Monitoring *Rubus arcticus* ssp. *acaulis* (dwarf raspberry), Bighorn National Forest, Wyoming 2000-2017

Prepared for the Bighorn National Forest

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May 2018

Agreement No. 16-CS-11020200-026

ACKNOWLEDGEMENTS

This project reflects the initiative and ongoing commitment of Bighorn National Forest as coordinated by Bernie Bornong and supported by Greg Karow, and with the foundation laid by fieldwork of Stephanie Mills, Katharine Zacharkevics, Matthew Spann, Karla Ward and Katharine Brown. The first compendium of *Rubus articus* ssp. *acaulis* information and the study framework were the works of Walter Fertig, Wyoming Natural Diversity Database (WYNDD) in collaboration with Bighorn National Forest. Forest Service employees assisting Fertig included Kevin O'Dea and JoAnn Storlie. Other Forest Service employees carrying out the ensuing monitoring included Susan Bell, B. Boden, Beth Davidson, Tucker Galloway and Andrew King. Separate from the monitoring work, James Zier, contracting with WYNDD, expanded documentation by discovering a new population as part of sensitive species surveys in fen habitat of Bighorn National Forest. Jennifer Whipple of Yellowstone National Park provided original data and 2011 updates from the Park to WYNDD. Special thanks are extended to individuals who directly participated in, or otherwise contributed to, joint 2017 work: Karla Warder, Katharine Brown and Bernie Bornong. The current project was funded as a challenge cost share - Agreement No. 16-CS-11020200-026 between Bighorn National Forest and WYNDD.

ABSTRACT

The purpose of this project was to provide analysis of *Rubus articus* ssp. *acaulis* (dwarf raspberry) monitoring data (2000-2017) and to update state status information on the species. Monitoring results indicate that one of the six transects established for monitoring the Sourdough Creek population exhibits significant increase, and the other five show decline. This is consistent with a hydrologically-dependent species showing different patterns in segments of the population with different local hydrology conditions, though it does not prove causation. This report offers a framework for interpreting results and landscape context. It also provides an update to the statewide species status of *R. a.* ssp. *acaulis,* including populations discovered since the start of monitoring.

Citation for this report:
Heidel, B. 2018. Monitoring *Rubus articus* ssp. *acaulis* (dwarf raspberry), Bighorn National Forest, Wyoming, 2000-2017. Report prepared for the USDA Forest Service – Bighorn National Forest by the Wyoming Natural Diversity Database - University of Wyoming, Laramie, Wyoming.

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INTRODUCTION

Rubus arcticus var. *acaulis* (syn. *R. acaulis*; dwarf raspberry, also called northern blackberry, nagoonberry) has been monitored by Bighorn National Forest (NF) almost continuously from 2000-2017. The monitoring design was set up in collaboration with Wyoming Natural Diversity Database (WYNDD), and the most recent reading in 2017 and analysis were also conducted in collaboration. The primary purpose of this project was to analyze the multi-year monitoring data, and secondarily, to update the species' status information.

Rubus arcticus var. *acaulis* was officially designated as Sensitive by the USDA Forest Service in the Rocky Mountain Region (Region 2) National Forests of Colorado and Wyoming in 1993 (Estill 1993). It was recognized as Sensitive in the current Bighorn NF Resource Management Plan (USDA Forest Service 2005), and will be addressed in a pending Region 2 sensitive species list updates (T. Johnson, pers. commun. to B. Heidel). When originally designated, it was only known in the state from a single population in Yellowstone National Park and a vague, historical collection record from the Bighorn Range in 1900.

Stephanie Mills and Katharine Zacharkevics, ecology field technicians with Bighorn NF, discovered *Rubus arcticus* var. *acaulis* in the Big Horn Mountains in 1994 while conducting surveys on Sourdough Creek for the proposed Tie Hack Dam. Zacharkevics conducted expanded surveys on Sourdough Creek in 1995 and located six subpopulations numbering several thousand stems along a 2.4 km (1.5 mile) stretch, southwest of the proposed dam area.

Surveys for *Rubus arcticus* ssp. *acaulis* were subsequently conducted in other drainages as part of Forest Service work in 1994-95 by Zacharkevics and Mills. The population dynamics and potential management needs of *R. a.* ssp. *acaulis* were poorly known, so in 1999, Bighorn NF contracted WYNDD to conduct an ecological assessment of the Sourdough Creek watershed, establish a pilot monitoring program to provide information on the population trend of *R. a.* ssp. *acaulis* at this site, and to further survey potential habitat in adjacent watersheds to determine if more suitable habitat may be present. Walter Fertig conducted the 1999 fieldwork to expand the body of information known about the species on Sourdough Creek and provide a monitoring framework, expanding the distribution of the species to a total of ten discrete locations (subpopulations) on Sourdough Creek. It was not found during surveys on fifteen other drainages in the 1994-1995 or 1999 fieldwork (Appendix C, Fertig 2000).

More recently, a technical conservation assessment was prepared for *Rubus arcticus* ssp. *acaulis* (Ladyman 2006), including a literature review and compilation of data from across Region 2 (Colorado and Wyoming). A new Bighorn NF population was documented on Muddy Creek by Matthew Spann in 2006 in the course of surveys for a proposed timber sale. The next new Bighorn NF population was discovered in Frying Pan Lake by Jim Zier in 2010 the course of surveying for sensitive species of fen habitats (Heidel 2011). Most recently, Karla Warder and Katharine (Kat) Brown discovered a new population on Pole Creek in the course of 2017 willow browse studies. Warder was later able to relocate and get more detailed information on the Frying Pan Lake population as well.

Throughout this report, *Rubus arcticus* ssp. *acaulis* is referred to by its full name or just as "the species" because, of the three subspecies, only one is present in Wyoming. It was referred to as *R. acaulis* in its original designation as Sensitive, in the current Wyoming flora (Dorn 2001) and in prior WYNDD reports and databases. The current nomenclature follows taxonomic treatment in the *Flora of North America* (Alice et al. 2014) and as updated in the PLANTS database (2018). *Rubus arcticus* ssp. *acaulis* is restricted to North America and is present as far south Oregon and Maine on the coasts, Colorado in the Rocky Mountains, and from Minnesota to Michigan in the Great Lakes. The two other subspecies are restricted to more northern latitudes in North America, and their distributions include other continents.

The Sourdough population of *Rubus arcticus* ssp. *acaulis* remains the most extensive of those known in Wyoming, and the largest by available stem count estimates. So, this monitoring study remains relevant in its original objectives. A Muddy Creek monitoring study was initiated in 2015 in light of a proposed timber sale, and results from it are incorporated for comparison. Monitoring results are followed by a report of state species information, which provides important context for monitoring results.

METHODS

<u>Monitoring of *Rubus arcticus* ssp. *acaulis* on Sourdough Creek</u>
The monitoring protocol developed by Fertig for the Sourdough Creek population of *Rubus arcticus* ssp. *acaulis* (2000) was intended to be repeatable, consistent, and cost-efficient in collecting quantitative data on trends, rather than testing specific hypotheses about the relationship between environmental variables and the distribution of this species.

Fertig established two permanent monitoring macroplots in marsh habitat (planeleaf willow/beaked sedge; *Salix planifolia/Carex utriculata* communities), and three permanent belt transects in spruce woods habitat (Engelmann spruce/twinberry forests; *Picea engelmannii/Linnaea borealis*) along the middle and lower reaches of Sourdough Creek, respectively. The macroplots were set up for randomized sampling using a 0.2 x 0.5 m Daubenmire frame, and the belt transects were set up for continuous sampling within 1 m x 2 m areas.

Pilot monitoring studies in 1999 were conducted to assess baseline abundance, density, and frequency of three *Rubus arcticus* ssp. *acaulis* subpopulations along Sourdough Creek (these data are summarized in Appendix B of Fertig 2000). A variety of plot sizes were employed to test the efficiency and statistical relevance of different plot designs and sampling strategies. Analysis of the preliminary results for stem number and density (Appendix C of Fertig 2000) indicated that a prohibitively large number of samples would be required for these results to be statistically relevant at 80, 90, or 95% confidence interval within 5-20% of the sample mean. These data still have some value for elucidating general patterns of density and population size, but due to statistical concerns the numbers should not be extrapolated across the entire population. Frequency data, however, fell within the desired 30-70% range for baseline data, allowing future shifts in abundance or distribution to be readily observed (Elzinga et al. 1998). Ultimately, Fertig decided to count all stems of *R. a.* ssp. *acaulis* and classify them by growth form (reproductive –

i.e., flowering or fruiting vs. vegetative). A 0.2 x 0.5 m Daubenmire frame was also used in the upper right hand corner of each 0.4 x 1 m grid to measure presence or absence of *R. a.* ssp. *acaulis* for frequency monitoring.

In 2000, the 1999 study design was revised by Bighorn NF, adding a planeleaf willow/beaked sedge sample area, and using continuous sampling along belt transects in all three planeleaf willow/beaked sedge sample areas. The six permanent belt transects monitored in 2000 were in the same locations as 1999 sample areas, and though transect lengths varied, the frequency data were comparable over time. The replacement of species' stem counts with presence/absence data by frame also greatly reduced the amount of time required, such that the monitoring could be conducted by a team of two within one day's time.

Sourdough Creek monitoring *Rubus arcticus* ssp. *acaulis* transects were placed in areas of high density within the two general kinds of habitat (marsh and spruce woods). Most transects were aligned parallel to the creek because most occupied habitat is located within 5 m of the stream channel. The placement of monitoring transects among the ten discrete population segments is summarized in Table 1. The six transects cover a total sample area of 65.4 m².

Table 1. Transect Placement and Local Population Attributes of *Rubus arcticus* ssp. *acaulis* along Sourdough Creek (Fertig 2000, with addition of transect information). They are listed from upstream to downstream.

Orig. ID*	**Transect no. and length**	**Shape ID**	**App. # of stems**	**App. extent of occupied habitat**	**Habitat**
A*	5 – 16.8 m	56556	3000-6000	Ca 7 m wide x 0.1 km long stream segment	Planeleaf willow/beaked sedge
B*	3 – 16 m, 4 – 14.8 m	56554	3000-6000	25-30 m wide x ca 0.15 km long stream segment	Planeleaf willow/beaked sedge
B1	-	56553	50-75	1 x 3 m	Planeleaf willow/beaked sedge
C	-	56552	200	Ca 5 x 10 m	Planeleaf willow/beaked sedge
D	-	51550	50-100	Ca 5 x 50 m	Planeleaf willow/beaked sedge
D1	-	51548	25-50	Ca 10 x 30 m	Planeleaf willow/beaked sedge
E*	1 – 6 m, 1.5 – 6 m, 2 – 5.8 m	51547	10,000-15,000	Ca 3 m wide x 0.3 km long stream segment	Planeleaf willow/beaked sedge & Engelmann spruce/twinberry
F	-	51546	10,000-15,000	Ca 3 m x 0.1 km long stream segment	Engelmann spruce/twinberry
G	-	51545	15,000-20,000	Ca 6 m x 0.3 km stream segment	Engelmann spruce/twinberry
H	-	51544	10,000-15,000	Ca 6 m x 0.3 km stream segment	Engelmann spruce/twinberry

*Polygons that contain monitoring transects

Monitoring was conducted by Bighorn NF in early summer of ensuing years, timed during, or close to, flowering of *Rubus arcticus* ssp. *acaulis* for consistency in detection and growth stage. It was repeated from 2000-2011, with a pause, and extended from 2014-2017. One- to three-person teams (usually two-) conducted monitoring of all six transects in one day (except for 2007 gaps).

