Status of Laramie Columbine (*Aquilegia laramiensis*) and Results of Field Survey

prepared for
the Wyoming Natural Diversity Database,
University of Wyoming, and
Medicine Bow National Forest

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Abstract

Field work in 2003 produced 21 new sites for the Laramie columbine, *Aquilegia laramiensis.* This brings the total number of occurrences known for the species to 33, two of which are considered historical without precise location information. The overall range remains quite limited. Most populations are found in the northern part of the Laramie Mountains, within an area approximately 35 air miles in length from southeast to northwest. Several disjunct occurrences have been documented to the south as far as Ragged Top Mountain east-northeast of Laramie. Additional surveys are needed in these areas.

Predicted distribution maps from habitat modeling were provided prior to field work. These maps were of limited use for survey site selection, in part because identification of suitable habitat for *Aquilegia laramiensis* requires a finer level of detail than is available as Geographic Information System (GIS) data at this time. Familiarity with the area, topographic maps and drive-bys were the most useful tools for site selection.

All occurrences found in 2003 were on granite outcrops on shaded microsites. Shading usually is furnished by aspect, position or topography. At a few sites surveyed, outcrops were small enough to be shaded by tree cover. The species is not restricted to granite, and has been found at two locations in areas of gneiss outcrops outside the study area to the south.

Most Laramie columbine populations are small. On small outcrops, there may be only one or a few small patches of plants, with a few to 10 – 20 individuals. In large systems of rock outcrops, populations consist of many scattered patches. These sites are difficult to survey, and populations probably are significantly larger than our size estimates. However it is clear that *Aquilegia laramiensis* only occupies a small fraction of the total rock at sites.

No significant threats to overall viability of the Laramie columbine are apparent. At some sites, collecting for cultivation is a potential concern, but the rugged habitat of the columbine generally is difficult to access. Grazing, timber harvest and recreation do not pose obvious threats at this time.

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.

Discovery of new sites and lack of threats suggest that conservation ranks for *Aquilegia laramiensis* be reconsidered. However, its limited range and small population sizes suggest caution regarding downlisting. We recommend that additional survey for the species be done first, in the southern part of its range where land ownership, land use and access may present problems not recognized at this time.

Acknowledgements

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Introduction

In 2003, we entered into an agreement with the Wyoming Natural Diversity Database (WYNDD) to conduct field surveys for the Laramie columbine, *Aquilegia laramiensis*, with funding from Medicine Bow National Forest. This species is restricted to the Laramie Mountains in southeast Wyoming (Figure 1). It is listed as a species of concern by the Forest Service, Bureau of Land Management and WYNDD.

Aquilegia laramiensis was first collected in 1895 "at the foot of Laramie Peak" in the northern Laramie Mountains by Aven Nelson. He published a description of the species the next year (Nelson 1896). Nelson made more collections in 1900 and 1901, extending the known range to Ragged Top Mountain in the Laramie Mountains east-northeast of Laramie, roughly 60 miles south of Laramie Peak. The next new records were not reported until the 1970s and 1980s. All were in the northern Laramie Mountains in the general area of Laramie Peak. In 1993, C. Refsdal collected the columbine roughly halfway between Laramie Peak and Ragged Top Mountain. Several new records were found during general floristic surveys of the area (Packer 2000), including a range extension about 16 miles to the northwest in the vicinity of School Section Mountain by B.E. Nelson in 1997. By 2002, the species was known from 12 sites; two were considered historical without precise location data.

Though no rangewide surveys for *Aquilegia laramiensis* had been done prior to 2003, several sites had been surveyed in more detail by WYNDD, its predecessor the WY Natural Heritage Program, and the Forest Service (WYNDD 2004). Overall however, little population and habitat data were available. No threats had been documented, but so little was known about the species that it was impossible to assess conflicts with human activities. The columbine appeared to be rare, but there were large areas of unsurveyed potential habitat. The Laramie Mountains are rugged, with many areas of extensive rock outcrops. Access is difficult due to rugged topography, lack of roads and a mixed pattern of public and private lands.

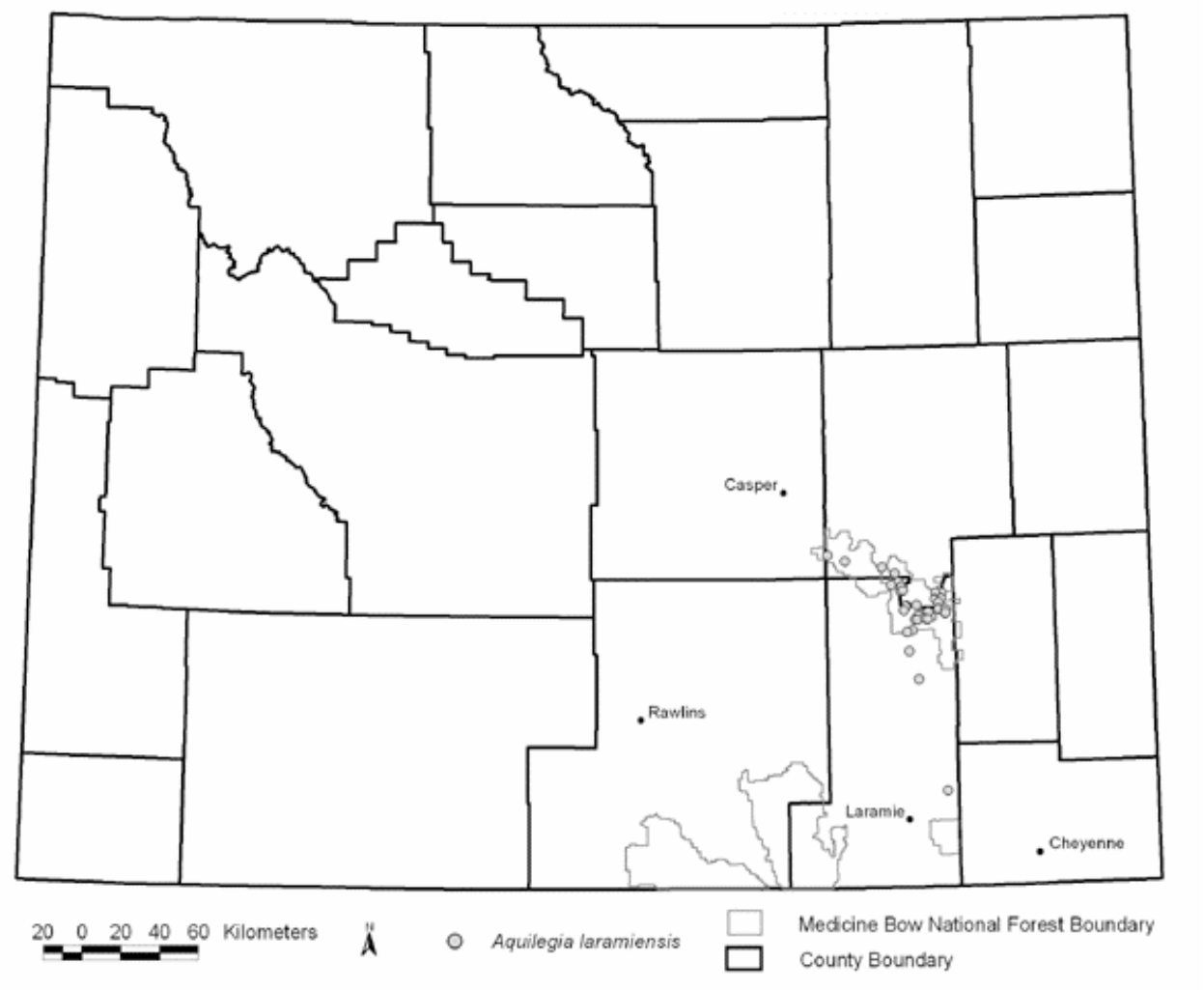
Methods

The primary goals of this project were 1) to document the distribution and status of the Laramie columbine through field survey; and 2) to compile new and existing information into a status report. Because so little survey for Laramie columbine had been done prior to this project, our field work focused on documenting distribution and abundance of the species to determine if it is indeed rare. Qualitative descriptions of habitat and assessment of obvious existing and potential threats were made. Only limited information on species biology was collected.

Study Area

The Laramie columbine is endemic to the Laramie Mountains in southeast Wyoming (Figure 1), which extend north and then northwest from northeastern Colorado near the Wyoming border approximately 140 miles, ending in the vicinity of Douglas, Wyoming (Blackstone 1996). Most known populations of columbine are in the northern part of the range. Several disjunct sites are found to the south as far as Ragged Top Mountain east-northeast of Laramie. For this project, survey was limited to Forest Service lands in the northern part of the range, with one survey site on Forest land southeast of Laramie.

