**	**South Mountain**	**026N072W Sec: 10 Note: N2 of SE4**	**USFS**	**B**	**7400**	**7620**	**7/2/2014**
34	**Kloer Creek**	**Albany**	**South Mountain**	**026N072W Sec: 11 Note: SE4 of NW4 of SE4**	**USFS**	**B**	**7350**	**7450**	**7/2/2014**
35	Elmers Rock	Albany	Bull Camp Peak	023N072W Sec: 24 Note: SE4 of SW4	BLM Rawlins FO		7100		6/12/2004
36	Laramie River trib. east of Elmers Rock	Albany	Bull Camp Peak	023N071W Sec: 20 Note: SW4 of SW4	BLM Rawlins FO		6600		6/12/2004
37	Sugar Loaf Ridge east end	Albany	Moonshine Peak	023N071W Sec: 17 Note: NE4 of SE4	BLM Rawlins FO		7567		6/12/2004
38	Duck Creek Falls	Albany	Davidson Flats	023N072W Sec: 01 Note: NE4 of NE4	BLM Rawlins FO		5400		6/12/2004
39	Ashley Creek tributary	Albany	Davidson Flats	024N071W Sec: 32 Note: SW4 of SE4	BLM Rawlins FO		6200		6/12/2004
40	Lower Duck Creek	Albany	Moonshine Peak	023N071W Sec: 04 Note: W2 of NW4	BLM Rawlins FO		5860	6240	6/13/2004
42	Laramie River canyon	Albany	Bull Camp Peak	023N071W Sec: 30 Note: W2 of SW4*023N072W Sec: 25 Note:	BLM Rawlins FO		6380	6600	6/17/2004
43	Lower Pine Mountain	Albany	Davidson Flats	024N071W Sec: 29 Note: NW4 of NW4	BLM Rawlins FO		6960		6/19/2004
44	**Rattlesnake Rock**	**Albany**	**South Mountain**	**026N072W Sec: 32 Note: NE4 of NE4**	**BLM Rawlins FO**	**B**	**7480**		**8/16/2014**
45	Rabbit Creek Rocks	Converse	Buffalo Peak	030N074W Sec: 30 Note: SE4 of SE4	State of Wyoming		7080		6/26/2004

EO No.	Directions	County	USGS topographic map (7.5’)	Township-Range Section	Agency	Fire Status [3]	Min. Elev. (ft)	Max. Elev. (ft)	Last Observed Date
46	**Sellers Mountain**	**Albany**	**Garrett**	**025N073W Sec: 26 Note: SW4; plus historical record in the same township (formerly EO#001)**	**BLM Rawlins FO**	**B**	**7400**	**7760**	**6/18/2014**
47	Indian Head Rock	Albany	Cottonwood Creek	025N073W Sec: 06 Note: SE4 of SE4	BLM Rawlins FO		7400	7400	7/1/2004
49	Point of Rocks	Converse	Blue Nose Creek	030N074W Sec: 33 Note: SW4 of SW4 of NE4	BLM Casper FO		7500		6/5/2009
50	Between LaPrele and Buckhorn Creeks	Converse	Buffalo Peak	029N074W Sec: 06 Note: SW4 of SE4 of NW4	BLM Casper FO		7700		6/10/2009
51	Mary Cooper Creek	Converse	Braae	028N071W Sec: 20 Note: E2 of SE4 of SE4*028N071W Sec: 21 Note:	BLM Casper FO		6200	6400	6/11/2009
52	Wagonhound Benchmark	Converse	Blue Nose Creek	030N074W Sec: 25 Note: SW4 of NE4	BLM Casper FO		7900		6/20/2009
53	Northeast of Slick Rock summit	Converse	Saddleback Mountain	029N072W Sec: 20 Note: SW4 of NW4	BLM Casper FO		6600		6/23/2009
54	Lower Burnt Mountain	Converse	Saddleback Mountain	028N072W Sec: 06 Note: NW4 of SW4	BLM Casper FO		6500		6/23/2009
55	Deer Canyon	Converse	Saddleback Mountain	028N072W Sec: 07 Note: NE4	USFS		6360	6700	7/28/2008
59	Peak 8641	Albany	Cow Creek Mountain	026N073W Sec: 14 Note: NE4 of NE4 of SW4	USFS		8640		2/3/2009
60	**Upper Cottonwood Creek**	**Albany**	**South Mountain**	**026N072W Sec: 02 Note: *026N072W Sec: 03 Note:**	**USFS**	**B**	**7800**	**7925**	**7/24/2014**

RESULTS – FIRE RESPONSE

Aquilegia laramiensis responses

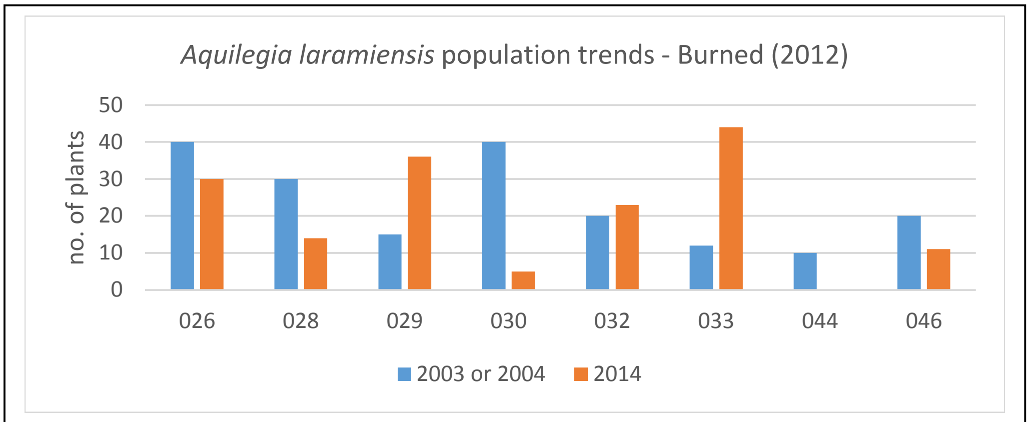
Aquilegia laramiensis was documented surviving at all sites that burned, indicating resilience to fire over the short-term (Figure 5). We infer that all established *A. laramiensis* plants observed in 2014 were survivors rather than a flush of new plants in 2013, because severe drought followed the 2012 fires. This survivorship of plants in 2014 is all the more significant in light of 2012 fire conditions which were about the worst-case scenario for *A. laramiensis*, occurring during or directly after flowering and then followed by at least a year of severe drought.

We did not find traces of dead *Aquilegia laramiensis* plants, so mortality could not be detected or immediate fire effects addressed. Either the plants were consumed in the fire or the remnant was so fragile as to disintegrate since fire. Only one occurrence, EO#044, appeared to have been extirpated as a result of recent fire activity where most plants in well-vegetated habitat did not survive. The exception was a surviving plant under an overhang. At some time between the June visit and an August re-visit to the same spot, the overhang broke off and crushed the lone surviving plant.

Of the 17 sites that had earlier numeric estimates of *Aquilegia laramiensis* numbers for direct comparison, results were mixed in showing both increase and decrease among the occurrences that burned in 2012. Results are tempered by the fact that the 11 populations which burned in 2012 were fairly small by original counts or estimates, and by the fact that not all microhabitat within fire perimeters actually burned. Both occurrences that burned in 2002 declined from the original 2003 or 2004 counts or estimates by 2014. The majority of the occurrences in unburned settings increased, with dramatic exceptions. Some of the greatest absolute and relative changes in numbers were populations in unburned and old burn settings. The populations with the biggest apparent declines were the largest ones, and they were not burned in 2012 wildfires. The four populations that showed over 100% increase, including two in burned and two in unburned settings, were all ones are likely to have had more subpopulations or microhabitat surveyed in 2014 than in earlier surveys, i.e., more survey time.

There are caveats to accompany comparison of 2014 counts and estimates made earlier by Marriott and Horning (2004a, b). They made no attempt to count every plant at a given location, and the exact location may not have been revisited in 2014. For that matter, 2014 surveys may not have reached the full extent of earlier ones. The comparisons are as direct as we could make them by limiting the occurrences included in the comparison chart to those where the location of the original count seemed to be clear from GPS location data and descriptive information.

Even if we can't produce statistical analyses of *Aquilegia laramiensis* trends, we can draw from vegetation data as important context and clues to long-term trends. Interpretations and hypotheses to explain species' and vegetation results are presented in the discussion section.



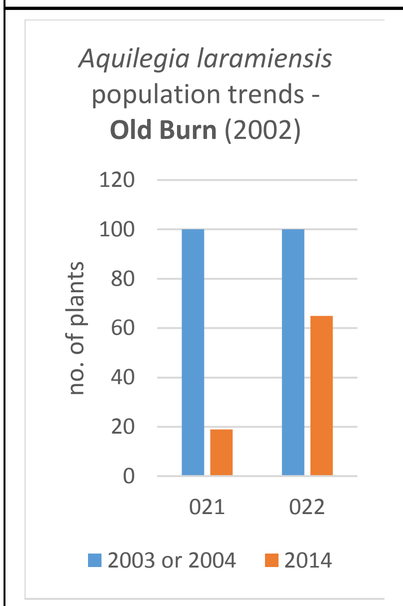
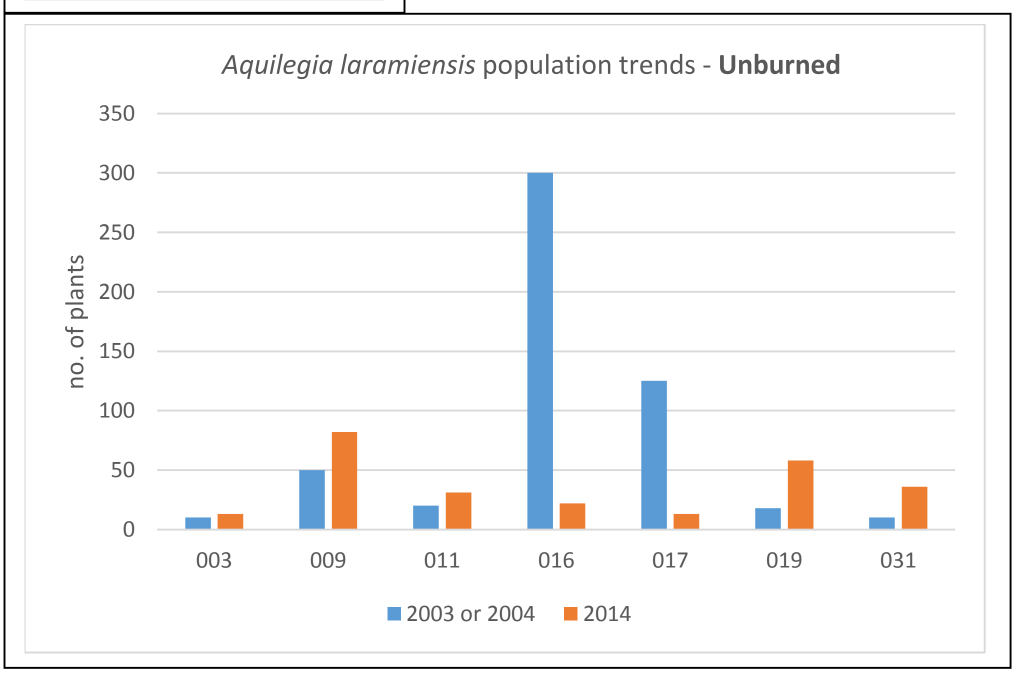


Figure 5. *Aquilegia laramiensis* population trends by fire status (Each population is referred to by an EO number, recorded below each pair of data; see Table 3.)