Monitoring of *Rubus arcticus* ssp. *acaulis* on Muddy Creek

In 2006, a new population of *Rubus arcticus* ssp. *acaulis* was discovered by Matthew Spann (Bighorn NF) as part of a timber clearance survey. In 2015, as the prospect of a timber sale was being addressed on adjoining slopes, a monitoring study was implemented and re-read in 2016. Plans for the timber sale ended, but this transect was reread in 2017 in part to compare three years of Muddy Creek results with the corresponding three years of data on Sourdough Creek. Study design followed conventions of Sourdough Creek, with three permanent belt transects in areas that include high density, and recording of species' frequency within Daubenmire frames (Table 2). Files on hand in the Bighorn NF office provided record of study design and site conditions.

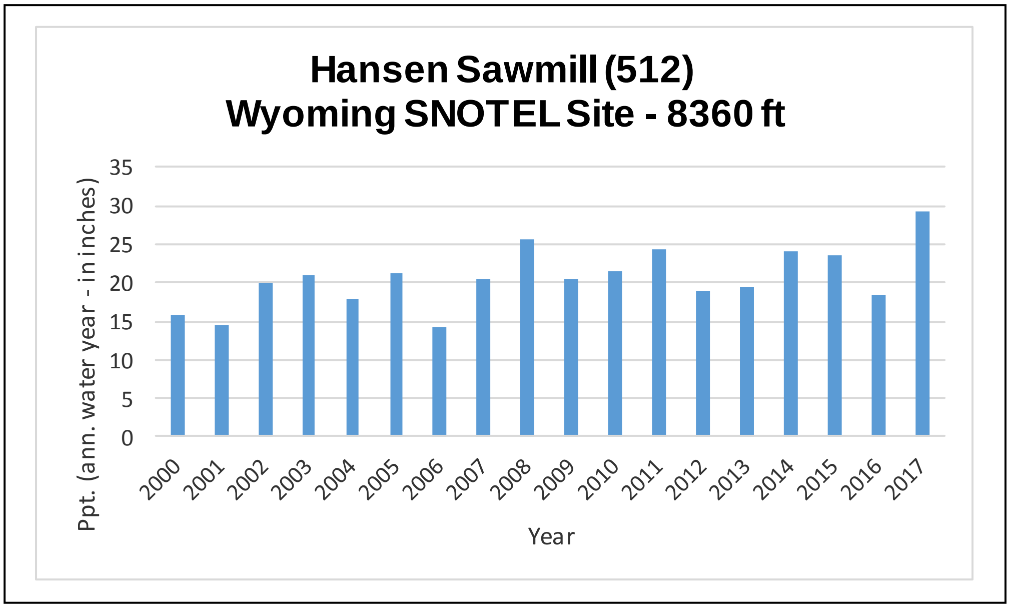
Table 2. Transect Placement and Local Population Attributes of *Rubus arcticus* ssp. *acaulis* along Muddy Creek (Bighorn NF file notes.) They are listed from upstream to downstream.

Transect no. and length	**Shape ID**	**Habitat**
1 – 16 m	51807	Willow thickets of *Salix planifolia* and *S. geyeriana* with dense grass cover and little or no hummock development near creek.
2 – 16 m	51807	Willow thickets of *Salix planifolia* and *S. geyeriana* with dense grass cover and little or no hummock development near creek.
3 – 16 m	51807	Willow thickets of *Salix planifolia* and *S. geyeriana* with dense grass cover and little or no hummock development near creek.

The Sourdough Creek monitoring report by Fertig (2000) and the Muddy Creek sensitive plant survey report by Matthew Spann and later monitoring information by others provided detailed habitat information and population size information. They are incorporated into the species status section, which is updated to represent all four extant populations on Bighorn NF. Supplementary data were collected on Sourdough Creek in the 2017 fieldwork (soil moisture levels between transects) and data was also compiled from the nearest SNOTEL station to address annual precipitation levels (2000-2017) as context for monitoring results.

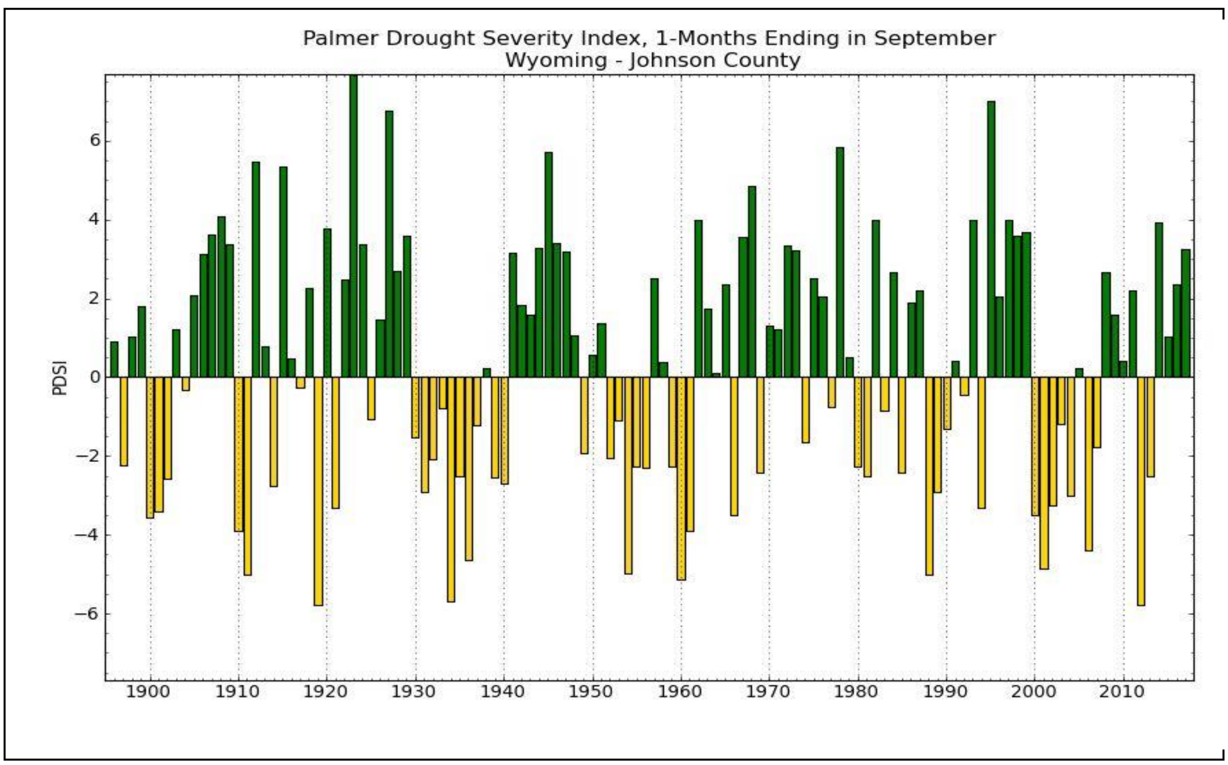
Annual precipitation values have ranged from 14.2" to 29.3" at the nearest SNOTEL monitoring station (Figure 1) over the course of the monitoring period (2000-2017; as annual water years). The lowest annual precipitation total was in 2006 and the highest was in the most recent year (2017). The first two years of monitoring, in 2000 and 2001, also marked low years. The early and late values might skew the trend. There is an overall positive trend in annual precipitation during the monitoring period.

Figure 1. SNOTEL annual water year totals for Hansen Sawmill Station (USDA NRCS 2018)



A long-term representation of weather conditions in the monitoring period is shown by the Palmer Drought Severity Index for Johnson County, WY since the start of record-keeping (1895-2017) over the 12-month period ending in September of each year (i.e., the water-year)(USDI NOAA Westwide Drought Tracker 2018). It indicates that 2000-2004, 2006-2007, and 2012-2013 were drought years, on par with drought periods in the 1930's and 1950's (Figure 2).

Figure 2. Palmer Drought Severity Index (PDSI) trends in Johnson County, Wyoming (1895-2017)



The statistical test used for evaluating monitoring results were laid out by Fertig (2000), and are reprinted in Table 3.

In addition, pilot sampling of soils was conducted by removing a core of about 15 cm depth at a representative place along each of the six transects at Sourdough Creek and the three transects at Muddy Creek. A sample from Pole Creek was also collected for comparison (total=10). Samples were stored in a paper bag within a cooler and their "wet weight" was measured upon return to Laramie. It had rained on 4 July prior to the 6-7 July sampling on Sourdough Creek and Muddy Creek. Samples were air-dried at room temperature for three weeks and their "dry weight" was measured. The difference was determined to calculate the % water weight in each sample at the time of monitoring. This percentage value reflects the water content at the time and the water-availability context at the time (all of which relate to water-holding capacity, depth to water table, precipitation events, and all evaporation and transpiration processes). We were not able to measure organic content, but there were two fibrist soil samples that belonged to the histosol order (Sourdough Creek Transect 5 sample and Pole Creek sample) that ranged from 70.8-81.6 % water weight. They were outliers by comparison with the rest of soil samples, having 20.2-31.2 % water content (Figure 3).

Figure 3. Soil wetness from soil samples collected in nine monitoring transects (Muddy Creek, Sourdough Creek), and from a representative sample in the Pole Creek population

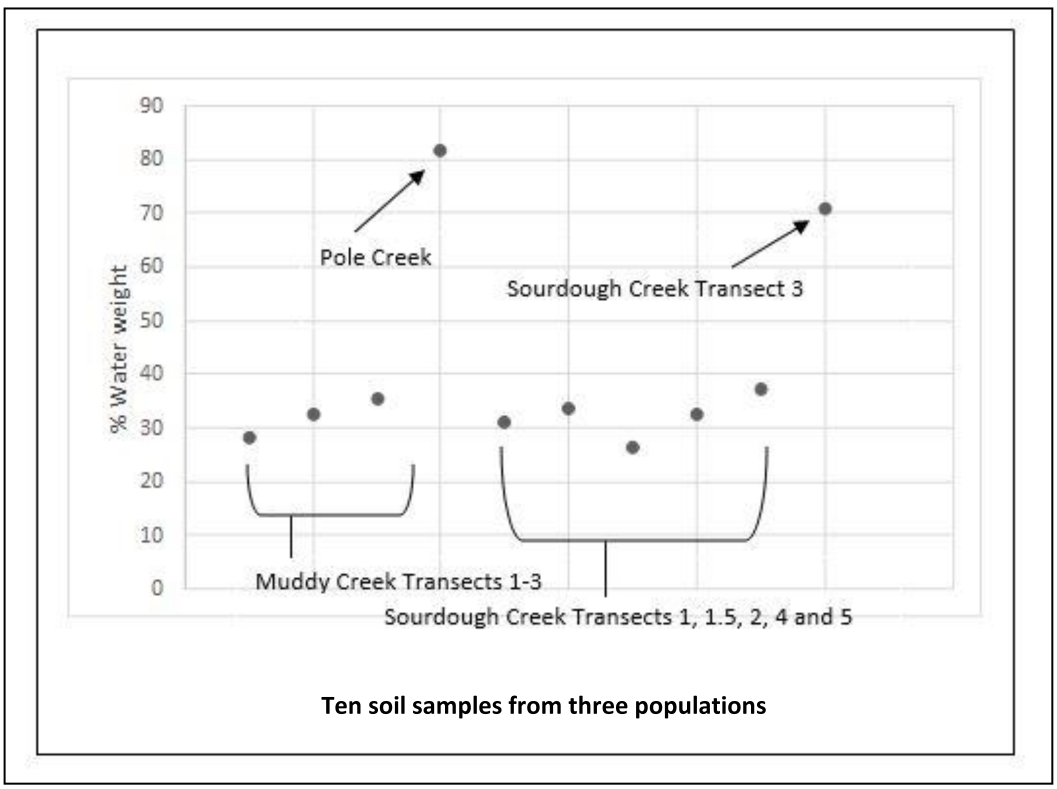


Table 3. Tests for determining the significance of changes in frequency –
McNemar's Test for Paired Sample Frequency Data

(The following text is reprinted from Fertig [2000] as used in analyzing the monitoring dataset.)