Figure 1. Range of *Aquilegia laramiensis*; 2003 study area included Forest lands north and southeast of Laramie.



The Laramie Mountains are typical of the Laramide mountain-building episode, when most of the Rocky Mountain ranges were uplifted. The range is a broad anticline with sedimentary rocks exposed on the flanks. Precambrian intrusive and metamorphic rocks are found at high elevations (Blackstone 1996), and underlie all of the study area.

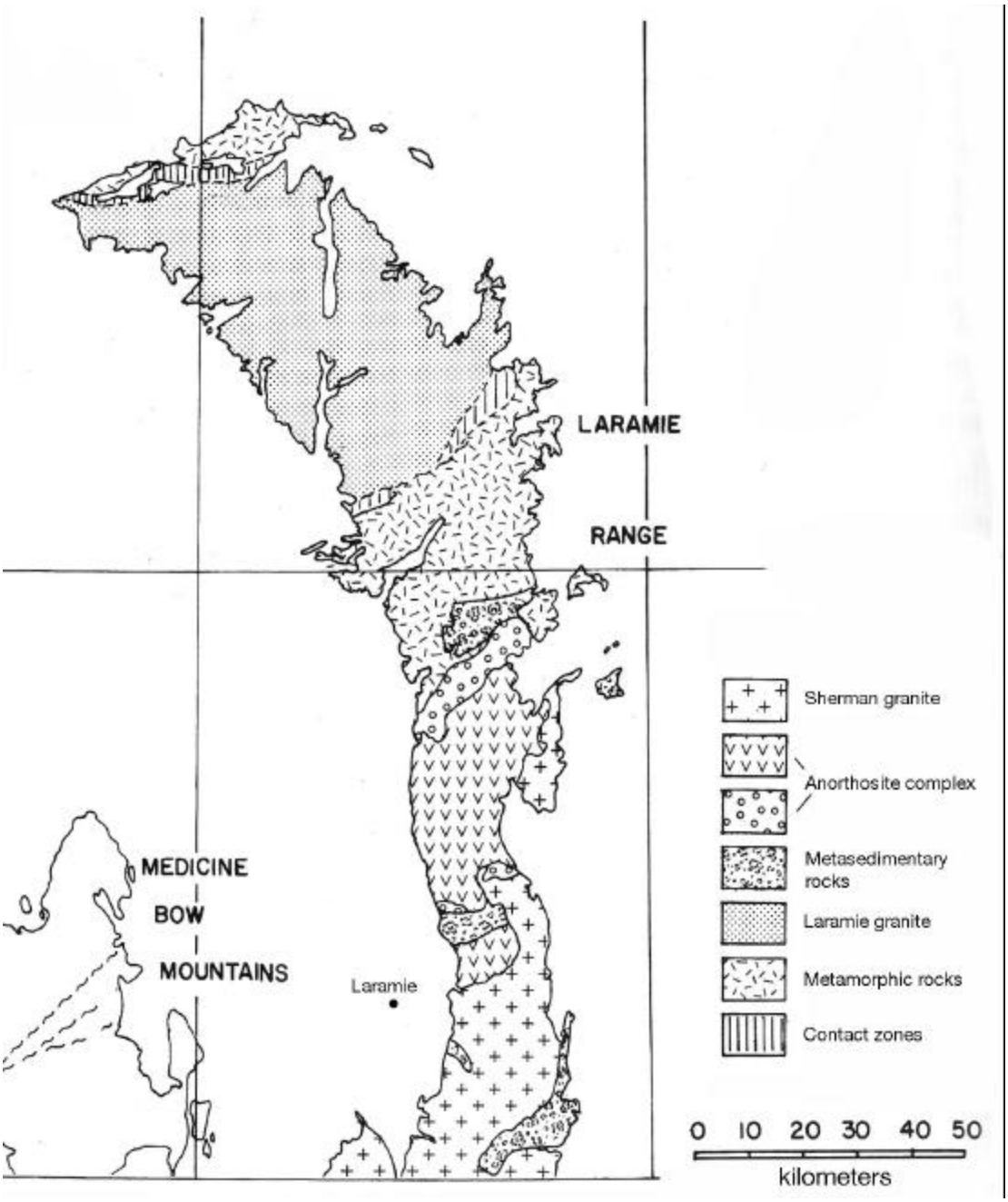
Within the study area, elevations range from around 6000 ft in the foothills on the east side to 10,272 ft at Laramie Peak. However most of the "high country" is in the range of 8000 to 9000 ft, with Laramie Peak standing as an isolated high point.

Based on Precambrian bedrock, the Laramie Mountains can be divided into four sections from north to south (Figure 2; Johnson and Hills 1976). Most populations of Laramie columbine are in the northernmost section, north of the Laramie River, where higher elevations are underlain by the Archean (earlier Precambrian) Laramie granite (Condie 1969, Johnson and Hills 1976). Precambrian rocks in this area have not been well studied, and classification and origin remain unclear.

In the next section south, from the Laramie River almost to Sybille Canyon and Wyoming Highway 34, high elevations are underlain by Archean metamorphic rocks, mainly

gneiss. This section has been called the Central Metamorphic Complex (Condie 1969; Johnson and Hills 1976). The southern half of the Laramie Mountains includes two zones of Proterozoic (later) Precambrian igneous rocks: the Laramie anorthosite complex to the north, and the Sherman granite to the south. A small zone of Archean metamorphic rocks is located near the south end of the anorthosite complex, east-northeast of Laramie. The Sherman granite of the southernmost part of the range is familiar to travelers on Interstate 80 between Laramie and Cheyenne where it forms prominent outcrops.

Figure 2. Precambrian rocks exposed in the Laramie Mountains (modified from Johnson and Hills 1976).



The Laramie Mountains are cold and semi-arid. The Double Four Ranch climate station is located in the southeast corner of the study area at 6200 ft; conditions at this station probably represent some of the warmest and driest of the study area. Climatic data are shown in Table 1.

Table 1. Monthly Climate Summary, Double Four Ranch, Wyoming. Period of record: 8/1/1984 to 7/31/2003.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Av max temp, F	34.5	38.0	44.2	54.2	64.0	74.4	82.4	81.0	71.7	59.5	44.3	36.0	57.0
Av min temp, F	13.7	16.1	20.0	27.0	35.3	42.2	47.9	46.0	37.3	29.1	21.7	15.5	29.3
Av total precip, in	.39	.45	.95	1.73	2.77	2.35	1.73	1.18	1.17	.83	.70	.50	14.76
Av total snow, in	7.1	7.7	13.0	10.9	3.3	0.3	0	0	1.3	3.9	8.4	9.0	64.9
Av snow depth, in	3	3	2	1	0	0	0	0	0	0	1	3	1

Major vegetation types in the study area include coniferous forest dominated by ponderosa pine (*Pinus ponderosa*), lodgepole pine *(P. contorta*) and/or subalpine fir (*Abies lasiocarpa*). Stands of quaking aspen (*Populus tremuloides*) are occasional. Forest cover can be nearly continuous, for example on the slopes of Laramie Peak. Often however, tree cover is patchy, and there are large areas of sagebrush grassland.

Land ownership patterns in the Laramie Mountains vary from north to south. The northern part is predominantly under Forest Service management at higher elevations. Most of the 2003 field work was done in this area. To the south as far as WY Highway 34, lands are a mix of private, BLM and State. Continuing south, ownership is mainly private with isolated State parcels. Another large area of Forest Service land is found in the southernmost part of the Laramie Mountains. A single site was surveyed in the southern part of the range in 2003.

Survey Site Selection

Because there had been little prior survey for the columbine, especially in proportion to the extent of potential habitat (granite outcrops), we decided to survey as many sites as possible well-distributed through the study area to determine if the species is indeed rare. Field work was restricted to Forest Service lands for the most part. Some State land was visited when in proximity. Private land was crossed occasionally with permission, but no surveys for Laramie columbine were made on private lands. Maps of survey sites are on file at WYNDD.

Survey was limited to the northern part of the range with the exception of one site on Forest land southeast of Laramie at Eagle Peak. Little time was spent in the southern part of the range for several reasons. First, in spite of easy access and relatively frequent collecting in the area, *Aquilegia laramiensis* had not been found there. Second, the area does not have the same types of habitat seen in the northern Laramie Mountains where the columbine is most common. It seems too dry, perhaps due to climatic differences and rock type (see discussion under **Species Information**, **Habitat**).

Field work began with a visit to a known columbine site, at Friend Park Campground at the base of Laramie Peak, to become familiar with the species and its habitat. We then visited three similar unsurveyed sites in the general area, and found columbine populations at all. Based on these findings, as well as habitat descriptions from other known sites, we gave highest priority to similar sites. However, because we also wanted to determine the range of the species, survey sites were selected throughout the northern Laramie Mountains in areas of

granite outcrops. As a result, there remain many unsurveyed sites with high potential habitat, especially in the vicinity of Laramie Peak where the columbine is most common.