At several occurrences, particularly those in burned settings surveyed in late summer, abundant *Aquilegia laramiensis* seedlings were observed. High seedling numbers were most frequently observed at recently burned sites, with hundreds of seedlings growing densely among other post-fire associates. It is possible that *A. laramiensis* responds to fire with a post-disturbance flush of germination. Considering the crowded number of seedlings at many locations, survivorship may be low. Weather conditions, especially during the spring and early summer months of 2014, were presumably favorable for *A. laramiensis* germination. Since the 2013 growing season was one of drought, and flowering was likely to have been diminished, this indicates that *A. laramiensis* has a seed bank. Seedlings were usually located in the immediate vicinity of established plants. Evidence of long distance dispersal was not observed.

Vegetation and other environmental responses

In order to explain vegetation responses to wildfire, it is helpful to recapitulate the scale of consideration. *Aquilegia laramiensis* occupies specialized habitat that is usually a very small area on the landscape. We refer to it in this report as occupied habitat, but it might also be referred to as microhabitat (Figure 6) that was measured within 1 m of live plants, paralleling the slope. It is the environment directly experienced by individual plants. It is likely that the species is affected by conditions beyond the occupied habitat, and this zone of immediate influence is referred to in this report as adjoining habitat (Figure 7) that was measured 15 m downslope from live plants. Finally, the species may or may not be affected by conditions across the landscape (Figure 8); we did not address landscape-level change. Scenes at all three scales are presented in this section, as context for the vegetation sampling results.

In occupied habitat directly among *Aquilegia laramiensis*, shrub density is comparable between burned (2012) and old burn (2002) settings, and are much higher than in unburned settings (Figure 9). In comparing shrub composition of burned and unburned occupied habitat, there is a guild-shift from fire-adapted shrubs, particularly *Rubus idaeus* (red raspberry), to the fire-vulnerable shrubs such as *Physocarpus monogynous* (mountain ninebark). No live conifers were recorded at recently burned sites within 1 meter of occupied habitat and the only tree cover recorded was *Populus tremuloides* (quaking aspen).

In adjoining habitat directly downslope from *Aquilegia laramiensis*, fire-adapted shrubs appear to have flourished in the old burn settings compared to the shrub cover of new burn conditions and unburned conditions (Figure 10). The adjoining habitat has the same general guild-shift in shrub composition as occupied habitat in comparing burn and old burn conditions with unburned conditions. However, it appears at a glance that shrub cover is much higher in old burns of adjoining habitat than new burns of adjoining habitat, even though frequency values are similar.

Figure 6. Occupied habitat of *Aquilegia laramiensis* in the three fire history settings (including burned, old burn and unburned settings, centered on *Aquilegia laramiensis* plants; within 1 m)

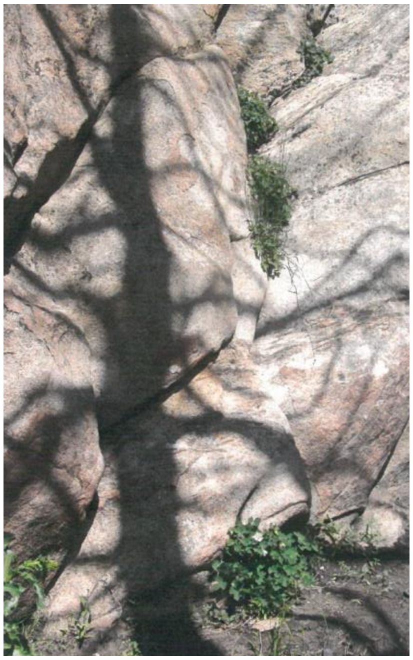


Figure 6a. Occupied habitat at recently burned site, south-facing slope, at EO#046 on Sellers Mountain by Bonnie Heidel

Figure 6b. Occupied habitat at old burn site at EO#022 on Black Mountain by Jill Welborn

Figure 6c. Occupied habitat at unburned site at EO#052 on Wagonhound Benchmark by Dennis Horning

Figure 7. Adjoining habitat of *Aquilegia laramiensis* in the three fire history settings in transects (including burned, old burn and unburned settings, looking upslope to occupied *Aquilegia laramiensis* habitat at upper end of the transect in rock outcrops)

Figure 7a. Typical tree density at recently burned site, EO #032 on Round Mountain by Jill Welborn

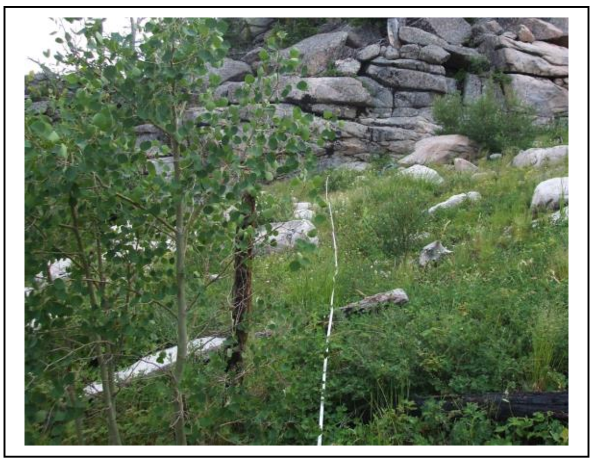


Figure 7b. Typical tree density at old burn site, EO #022 near Black Mountain lookout by Jill Welborn

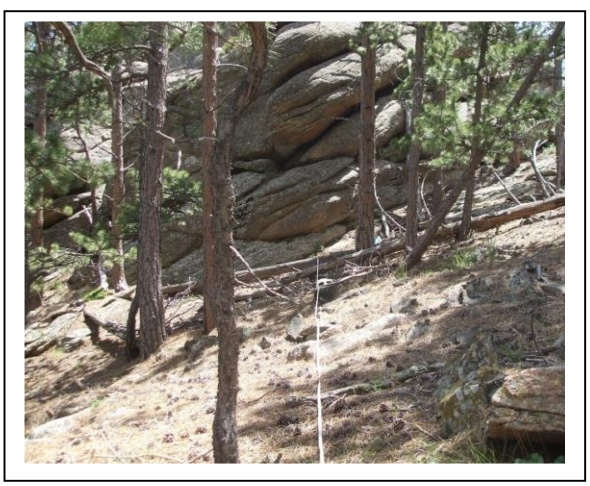


Figure 7c. Typical tree density at unburned site, EO #005 northeast of Harris Park by Jill Welborn

Figure 8. Landscape view of Arapaho Fire two years later, and *Aquilegia laramiensis* habitat, looking southeast from the vicinity of Bull Gap. The rock outcrop where EO#031 is located is the middle outcrop. The farther outcrop was searched but no *Aquilegia laramiensis* plants were found by Jill Welborn.

Finally, in tree compositions, the transition from dead to live forests is captured in the three snapshots of vegetation data (Figure 11). The small sample size of old burn vegetation may not be significant, but it is interesting that *Pinus ponderosa* (Ponderosa pine) approaches or exceeds density of *Populus tremuloides* (quaking aspen) in the old burn settings. It is also clear that the unburned settings represent a considerable diversification in tree canopy structure and composition relative to the burn and old burn vegetation.

A substantial area of the Arapaho Fire was traversed in the course of visiting occurrences for the project. The crown fire was very extensive and had very few unburned pockets and live tree refugia. Despite the pervasive crown fire, several of the 11 burned occurrences had unburned microhabitats of occupied habitat. In general, crown fires prevailed and the species experienced moderate fire severity (Figure 8).