McNemar's test is used to test whether an observed change in frequency at a permanent plot over time is significantly different from the null hypothesis of no change. To use the test, data from two different years are compared in a 2 x 2 matrix in which similarities and differences in frequency values are recorded in the appropriate cells (see below):

	Year 1 Present	Year 1 Absent
Year 2 Present	% present both years	% increase in presence
Year 2 Absent	% decrease in presence	% absent both years

McNemar's test is interested only in the % of cells that increase or decrease in presence between the two years. A chi-square value is determined for these cells using the following formula (Zar 1996):

$$\chi^2 = \frac{(|\text{(\% increased presence - \% decreased presence)}| - 1)^2}{\text{\% increased presence + \% decreased presence}}$$

Many computerized statistical packages can do this calculation automatically and generate a P value for comparison with the null hypothesis at the desired level of confidence. The P value for the null and χ^2 can also be calculated from a chi-square distribution table (see page 334 of Elzinga et al. 1998), based on the desired α value (typically 0.05 in most studies). The value of χ^2 at 1 degree of freedom (the typical value in 2 x 2 blocks) can then be compared to the null value at the desired α to see if the χ^2 is lower than the null (in which case the null hypothesis is not rejected and the observed difference is not significant) or higher (in which the null hypothesis is rejected).

Chi-Square Test for Independent Data

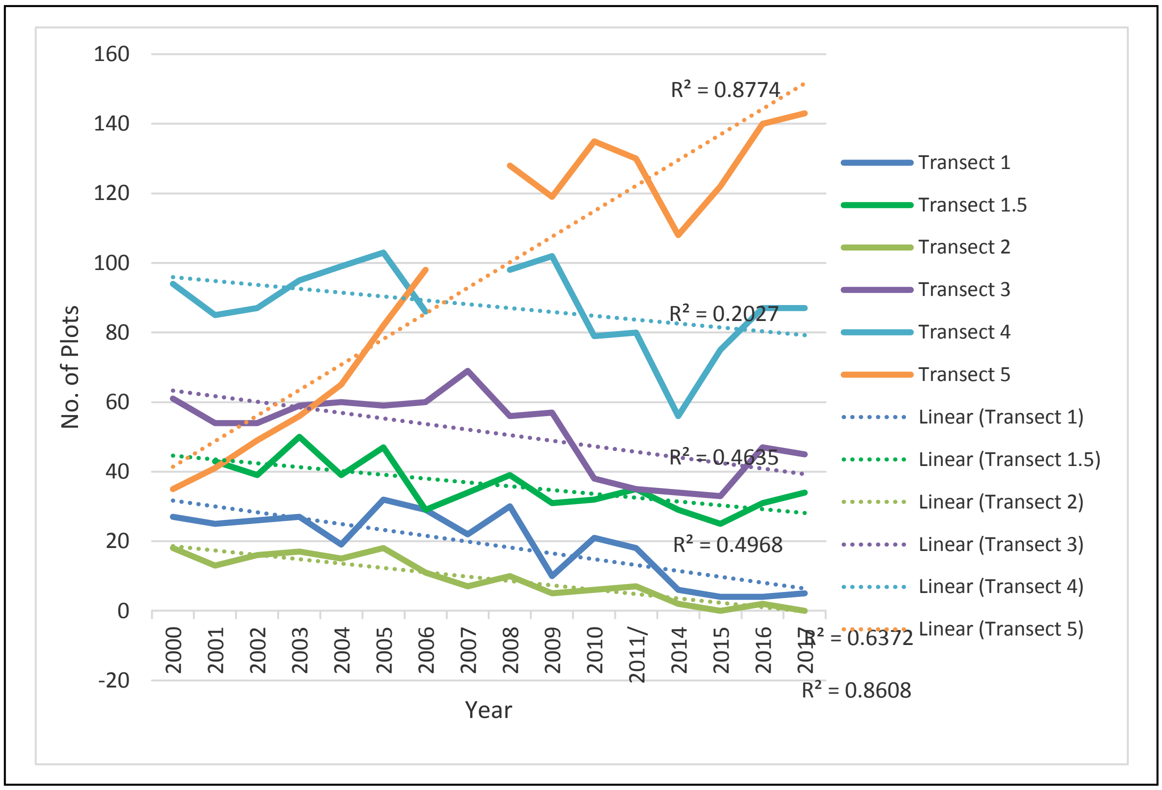
If frequency plot data from year to year are derived from temporary plots that are randomly selected each year (and thus independent), the chi-square test can be used. See Elzinga et al. (1998, pp. 241-243) for further information on this test.

Note: The frequency is an absolute value (number of plots per transect) rather than a relative value (% of plots per transect). Transects differ in their number of plots, and in the original continuity and density of their original placement.

RESULTS

Rubus arcticus ssp. *acaulis* trends show prevailing increases in frequency on one transect (Transect 5 in marsh, which is also the transect farthest upstream), and declines on all five other transects (Figure 4). The linear regression lines are superimposed for reference only to visualize trend, but noting that trends may be nonlinear, oscillating, and differing appreciably depending on the timeframe. One of the more striking patterns is that the five transects in decline are all declining at similar rates (slope of the linear regression line) despite their original differences of setting, size and original values.

Figure 4. Overview of *Rubus arcticus* ssp. *acaulis* trends on six Sourdough Creek transects



In past pilot analyses, *Rubus arcticus* ssp. *acaulis* monitoring data from Sourdough Creek were graphed for the first ten years of data (2000-2009) showing that all three transects in marsh settings exhibited increase, while the three in spruce woods showed decline (Heidel 2010). Trends since 2009 tend to show increases on four of the six transects. The trends with the least amount of variation in results (highest consistency, as reflected in high R^2 values exceeding 0.5) were the two transects at opposite ends: the transect with greatest increase (Transect 5) that reached a new record in frequency in 2017 (143 of 168 plots), and the transect of greatest decrease (Transect 2) that had zero plants present in 2017, as it did once before (2015; 0 of 58 plots). It is possibly extirpated in this sampling area, which represents the smallest sample area of the six transects (5.8 m^2).

The McNemar's analysis of trend is represented for each transect by year to highlight those years in which plot frequency values differed significantly from plot frequency values of 2000 (also calculated for the immediate prior year) as marked by stars (Figure 5). The threshold of 3.841 was determined for Chi-Square distribution for 1 degree of freedom for a two sided test and an alpha of 0.05. The null hypothesis assumes there is no change.

Figures 5(a-f). *Rubus arcticus* ssp. *acaulis* trends on each of six Sourdough Creek transects[1]

Figure 5(a). TRANSECT 1

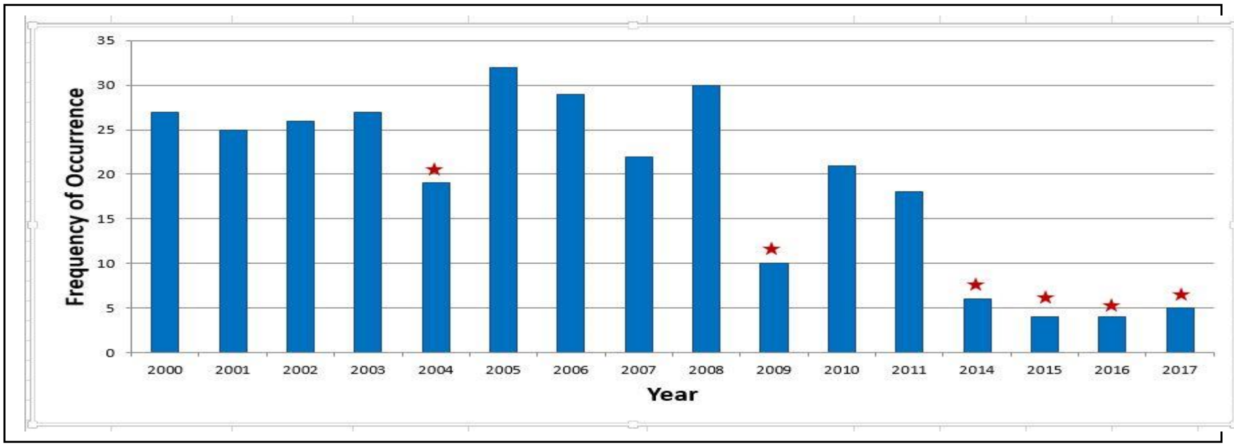
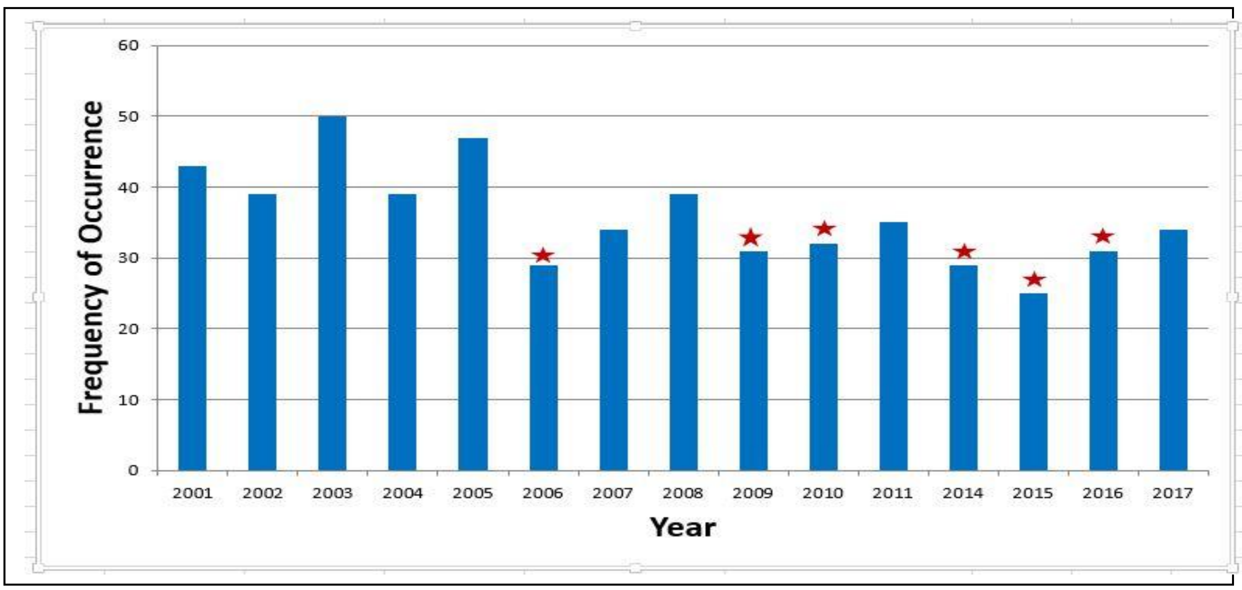


Figure 5(b). TRANSECT 1.5



[1] Red stars mark annual frequency data with significant decline.
Blue stars mark annual frequency data with significant increase.