We gave highest priority to sites with large granite outcrops with steep northerly aspects. Less prominent outcrops were checked when easily accessed. Suitable outcrops were most easily found using topographic maps rather than aerial photos. Photos did not show vertical relief as well as did topographic maps. Horning's familiarity with the area, specifically locations of large rock outcrops and access routes, was a very useful resource for selecting survey sites.

Access was important in survey site selection. The northern Laramie Mountains are quite rugged with limited road access, compounded by patchwork public/private ownership in some areas. To maximize the number of sites surveyed, we did not visit remote sites except in areas where Laramie columbine had not been previously reported, and where there was no suitable habitat within several hours walking distance of roads of any kind. Many roads used during survey were poor two-tracks requiring a four-wheel drive vehicle.

No attempt was made to relocate the two historical records which lack precise location data (see Table 2). Several sites with columbines were found in the vicinity of Aven Nelson's first collection in Cottonwood Canyon at the "foot of Laramie Peak." The Antelope Basin collection made in 1900 is outside the area of Forest lands.

Predictive habitat modeling by WYNDD prior to field work identified some potential habitat on Forest lands in the Medicine Bow Mountains west of the Laramie Mountains. This area was not included in 2003 surveys due to time restrictions. Habitat modeling is addressed in the next section and under **Discussion**.

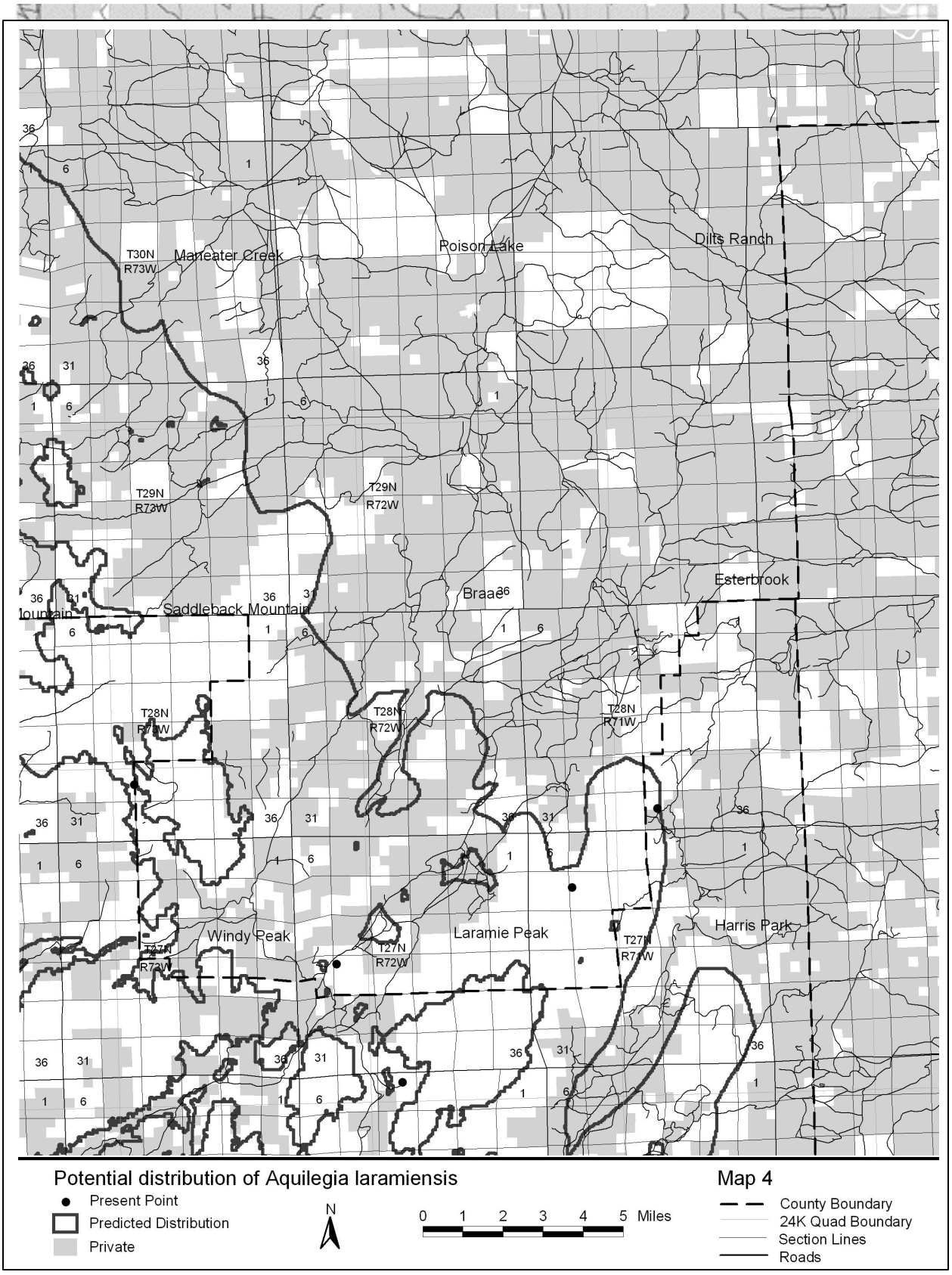
Predictive Habitat Models

Fertig and Thurston (2003) used predictive habitat modeling to generate maps of potential habitat for 44 Wyoming rare plant species, including *Aquilegia laramiensis*. Maps from that project were provided by WYNDD prior to field work. An example is shown in Figure 3. An overview of the habitat modeling is included in Appendix A.

The predicted distribution maps for *Aquilegia laramiensis* are based on four habitat variables: Wyoming soil classification, total January shortwave radiation, average January air temperature and local relief (listed here in order of usefulness in classifying potential habitat). Of the data available for Geographic Information Systems (GIS), these variables were found to be the most useful for predicting presence/absence. Soil classification was found to correlate most strongly with known occurrences of the columbine, probably because the species is restricted to rock outcrops, and these are classified as distinct soils units.

Though there was not time for systematic testing of the model, we were asked to provide feedback on its usefulness in designing survey. We surveyed what appeared to us to be good potential habitat both within and outside of predicted areas. We discovered on our first day of field work that good potential habitat existed outside of predicted areas, and for that reason did not use the maps as a first cut in selecting sites.

Figure 3. Example of predicted distribution map, with polygons of potential habitat delimited (from Fertig and Thurston 2003).



Data Collection

Our primary goal was to survey as many potential sites as possible to determine whether the Laramie columbine was rare or just undersurveyed, and so data collection was kept simple. Generally, surveyors spent less than one hour at a given site, with access to sites much more time-consuming. No effort was made to find every plant at a site; some populations may be significantly larger than documented.

Data collection was designed to accurately document locations, estimate population size, characterize habitat qualitatively, note any obvious threats or potential threats, and estimate amount of unsurveyed potential habitat in the area. A sample survey form is included in Appendix B.

Photographs of plants and habitat were taken at most sites. Photos are on file at WYNDD. Most populations were sufficiently large to allow some collecting. Specimens are deposited at the Rocky Mountain Herbarium (RM) at the University of Wyoming in Laramie.

Surveys began in mid-June and continued through the end of August. Field work is possible until the snows fly, as the species can be documented confidently based on fruit. Based on our work in 2003, it appears that experienced surveyors probably can identify populations based on vegetative material in combination with habitat. However, other members of the Ranunculaceae with similar leaves occur in the area, and it is recommended that flowering or fruiting material be present to confidently report new populations.

Results

Findings from the 2003 field season are summarized here. Detailed discussions are included under **Species Information** below.

As expected, we found many new Laramie columbine locations. There are now 33 documented occurrences (Table 2). Two are historical records with imprecise locations. Twenty-one are discoveries made in 2003. An additional occurrence added in 2003 is based on a 1997 specimen found in the Rocky Mountain Herbarium (Packer 2000). An unreported columbine site on Albany Peak surveyed in 2001 by Forest Service staff, Douglas Ranger District, is included in one of our surveyed occurrences.

The known range of *Aquilegia laramiensis* was expanded, mainly to the east and northwest (Figure 6). Its overall range remains limited, and populations generally are small. The rugged habitat is largely inaccessible; no significant threats are apparent.

Of the 46 sites surveyed, 24 were within areas of predicted habitat for the Laramie columbine (Fertig and Thurston 2003). Of these, 15 supported columbine populations. Of the 22 survey sites selected outside of predicted areas, eight were found to have populations of columbine, including several that were relatively large. Predictive habitat modeling is addressed in more detail under **Discussion** below.