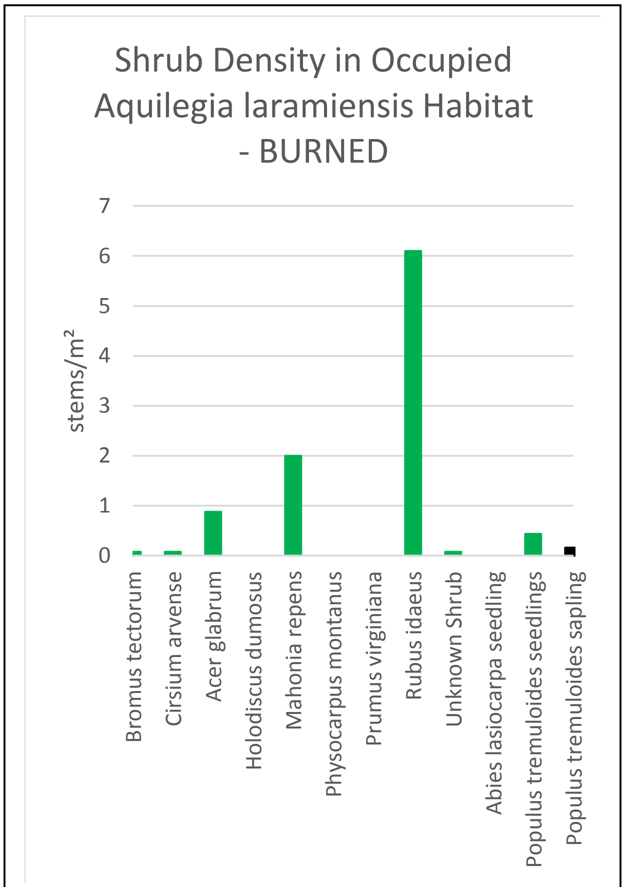
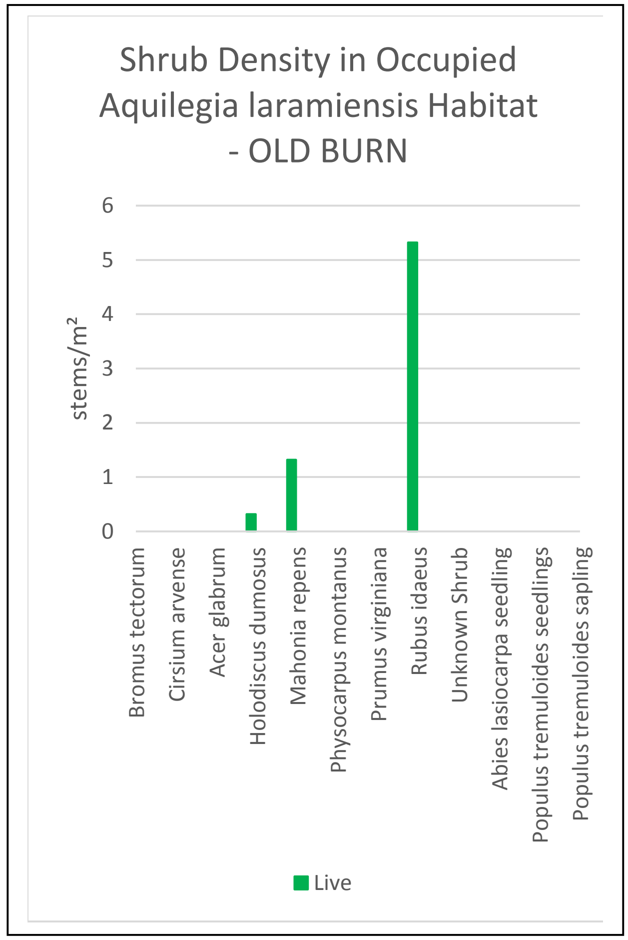


Figure 9. Shrub density in occupied *Aquilegia laramiensis* habitat by fire status – burned, old burn, and unburned



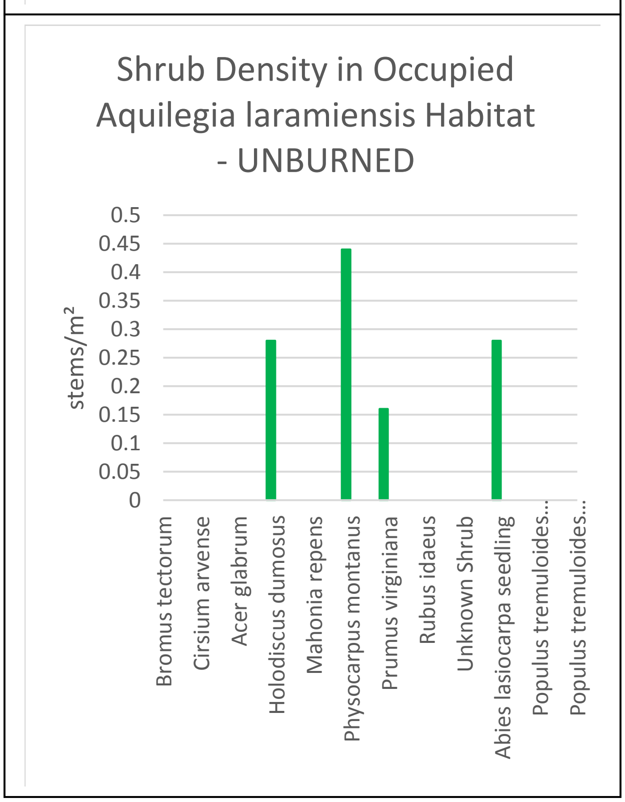
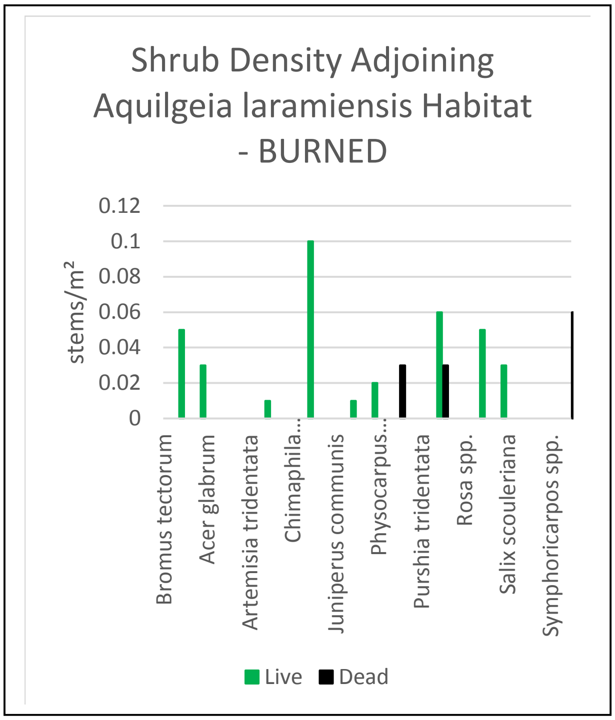
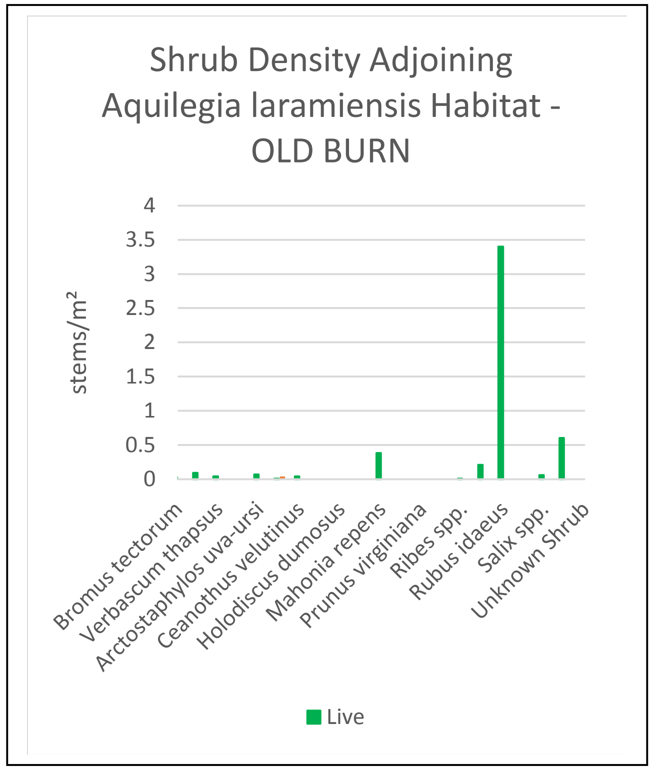
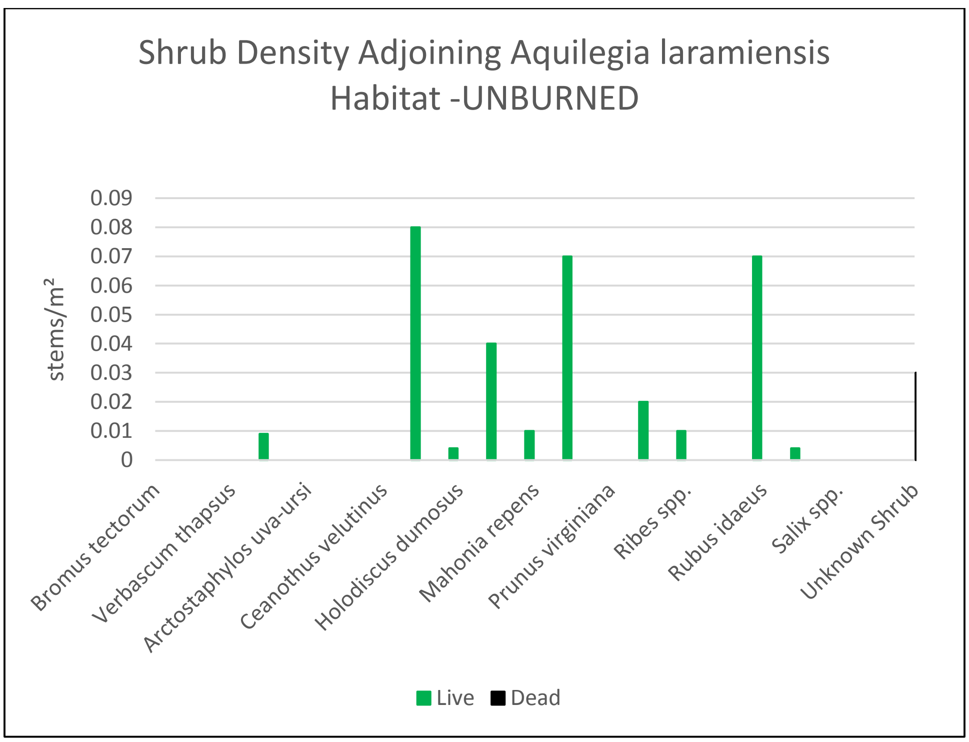


Figure 10. Shrub density adjoining *Aquilegia laramiensis* habitat by fire status







The physical environmental conditions occupied by *Aquilegia laramiensis* plants in burned habitat ranged from growing in ashy soil of lightly burned microsites, to unburned microsites situated within burned occurrences. Soils generally appeared intact and either lightly burned or unburned. Patches of ashy, powdery soils with substantial organic matter consumption were observed throughout the burned areas travelled, but were usually limited to local hot spots. Evidence of burning very near *A. laramiensis* plants, such as charred woody debris, charred bryophytes, charred rock, charred surface litter, or burned shrub or tree stumps was observed at nearly all recently burned occurrences. Heat damaged rock faces were evident at a few occurrences. Spalling was not extensive and fire impacts to the rock faces often associated with *A. laramiensis* microhabitat were minimal overall. Where rock damage occurred, heavy accumulation of flakes that spalled off the rock face could result in local reduction of suitable habitat. However, most often we saw plants in light burn conditions or in patchy burn patterns. Most often, at recently burned occurrences, a mosaic of light to no burning was observed within occupied habitat, with a portion of the habitat displaying charring of nearby woody debris or charring of surface organic matter, and a portion of habitat unburned. Microsite variability greatly modified the fire conditions to which individual plants were exposed.