Figure 5(c). TRANSECT 2

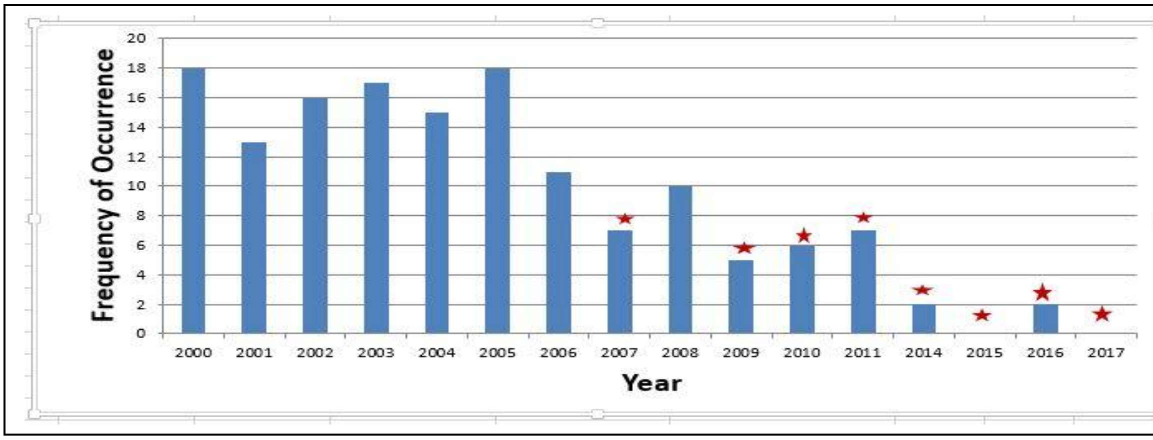


Figure 5(d). TRANSECT 3

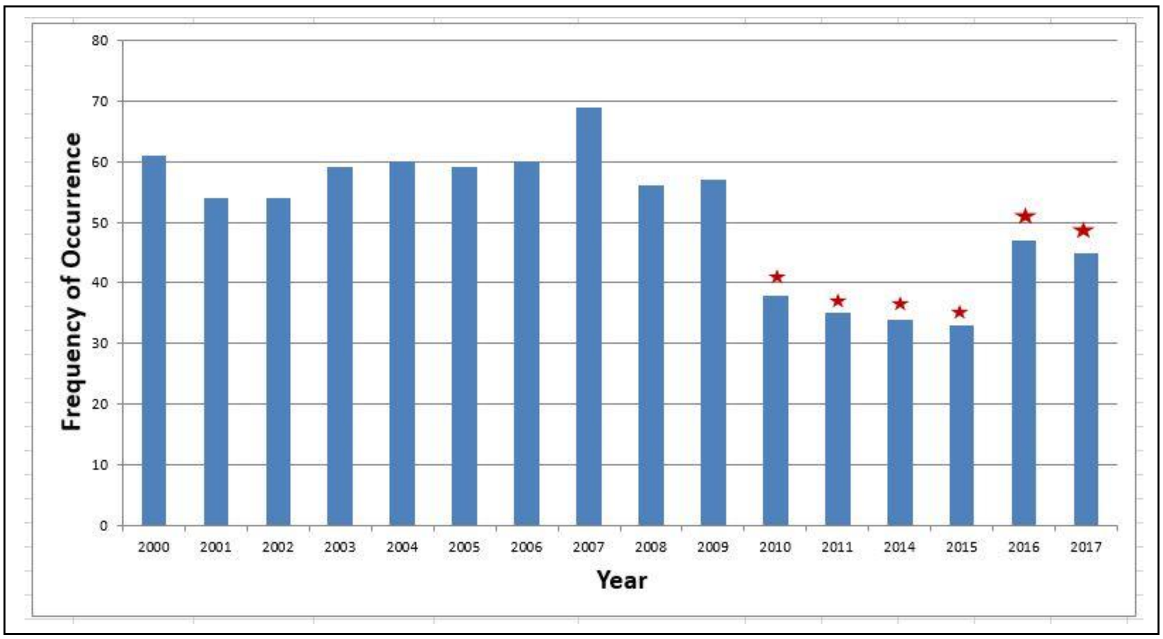


Figure 5(e). TRANSECT 4

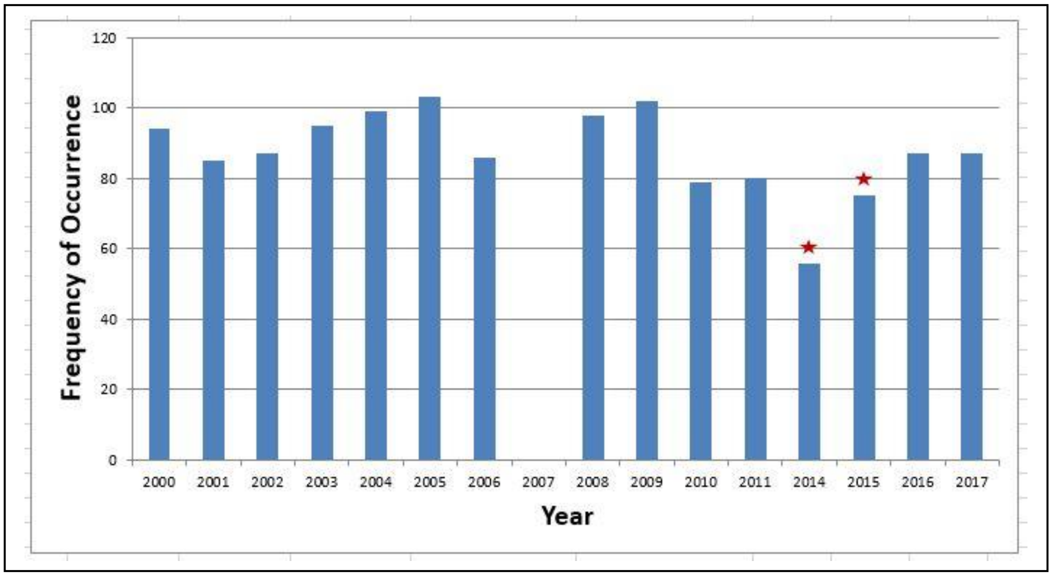
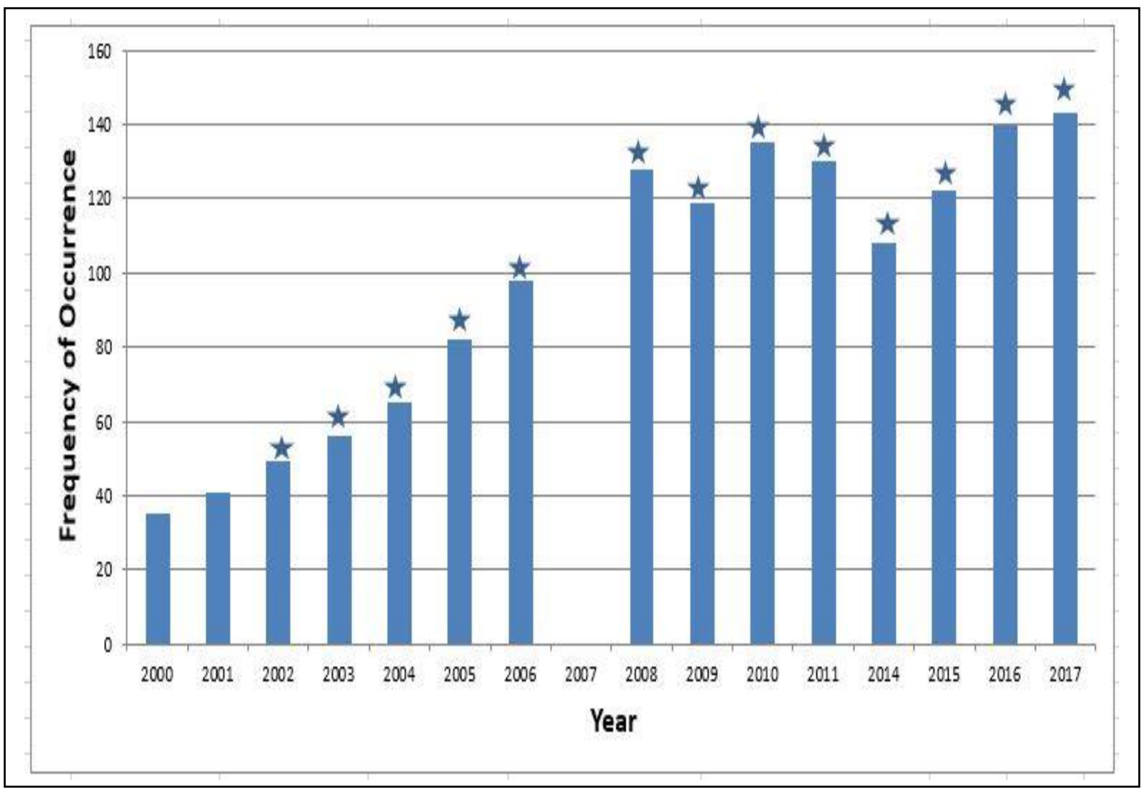


Figure 5(f). TRANSECT 5



The McNemar's analysis of trend was also conducted for the three years of Muddy Creek data (Figure 6).

Figures 6a-c. *Rubus arcticus* ssp. *acaulis* trends on each of three Muddy Creek transects[2]

Figure 6(a) – TRANSECT 1

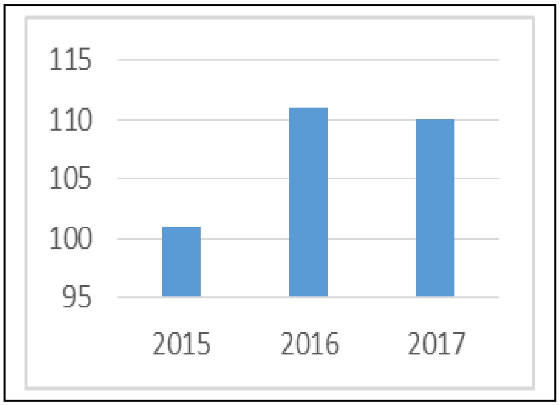


Figure 6(b) – TRANSECT 2

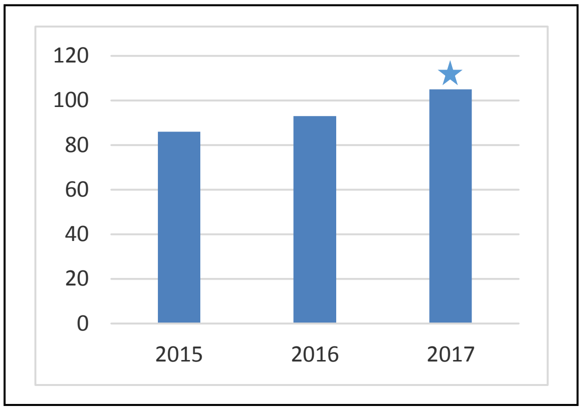
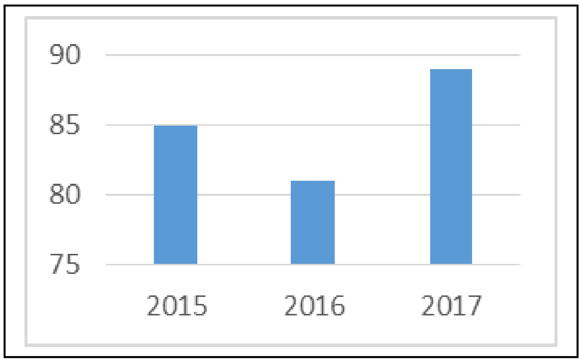


Figure 6(c) - TRANSECT 3



[2] Note: Only the graph for TRANSECT 2 shows the "y axis" from 0-total and has significant increase. The relative trends on TRANSECTS 1 and 3 are far smaller.

Complete sets of raw data from the Sourdough Creek transects that include addition of 2017 results accompany this report as Appendix A, submitted in electronic form.

The three years of results from Muddy Creek (Figure 6) add little to the interpretation of Sourdough Creek results. They demonstrate slight increases, but with only one of the three being significant (Transect 2). Data from the same three years of Sourdough Creek transects might have similarly suggested slight increases, but with very few in the three year dataset significant by McNemar's analysis.

DISCUSSION

The compiled monitoring results and updated species information in this report represent a compendium for agency decision-makers. Fertig (2000) said that trend data are needed to confirm if the *Rubus arcticus* ssp. *acaulis* population on Sourdough Creek is truly stable, and suggested that such data provide an early warning system should changes in management be needed to ensure the population's continued survival.

The resulting monitoring dataset, spanning 18 years, shows that trends are not stable in at least four of the six transects, including one transect with marked increase as present in a marsh setting, and three transects with demonstrable decrease including all three in a spruce woods setting, despite whatever oscillations might obscure trend.