New information on habitat was collected in 2003. The maximum elevation was increased to 10,100 ft from 8520 ft. The species was found on most aspects rather than just northerly as previously reported, but all microsites were well shaded in some fashion. The columbine was not found on all types of granite in the area, appearing to be absent from a reddish coarse-grained type found in the western part.

Significantly more study material of *Aquilegia laramiensis* is now available, including 22 new specimens and many photos. Earlier descriptions generally are accurate, but we found some differences in size, flower color and fruit characteristics.

Species Information

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. *A brevistyla* (small-flower columbine) is a northern species with disjunct populations in MT, WY and SD. *A. saximontana* (Rocky Mountain columbine) is restricted to high elevations in the Rocky Mountains in CO (Whittemore 1997).

Legal Status

Federal Status: Sensitive, USDA Forest Service Region 2; Sensitive, USDI Bureau of Land Management (BLM), WY State Office (Keinath and others 2003).

Aquilegia laramiensis has been designated a Sensitive species by both the BLM and the Forest Service. 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 Endangered Species Act (ESA) (USDI Bureau of Land Management 2002).

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 Forest lands is a concern due to "significant current or predicted downward trends" in population size or habitat capability (USDA Forest Service 2003)

With new information for *Aquilegia laramiensis* now available, Sensitive status may need to be reassessed (see **Discussion, Conservation Status**).

Natural Heritage Rank: NatureServe (formerly the heritage division of The Nature Conservancy) and the Wyoming Natural Diversity Database (WYNDD) have assigned the rank of G2S2 to the Laramie columbine, defined as "imperiled because of rarity" on a global and state basis (NatureServ 2003; Keinath and others 2003). In the absence of other factors, a rank of "2" generally is assigned to species represented by 6-20 populations. With the discovery in 2003 of additional columbine sites, it may be appropriate to reconsider the rank of this species. However, other factors such as small population size may offset the increased number of occurrences in assessing status (see **Discussion, Conservation Status**).

Description

Aquilegia laramiensis is a perennial, leafy, many-stemmed herb 5-20 cm tall (Figures 4 and 5). Leaves are mostly twice ternately compound with leaflets 0.5-3 cm long. Flowers are nodding and borne among the leaves, with greenish-white to lavender sepals and cream to lavender, short-spurred petals (spurs 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; Fertig and others 1994; observations by the authors in 2003).

Three other columbines with cream, blue or lavender flowers occur in WY: *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 Laramie columbine. This species has significantly larger flowers with spurs 20-50 mm long (vs. less than 10 mm in the Laramie columbine).

During survey in 2003, we wondered if we could recognize the Laramie columbine vegetatively with sufficient familiarity. Vegetatively the species can be confused with *Thalictrum* spp. (meadow rues), which have very similar twice ternately compound leaves. Although meadow rue in the study area typically grows in more mesic, less rocky habitat, we did not feel confident in most cases recognizing occurrences based only on vegetative material.

Figure 4. Drawing of *Aquilegia laramiensis* by Isobel Nichols (Fertig and others 1994).

Figure 5. Photographs of *Aquilegia laramiensis* (Horning, Marriott photos).

Figure 5 continued. Photographs of *Aquilegia laramiensis* (Horning photos).

Geographic Range

Aquilegia laramiensis is endemic to the Laramie Mountains in Albany and Converse counties in southeast Wyoming (Figure 6). Most known populations are in the northern part of the range within an area approximately 35 air miles in length from southeast to northwest. 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. There are extensive tracts of easily-accessible National Forest land in the southernmost part of the range, but Laramie columbine has not been found there. Locations of *Aquilegia laramiensis* are summarized in Table 2. Complete element occurrence records and maps are on file at WYNDD.

Figure 6. Distribution of *Aquilegia laramiensis*, Laramie Mountains, southeast Wyoming.

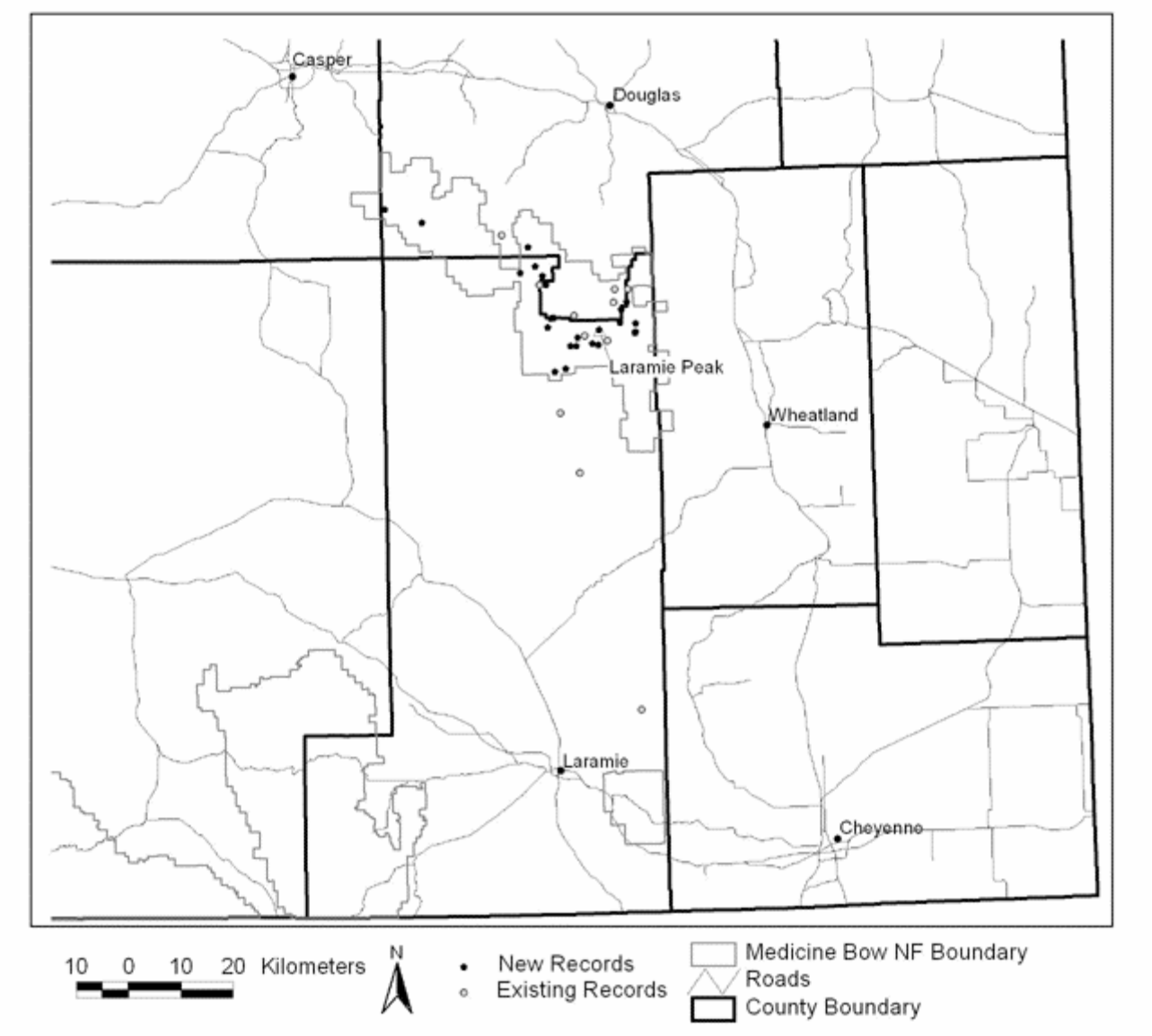


Table 2. Known locations of *Aquilegia laramiensis.*

Occurrence 001
Laramie Range, Antelope Basin.
025N073W SEC 34 TRS APPROXIMATE Last observed: 1900-07-09
BLM RAWLINS FIELD OFFICE Albany County

Occurrence 002
Laramie Range, Ragged Top Mountain, ca 17 miles northeast of Laramie.
017N071W SEC 16 TRS APPROXIMATE Last observed: 1981
STATE OF WYOMING Albany County

Occurrence 003
Laramie Range, ca 1 mi southeast of Buzzard Peak, ca 5 mi northwest of Laramie Peak.
027N072W SEC 20 Last observed: 1979-07-04
Douglas Ranger District, Medicine Bow National Forest Converse County

Occurrence 004
Laramie Range, Cottonwood Canyon at foot of Laramie Peak.
027N071W SEC 31 TRS APPROXIMATE Last observed: 1895-08-04
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 005
Laramie Range, about 3 miles north-northwest of Harris Park.
028N071W SEC 34 Last observed: 1974-06-04
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 006
Laramie Range, north of Laramie Peak off Horseshoe Creek.
028N071W SEC 32 Last observed: 1981-07 Converse County