Figure 11a. Tree density adjoining *Aquilegia laramiensis* habitat by fire status

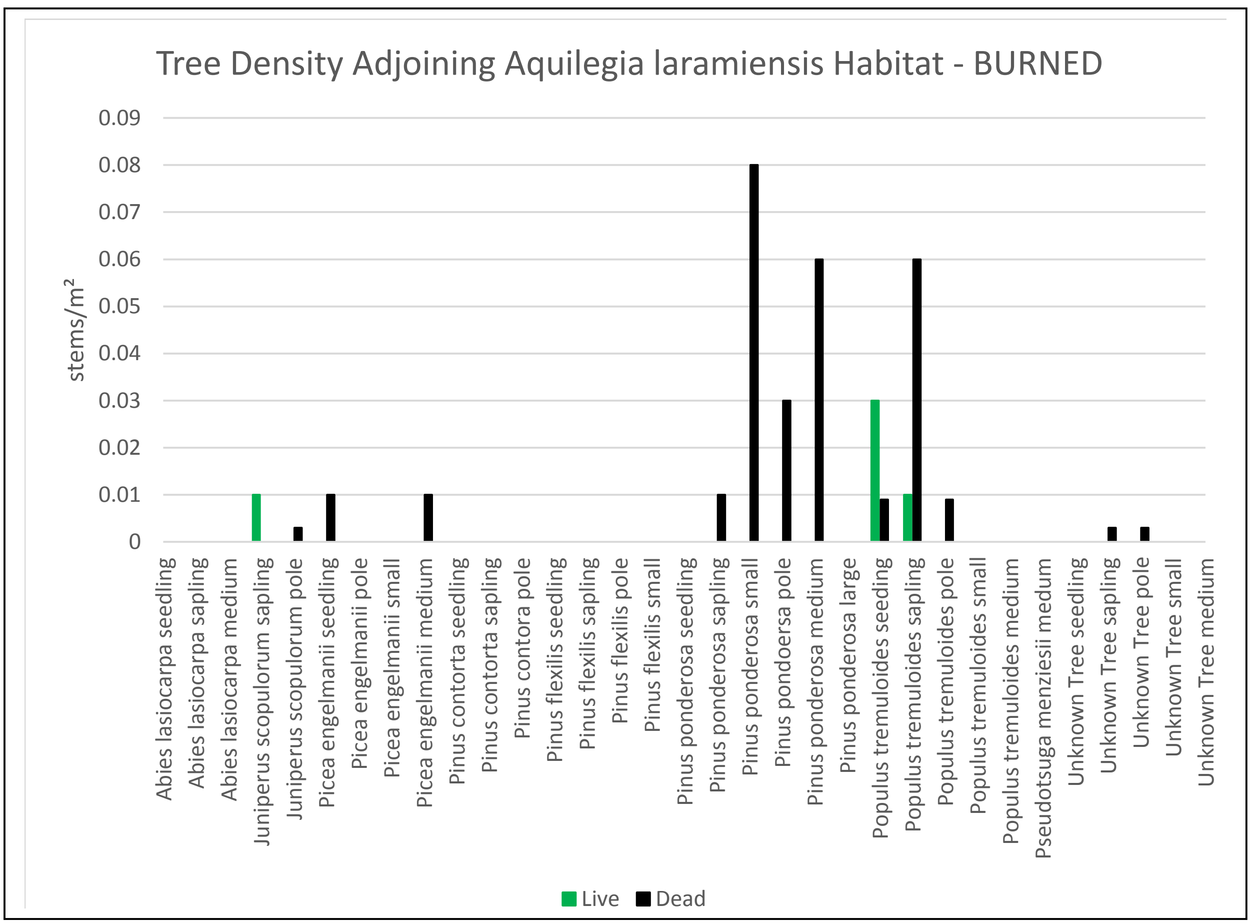
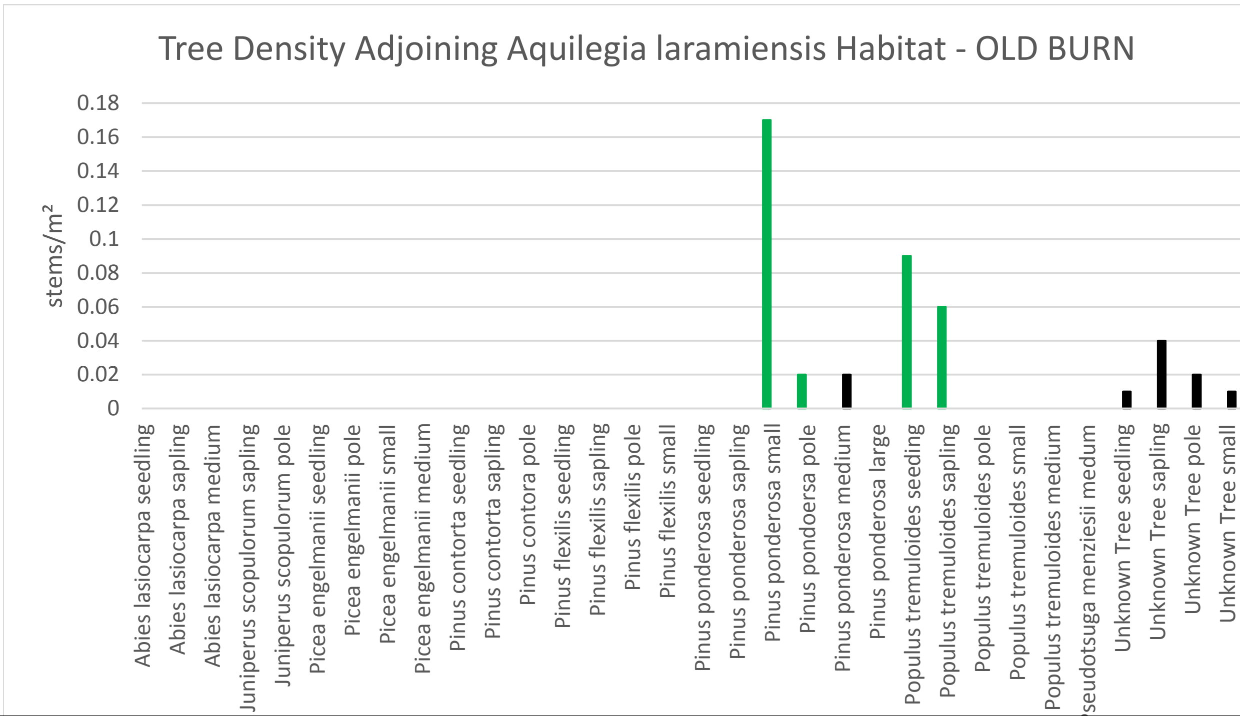
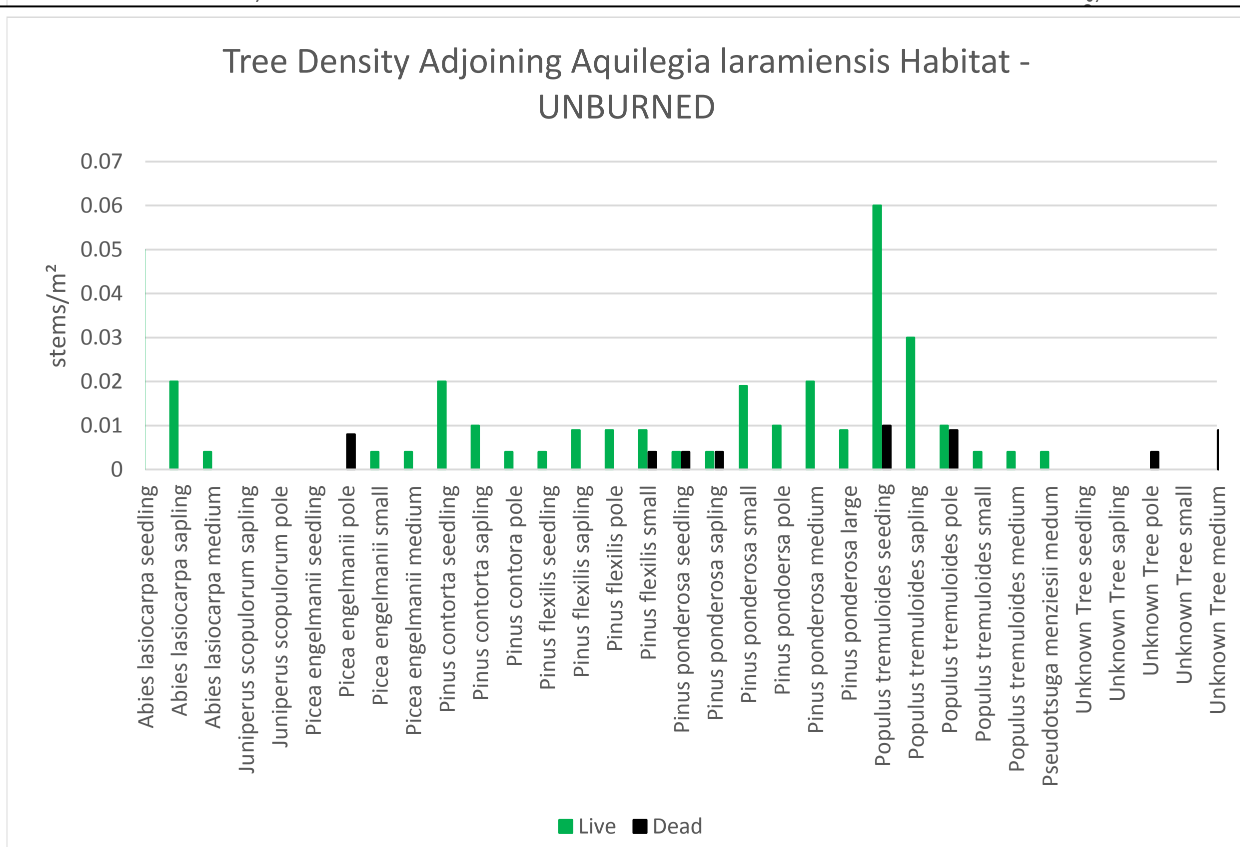


Figure 11b and c. Tree density adjoining *Aquilegia laramiensis* habitat by fire status (continued)





The mass of rock formations and cool air pockets created by alcoves and overhangs, cooler northerly aspect, and lack of fuels associated with *Aquilegia laramiensis* microsites likely tempered fire behavior in the immediate vicinity of *A. laramiensis* plants. There were exceptions and EO#028 near the Laramie Peak summit burned more severely than most burned occurrences. Severely burned, ashy soils and some deep charring on tree boles was observed at the site generally, but microsites with remaining *A. laramiensis* were lightly burned or unburned. However, the estimated population number of *A. laramiensis* plants declined from 30 to 14 at this occurrence, suggesting some microsites may have burned. It is possible that incinerated microsites were overlooked or not recognized because of the absence of *A. laramiensis* plants.