Three tentative hypothesis are presented as explanations for results, e.g., habitat dessication, a phenomenon such as willow dieback that changed succession, and changes that took place on a local scale rather than across the entire valleybottom. These hypotheses also differ by scale, e.g., regional dessication, valleybottom successional phenomena, and localized hydrological change. They are not mutually exclusive.

1. <u>Regional dessicaton</u>. SNOTEL data show that 2000 and 2001 were relatively dry years (Figure 1), and it is possible they represented a dry interval that set in motion valleybottom dessication as part of a drought interval. This is consistent with the majority of monitoring years being drought years as indicated by Palmer Drought Severity Index values for Johnson County, WY (2000-2004, 2006-2007, 2012-2013) (Figure 2). Essentially, the 2000 baseline year coincided with the start of a prolonged dry period (2000-2004) with one near-normal interlude in 2005, but lapsing into drought for another two years (2006-2007). Regardless of starting year and duration, decline is evident on most transects by 2009. Note: Additional datasets would be appropriate to evaluate this hypothesis (USGS streamflow data), also evaluating the selection of any given year as the baseline year and the given time period as the basis for comparing *Rubus arcticus* ssp. *acaulis* results. It is not known if *Rubus* frequency numbers are more strongly influenced by the current growing season or some sort of lag response to the preceding one(s).

2. <u>Valleybottom succession</u>. Even though there were no major changes to *Rubus arcticus* ssp. *acaulis* management over the course of monitoring, there may have been changes to its habitat suitability. Two such possibilities include a willow dieback event and a lag

effect in the hydrological and vegetation succession changes associated with the Highway 16 crossing upstream from the population. Pertinent historical data would need to be compiled to weigh this further, but the increasing trends of Transect 5 compared to the other five transects argue against a valleybottom-wide change.

3. Localized hydrological change. It may be appropriate to interpret *Rubus arcticus* ssp. *acaulis* results as representing three sets of results rather than six because it appears as though transects positioned within the same locale (i.e., the same polygon subpopulation boundary) are more similar to one another than they are to any of the rest of transects. This transforms the question to one of local differences (and possible causative agents). A remnant of an old beaver dam below Transect 5 was observed, and it appeared as though it still impounds water that may lend stability in water availability throughout the growing season, absent from other transects in marsh settings. The prevailing declines of the spruce woods population segments are pervasive. It would be interesting to know if rain gauges show the same net precipitation in spruce woods as in marsh. It appears as though the stream bank between the channel and occupied habitat has experienced erosion, with small-scale cutbanks forming in places that could contribute to a lowering of the local water table in occupied habitat. An excellent set of photographs showing the spruce woods transects were taken in 2002-2004 for considering this further.

Fertig (2000) recommended that the distribution of *Rubus arcticus* ssp. *acaulis* should be remapped periodically along Sourdough Creek (preferably using a global positioning system) to detect gross changes. All current distribution has been updated with GPS mapping by Bighorn NF, and the relative stability of the species within transects is notable. Based on the long-term monitoring data and 2017 observations, it is plausible that the species has limited colonizing ability except by vegetative growth and would not show up in new locations. It is extirpated in all likelihood at one of the six transects, the spruce woods transect farthest from the creek, and persists in the rest of the polygon including the plants in two other nearby spruce woods transects. If the rest of the downstream population segments are in spruce woods settings (F-H in Table 1), then they would be particularly important to resurvey.

Photo points can also be a powerful tool for measuring changes in habitat suitability, especially when used in conjunction with quantitative data or detailed observations of plant abundance or distribution. Permanent photo points were established in 1999 to document the current condition of the vegetation along Sourdough Creek. The pair of photos (Figures 7 and 8) represent just the marsh transect settings (Transects 3-5) and show the following:

- Willow cover and stature have declined. This is particularly conspicuous in comparing the foregrounds of the 1999 and 2017 photographs. Though this is close to the highway embankment, the pattern is consistent throughout the visible valleybottom.
- Stream channel placement and visible stream border features are very similar over time.
- A localized area of past logging (central right) is more apparent in the 1999 photo
- A localized area of increased tree cover (central left) is apparent in the 2017 photo

Figure 7. *Rubus arcticus* ssp. *acaulis* photo point 1 depicting habitat condition of the middle reach of Sourdough Creek. Photo is oriented at 27 ° northeast from the 7th road marker on the north side of US Highway 16 (T50N R84W S34 SE4). WYNDD photograph by Walter Fertig, 18 July 1999. Transect 5 is located close to the center. Note pine tree (center) and rock outcrop (left).

Figure 8. Replication of the preceding photograph, slightly different angle, different camera lens. WYNDD photograph by Bonnie Heidel, 7 July 2017. Note pine tree (center) and rock outcrop (left).

These photopoint comparisons might support any of the three hypothesis, e.g., habitat dessication, a phenomenon such as willow dieback that changes succession, and changes that take place on a local scale rather than across the entire valleybottom.

Given the relatively broad habitat tolerance of *Rubus arcticus* ssp. *acaulis* in the Sourdough Creek drainage and the distribution of similar habitats elsewhere in the Bighorns, the limited distribution of *R. a.* ssp. *acaulis* in Bighorn NF posed an enigma in 2000 that is only beginning to come into focus now. The species' reported rarity was in some part an artifact of the difficulty of locating it, especially in vegetative condition. Fertig hypothesized that it is probably not occupying its full potential range, but an alternative explanation is that it occupies habitats or microhabitats that are vestiges of once more widespread environments as conditioned by climate and natural or man-made disturbances. Its persistence in a setting with grazing, flooding, tie hacking, clear cutting, and recreational use does not prove it requires disturbance, nor does it prove that it is impacted by disturbance. It indicates that the species and its habitat have some resiliency. It is hypothesized that the high water-holding capacity of soils throughout occupied habitat is one of the environmental factors enabling resiliency, but that only under locally-conducive conditions, as near the old beaver dam, is water availability high through the growing season.

To recapitulate, by 2009, *Rubus arcticus* ssp. *acaulis* exhibited demonstrable increase at one monitoring transect and decline at least three other monitoring transects, relative to 2000. Decline at the majority of transects is reason to evaluate causative agents, consistent with the original report. Four tasks are described for possible consideration to evaluate causes.

1. A more complete review of Bighorn NF aerial imagery and orthophotographs is appropriate (representing the full scope of *R. a.* ssp. *acaulis* distribution on Bighorn NF and all available years) to look for landscape patterns that might accompany vegetation change. In particular, the presence, placement and longevity of beaver dams warrants consideration.
2. The history of highway construction and any phases of building up of the road bed warrant consideration.
3. Hydrological information is be sought if, for example, there were stream flow data at the Tie Hack Reservoir inlet or from analogous drainages.
4. Climate correlation and possible expansion of meteorological datasets might be evaluated with available monitoring results.

If *Rubus arcticus* ssp. *acaulis* is a species of relict habitat with limited colonizing ability, then this would place a premium on maintaining the vestiges. Distribution of this report and consultation with hydrology experts and riparian ecologists is encouraged with receipt of this report by Bighorn NF.

SPECIES REPORT[3] on *Rubus arcticus* ssp. *acaulis*
– including text from Fertig (2000) with extensive updates

Classification:
Scientific Name: *Rubus arcticus* L. ssp. *acaulis* (Micx.) Focke
Common Name: Dwrf raspberry, northern blackberry, or nagoonberry.
Family: Rosaceae (Rose family).
Synonyms: *Rubus acaulis* Michx, *Cylactis arctica* (L.) Raf. ssp. *acaulis* (Michx.) Weber).
Phylogenetic Relationships: *Flora of North America* authors (Alice et al. 2014) recognize 37 species of *Rubus* in North America (north of Mexico) in taking a conservative approach due in part "to the broad geographic distribution of many species in which quantitative characters are highly variable and the general absence of empirical data demonstrating that minor morphological variants are genetically based and not environmentally plastic." *Rubus* is one of the largest and most taxonomically complicated genera in the world, with 250-700 species and recognition further complicated by hybridization, polyploidy and apomixes (Alice et al. 2014, Gleason and Cronquist 1991). *Rubus acaulis* Michx. has long been recognized at the species level (Michx. 1803, in Fl. Bor. Am. 1:298.) and in subsequent regional floras of the lower 48 states. It is more widespread in Alaska and Canada where most authors treat it as a variety or subspecies of *R. arcticus*, and where there are two other varieties or subspecies (Douglas DATE, Hulten 1968, Porsild and Cody 1980). Above the species level, subgroups have been proposed for understanding relations in the genus (Bailey 1941) but polyphylly has been documented within them (Alice et al. 2014). Weber and Wittmann (2012) elevated the subgroup *Cylactis* to genus. Their change may not be warranted given the strong similarities in leaf, floral, and fruit morphology between this group and other subgenera of *Rubus.*

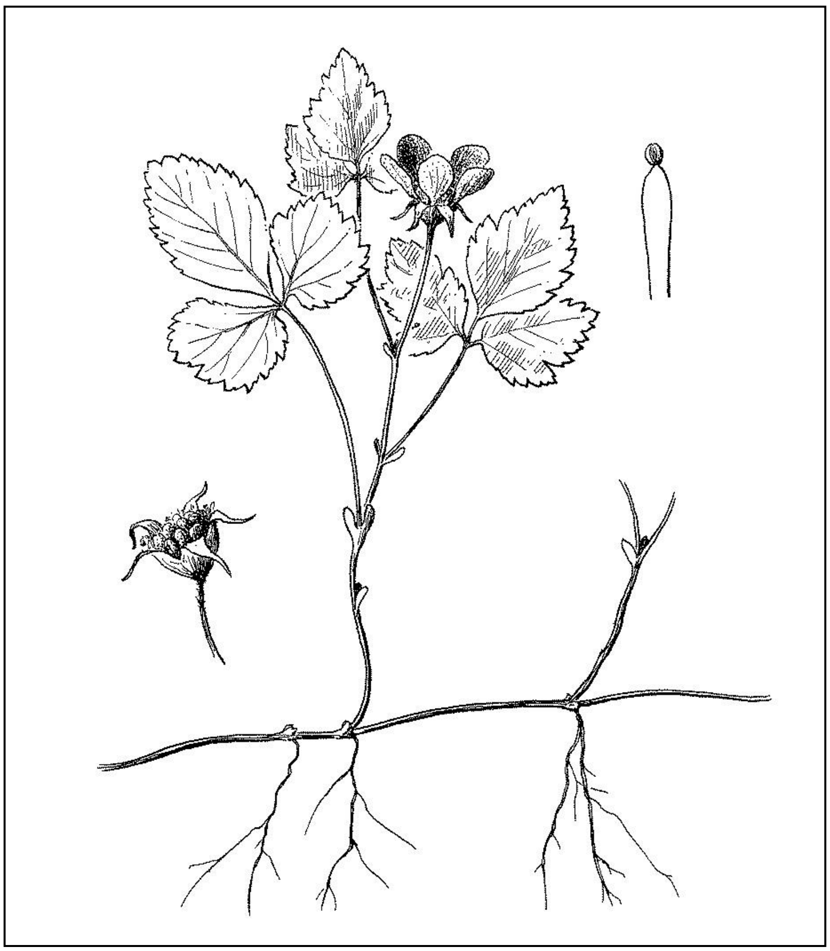
Legal Status: *Rubus arcticus* ssp. *acaulis* is listed as Sensitive by the US Forest Service Rocky Mountain Region (2018). It ranges widely across Alaska and northern Canada, but occurs only sporadically south of the Canadian border in Minnesota, Montana, Wyoming, and Colorado. Due to concerns over its long-term survival in the southern Rocky Mountains, this species was recommended for Sensitive designation in U.S. Forest Service Region 2 (Rocky Mountain Region) in 1990 (Marriott et al. 1990) and first added in 1993 (Estill 1993). The Sensitive list includes those species identified by the Regional Forester with "significant current or predicted downward trends in population numbers, density, ... or habitat capability" which makes them vulnerable to extirpation (Forest Service Manual 2670.5). They are typically managed to prevent them from declining further and becoming listed as Threatened or Endangered under the Endangered Species Act. This species is not protected under state law in Wyoming or Colorado.