Occurrence 007
Laramie Range, north of Laramie Peak, cliffs east of Ashenfelder Creek.
027N071W,027N072W SEC 05,07-08,18-20 24,25,35 Last observed: 1988-08-02
Ashenfelder Basin Special Interest Area; Douglas Ranger District, Medicine Bow National Forest Converse County

Occurrence 008
Laramie Range, south side of Tunnel Road, 0.25 miles east of Dodge Creek, northeast of Wheatland Reservoir No. 2.
023N072W SEC 19 Last observed: 1993-07-30 Albany County

Occurrence 009
Laramie Range, Friend Park at base of Laramie Peak near campground, also on ridge system to north.
026N072W,027N072W SEC 04, 33,34 Last observed: 2000-06-25
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 010
Laramie Range, School Section Mountain, ca 18.5 air mi west-northwest of Esterbrook.
029N074W SEC 16 Last observed: 1997-08-14
STATE OF WYOMING Converse County

Occurrence 011
Laramie Range, Big Bear Canyon ca 1.3-1.5 air miles southwest of South Sawtooth Mountain and ca 1.5-1.7 air miles east of Blacktail Peak.
028N073W SEC 28,29 Last observed: 2003-06-21
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 012
Laramie Mountains - northwest end (also known as Deer Creek Range); Deer Creek.
030N077W SEC 27 Last observed: 2003-06-28
Douglas Ranger District, Medicine Bow National Forest Converse County

Occurrence 013
Northwest Laramie Mountains, Box Elder Creek drainage north of Breakneck Hill.
029N076W SEC 4 Last observed: 2003-06-28
STATE OF WYOMING Converse County

Occurrence 014
Laramie Mountains, ridge east of upper Curtis Gulch.
029N073W SEC 30 Last observed: 2003-07-06
Douglas Ranger District, Medicine Bow National Forest Converse County

Occurrence 015
Laramie Mountains, LaBonte Creek drainage just west of Curtis Gulch Campground
28N073W SEC 8 Last observed: 2003-06-21
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 016
Laramie Mountains, LaBonte Canyon just west of Big Bear Canyon.
028N074W SEC 13 Last observed: 2003-06-21
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 017
Laramie Mountains, divide south of LaBonte Canyon, east of Big Bear Canyon.
028N073W SEC 21 Last observed: 2003-07-06
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 018
Laramie Mountains, south side of La Bonte drainage near top of Bear Canyon.
028N073W SEC 27 Last observed: 2003-06-21
Douglas Ranger District, Medicine Bow National Forest Converse County

Occurrence 019
Laramie Mountains, dry unnamed spur of Laramie River off of FS Rd 671
026N073W SEC 36 Last observed: 1998-07-06
STATE OF WYOMING Albany County

Occurrence 020
Laramie Mountains in vicinity of Black Mountain south of Esterbrook.
027N071W SEC 10 Last observed: 2003-06-22
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 021
Laramie Mountains, Black Mountain south of Esterbrook.
027N071W SEC 16 Last observed: 2003-06-22
State of Wyoming Albany County

Occurrence 022
Laramie Mountains, Windy Peak, summit and west side.
027N073W SEC 22, 23 Last observed: 2003-07-05
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 023
Laramie Mountains, ridge east of Indian Peak.
026N073W SEC 35 Last observed: 2003-07-05
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 024
Laramie Mountains, west side of Cottonwood Creek drainage northeast of Laramie Peak.
027N071W SEC 29 Last observed: 2003-06-22
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 025
Laramie Mountains, east side of Cottonwood Creek drainage east of Laramie Peak.
027N071W SEC 26 Last observed: 2003-06-22
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 026
Laramie Mountains, Grouse Creek east of Slick Mountain.
027N073W SEC 34 Last observed: 2003-07-05
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 027
Laramie Mountains, near summit of Laramie Peak.
027N072W SEC 35 Last observed: 2003-07-26
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 028
Laramie Mountains, Albany Peak. Also on upper west slopes of ridge running southwest.
026N071W,027N071W SEC 2, 35 Last observed: 2001-08-06
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 029
Laramie Mountains, Ridge between upper forks of Friend Creek
026N072W SEC 5 Last observed: 2003-06-08
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 030
Laramie Mountains, upper Friend Creek drainage near Bull Gap and Jack Squirrel Peak.
026N072W SEC 7 Last observed: 2003-06-08
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 031
Laramie Mountains, Round Mountain in upper Friend Creek drainage.
026N072W SEC 8 Last observed: 2003-06-08
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 032
Laramie Mountains ca 2 air miles south of Laramie Peak and northwest of Kloer Creek.
026N072W SEC 11 Last observed: 2003-06-24
Douglas Ranger District, Medicine Bow National Forest Albany County

Occurrence 033
Laramie Mountains, upper Arapaho Creek, near Friend Park Trail.
026N072W SEC 10 Last observed: 2003-06-24
Douglas Ranger District, Medicine Bow National Forest Albany County

Habitat

Aquilegia laramiensis has been documented at elevations ranging from 6300 ft on the east side of the Laramie Mountains to 10,100 ft near the summit of Laramie Peak. Most of the columbine populations found in 2003 were on large rock outcrops to several hundred feet in height that dominated the landscape. Some areas, such as ridge crests, were essentially all rock outcrop, sometimes several miles in length (Figure 7). At only a few sites where *Aquilegia laramiensis* was found were the rock outcrops small enough to be well-shaded by tree cover. In all situations, the columbine occupied only a very small fraction of the area covered by rock, with distribution quite patchy and intermittent. Plants are found on small shaded microsites such as ledges, bases of outcrops, large crevices and soil pockets among boulders (Figure 8).

As described by earlier workers, Laramie columbine often is associated with northerly-facing granite outcrops. However we found that it is not restricted to northerly aspects. Instead, it grows on well-shaded, often level microsites, with shade provided by aspect, position or topography, such as under overhanging rock, inside large crevices or among large boulders (Figure 8). The species appears to require some soil development. It was found growing in soil pockets on or adjacent to rock outcrops, rather than growing directly out of crevices. Earlier descriptions characterizing habitat as pockets of "rich soil" are not accurate. Many of the microsites had coarse, poorly-developed soil typical of soil pockets on rock outcrops.

Figure 7. Extensive outcrops of granite near Laramie Peak. *Aquilegia laramiensis* occurs as widely-scattered patches on favorable microsites (Horning photo).

Figure 8. Photographs of *Aquilegia laramiensis* habitat. Top: under overhanging rock at base of outcrop. Bottom: on soil pockets on small ledges. (Horning photos)

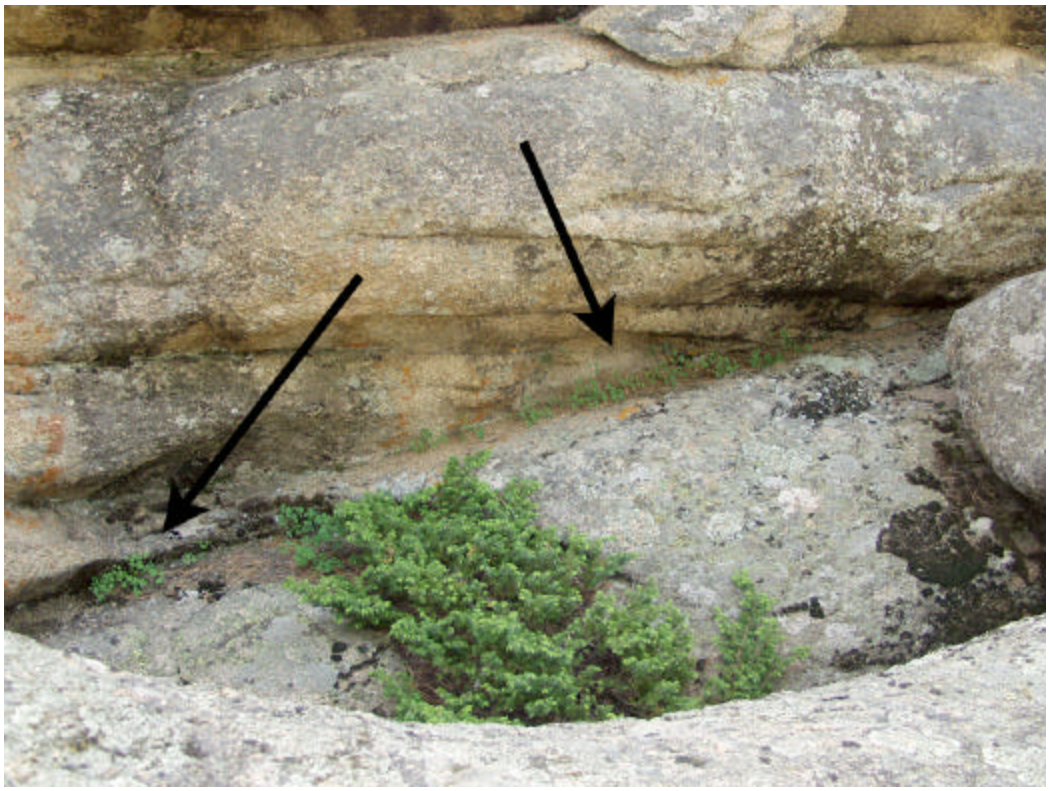


Figure 8 continued. *Aquilegia laramiensis* habitat. Top: on soil pockets among boulders. Bottom: on flat microsites in gully shaded by rock walls (Horning photo).