Some of the associated herbaceous species were strongly associated with recently burned sites (Table 4); these species were not observed or only found at low frequency at unburned and old burn sites. These include *Arabis pycnocarpa* var. *pycnocarpa* (creamflower rockcress), *Chamerion angustifolium* (fireweed), *Corydalis aurea* (scrambled eggs), *Collinsia parvifolia* (maiden blue-eyed mary), and *Cryptantha fendleri* (sanddune cryptantha). Other associates were frequently noted across all burn conditions. Examples of these plants include *Senecio rapifolius* (openwoods ragwort) and *Cystopteris fragilis* (brittle bladderfern). *Apocynum androsaemifolium* (spreading dogbane) was infrequent or absent in recently burned and unburned sites, but was found at 44% of old burn subpopulations where associates were recorded. Unburned sites generally had fewer associates noted, but *Senecio rapifolius* (openwoods ragwort), *Heuchera parviflora* (littleflower alumroot), and *Physocarpus monogynus* (mountain ninebark) were most frequently observed at them.

It has been thought that sparse vegetation was characteristic of *Aquilegia laramiensis* habitat. While this may hold true at unburned sites, the opposite was often true at recently burned and old burn sites. Adjoining habitat within old burn conditions had the highest woody vegetation density of both shrubs and trees, even though the landscape appeared open. The open conditions at unburned and old burn sites likely create more habitat for associated species. Moreover, typical *A. laramiensis* microhabitats situated in rock crevices, alcoves, and along rock bases possibly offer more moisture and protection from the elements than the open ground away from rock formations.

The 2014 fieldwork provided an opportunity to catalogue species associated with *Aquilegia laramiensis* by fire status. The list in Table 4 is a sequencing of species by their relative frequency in the 2012 burn setting and within 1 m of *A. laramiensis* plants, including a sample of 29 plots in new burn settings, 9 plots in old burn settings, and 45 plots in unburned settings. It builds on the prior associated species lists and the general floristic data built for the northern Laramie Range (Packer 2000).

Table 4. Species associated with *Aquilegia laramiensis*; frequency data by fire status[4]

Genus	Species	Subtaxon	Common Name	Life Form	% Frequency new burn	% Frequency old burn	% Frequency unburned	% Frequency all sites
Rubus	*idaeus*		American red raspberry	shrub	59%	67%	7%	31%
Senecio	*rapifolius*		openwoods ragwort	forb	55%	89%	47%	54%
Arabis	*Hirsute*	var. pyncocarpa	creamflower rockcress	forb	31%	11%	2%	13%
Descurainia	*Incana*	ssp. incisa or ssp. viscosa	mountain tansymustard	forb	31%	22%	9%	18%
Heuchera	*parvifolia*		littleleaf alumroot	forb	28%	56%	38%	36%
Physocarpus	*monogynus*		mountain ninebark	shrub	28%	33%	36%	33%
Acer	*glabrum*		Rocky Mountain maple	shrub	24%	22%	9%	16%
Cystopteris	*fragilis*		brittle bladderfern	fern	24%	11%	27%	24%
Woodsia	*scopulina*		Rocky Mountain woodsia	fern	21%	56%	13%	20%
Collinsia	*parviflora*		maiden blue eyed Mary	forb	17%	0%	0%	6%
Chamerion	*angustifolium*		fireweed	forb	14%	11%	0%	6%
Corydalis	*Aurea*		scrambled eggs	forb	14%	0%	0%	5%
Cryptantha	*fendleri*		sanddune cryptantha	forb	14%	0%	0%	5%
Holodiscus	*dumosus*		rockspirea	shrub	14%	33%	18%	18%
Potentilla	*fissa*		bigflower cinquefoil	forb	14%	33%	24%	22%
Asplenium	*septentrionale*		forked spleenwort	fern	10%	56%	7%	13%
Bromus	*tectorum*		cheatgrass	graminoid	10%	11%	2%	6%
Dryopteris	*filix-mas*		male fern	fern	10%	0%	2%	5%
Mimulus	sp.		monkeyflower	forb	10%	11%	4%	7%
Polemonium	*brandeegei*		Brandegee's Jacob's-ladder	forb	10%	11%	13%	12%
Prunus	*virginiana*		chokecherry	shrub	10%	11%	4%	7%
Agrostis	*scabra*		rough bentgrass	graminoid	7%	22%	2%	6%

[4] The species in this table are sequenced from the most to least frequent as found in new burns.

Genus	**Species**	**Subtaxon**	**Common Name**	**Life Form**	**% Frequency new burn**	**% Frequency old burn**	**% Frequency unburned**	**% Frequency all sites**
Allium	*textile*		textile onion	forb	7%	0%	4%	5%
Cirsium	*arvense*		Canada thistle	forb	7%	11%	4%	6%
Epilobium	sp.		willowherb	forb	7%	0%	0%	2%
Lactuca	*serriola*		prickly lettuce	forb	7%	0%	0%	2%
Logfia	*arvensis*		field cottonrose	forb	7%	0%	0%	2%
Maianthemum	*stellatum or racemosum*		false lily of the valley	forb	7%	0%	0%	2%
Parietaria	*pensylvanica*		Pennsylvania pellitory	forb	7%	0%	2%	4%
Poa	*fendleriana*		muttongrass	graminoid	7%	0%	0%	2%
Populus	*tremuloides*		quaking aspen	tree	7%	11%	2%	5%
Ribes	sp. or *cereum*		currant	shrub	7%	22%	9%	10%
Saxifraga	*rivularis*		weak saxifrage	forb	7%	0%	0%	2%
Adoxa	*moschtellina*		muskroot	forb	3%	0%	0%	1%
Antennaria	sp.		pussytoes	forb	3%	0%	7%	5%
Apocynum	*androemsifolium*		spreading dogbane	forb	3%	44%	0%	6%
Arnica	*cordifolia*		heartleaf arnica	forb	3%	0%	0%	1%
Draba	sp.		draba	forb	3%	0%	2%	2%
Pseudoroegneria	*spicata*		bluebunch wheatgrass	graminoid	3%	11%	2%	4%
Fragaria	*virginiana*		Virginia strawberry	forb	3%	11%	0%	2%
Gallium	sp. or *boreale*		bedstraw	forb	3%	0%	2%	2%
Lappula	*squarrosa*		European stickseed	forb	3%	0%	0%	1%
Mahonia	*repens*		creeping barberry	shrub	3%	11%	4%	5%
Ozmorhiza	sp.		sweetroot	forb	3%	0%	0%	1%
Penstemon	sp.		beardtongue	forb	3%	11%	0%	2%
Piptatheropsis	*micrantha*		littleseed ricegrass	graminoid	3%	22%	7%	7%
Poa	sp. or *interior*		bluegrass	graminoid	3%	22%	11%	10%
Polypodium	*saximontanum*		Rocky Mountain polypody	fern	3%	0%	4%	4%
Ranunculus	sp. or *ranunculinus*		buttercup	forb	3%	11%	4%	5%
Rosa	*woodsii*		Woods' rose	shrub	3%	0%	0%	1%
Taraxacum	*officinale*		common dandelion	forb	3%	0%	0%	1%

Genus	Species	Subtaxon	Common Name	Life Form	% Frequency new burn	% Frequency old burn	% Frequency unburned	% Frequency all sites
Arabis	*glabra*		tower rockcress	forb	3%	0%	0%	1%
Abies	*lasiocarpa*		subalpine fir	tree	0%	11%	2%	2%
Achillea	*millefolium*		common yarrow	forb	0%	22%	7%	6%
Allium	*geyeri*		Geyer's onion	forb	0%	0%	4%	2%
Arctostaphylos	*uva-ursi*		kinnikinnick	shrub	0%	0%	2%	1%
Artemisia	*ludoviciana*		white sagebrush	forb	0%	11%	2%	2%
Brickellia	sp.		brickellbush	shrub	0%	11%	0%	1%
Bromus	*ciliatus*		fringed brome	graminoid	0%	11%	0%	1%
Carex	*inops*	ssp. heliophila	sun sedge	graminoid	0%	0%	2%	1%
Carex	*xerantica*		whitescale sedge	forb	0%	0%	2%	1%
Cerastium	*arvense*		field chickweed	forb	0%	0%	2%	1%
Claytonia	*rubra*		redstem springbeauty	forb	0%	0%	2%	1%
Cryptogramma	*acrostichoides*		American rockbrake	fern	0%	0%	2%	1%
Pteryxia	*hendersonii*		Henderson's wavewing	forb	0%	22%	2%	4%
Danthonia	*spicata*		poverty oatgrass	graminoid	0%	11%	0%	1%
Delphinium	*nuttallianum*		twolobe larkspur	forb	0%	0%	2%	1%
Dianthus	*armeria*		Deptford pink	forb	0%	0%	2%	1%
Dodecatheon	*pulchellum*		darkthroat shootingstar	forb	0%	0%	2%	1%
Erigeron	*compositus*		cutleaf daisy	forb	0%	0%	4%	2%
Festuca	*saximontana*		Rocky Mountain fescue	graminoid	0%	0%	2%	1%
Heracleum	*sphondylium*		eltrot	forb	0%	0%	2%	1%
Heterotheca	*villosa*		hairy false goldenaster	forb	0%	22%	9%	7%
Heuchera	*bracteata*		bracted alumroot	forb	0%	0%	2%	1%
Juniperus	*communis*		common juniper	forb	0%	0%	4%	2%
Juniperus	*scopulorum*		Rocky Mountain juniper	tree	0%	0%	2%	1%
Mertensia	*lanceolata*		prairie bluebells	forb	0%	11%	2%	2%
Oryzopsis	*asperifolia*		roughleaf asperifolia	graminoid	0%	11%	0%	1%
Oxytropis	*sericea*		white locoweed	forb	0%	11%	0%	1%
Pinus	*flexilis*		limber pine	tree	0%	0%	9%	5%