Natural Heritage Rank: The network of Natural Heritage programs gives *Rubus arcticus* ssp. *acaulis* a rank of G5, indicating that the species is "demonstrably secure, although [it] may be rare in parts of its range, especially at the periphery." It is ranked S2 as imperiled in Wyoming (Heidel 2018) and S1 as critically imperiled in Colorado (Colorado Natural Heritage Program 2018) and tracked as a species of concern in both states. It is not currently tracked as a species of special concern in Montana.

[3] The status of *R. a.* ssp. *acaulis* is presented in the following pages, an update of the information presented by Fertig (2000) and an expanded treatment compared to the on-line Wyoming species accounts.

<u>Description</u>: Dwarf raspberry is a strongly rhizomatous perennial herb with non-bristly or prickly annual stems (2) 12-15 cm tall (Figs. 7-8). Stems are finely pubescent, erect, bear 2-5 alternate leaves and are herbaceous (non-woody). Leaves are divided into 3 ovate to obovate leaflets, 1-3.5 cm long with serrated margins and blunt or rounded tips. Flowers are usually solitary and equal to or shorter than the leaves. Petals are rose-pink, narrowly spoon-shaped, 10-15 (20) mm long, and erect to spreading (forming a shallow cup). Fruits are red, globe-shaped aggregations of drupelets (blackberries or raspberries) about 1 cm broad (Hitchcock and Cronquist 1961; Hulten 1968; Moss 1983; Dorn 2001; Fertig et al. 1994, Fertig 2000, Alice et al. 2014, Ackerfield 2015; Figure 9).

Figure 9. Illustration of *Rubus arcticus* ssp. *acaulis*, by Jeanne R. Janish, from Hitchcock and Cronquist (1961). Used with permission.



<u>Similar Species</u>: *Rubus pubescens* has white petals 5-8 mm long and sharp-toothed leaflets. Other *Rubus* spp. in Wyoming have woody, prickly-bristly stems over 1 m tall or simple leaves. *Fragaria* spp. have white flowers on leafless stems and have above-ground stolons. Small, vegetative specimens of *Geum macrophyllum* have pinnately compound leaves with 5 or more leaflets (the terminal leaflet being largest) (Fertig et al. 1994).

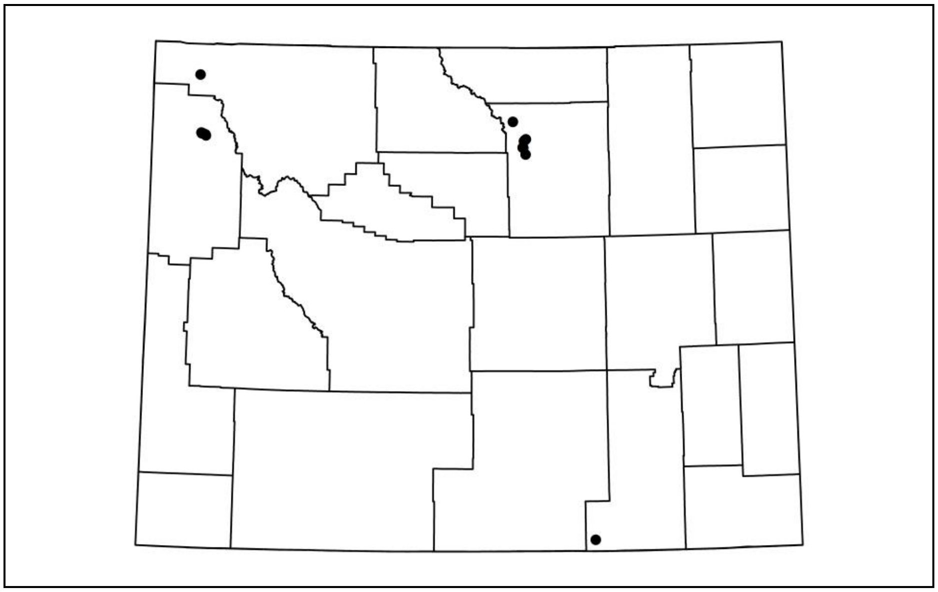
Figure 10. *Rubus arcticus* ssp. *acaulis*, by B. Heidel

Phenology: Flowers late June-mid July. Data are not available on fruiting. *Rubus arcticus* ssp. *acaulis* populations were observed in flower and vegetative condition in mid July 1999. 24-39% of all stems were in flower in willow thicket/sedge marsh habitat, while only 23-27% were in flower in forested areas (Fertig 2000).

Note: Species' diagnostic traits include flower characteristics. The first discovery of this species in Medicine Bow NF was made by Kathy Roche in 2004 when the species was in vegetative condition. The original specimen was identified by comparing with herbarium material and ruling out other taxa. The species is difficult to verify with certainty and to detect in vegetative condition, so survey and documentation work are ideally concentrated during the flowering period.

Geographic Range: *Rubus arcticus* ssp. *acaulis* ranges from central Alaska and the Northwest Territories to Newfoundland, south to New Brunswick, Minnesota, Manitoba and British Columbia, with scattered populations extending south in the Rocky Mountains to Montana, northern and southcentral Wyoming, and north-central Colorado (Hulten 1968; Porsild and Cody 1980; Spackman et al. 1997). In Wyoming, this species is restricted to the Yellowstone Plateau, the Big Horn Mountains, and the Medicine Bow Range in Albany, Johnson and Teton counties.

Figure 11. Wyoming distribution of *Rubus arcticus* ssp. *acaulis*



The first collection of *Rubus arcticus* ssp. *acaulis* in Wyoming was made in a 1900 collection by Frank Tweedy at the "headwaters of Clear Creek and Crazy Woman River." The location of the 1900 collection is consistent with that of the newly-documented population on Pole Creek. Reinforcement for this interpretation is found in finding another species that had been collected by Tweedy on the same trip, *Pyrrocoma clementis* var. *villosa* (Hairy tranquil goldenweed), an upland species that was found in walking up Pole Creek en route to *Rubus* habitat, and that did not have any extant populations known on the east side of Bighorn NF until this 2017 discovery. Many new locations of *P. c.* var. *villosa* were documented in 2017 incidental to the monitoring study (Appendix B).

Habitat: Across its range, *Rubus arcticus* ssp. *acaulis* occurs in muskegs, boggy woods, fens, bogs, swamps, thickets and moist tundra; 0-3000 m (Alice et al. 2014). In Colorado, it is "uncommon in moist bogs and along creeks, 8500-10,000 ft" (Ackerfield 2015). Wyoming populations are found in a variety of settings that include hummocky marshes dominated by *Salix planifolia* and *Carex utriculata*, streamsides in shady *Picea engelmannii/Linnaea borealis* forests, fens, and margins of boggy beaver dam ponds, at elevations of 2257-2870 m (7400-9410 ft). Populations typically occur on organic-rich histisols or inceptisols derived from Quaternary alluvial/colluvial deposits or gneiss bedrock on gentle slopes or flats (Love and Christiansen 1985). Other common associated species include *Equisetum arvense*, *Pedicularis groenlandica*, *Dasiphora fruticosa* [synonym *Pentaphylloides floribunda*, *Potentilla fruticosa*], *Fragaria virginiana*, *Geum macrophyllum*, and *Thalictrum sparsiflorum*. A more complete list of associated species is presented in Table 4.

Average annual precipitation within the range of *Rubus arcticus* ssp. *acaulis* in Wyoming varies from 508-762 mm (20-30 inches) on the east slope of the Bighorn Range to 1016 mm (40 inches) in the Yellowstone Lake area (Martner 1986) but get as low as 360 cm (14 inches; see Figure 1). Peak precipitation comes in May and June in the Bighorn Range and December-January and June in Yellowstone. Mean annual temperature is 0-2.2° C (32-36° F) in the Bighorns and 0° C (32° F) at Yellowstone Lake. Mean maximum and minimum temperatures in January are -3.3° and - 11.6° C (26° and 6° F) in the Bighorns and - 4.4° and - 17.6° C (24° and 0° F) at Yellowstone Lake, while mean maximum and minimum July temperatures are 23.1-24.2° and 5.5-7.7° C (74-76° and 42-46° F) in the Bighorns and 23.1° and 3.3° C (74° and 38° F) in Yellowstone (Martner 1986).

Ladyman (2006) suggested that *Rubus arcticus* ssp. *acaulis* has narrow hydrological requirements. The species is situated close to surface water and in settings with shallow water tables in Bighorn NF populations. The availability of shallow groundwater to maintain moist microhabitat might be conditioned by such factors as surface runoff patterns in the catchment, streamflow patterns during the growing season, local springs, seeps and inlets, gradients and downcutting patterns, and any natural or manmade alterations to flow. Perhaps the driest known Wyoming population is the Medicine Bow NF population within a lodgepole pine forest, although it is near wetland habitat and perhaps has a shallow water table. Fertig noted that it appeared to have more stems in wet years and it is possible that moisture is a factor in the survival and growth of its delicate woody rhizomes.

Table 4. Plant species associated with *Rubus arcticus* ssp. *acaulis*

Scientific name	Common name	Marsh	Spruce Woods	Fen
Aconitum columbianum	Columbian monkshood	X		
Arenaria lateriflora	Bluntleaf sandwort		X	
Astragalus alpinus	Alpine milkvetch	X	X	
Astragalus americanus	American milkvetch	X	X	
Betula glandulosa	Bog birch			X
Botrychium ascendens	Triangle lobe moonwort	X		
Botrychium lanceolatum	Lance-leaved grapefern	X		
Calamagrostis canadensis	Bluejoint reedgrass	X		
Carex aquatilis	Water sedge	X		
Carex aurea	Golden sedge	X		X
Carex canescens	Gray sedge	X		X
Carex disperma	Soft-leaved sedge	X	X	X
Carex utriculata	Beaked sedge	X		X
Epilobium angustifolium	Fireweed	X		
Epilobium halleanum	Glandular willowherb			X
Equisetum arvense	Field horsetail	X	X	
Eriophorum chamissonis	Russet cottongrass			X
Eriophorum polystachion	Many-spiked cotton-grass		X	X
Fragaria virginiana	Virginia strawberry	X	X	
Galium boreale	Northern bedstraw	X		
Galium trifidum	Threepetal bedstraw	X		X
Geranium richardsonii	White geranium	X		
Geum macrophyllum	Large-leaved avens	X		
Kalmia microphylla	Alpine laurel			X
Linnaea borealis	Twinberry		X	
Luzula parviflora	Small-flowered woodrush			X
Mertensia ciliata	Ciliate bluebells			X
Moneses uniflora	Woodnymph		X	
Pedicularis groenlandica	Elephant's-head	X		
Pentaphylloides floribunda	Shrubby cinquefoil	X		X
Phleum alpinum	Alpine timothy	X		X
Picea engelmannii	Engelmann spruce		X	
Picea "glauca"	White spruce	X		
Polygonum viviparum	Alpine bistort	X		
Potentilla gracilis	Slender cinquefoil		X	
Pyrola asarifolia	Pink wintergreen		X	X
Pyrola minor	Lesser wintergreen		X	
Rosa sayi	Prickly rose	X		
Salix bebbiana	Bebb willow	X		
Salix boothii	Booth willow	X		
Salix geyeriana	Geyer willow	X		
Salix planifolia	Planeleaf willow	X		X
Saxifraga subapetala	Oregon saxifrage	X		
Sedum rhodanthum	Redpod stonecrop			X
Streptopus amplexifolius	Clasping-leaved twisted-stalk		X	
Thalictrum venulosum	Veiny meadow-rue			X
Thalictrum sparsiflorum	Few-flowered meadow-rue	X		
Trifolium repens	White clover	X	X	
Vaccinium membranaceum?	Thinleaf huckleberry			X
Veronica wormskjoldii	American alpine speedwell		X	

Habitat conditions of the Sourdough Creek population were the "search image" in surveys for *Rubus arcticus* ssp. *acaulis* elsewhere on Bighorn NF, targeting riparian marshy willow thicket and spruce woods. Fertig (2000) noted that the variety of habitats occupied by it along the middle to lower stream segments of Sourdough Creek suggests that this species should be more widely distributed along streams in the southeastern Bighorn Range. One of the three populations found on the Forest since then is consistent with a marshy willow thicket characterization, the population on Muddy Creek. The other two new populations found on the Forest are in fen habitat, i.e., on peat deposits over 40 cm thick. The Frying Pan Lake population is in a basin fen setting, but the Pole Creek population is in a riparian fen setting, between a pocket of fen habitat and the creek. Both fen habitats have *Salix planifolia* among the dominants, although mosses and graminoids have as great or greater cover values as shrubs, and the shrubs are mostly less than a meter tall, so the vegetation appearance differs at these sites. It is possible that closer examination of the Sourdough Creek setting would clarify the common denominators between the habitats of the four populations. They all appear to have soils high in organics. Information on the origin of the "Sourdough Creek" place name was not found. Marl accumulation is a pronounced feature in some Wyoming peatlands, it resembles sourdough starter, and it is possible that this semblance may have been the basis for the creek name.