Field work in 2003 focused on sites thought most likely to support Laramie columbine, with large rock outcrops with prominent steep faces and shaded microsites. However, the columbine has been found by other workers at somewhat drier sites south of the study area. Refsdal found *Aquilegia laramiensis* in crevices in outcrops less than 100 ft high in sagebrush grassland with scattered conifers (Fertig and others 1994). Packer (2000) found it in "sagebrush grassland among boulders."

Not all Laramie columbine populations are in areas underlain by granite, and not all granite provides habitat for the species. With the exception of the Eagle Rock site southeast of Laramie, all 2003 surveys were in areas underlain by the Laramie granite (Johnson and Hills 1976; Figure 2). However, there were obvious differences in types of granite seen. With the exception of one site near Box Elder Creek, *Aquilegia laramiensis* was absent from a coarse-grained reddish granite found in the northwestern part of the study area, west of the Fetterman Road. 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 Laramie columbine occurs on Ragged Top Mountain east-northeast of Laramie, which is underlain by gneiss (McCullough 1974). Refsdal's 1993 collection halfway between Laramie Peak and Ragged Top also is in an area of gneiss outcrops. These areas were not included in the 2003 survey.

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 columbine 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. In 2003, a single site was surveyed in this area, at Eagle Rock. The granite at this site is finer grained than the Sherman granite, and forms more prominent steep faces. However, the northerly aspects were not steep, and all aspects seemed too dry for suitable columbine habitat.

At sites surveyed in 2003, the vegetation adjacent to rock outcrops most commonly was coniferous forest dominated by *Pinus contorta* or *Abies lasiocarpa*. Stands of quaking aspen were occasional. A fairly consistent set of associated species was found at columbine microsites (Table 3). *Aquilegia laramiensis* was found growing immediately adjacent to other species at some sites, and as isolated patches at others.

Table 3. Associated plant species commonly found at *Aquilegia laramiensis* microsites.

Scientific Name	Common Name
Cystopteris fragilis	fragile fern
Heuchera parvifolia	little-flowered alumroot
Holodiscus dumosus	glandular oceanspray
Physocarpus monogynus	mountain ninebark
Polemonium brandegei	Brandegee's jacob's-ladder
Potentilla fissa	big-flower cinquefoil
Rubus idaeus	red raspberry
Senecio rapifolius	Idaho ragwort
Woodsia scopulina	Rocky Mountain woodsia

Population Size and Trends

There are 33 documented occurrences of Laramie columbine (Table 2; element occurrence records and maps are on file at WYNDD). Two are historical records without precise locations. Twenty-one are occurrences discovered during the 2003 field project.

Most populations are small in area and numbers of plants. On small outcrops, we typically found 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 sampling of potential microsites. Some may be inaccessible entirely. Though it was difficult to estimate population size at larger sites, it was clear that the Laramie columbine occupies only a tiny fraction of the area covered by rock.

Longevity of individuals of *Aquilegia laramiensis* and the ability of populations to persist at a site are unknown. There is no information available on trends in numbers of populations or population sizes.

Impact of fire on *Aquilegia laramiensis* is of interest to land managers. Several occurrences found in 2003 are within the perimeter of the 2002 burn northeast of Laramie Peak. No pre-burn data are available for the Laramie columbine, and it is not known if any populations were lost. However, at some sites burned trees were seen next to healthy columbine populations, and apparently the species can survive nearby burning in some cases. Possible impacts of fire are discussed further under **Existing and Potential Threats**.

Population Biology and Ecology

During the 2003 field season, plants were seen in flower from the beginning of survey on June 8 until the last population was found on July 26. By this time, fruits also were present. Dried fruits from the previous season(s?) were found at many sites.

No indications of browsing or pests were observed. Nothing is known regarding pollination and seed dispersal mechanisms for this species.

Current Management

Most known *Aquilegia laramiensis* sites are on lands managed by Medicine Bow National Forest, Douglas Ranger District. The columbine has been collected at five sites managed by the State of Wyoming, although one collection was made in 1925, and the location is not precise (WYNDD 2004). The species has been reported as occurring on BLM land based on a collection made in 1900 by Aven Nelson in Antelope Basin. However, the location is not precisely known, and ownership could be private or State. The BLM does manage lands south of the 2003 study area with good potential habitat for the Laramie columbine (pers. obs. by the authors).

All public lands where the columbine occurs currently are managed for multiple use. The species is found in the Ashenfelder Basin Special Interest Area north of Laramie Peak. Multiple use is not necessarily restricted in this area, but the Forest Service is instructed to emphasize management for special botanical characters (Jones 1989). Potential habitat for *Aquilegia laramiensis* was identified in the LaBonte Canyon Research Natural Area, but no survey for the species was done (Jankovsky-Jones and others 1995).

Existing and Potential Threats

In the northern Laramie Mountains, lands where *Aquilegia laramiensis* occurs are managed for multiple use, including timber harvest, grazing and recreation. There has been

concern that timber harvest in areas of columbine populations could remove needed shading. However, most sites surveyed in 2003 were not shaded by tree cover but by aspect or overhanging rock. In addition, most sites were not within harvestable stands of trees. Sites surveyed in 2003 are basically inaccessible to livestock without extreme effort, and provide little forage.

Collecting for cultivation has been identified as a potential threat at some sites. Our work in 2003 confirmed this potential. Populations are relatively small, and could easily be destroyed by collectors at accessible sites. The potential *overall* impact of collecting on species viability is more difficult to evaluate. Many of the sites surveyed in 2003 were difficult to access, and there remain many unsurveyed sites with potential habitat that are even more difficult to reach. However with large increases in human population and improved access in the area, significant impact is conceivable, though it is hard to imagine that degree of change at this time.

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, position and topography rather than tree cover. Laramie columbine apparently can tolerate nearby fire, at least in some cases. It was found in several areas where fire had come quite close in 2002. For example, on the summit of Black Mountain, burned trees were standing next to rock outcrops within 10-25 ft of microsites where the columbine was growing.

Discussion

Information Needs

Additional survey will surely yield additional populations of *Aquilegia laramiensis*, for example on large rock outcrop systems in the area of Laramie Peak. However, access to these sites is difficult and time-consuming, and in the absence of threats, it seems more important to determine the species' range to the south. A few isolated collections have been made in areas of BLM and private ownership in the central part of the Laramie Mountains, and additional survey is needed.

Surveys for *Aquilegia laramiensis* is needed in the LaBonte Canyon Research Natural Area to determine if the species occurs in this protected area. Potential habitat for the columbine has been identified in the canyon (Jankovsky-Jones and others 1995).

Very little is known about the life-history and biology of the species. Currently this type of information does not appear to be a high-priority need for management and viability of the species.

Because no pre-burn information on Laramie columbine distribution and abundance were available prior to our surveys, it was impossible to evaluate impacts of fire. Observations suggested that the species can tolerate nearby burning in some cases. If fires occur in areas of known columbine populations in the future, it would be useful to resurvey those sites for impacts. Similarly, if prescribed fire is planned in the northern Laramie Mountains, surveys for *Aquilegia laramiensis* should be done pre-burn, with reassessment post-burn.

Conservation Status

Prior to the 2003 field season, Laramie columbine had been documented at 12 sites. Two were considered historical without precise location information. The species appeared to be rare and restricted in distribution. Nothing was known about trends, and discussion of threats and management needs was largely speculative. Little data were available beyond location for most populations.

It was suspected that additional columbine locations would be found, as there was much unsurveyed potential habitat in the northern Laramie Mountains, and this proved to be the case. There are now 33 known populations. However the overall range of the species remains limited, and populations are small.

There are no obvious threats to overall viability of the Laramie columbine. At a few accessible sites, collecting for cultivation could become a concern, but the rugged habitat of the columbine generally is difficult to reach. Grazing, timber harvest and recreation do not pose obvious threats at this time.

New sites and lack of threats suggest that conservation ranks be reconsidered. However, limited range and small population sizes suggest caution regarding downlisting. We recommend that additional survey for the species be done first, in the southern part of its range where land ownership, land use and access may present problems not recognized at this time.