Genus	Species	Subtaxon	Common Name	Life Form	% Frequency new burn	% Frequency old burn	% Frequency unburned	% Frequency all sites
Populus	*angustifolia*		narrowleaf cottonwood	tree	0%	0%	2%	1%
Purshia	*tridentata*		antelope bitterbrush	shrub	0%	0%	2%	1%
Rumex	sp.		dock	forb	0%	0%	2%	1%
Scrophularia	*lanceolata*		lanceleaf figwort	forb	0%	11%	0%	1%
Scutellaria	*brittonii*		Britton's skullcap	forb	0%	0%	2%	1%
Sedum	*lanceolatum*		spearleaf stonecrop	forb	0%	0%	2%	1%
Selaginella	*densa*		lesser spikemoss	forb	0%	0%	4%	2%
Symphoricarpos	*oreophilus*		mountain snowberry	shrub	0%	0%	2%	1%
Viola	sp. or *adunca*		violet	forb	0%	11%	4%	4%

RESULTS - SPECIES INFORMATION

The following species information draws heavily from three prior reports by Marriott and Horning (2004a, b; 2009) and Marriott & Pokorny (2006). It incorporates 2014 results. Those sections of the report that are direct quotations are identified as such and, in general, more detailed treatment is presented in Marriott & Pokorny (2006).

Classification

Scientific Name*:* *Aquilegia laramiensis* A. Nels. (1896). Holotype: USA, Albany Co., WY: Cotton-wood Canyon at the foot of Laramie Peak, 1895, Aven Nelson 1581 (RM).
Common Name: Laramie columbine
Family: Ranunculaceae (Buttercup or Crowfoot family)
Synonyms: none
Phylogenetic Relationships: In discussing the genus *Aquilegia*, Munz (1946) referred the reader to Payson's "excellent" account of usable characters and morphology in American columbines, and recognized his three sections within the genus. *Aquilegia laramiensis* is in section Cyrtoplecrae, characterized by biternate leaves, small blue or white nodding flowers, large dilated laminae (expanded part of a petal), short usually hooked spurs, mostly included stamens, and short styles (Payson 1918). Only two other North American species fall into this section. *Aquilegia brevistyla* (small-flower columbine) is a northern species, with disjunct populations in central Montana and in the Black Hills of South Dakota and Wyoming. *Aquilegia saximontana* (Rocky Mountain columbine) is restricted to high elevations in the Rocky Mountains in Colorado (Whittemore 1997; Payson 1918).
History of the Species: *Aquilegia laramiensis* was described by Aven Nelson (1896). There were few collections of it until the first concerted searches were conducted and its status summarized (Dorn 1979). Then it was only known from eight collections that represented four extant populations. Since that time, there have been systematic surveys conducted in portions of the northern Laramie Range (Marriott and Horning 2004a, b; 2010) and a conservation assessment prepared (Marriott and Polkorny 2006).

Legal Status

U.S. Fish & Wildlife Service: None. In 1975, *Aquilegia laramiensis* was included in the first list of species considered for designation under the Endangered Species Act (ESA) by the Smithsonian Institution in 1975 (Ayensu and DeFilipps 1978), and proposed as Endangered the following year (USDI Fish & Wildlife Service 1976). It became a Category 2 candidate for listing under the Act beginning in 1980 (U.S. Fish and Wildlife Service). The recognition of Category 2 species was replaced with a new Species at Risk category in 1996. However, the list is not maintained and species in this category are not considered formal candidates for listing at present. As a result, this species currently has no legal protection status under the ESA.

Agency Status: Sensitive, USDA Forest Service Region 2; Sensitive, USDI Bureau of Land Management (BLM), Wyoming State Office.

Aquilegia laramiensis has been designated a Sensitive species by both the Wyoming State Office of BLM and by the U.S. Forest Service Rocky Mountain Region. BLM designation obligates that agency to ensure that the overall welfare of the species is considered in land management, and that agency actions do not contribute to the need to list the species under the provisions of the ESA (USDI Bureau of Land Management 2010).

Forest Service designation confers similar obligations on the agency. The ultimate goal is to avoid listing under the ESA. Sensitive Species are those for which viability on National Forest is a concern due to "significant current or predicted downward trends" in population size or habitat capability (USDA Forest Service 2013). The new information for *Aquilegia laramiensis* has been incorporated into a species evaluation document (Appendix E).

Natural Heritage Rank: NatureServe (formerly the heritage division of The Nature Conservancy) and the Wyoming Natural Diversity Database (WYNDD) have assigned the rank of G2G3/S2S3 to *Aquilegia laramiensis*. This was taken to mean that it is either "imperiled throughout its range" or "vulnerable" on a global and state basis (NatureServe 2015; Heidel 2012). In the absence of other factors, a rank of "2" generally is assigned to species represented by 6-20 populations and a "3" is generally assigned to species represented by 21-80 populations, provided that all of those populations are viable. With the results of this fire response research, a re-ranking to G3S3 is being pursued.

Description – from Marriott and Pokorny (2006)
Aquilegia laramiensis is a perennial, leafy, many-stemmed herb 5-20 cm tall arising from a rather large, semi-fleshy root. Leaves are mostly twice ternately compound with leaflets 0.5-3 cm long. Flowers are nodding and borne among the leaves, 1-1.5 cm mm long, with sepals and spurs that are often greenish-white, and petals that are often cream colored, varying in color from bright white to bluish-tinged or pale lavender. The slender hooked spurs are shorter than the sepals and usually less than 10 mm long. Fruits are follicles 1-1.5 cm long with spreading tips. The follicles are finely hairy when green; dried fruit from previous years are glabrous (Nelson 1896; Nelson & Coulter 1909, Fertig et al. 1994; observations by Marriott and Horning, and by Heidel and Wellborn).

Similar Species: Three other columbines with cream, blue or lavender flowers occur in Wyoming: *Aquilegia coerulea* (Colorado columbine), *A. brevistyla* (small-flower columbine) and *A. jonesii* (Jones' columbine). Of these only *A. coerulea* is known from southeast Wyoming – in the Medicine Bow Mountains and at a single site in the southern Laramie Mountains southeast of Laramie. It has not been documented within the range of the *A. laramiensis*. This species has significantly larger flowers with spurs 20-50 mm long (vs. less than 10 mm in *A. laramiensis*).

Figure 12. Images of *Aquilegia laramiensis*

Figure 12a. Illustration by Isabel Nichols

Figure 12b. Close-up (burned setting) by Bonnie Heidel

Figure 12c. Whole plant (burned setting) by Bonnie Heidel
Figure 12d. Seedlings on 15 Aug 2014 (unburned setting) by Bonnie Heidel

Diagnostic characteristics: *Aquilegia laramiensis* is readily recognized in flower by its white flower with short spurs (Figure 12) and it can be reliably identified as a columbine in fruit. Most of the 2014 surveys were conducted when the species was in flower, and a few later surveys were in fruit. However, to census the population, we also needed to identify vegetative plants. It was previously noted that the species can be confused with *Thalictrum* spp. (meadow rues), which have very similar twice ternately compound leaves (Marriott and Horning 2004a), though *Thalictrum* spp. in the study area typically grow in more mesic, less rocky habitat and they have not been found growing together to date. *Aquilegia laramiensis* has crenate leaf lobes and slight pubescence on the underside of the leaf, arising from stems and petioles that are more or less decumbent and diffuse (Nelson & Coulter 1909). Even the seedlings maintain the characteristic leaf shape, though leaves may be much smaller and the immature plants much shorter.

Phenology: Mid June-July (August). *Aquilegia laramiensis* has been observed in flower as early as 8 June in an early year (Marriott and Pokorny 2006), and may prolong flowering into late summer under suitable conditions.

Geographic Range – updated from Marriott & Pokorny 2006
Aquilegia laramiensis is endemic to the Laramie Mountains in Albany and Converse counties in southeast Wyoming. Those in the northern Laramie Range span an area that is ca 50 km long and little more than 20 km wide at most from southeast to northwest. All records are presented in Table 3. Element occurrence records of each are presented in Appendix B and represented in Figures 4 and 13.

Extant sites: There are 51 extant occurrences.

Historical sites: In 1895, Aven Nelson collected *Aquilegia laramiensis* in Cottonwood Canyon at the foot of Laramie Peak (EO#004). Surveys in 2014 documented it in Cottonwood Canyon at the foot of Laramie Peak for the first time in intervening years. The historic collection is treated as a separate historic record from a new record (EO#060), but they may be one and the same.

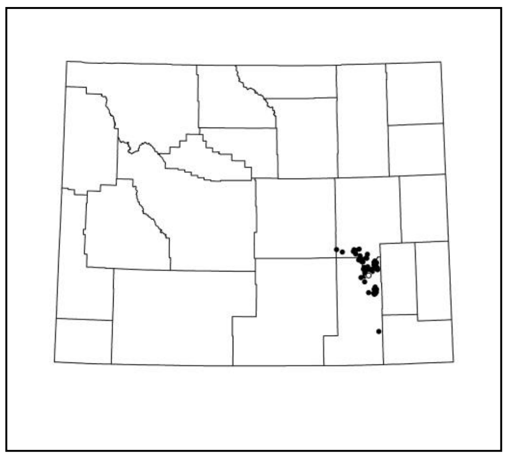


Figure 13. Distribution of *Aquilegia laramiensis*

Unverified/Undocumented reports: None known.