One of the challenges in habitat characterization is to determine the species' requirements for stability or for natural disturbance. Ladyman (2006) cited literature noting that a close relative, *R. a*. ssp. *arcticus*, benefits from some intermediate level of natural disturbance in Europe. One of the eight Wyoming populations is only known from a disturbed skid trail setting, though it is not known if potential habitat has been surveyed throughout the area and is not to be assumed that skid trail surface disturbance created suitable habitat. Some upland members of the genus are adapted to fire, but wetland species may respond differently. There is no documentation of Wyoming populations producing fruits. If fruits are not produced, then colonization would be limited to vegetative reproduction.

Population Size and Ecology:
Rubus arcticus ssp. *acaulis* is presently known from eight extant occurrences in Wyoming, in addition to the one vague, historical population that may coincide with the newest of populations (Table 7). Half of the extant occurrences are on Bighorn NF, in addition to the historic collection record by Tweedy in 1900. Three are in Yellowstone National Park, two of which are fairly close to one another in the Heart Lake area.

Sourdough Creek contains 10 main subpopulations of *Rubus arcticus* ssp. *acaulis*, each of which numbered between 25 to 20,000 stems (Table 1). Subpopulations occupy areas ranging in size from 3 square meters to linear patches nearly 0.3 km long (0.2 miles). The total area inhabited by this species along Sourdough Creek is only about 2 hectares (ca 5 acres). The other three populations on Bighorn NF are in a much smaller stream reach segments (Muddy Creek, Pole Creek) or much more continuous in a basin setting (Frying Pan Lake).

The distribution of *Rubus arcticus* ssp. *acaulis* plants along Sourdough Creek is strongly clustered. Density ranges from 27-50 stems per square meter in willow thicket/marsh habitats and 10-48 stems per square meter in riparian Engelmann spruce forests. In light of vegetative reproduction, there is no basis for converting stem tallies to tallies of genetically unique individuals (Figures 12-13). Large patches of seemingly suitable habitat, however, are unoccupied both within clusters of stems and between subpopulations. Frequency within occupied patches (based on randomly distributed 0.2 x 0.5 plots) ranges from 50-60% in willow thicket/marsh habitat. The patchy distribution of this species may be directly related to its rhizomatous growth form and limited ability to colonize new mounds.

Figure 12. Population census questions. How many *Rubus arcticus* ssp. *acaulis* plants are there in this photograph? This close-up view of a high-density mound at the new Pole Creek population represents an area less than 1/2 m^2. There might be close to 100 leaves, and if each stem has 1-4 leaves (with an average of at least 2) then this could represent 50 plants. Photo by B. Heidel.

Figure 13. Underground view of population census questions. *Rubus articus* ssp. *acaulis* specimen represents part of one genet, with at least two ramets and possibly many more. Photo by B. Heidel.

The species was reported at one of the Yellowstone National Park populations was reported as "relatively abundant" in 1997 (Jennifer Whipple, pers. comm. to W. Fertig). The Sourdough Creek population in Bighorn NF contained an estimated 51,000-77,000 stems in 1999. Because of the rhizomatous nature of *Rubus arcticus* ssp. *acaulis*, the actual number of genetically distinct individuals is probably much lower (perhaps a magnitude lower in the low thousands). The species often occupies habitat with hummocked, microtopography relief and it is not known whether plants can spread vegetatively between hummocks. If not, then a tally of hummocks may represent the minimum number of genetically unique individuals.

The Sourdough population is divided into 10 main subpopulations, each ranging in size from 25-20,000 stems. Patches may cover an area of less than 3 square meters or extend almost continuously for nearly 0.3 km (0.2 miles). Density ranges from 10-48 stems per square meter in densely forested habitats to 27-50 stems per square meter in willow thicket/beaked sedge marsh communities. Flowering levels also differ between settings: 23-26% of all stems produced flowers in riparian Engelmann spruce habitats, while 24-39% of all stems were reproductive in willow thickets and marshes (Fertig 2000).

The Muddy Creek population is mapped as a single area of occupied habitat. It was initially estimated as having hundreds of plants (Spann 2007 field survey) and more recently estimated as having 1000s of plants (Brown and King 2014 field survey). This probably refer to the number of stems, and as discussed earlier, the number of stems may represent the number of vegetative shoots rather than the number of genetically unique individuals.

In theory, *Rubus arcticus* ssp. *acaulis* can spread asexually by underground rootstalks and sexually by production of fleshy, blackberry-like aggregate fruits. Bailey (1941) suggested that members of the subgenus *Cylactis* may produce functionally unisexual flowers to facilitate cross pollination. One of the questions raised about species' conservation is the scarcity of flowers and apparent lack of fruit production in Colorado and Wyoming populations (Ladyman 2006). This observation is underscored on Bighorn NF by Kat Brown, familiar with the species in Alaska at the fruiting stage, who has visited the Sourdough population at different times of the growing season without finding fruits. In a September survey to the Frying Pan Lake population, Warder noted "It appears that the flowers started to dry out before fruit could fully form. In all the plants that appeared to have flowered (10% or less), the fruit was very dry and small, and disc-shaped, less than 5 mm. It appears that the flowers may not be getting pollinated and the plants are not producing seed."

Ladyman (2006) offered three possible explanations based on research of the type subspecies, *R. a.* ssp. *arcticus*, in Europe:

1. The nonfruitng populations may be triploid,
2. Populations may be composed of clones that represent only one or two incompatible genotypes, or
3. Populations may be pollinator-limited.

There are at least two additional explanations or elaborations on preceding ones. Plants that produce functionally unisexual flowers tend to produce high proportions of male flowers when under stressful conditions. It is possible that populations have had very few plants with female flowers in most years, or else that fruits abort under stressful conditions. Honeybees were observed pollinating *R. acaulis* flowers in the Bighorns in 1999 (Fertig 2000).

Although no evidence of hybridization has been found in Wyoming, *R. arcticus* ssp. *acaulis* can hybridize with *R. pubescens* (nearest locations are in the Black Hills of Wyoming), *R. arcticus* ssp. *arcticus,* and *R. arcticus* ssp. *stellatus* where their ranges overlap in southern Canada and Alaska (Hulten 1968; Porsild and Cody 1980).

Threats: Logging, recreation, and impoundments have been reported as the main threats to *R. arcticus* ssp. *acaulis* populations in Wyoming. Construction of the Tie Hack Dam was once considered an important threat to the Sourdough Creek population (Fertig et al. 1999), but the reservoir has inundated little, if any, *R. acaulis* habitat. Past cutting, tie hacking, and grazing along Sourdough Creek were interpreted as having had little impact on this population based on the assumption that the current distribution and environment resemble the historic cones. Fertig (2000) noted that cattle graze the middle reaches of the creek in late July to early August, concentrating mostly in the drier meadows on the north bank. Due to its accessibility, fishermen regularly use the middle reach of the creek and created a trail along the north side. The watershed was historically flooded to facilitate the transportation of trees cut for railroad ties.

Little evidence of herbivory was observed on stems, leaves, or inflorescences during 1999 surveys. Moose and elk summer ranges are in the area. Big game may graze or trample some *Rubus* plants in willow thicket and marsh habitats. Cattle graze the middle reach of Sourdough Creek after late July, but seem to congregate mostly in the open meadows on the north side of the creek (away from *R. acaulis* habitat). The effects of trampling and resulting hummock formation may be as great or greater than herbivory, but this has not been examined. A portion of occupied habitat at Frying Pan Lake has pronounced development of hummocks associated with cattle grazing, and it persists on hummocks.

Land Ownership: All known populations of *Rubus arcticus* ssp. *acaulis* are on public lands managed for multiple use (Table 5). Each are part of grazing allotments, with the Frying Pan Lake population having the highest concentrated use. Three are protected in Yellowstone National Park. To the extent that *Rubus arcticus* ssp. *acaulis* is a fen species, its habitat at Frying Pan Lake and Pole Creek might fall under the regional direction in the USFS memo 2070/2520-

Table 5. *Rubus* populations on Bighorn NF and land-use category

Population	**Land-Use Category**[4]
Sourdough Creek (003)	5.13 Forest Products
Muddy Creek (007)	4.2 Scenery (U.S. Hwy 16 corridor)
Frying Pan Lake (008)	3.31 Backcountry Recreation. Year-round motorized use.
Pole Creek (009)	5.13 Forest Products

[4] Bighorn NF (2005)

7/2620 which emphasizes the protection, preservation and enhancement of fens to all Region 2 forest supervisors (USDA 2002).

To highlight land use developments, 1956 and 1999 aerial photographs on file at Bighorn NF were borrowed and reviewed. In addition to field notes, they indicate the following (Table 6):

Table 6. *Rubus* populations on Bighorn NF and land-use notes (field observations and photointerpretation – both 1956 black and white and 1999 color)

Population	Land-Use Notes
Sourdough Creek (003)	-U.S. Hwy 16 roadbed and crossing were constructed at some time between 1956-1999 (visible on 9/29/99 imagery: 24-612020; 699-150). The road bed is elevated app 5 m above the valley bottom. The culvert is in alignment with the channel and has suitable capacity for its volume – there are no signs of seasonal impoundment or impeded flow. The road may have been built up, but appears to be confined to the ROW. The flanks of the road are fairly steep and have at least a little roadside erosion. It is possible that the valley bottom has a slope to its groundwater table that parallels the direction of flow, such that the crossing reduces subsurface movement even if there is no interruption in surface flow. -A transmission line was constructed at some time between 1956-1999 within 0.3 mile downstream of the Hwy – there are no signs of altered flow. -There is only one recently logged area on the south side of the creek. It was not a clearcut because scattered seed trees remain. -The 1956 aerial photo (9/1/56 imagery; EAJ-7; 176) coverage just barely covers a small segment of Sourdough Creek occupied habitat but indicates that clearcut logging in blocks or bands above the creek (at least on the south side) was widespread. -The 1956 aerial photo shows less than a 0.2 mi segment of Sourdough Creek but indicates that there were three beaver dam impoundments in that reach (by contrast to current conditions with no active beaver dams and only remnants of beaver dams). -The downstream transects showed a little evidence of slumping and possible cutbank formation between the transect and the adjoining stream. -The creek appears in the extreme corner of the 1956 aerial photo so it is in less focus than the rest of the image, but shrub cover appears to be scarce. -No signs of trailing.
Muddy Creek (007)	The U.S. Hwy 16 roadbed has paralleled occupied habitat on Muddy Creek with consistent alignment between 1956-1999 (visible on 9/29/99 imagery: 24-612020; 699-144; and 9/1/1956 imagery; EAJ-7 170). -Thinning took place over large areas north of the Hwy between 1956-1999. -The two major beaver dams downstream of occupied habitat are in the same place and active in 1956 and 1999 aerial photography. -The relative continuity of shrub cover on the creek is evident in both aerial images. An increase in shrub cover away from the creek channel is evident in the 1999 image. -No signs of trailing.
Frying Pan Lake (008)	Imagery was not secured for evaluation.
Pole Creek (009)	1956 imagery was not secured for evaluation. -Thinning took place over large areas north of Pole Creek between 1956-1999 (visible on 9/29/99 imagery: 24-612020; 699-145), and a few clearcuts took place south of the creek. -The Muddy Creek Cow Camp structure is visible; no signs of trailing.