Predictive Habitat Modeling

For this project, predicted distribution maps produced with habitat modeling were of limited use for survey site selection. Identifying suitable potential habitat for *Aquilegia laramiensis* requires much finer level of detail than is available as Geographic Information System (GIS) data at this time. If we had been less familiar with the area, the maps might have been helpful in identifying general areas for surveys. However, we discovered on our first day of field work that good potential habitat existed outside of predicted areas, and for that reason did not use the maps as a first cut for site selection. Familiarity with the area, topographic maps and drive-bys were the most useful tools for selecting sites.

Of the 46 sites surveyed, 24 were within areas of predicted habitat for the Laramie columbine (Fertig and Thurston 2003). Of these, 15 supported columbine populations. Of the 22 survey sites selected outside of predicted areas, eight were found to have populations of columbine, including several that were relatively large.

Fertig and Thurston (2003) found their models to be conservative in predicting areas with low false positive rates, but we did not reach the same conclusion. We did not randomly test sites within predicted areas, as we could not justify using time better spent surveying high potential sites. However, even though sites we selected within predicted areas included what appeared to us to have high potential, we found no columbine populations at nine out of 24. If we had surveyed a randomly-selected set, the false positive rate would have been even higher. This is in part an artifact of scale. Given that the Laramie columbine is restricted to a limited set of microsites on rock outcrops, occurring only sparsely over large areas of rock, it is not surprising that it was difficult to accurately predict positive areas at the coarse scale used in the model.

Of greater concern are false negative predictions. Of the 22 sites surveyed outside of predicted habitat, *Aquilegia laramiensis* was found at eight. Two included the largest populations found during the field season (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 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.

Fertig and Thurston (2003) relied on computer analyses of small data sets (rare plant occurrences) and limited GIS data for characterizing habitat. It is not surprising that the maps were of limited use. The Black Hills example illustrates what is needed to make rare plant habitat modeling effective in identifying survey sites – familiarity with the species and its habitat needs. If GIS data are available for relevant habitat characteristics, predictive habitat modeling can be helpful. Obviously, this approach requires that habitat models be designed on a species-by-species basis, and for the area under consideration. For *Aquilegia laramiensis*, a model with much finer detail regarding topography (relief) and rock type is needed, and even then may not be as useful as topographic and geologic maps, drive-bys and over-flights.

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Appendix A. Predictive habitat modeling for *Aquilegia laramiensis.* From:

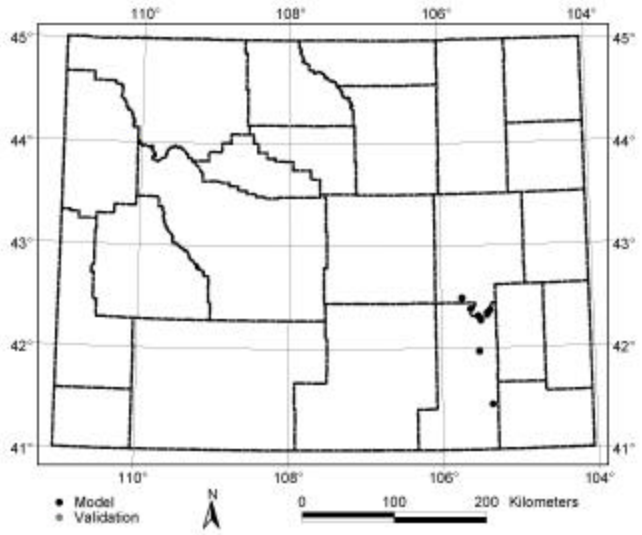
Fertig, W. and R. Thurston. 2003. Modeling the potential distribution of BLM Sensitive and USFWS Threatened and Endangered plant species in Wyoming. Unpublished report prepared for the BLM WY State Office by the Wyoming Natural Diversity Database, Laramie, WY.

Abstract

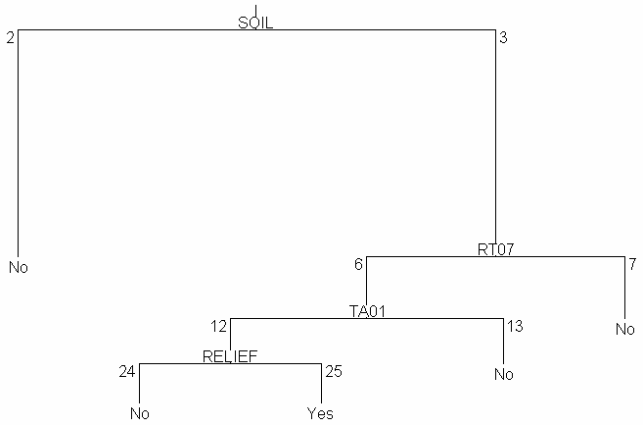
Predictive modeling of plant distributions rests on the assumption that correlations exist between the presence/absence of a species and selected climate, topographic, substrate, and land cover variables. Once these underlying patterns are determined, maps can be created in GIS that identify all areas that meet the specific conditions for a given species. Such maps can be used to prioritize areas for field surveys of rare plants or assist decision makers in project clearance activities. Using classification tree analysis, we developed correlational models for 44 Wyoming plant species listed as BLM Sensitive or Threatened or Endangered under the Endangered Species Act. Presence/absence of each species was the response variable in the models and was derived from location records of the Wyoming Natural Diversity Database and Rocky Mountain Herbarium. Environmental variables, including total monthly precipitation, average monthly air temperature, monthly shortwave radiation, number of wet days, growing degree-days, local topographic relief, bedrock and surficial geology, soils, elevation, and land cover, were used as predictors. Location data were randomly subdivided into model-building and validation data sets to test the classification success of the final models. Species with fewer than 16 present points were also modeled using the range/intersection method in which the range of environmental values at all present sites of a species were intersected in GIS to identify areas with similar attributes across the state. Wetland plants were modeled with classification tree or range/intersection methods and the resulting models were then overlaid with a riparian/aquatic model to highlight suitable wetland areas within the species' predicted range. We found that the distribution of rare species in Wyoming was most strongly correlated with specific bedrock and soil types, but was also influenced by topographic relief, land cover, and various monthly precipitation and temperature values. Overall, our models were conservative in the area predicted for these species and typically had low false positive or commission error rates. Due to the limited number of samples available, we were unable to determine the false negative or omission error rates with validation data for many of the plant species. For those that could be tested, the omission error rates were moderate to high. The distribution maps produced by correlational modeling did an excellent job of identifying areas where rare species are unlikely to occur and did a good job of highlighting areas of potential habitat that warrant additional on-the-ground survey.

Aquilegia laramiensis A. Nels.

Known Distribution in Wyoming



Classification Tree Used in Model Building



Numbers of Points for Modeling

	Model	Validation	Total
Known Present	8	0	8
Known Absent	960	206	1166
Total	968	206	1174

Classification Tree Output

Node_Num) Node_Def Node_Size (Num_No,Num_Yes) (Pct_No,Pct_Yes) Node_Type
1) root 968 (960,8) (100,100) Yes
2) SOIL:WY01,WY06C,WY07C,WY08C,WY10,WY11,WY14, WY15,WY16C,WY17C,WY18,WY20,WY23,WY27,WY34, WY35,WY36,WY38C,WY40C,WY41,WY42,WY44 928 (928,0) (96.7,0) No *
3) SOIL:WY31C,WY45 40 (32,8) (3.3,100) Yes
6) RT07<24.255 19 (11,8) (1.1,100) Yes
12) TA01<-5.505 12 (4,8) (0.4,100) Yes
24) RELIEF<92.5 3 (3,0) (0.3,0) No *
25) RELIEF>92.5 9 (1,8) (0.1,100) **Yes ***
13) TA01>-5.505 7 (7,0) (0.7,0) No *
7) RT07>24.255 21 (21,0) (2.2,0) No *

Data Source (Points)

Wyoming Heritage Program (8)