Sites where present status not known: None. Several disjunct occurrences have been documented as far south as Ragged Top Mountain east-northeast of Laramie. There may be additional populations in this area, but little survey has been done, in part because much of the land is private.

Areas surveyed but species not located: Negative results for 2002, 2003 and 2009 surveys are presented in the corresponding reports by Marriott (2004a, 2004b, 2010). There are extensive tracts of easily-accessible National Forest land in the Pole Mountain unit of Medicine Bow National Forest, but *Aquilegia laramiensis* has not been found there.

Habitat

Aquilegia laramiensis grows on granite rock outcrops including cliffs and boulders, particularly crevices, ledges and cliff bases shaded by aspect, overhanging rock, or trees. Soils are poorly developed, derived mainly from Laramie granite but also from other Precambrian igneous and metamorphic rocks. The setting is usually in forest, sometimes in openings, grassland or burned forest. It occurs with with *Cystopteris fragilis* (brittle bladderfern), *Heuchera parvifolia* (littleleaf alumroot), *Physocarpus monogynus* (mountain ninebark), *Potentilla fissa* (biglower cinquefoil) and *Woodsia scopulina* (Rocky Mountain woodsia) (Fertig et al. 1994, Marriott and Horning 2004 a, b, Marriott and Pokorny 2006, Heidel and Wellborn 2015). Elevations range from 5,400 ft to 10,200 ft (the latter near the summit of Laramie Peak).

The outcrops range from towering features on the landscape to isolated outcrops under the tree canopy and occasionally in parkland. Most of the populations found in 2003-2009 surveys were on prominent rock outcrops that rose several hundred feet in height and dominated the landscape. In the course of 2014 surveys, many population boundaries were expanded to include lower zones of the prominent rock outcrops and smaller rock outcrops. This discovery of it on a wider range of topographic positions and scale of outcrops probably reflects the greater visibility of rock outcrop habitat after the 2012 Arapaho Fire, greater ease of access after fire, and the relatively greater time allotted for relocating previously surveyed populations compared to the original surveys. Earlier interpretations still hold true, that *A. laramiensis* occupied only a very small fraction of the area covered by any given outcrop, with distribution that is patchy and intermittent. Plants are found on small, often sheltered microsites such as ledges, bases of outcrops, large crevices and soil pockets among boulders.

As described by Marriott and Horning (2004a, b; 2009) and earlier workers, *Aquilegia laramiensis* is often associated with north-facing granite outcrops. However, it has been found on all aspects that were generally well-shaded, with shade provided by aspect, position or topography, such as under overhanging rock, inside large crevices, among large boulders, at cliff bases, with or without the shade of trees. The species appears to require some measure of soil development, however scant it may appear at the surface. It was often found growing in level microsites associated with crevices and ledges, occasionally growing adjacent to rock outcrops.

The granite substrate occupied by *Aquilegia laramiensis* corresponds mainly with Laramie Granite as mapped by Johnson and Hills (1976). However, not all Laramie Granite is occupied, and there were obvious differences in types of granite, such as a coarse-grained reddish granite found in the northwestern part of the Range, west of the Fetterman Road, where it was not found. Neither Condie (1969) nor Johnson and Hills (1976) described this distinctive granite type, but Condie's study was limited to reconnaissance, and Johnson and Hills worked on the north edge of the 2003 study area. Moving south through the Laramie Mountains, at higher elevations the Laramie Granite is replaced by other metamorphic and igneous rocks. A population of *Aquilegia laramiensis* occurs on Ragged Top Mountain east-northeast of Laramie, which is underlain by gneiss (McCullough 1974). The southernmost part of the Laramie Mountains is underlain by the Proterozoic (later Precambrian) Sherman Granite at higher elevations. *Aquilegia laramiensis* apparently is absent from this area. In spite of easy access and relatively frequent collecting, no populations have been found. The area does not have the same types of habitat seen in the northern Laramie Mountains. It seems too dry, perhaps due to climatic differences. Also, the Sherman Granite forms different types of outcrops, without high steep faces.

The 2014 fieldwork provided an opportunity to catalogue species associated with *Aquilegia laramiensis* (see Table 4).

Topography: *Aquilegia laramiensis* grows on fractured granite outcrops that often include mountains and ridges of extensive rugged terrain, and on lower hills and smaller discontinuous outcrops. In any one locale, it is often concentrated at one topographic position, often at or near the top. But throughout its distribution, it is found in all topographic positions.

Soil relationships: Microsites have coarse, poorly-developed soil typical of soil pockets on rock outcrops (Marriott and Horning 2004a). They accumulate water by runoff. Often the soil is bare, but there is sometimes low bryophyte cover. The microsites include not only crevices but also rock bases, below overhangs and in alcoves on forest floor soils.

Regional climate: The northern Laramie Range has a mean annual temperature of 7 C (45 F) and a maximum recorded range of -40 °C (-40 °F) to 43 °C (35 °F) (Martner 1986).

Local microclimate: *Aquilegia laramiensis* occupies habitat that tends to be at least slightly if not distinctly sheltered from the surroundings. Moisture collects in the rock fractures, outcrop bases and overhangs. The habitat is often sheltered from direct solar radiation or at least from day-long exposure by aspect or outcrop contours, if not by vegetation. The habitat is often sheltered from direct exposure to wind. In turn, these conditions help maintain moist conditions and reduce evapotranspiration. The rock mass also tends to warm much slower than air temperatures and ameliorates diurnal fluctuation.

One of the aerial views of an *Aquilegia laramiensis* occurrence (EO#020 near spur of Laramie River) shows late-melting snow that closely follows the local pattern of *A. laramiensis* distribution (Figure 14). The possibility that this species requires or is favored by snowpack conditions may warrant further investigation.

Figure 14. Patterns of late snowmelt correspond with local patterns of *Aquilegia laramiensis* distribution at EO #020

Population Size and Trends

Overall, *Aquilegia laramiensis* population numbers declined. This is based on 2014 surveys of 22 (among 51) extant occurrences (43%). The net change in numbers was ameliorated in part by adding plants in expanded population boundaries due to greater amounts of survey time. The general declines are likely to reflect widespread trends (Table 3).

In any case, *Aquilegia laramiensis* is resilient to fire at some level, persisting at all burned sites. The population trends between 2003 or 2004 vs. 2014 indicated that decline was more common than increase in both burned settings, whether they burned in 2002 or 2012. Decline was also present at some level in unburned settings. Explanations for major declines in unburned and old burn settings are not available unless they were susceptible to the drought conditions that lead up to the major 2012 fire events. Trend data was compensated in part by finding population extensions and the four populations in burned and unburned settings that showed relatively high increases in numbers probably reflect expanded survey effort. We conclude that the extreme fire events of 2012 might or might not have killed some *A. laramiensis* plants but there are likely to be compounding factors.

Only one burned population is extirpated (EO#004 at Rattlesnake Rock). When originally surveyed in 2004, the species was present in low numbers in flammable habitat. When re-surveyed in June 2014, one surviving plant was found tucked under an overhang. It was visited again in August to check on the lone survivor, only to find out that the overhang broke off and crushed the plant.

Most populations are small in area and numbers of plants. On small outcrops, there were typically only one or a few patches of plants. Large systems of outcrops contained more patches, widely-scattered on appropriate microsites. Patches surveyed ranged in extent from 1 to 600 sq ft, with less than ten to several hundred individuals. In extensive systems of rock outcrops, it is difficult to survey even a significant portion of potential microsites. Some may be inaccessible entirely. Though it was difficult to estimate population size at larger sites, it was clear that the *Aquilegia laramiensis* occupies only a tiny fraction of the apparently suitable rock outcrop area.

Longevity of individuals of *Aquilegia laramiensis* and the ability of populations to persist at a site are apparent from fire response data. Likewise, Robert Dorn was able to relocate the population he initially visited in 1979 on the spur of the moment in 2004. The same population was revisited in 2014. There is no information on life history to know whether these might be the same plants or regeneration around parent plants.

Two of the largest occurrences as estimated in 2003 are ones that exhibited the greatest declines in 2014, and both were in unburned settings (EO#016 and EO#017). The plants were small at these sites, there was some evidence of herbivory, and there was some chlorosis along the leaf margins, but there was not any sign of drastic disturbance or other obvious explanation. We didn't reach the northern end of the Laramie Range and these two populations exhibiting largest declines were at the northern extent of surveys.

Population Biology and Demography

Species that form small populations such as *Aquilegia laramiensis* are often capable of self-compatible fertilization (selfing; Eckert and Schaefer 1998). This would ensure some level of reproduction, while having no gene exchange benefit. If selfing is feasible in *A. laramiensis,* it is at least constrained by the spatial separation of pollen presentation and pollen receipt (herkogamy; Barrett 2003) as seen by the pistil protruding beyond the stamens; and by the temporal separation of pollen presentation and pollen receipt (protandry) as seen by the anthers maturing before the pistil. Furthermore, the development of seed banks provides a means of gene exchange between different cohorts. There have been no genetic studies of *A. laramiensis* to characterize population structure.

Reproductive biology

Type of reproduction**:** Species in the *Aquilegia* genus reproduce by seed. As stated by Marriott and Pokorny (2006), there is no information on whether *A. laramiensis* is capable of selfing.

Pollination biology: There is great diversity of species in the *Aquilegia* genus with regard to flower characteristics, making it a model system to study reproductive evolution. Both flower color and spur length can affect reproductive isolation and speciation in the genus (Kramer and Hodges 2010). In general, white-colored species in the genus are associated with hawkmoth pollination, whereas short-spurred species in the genus tend to be favored more by bees than by hawkmoths (Kramer and Hodges 2010). No data are available on the pollinators of *Aquilegia laramiensis*.

Seed dispersal and biology**:** In the places where seedlings were noted in 2014 surveys, they were immediately beneath or near parent plants. It is not known if the species has any mechanism for long-distance dispersal.

Population ecology

General summary: There is little information available on population ecology. The populations that showed the greatest decline also had some of the unhealthiest-looking plants, suggesting that the species may be vulnerable to disease or some other agent of change.

Competition: *Aquilegia laramiensis* may compete for water and nutrients at a small scale, but does not seem to be affected by competition for light. It does most of its growth and flowers relatively early in the growing season, so it is also possible that that there is some level of competition ameliorated by the relatively milder conditions.