As for natural disturbances, the 1943 Duck Creek Fire reached as far east as Sourdough Creek (Figure 14). It appears as though the valleybottom was a firebreak for over a mile. The Duck Creek Fire did not cross Sourdough Creek, so it is likely that little or none of the valleybottom burned though runoff patterns and watershed function may have been affected. It is interesting that the distribution extent of *Rubus arcticus* ssp. *acaulis* apparently “stops” upstream at the valley segment reached by the fire. The Duck Creek Fire records are consistent with the area having a history of crown fires, and the prevalence of even-aged stands in the landscape.

Figure 14. Duck Creek Fire of 1943, digitized from 1954 aerial photo (Bighorn NF files)

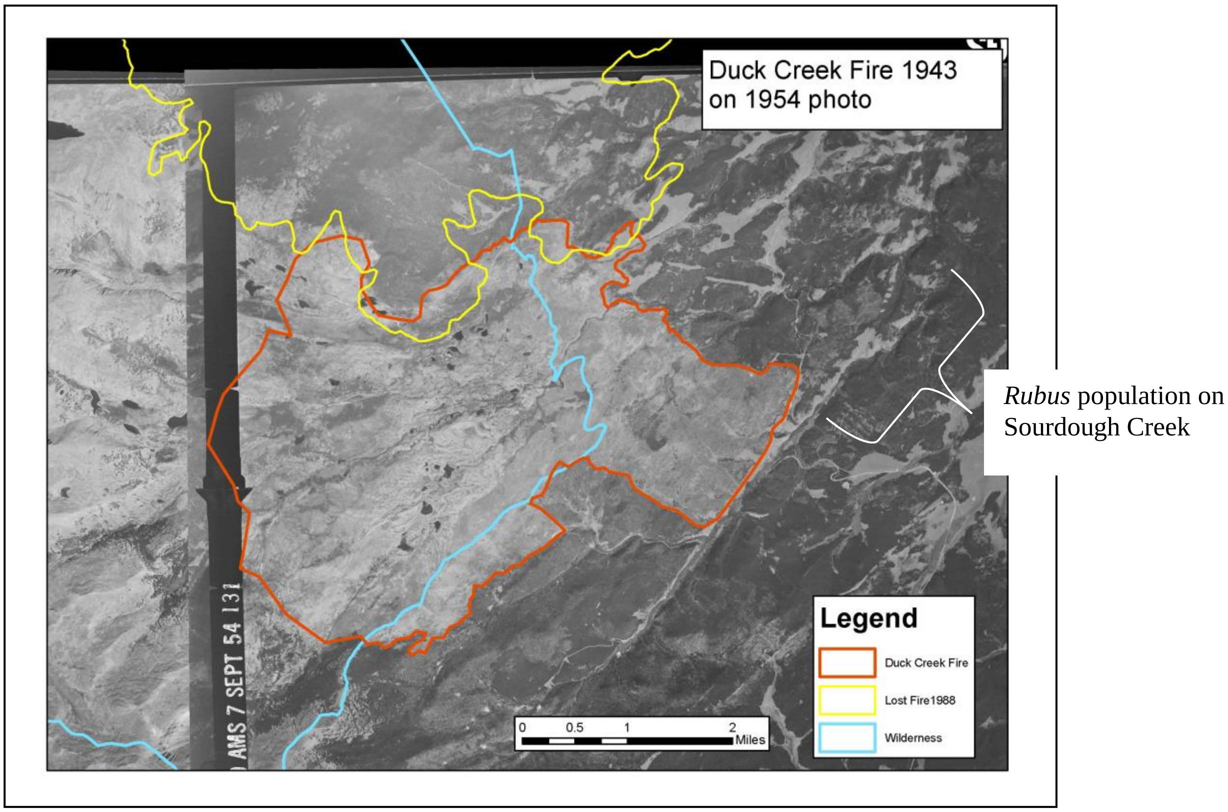


Table 7. Location information and demographic data for populations of *Rubus arcticus* ssp. *acaulis* in Wyoming

Big Horn Range

Occurrence # 001
County: Johnson
Legal Description: T50N R84W S17 (TRS approximate).
Latitude: 44° 18' 11" N (approximate centrum).
Longitude: 106° 59' 49" W (approximate centrum).
Elevation: 7000-9000 ft (2130-2740 m).
USGS 7.5' Quad: Hunter Mesa.
Location: East slope Bighorn Range, "headwaters of Clear Creek and Crazy Woman River". Tweedy's exact collection site is unknown.
Area: Size unknown.
Number of Plants: Not known.
Density: Not known.
Evidence of Reproduction: Observed in vegetative condition by Frank Tweedy in July-August 1900.
Evidence of Expansion/Contraction: This record is consistent with the Pole Creek population location as discovered in 2017, but cannot be proven to be the same.

Occurrence # 003
County: Johnson
Legal Description: T50N R84W S26 (S2 of SW4 of SE4, E2 of SW4 of SE4, & SW4 of NE4 of SE4), S34 (SW4SW4 of NE4 of SE4 & NE4NE4 of SE4), S35 (SE4 of NW4NW4 & W2 of SW4 of NW4).
Latitude: 44° 16' 02" N (centrum)
North: 44° 16' 39" N.
South: 44° 15' 24" N.
Longitude: 106° 56' 05" W (centrum)
East: 106° 55' 15" W.
West: 106° 56' 47" W.
Elevation: 7440-7740 ft (2265-2360 m).
USGS 7.5' Quad: Hunter Mesa.
Location: East slope Bighorn Range, along Sourdough Creek between 0.25 air miles NE of US Highway 16 NE to ca 0.2 air miles NE of the confluence of Sourdough and Little Sourdough creeks, 11-12 air miles SW of Buffalo.
Area: ca 5 acres of occupied habitat along a 1.5 mile stretch of creek. Population consists of 10 primary subpopulations.
Number of Plants: Population estimated at 51,000-77,000 stems in July 1999. The actual number of genetically distinct individuals is, however, much lower.
Density: Clones may be locally dense in areas of suitable habitat, but these patches are often widely scattered.
Evidence of Reproduction: Observed in flower and vegetative condition on July 12-17, 1999.
Evidence of Expansion/Contraction: Originally discovered in August 1994 and still extant in July 2017.

Occurrence #007
County: Johnson
Legal Description: T48N R84W Sec. 2 SW1/4 and Sec. 4 SE 1/4
Latitude:
Longitude:
Elevation: 7920
Location: Big Horn Mountains; Muddy Creek, ca 0.2 miles northeast of Hazelton Road.
Area:
Number of Plants: 1000+ plants
Evidence of Reproduction: Observed in vegetative condition in August 2006, and flower and vegetative condition on on June 28, 2007.

Evidence of Expansion/Contraction: Not known.

Occurrence #008
County: Johnson
Legal Description: T51N R85W Sec. 10 NE1/4.
Latitude:
Longitude:
Elevation: 9400-9440 ft
Location: Big Horn Mountains; Frying Pan Lake.
Area: 5-8 ac.
Number of Plants: 1000+ stems
Evidence of Reproduction: Warder noted: "It appears that the flowers started to dry out before fruit could fully form. In all the plants that appeared to have flowered (10% or less), the fruit was very dry and small, and disc-shaped, less than 5 mm. It appears that the flowers may not be getting pollinated and the plants are reproducing vegetatively."
Evidence of Expansion/Contraction: This is the first thorough mapping of the population; the prior visit was cut short and there is no basis for evaluating trend.

Occurrence # 009
County: Johnson
Legal Description: T49N R84W Sec. 22 E1/2 of NW1/4
Latitude:
Longitude:
Elevation: 8260 ft.
Location: Big Horn Mountains, both sides of Pole Creek, ca 0.7 miles northwest of Muddy Creek Cow Camp, ca 15 air miles southwest of Buffalo
Area:
Number of Plants: Between 2000-20,000 stems
Evidence of Reproduction: Plants observed in flower and vegetative condition on July 5, 2017.
Evidence of Expansion/Contraction: Not known.

<u>Medicine Bow Range</u>
Occurrence #006
County: Albany
Legal Description: T13M R79W Sec. 13 SE1/4 of SW1/4
Latitude:
Longitude:
Elevation: 9133 ft
Location: Medicine Bow Range; Fox Park area near headwaters of Mowberg Creek.
Area: Est. 5000 ft^2
Number of Plants: 200+ stems
Evidence of Reproduction: Revisited in 2014 by K. Haynes when collected and photographed in flower.
Evidence of Expansion/Contraction: Not known.

<u>Yellowstone Plateau</u>

Occurrence # 002
County: Teton
Legal Description: T50N R113W S28 (NW4NW4). TRS taken from BLM 1:100,000 quad.
Latitude: 44° 16' 48" N (centrum).
North: 44° 16' 50" N.
South: 44° 16' 47" N.
Longitude: 110° 28' 37" W (centrum).
East: 110° 28' 31" W.
West: 110° 28' 40" W.
Elevation: 7465 ft (2275 m).
USGS 7.5' Quad: Heart Lake.
Location: Yellowstone Plateau, banks of small creek draining into the NE shore of Heart Lake, ca 0.4 miles NW of the outlet of Beaver Creek, ca 7.5 miles E of the Lewis Lake Campground.
Area: 2 acres.
Number of Plants: Reported as

"relatively abundant" by Jennifer Whipple in 1997.
Density: Not known.
Evidence of Reproduction: Plants observed in flower and vegetative condition on July 7, 1997.
Evidence of Expansion/Contraction: Population originally discovered in late 1970s and still extant in 1997.

Occurrence # 004
County: Teton
Legal Description: T50N R113W S19 (SW4 of NE4). TRS taken from BLM 1:100,000 quad.
Latitude: 44° 17' 23" N (centrum).
Longitude: 110° 30' 25" W (centrum).
Elevation: 7460 ft (2273 m).
USGS 7.5' Quad: Mount Sheridan.
Location: Yellowstone Plateau, Witch Creek at S end of Heart Lake Geyser Basin.
Area: Not known.
Number of Plants: Not known.
Density: Not known.
Evidence of Reproduction: Plants observed in flower and vegetative condition by Jennifer Whipple on June 28, 1995.
Evidence of Expansion/Contraction: Population has not been relocated since 1995.

Occurrence #005
County: Park
Legal Description: T55N R114W Sec 13 NE ¼
Latitude: 44° 44' 58" N (centrum)
Longitude: 110° 32' 28"W
Elevation: 8080 ft (2463 m)
Location: Yellowstone Plateau; south slope of Washburn Ridge midway between Cascade and Grebe Lakes.
Area: Not known.
Number of Plants: Not known.
Evidence of Reproduction: Plants observed in flower and vegetative condition by Erwin Evert on June 25, 2001.
Evidence of Expansion/Contraction: Population has not been relocated since 2000.

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