Path Composition and Likelihood

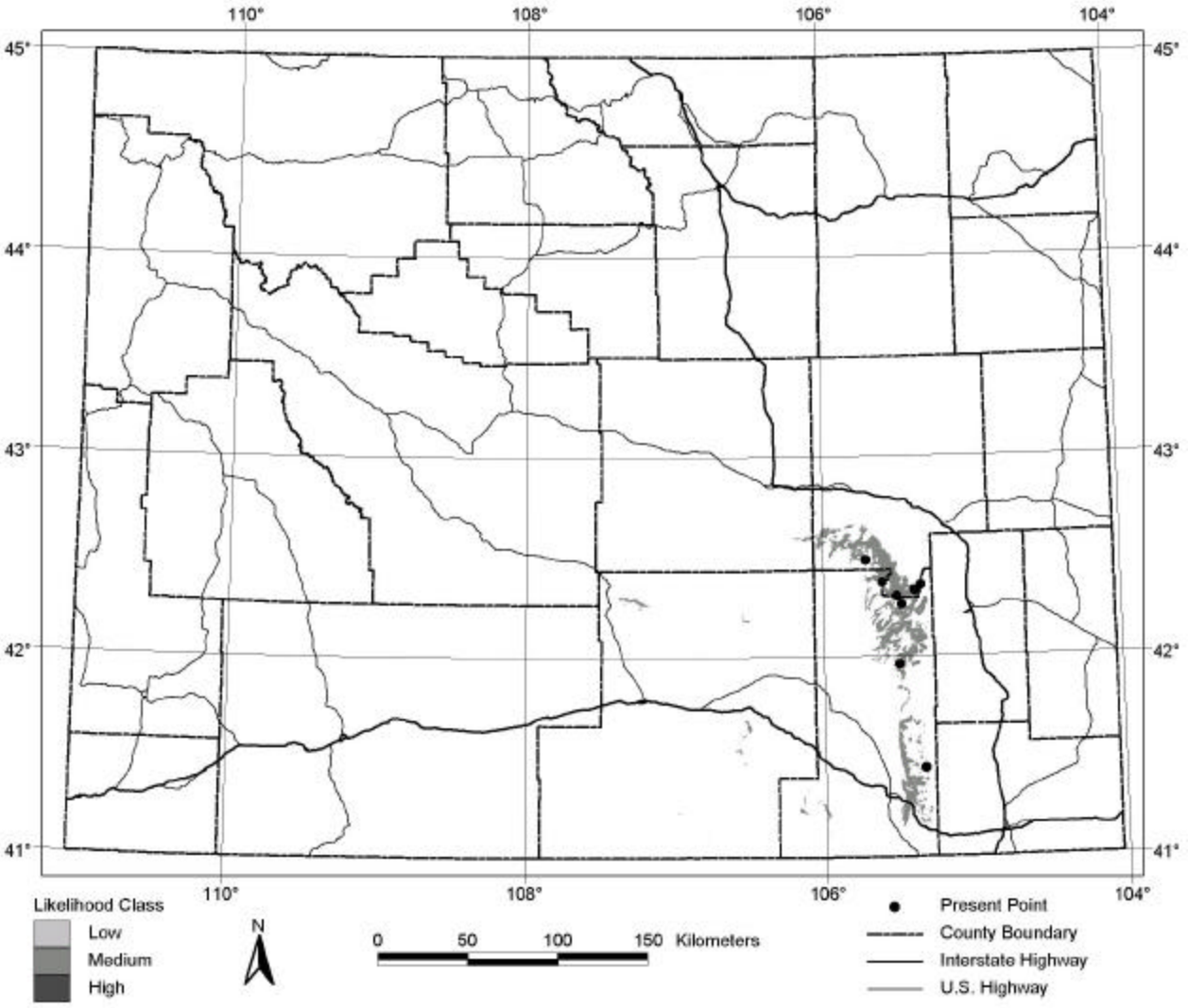
Yes Path	Node List	% of Present Points	Likelihood Class
a	25, 12, 6, 3	100.0	Medium

Modeling Notes

Independent variables: ELEV, RELIEF, PT01, PT04, PT07, PT10, NWD, RT01, RT07, TA01, TA04, TA07, TA10, TX07, NFD, GDD, BEDGEOL, LANDCOV, SOIL, SURFGEOL
Minimum number of observations before split: 1
Minimum node size: 2
Minimum node deviance: 0.01
Minimum percent for pruning: 0.1
Biomes used for validation: FOOT, IDGRS, RMF

LARAMIE COLUMBINE

Predicted Distribution in Wyoming



Classification Rates

Model-Building Points

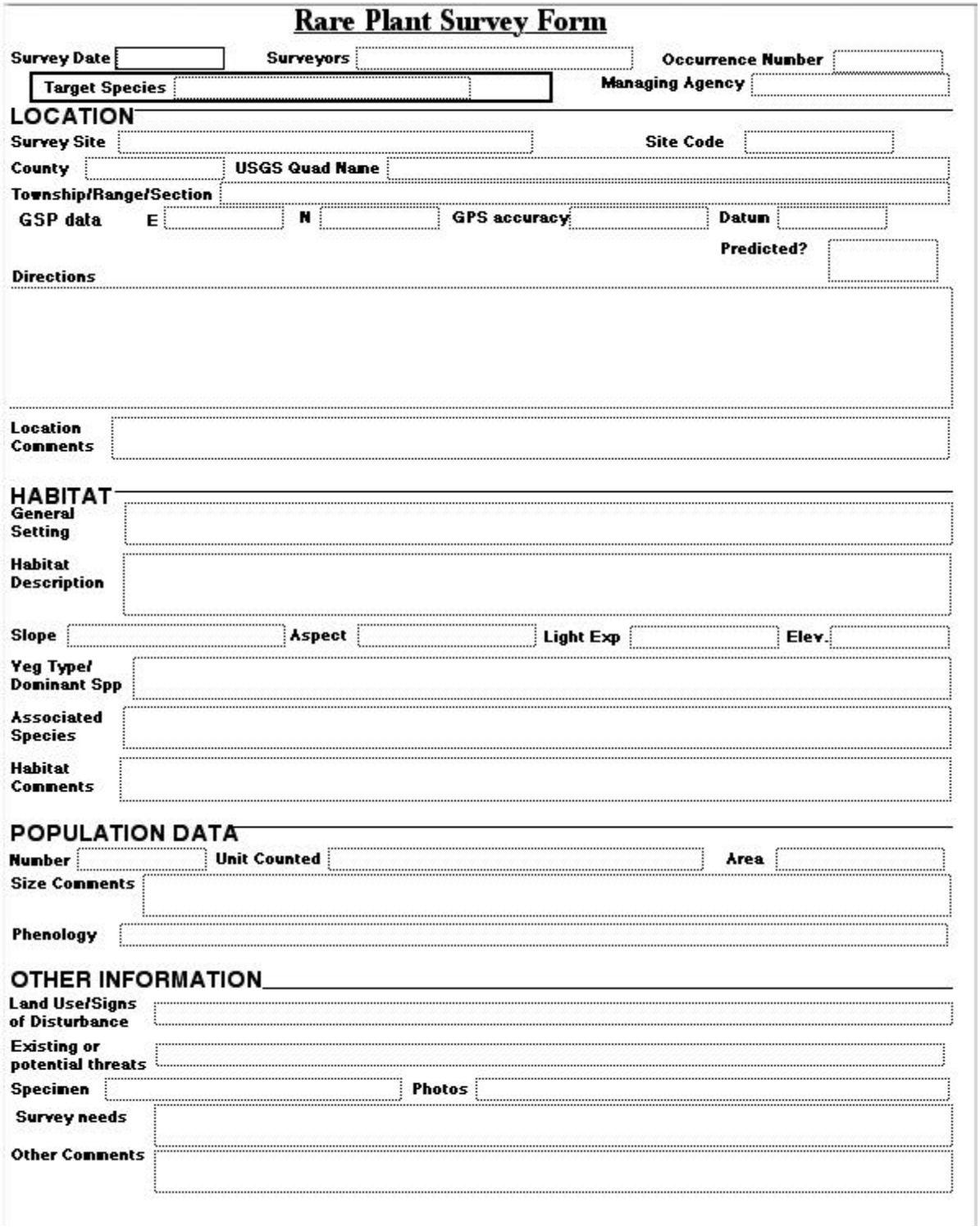
	Model Present	Model Absent		
Known Present	7 / 8 87.5%	1 / 8 12.5%	Total Correct	967 / 968 99.9%
Known Absent	0 / 960 0.0%	960 / 960 100.0%	Total Incorrect	1 / 968 0.1%

Validation Points

	Model Present	Model Absent		
Known Present	0 / 0	0 / 0	Total Correct	205 / 206 99.5%
Known Absent	1 / 206 0.5%	205 / 206 99.5%	Total Incorrect	1 / 206 0.5%

Area of Predicted Distribution: 1,691 km^2 (0.67% of WY)

Appendix B. Field form used in 2003 surveys for *Aquilegia laramiensis*.



Rare Plant Survey Form

Survey Date | Surveyors | Occurrence Number

Target Species | Managing Agency

LOCATION

Survey Site | Site Code

County | USGS Quad Name

Township/Range/Section

GSP data E | N | GPS accuracy | Datum

Predicted?

Directions

Location Comments

HABITAT

General Setting

Habitat Description

Slope | Aspect | Light Exp | Elev.

Veg Type/ Dominant Spp

Associated Species

Habitat Comments

POPULATION DATA

Number | Unit Counted | Area

Size Comments

Phenology

OTHER INFORMATION

Land Use/Signs of Disturbance

Existing or potential threats

Specimen | Photos

Survey needs

Other Comments