Herbivory: *Aquilegia laramiensis* occupies habitat that is accessible to few herbivores. Repeated visits to one locale in 2014 documented that some flowering plants had flowers browsed off between the time that they were in bud and the time they would have flowered two weeks later. This was in a burned setting where the only signs of herbivores were those of cottontail rabbits. The level of herbivory may have eliminated flowers but did not appear to kill the plants. Herbivory of flowering stems was also noted at a few other sites in 2014.

Hybridization: None.

Land ownership: The largest number of occurrences are on lands managed by the U.S. Forest Service (32 occurrences; 62%), followed by the Bureau of Land Management (19 occurrences; 37%) (Table 3). The latter are divided between the BLM Casper and Rawlins Field Offices.

ASSESSMENT AND MANAGEMENT RECOMMENDATIONS

Existing and Potential Threats to currently known populations

The northern Laramie Range where *Aquilegia laramiensis* occurs is managed for multiple use, including timber harvest, grazing and recreation. This section recapitulates study results and highlights other prospective threats.

There was previous concern that fire (wildfire or prescribed burn) could impact *Aquilegia laramiensis* by direct mortality as well as by removing the sheltering influence of shade.

Furthermore, the removal of forest cover around occupied habitat may indirectly influence the climate envelope and the successional direction of the larger landscape as it affects the suitability of occupied habitat or the constraints that adjoining habitat place on occupied habitat. Based on 2014 study results, with limited net and relative decreases or increases in species' numbers after the 2012 fires, it appears that fire is not a threat to the columbine in most cases for the following reasons:

a. *Aquilegia laramiensis* survives fire at some level, and may be adapted to it (fleshy roots).
b. *Aquilegia laramiensis* avoids fire because fire when passing through rocky habitat often leaves some areas and microhabitats unburned, or else the highest temperatures are least likely to reach the small concavities that signify occupied habitat.
c. It appears that *Aquilegia laramiensis* may form seed banks, enabling persistence and re-colonization after adverse conditions. It is not known if it has dispersal mechanisms and can disperse over long distances.
d. *Aquilegia laramiensis* survives direct exposure to sun and associated microclimate changes that results from crown fires, at least under the 2013-2014 climate conditions at the few sites where the crown fire removed all shade to the species.
e. Flowering of *Aquilegia laramiensis* may be enhanced by fire, thus increasing seed production and recruitment.
f. Occupied habitat of *Aquilegia laramiensis* is less apt to be affected by the indirect effects of fire including invasion of non-native species and ruderal species that signify competition, compared to the rest of the landscape including adjoining habitat.

Management practices and response

The pattern and extent of 2012 fires suggests that fire is a recurring event throughout the northern Laramie Range landscape, even if 2012 fires were outside the historical habitat range of variability. To date, most burned *Aquilegia laramiensis* occurrences are on lands managed by MBNF. In addition is it on unburned sites of the BLM Casper Field Office and both burned and unburned sites of the BLM Rawlins Field Office and State Lands. The only documented extirpation of a population was a case involving a convergence of contingencies at a very small population involving atypical habitat and a fluke of rock movement.

Almost all public lands where the columbine occurs currently are managed for multiple use. It appears that land uses have had limited direct effect on the species to date. The species may have an additional measure of protection at the Ashenfelder Basin Special Interest Area north of Laramie Peak and the La Bonte Research Natural Area.

Prescribed burn: This study suggests that prescribed burns may affect *Aquilegia laramiensis* positively and negatively. If pre-burn monitoring and possibly experimental controls were built into prescribed burns, then such management practices could provide basis for steering them toward beneficial outcomes.

Weed control: The spread of invasive weeds is a relatively new phenomenon in the Northern Laramie Range. Preliminary vegetation sampling information suggests that *Bromus tectorum* (cheatgrass) and *Cirsium arvense* (Canada thistle) are more common in burned rather than unburned settings near occupied habitat. The narrow zones of occupied habitat are subject to invasion, though less so than the surroundings. The implications of their invasion and competitions are not known.

Figure 15. *Bromus tectorum* (cheatgrass) in occupied habitat of *Aquilegia laramiensis.* Though present at very few occurrences, it was locally common growing with *Aquilegia laramiensis* in places at EO#060 on Cottonwood Creek by Jill Welborn

As noted by Marriott and Pokorny (2006), local application of herbicide by qualified personnel would generally not pose threats to *Aquilegia laramiensis*. However, the broken terrain is difficult to cover, and prospects of broadleaf aerial herbicide application were cited by the authors, noting such treatment as posing threats to this species and the native vegetation in general. In addition to cheatgrass and Canada thistle, the flush of ruderal species that follows fire may pose another form of competition, though not directly addressed in land management. All of the prospective management practices listed on the following pages may directly or indirectly promote spread of weeds, so weed management applies to them all.

Timber harvest: There has been concern that timber harvest in areas of columbine populations could remove needed shading. However, many sites were not shaded by tree cover but by aspect or overhanging rock. In addition, most sites were not within harvestable stands of trees. This underscores the interpretation offered by Marriott and Pokorny (2006).

Grazing: Much of the habitat of *Aquilegia laramiensis* is rugged and difficult to access, for livestock as well as for people (Marriott and Horning 2004a). Where it occurs at the base of outcrops, the habitat may be used for shelter more than anything else. Signs of grazing, trampling and other direct damage have not been observed.

Roads, travel planning and construction: Road construction that requires blasting may enter or impact occupied habitat of *Aquilegia laramiensis*. Most occurrences are outside of existing travel corridors.

Other: Collecting for cultivation has been identified as a potential threat at some sites. Populations are relatively small, and could easily be destroyed by collectors at accessible sites. The potential overall impact of collecting on species viability is difficult to evaluate. It is available commercially and perhaps the most important conservation measure would be to encourage retailers to use and advertise strictly propagated sources.

Conservation Status

The current interpretation of conservation status underscores earlier interpretations of Marriott and Pokorny (2006) and provides preliminary trend data:

> "Assigning conservation status to *Aquilegia laramiensis* is complicated by the existence of conflicting factors (Heidel personal communication 2004, Marriott personal observation). The species is often locally common within its range, but its global range is limited. Many occurrences are small, but it is not clear that this is a risk to the overall viability of the species. Large areas of habitat with high potential for *A. laramiensis* remain to be surveyed, and the larger occurrences that have been surveyed probably are significantly larger than current estimates. No trend data are available. There is little in the way of management conflict and little impact from human use in general. Climatic warming may significantly reduce the abundance of the species but is outside the realm of management…"

The greatest contribution of 2014 surveys are documenting a resiliency of the species and its habitat to wildfires that points to relative species' stability and viability. The single case of extirpation was where the species grew away from boulders in well-vegetated settings below outcrops, and all other populations persisted despite signs of burns that included high intensity at a local scale. We note that weed encroachment is a relatively new phenomenon that is fostered at some level by wildfires, and to which small populations may be especially vulnerable. We prepared an update to the species evaluation form used by the U.S. Forest Service to summarize current status information (Appendix E). We updated global and state ranks for the species using the rank calculator to G3/S3.

Predictive Habitat Modeling

Predicted distribution maps for *Aquilegia laramiensis* were produced with habitat modeling by Fertig and Thurston (2003) and are under revision at present (Heidel et al. in progress). In the past, it was noted that identifying suitable potential habitat for *A. laramiensis* requires much finer level of detail than is available as Geographic Information System (GIS) data at this time. Of greater concern were the false negative predictions using the Fertig and Thurston model. Of the 22 sites surveyed outside of predicted habitat in 2009, *A. laramiensis* was found at eight. Two included the largest populations found during past field surveys (Windy Peak, Sawtooth Ridge area), and one represents the northwesternmost range extension of the species.

Botanists have long used correlation with habitat variables in designing surveys for species of concern. A common approach begins with assessment of habitat at known sites and as reported in the literature. Similar sites are then selected for survey, with site selection modified as needed with new discoveries. With GIS data now available, it is possible in some cases to automate this selection procedure to good effect. For example, in the northern Black Hills, potential rare plant habitat was modeled based on distribution of sheltered north-facing aspects (Zacharkevics and Silvey 2002, unpublished data). This approach has been quite effective in identifying boreal remnant habitats characteristic of Black Hills rare plants because 1) the habitat requirements of the target species are well understood, and 2) the available GIS data are adequate in type and scale to characterize that habitat. That may not be the case for *Aquilegia laramiensis*, a matter that remains to be determined.

Information Needs

The most important information needs may be those that arise once report results and distribution data are put into the hands of biologists and other natural resource specialists who use them. The large declines in two unburned settings was a surprise, and additional surveys farther north in species' distribution may provide context. Any more large occurrences as reported in 2003, 2004 of 2009 but not surveyed in 2014 would also be valuable to resurvey, in an effort to broaden the 2014 trend study.

A monitoring program designed to get life history baseline data is suggested, collecting 3-5 years of demographic data along permanently-marked transects that stratify burned and unburned sites, and include both those that seemed to decline and those that seemed to increase (i.e., four monitoring sites). It would be possible to record individual plants by some combination of photo points and a fire-resistant marker system. It might be conducted in late flower or fruit to capture both the chlorosis and herbivory questions, and be conducted in combination or apart from the surveys described above.

If prescribed fire is planned in the northern Laramie Mountains, then surveys for *Aquilegia laramiensis* and monitoring programs conducted as control burn experiments are warranted. Surveys should be done pre-burn, with at least three years of data collected post-burn. A controlled burn experiment would provide more rigorous basis for evaluating species' response to fire and the many permutations of response associated with microhabitat that could not be addressed in this study. Very little is known about the life-history and biology of the species, and any study that tracked individual plants could greatly augment the knowledge base.

Likewise, additional research of the *Aquilegia laramiensis* seed ecology and *in situ* seed bank would also be informative. It would be valuable to follow any seedling establishment episodes picked up in monitoring studies for at least two more years.

Finally, information-sharing on any new populations of *Aquilegia laramiensis* or species studies would contribute to the status picture overall. Both of its two closest relatives, *A. brevistyla* and *A. saximontana*, are rare in the Rocky Mountains and species studies on any segment of this species complex may have bearing for the whole.

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