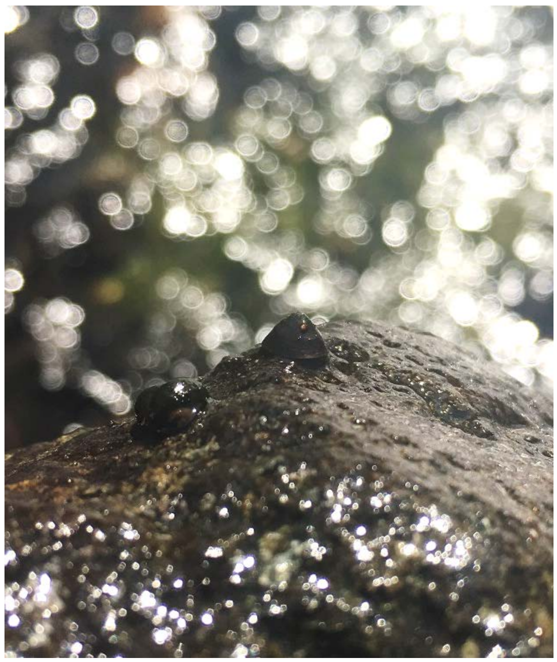
Banbury Springs Limpet
(*Lanx* n sp.) (undescribed)

5-Year Review:
Summary and Evaluation



U.S. Fish and Wildlife Service/
Idaho Fish and Wildlife Office
Boise, Idaho

5-YEAR REVIEW

Species reviewed: Banbury Springs Limpet (*Lanx* n sp.) (undescribed)
(Currently recognized as *Idaholanx fresti*)

5-YEAR REVIEW
Banbury Springs Limpet/*Lanx* n sp.

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional or Headquarters Office: Pacific Regional Office, Portland, Oregon

Lead Field Office:

Idaho Fish and Wildlife Office, Boise, ID; (208) 378-5243.

Greg Burak, Idaho Fish and Wildlife Office, Fish and Wildlife Biologist
Dave Hopper, Idaho Fish and Wildlife Office, Fish and Wildlife Biologist
Tracy Melbihess, Idaho Fish and Wildlife Office, Chief of Classification and Recovery
Kathleen Hendricks, Idaho Fish and Wildlife Office, Assistant State Supervisor
Chris Swanson, Idaho Fish and Wildlife Office, Deputy State Supervisor
Gregory M. Hughes, Idaho Fish and Wildlife Office, State Supervisor

Cooperating Field Office(s): Not Applicable (NA)

Cooperating Regional Office(s): NA

1.2 Methodology used to complete the review:

In conducting this review, we (the U.S. Fish and Wildlife Service (Service)) utilized information obtained since the 2006 5-year status review for the species that is contained in peer-reviewed literature and numerous technical reports by various government agencies and non-government entities. These reports include peer reviewed scientific studies related to the species taxonomic description; species monitoring data conducted by the Idaho Fish and Wildlife office (IFWO); water quality data collected by the IFWO and Idaho Power Company; water quantity and quality reports produced by the U.S. Geological Survey, Idaho Department of Water Resources and Idaho Department of Environmental Quality; regulations and conservation measures produced by the Idaho Department of Fish and Game, Idaho Water Resources Board, and Idaho Department of Water Resources; and, various other scientific literature regarding the species and its habitat requirements.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review: February 12, 2016. Endangered and Threatened Wildlife and Plants; Initiation of 5-

Year Status Reviews of 76 Species in Hawaii, Oregon, Washington, Montana, and Idaho. 81 FR 7571.

1.3.2 Listing history

Original Listing
FR notice: FR 57: 59244-59256
Date listed: December 14, 1992
Entity listed: Banbury Springs Limpet (*Lanx* n sp.) (undescribed)
Classification: Endangered

Revised Listing, if applicable
FR notice: NA
Date listed: NA
Entity listed: NA
Classification: NA

1.3.3 Associated rulemakings: NA

1.3.4 Review History: September 15, 2006. Banbury Springs Limpet (*Lanx* n sp.) (undescribed), 5-Year Review: Summary and Evaluation. Recommendation: No change in classification needed; Recovery Priority Number revised from an 8 to a 6 as a result of the 2006 review.

1.3.5 Species' Recovery Priority Number at start of 5-year review: Subsequent to the 2006 review, we revised the Recovery Priority Number to a 5C during an end of year data call because it is believed to be a species, it is subject to a high degree of threat, is rated low in terms of recovery potential, and may be in conflict with construction or other development projects or economic activity.

1.3.6 Recovery Plan or Outline

Name of plan or outline: Snake River Aquatic Species Recovery Plan
Date issued: December 1995
Dates of previous revisions, if applicable: NA

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

Not applicable as the DPS policy only applies to vertebrates.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

_X_ ***Yes***

___ ***No***

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

____ ***Yes***
__X_ ***No***

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

As stated in the 1995 final Recovery Plan, "The 5 federally listed snails outlined in the Snake River Aquatic Species Recovery Plan (Plan) may be reclassified or recovered by implementing various conservation measures that preserve and restore main stem Snake River and tributary cold-water spring habitats. These habitats are essential to their survival within the specified recovery areas described below. The Plan includes short-term recovery goals that will provide specific downlisting/delisting criteria for the listed species. Recovery will be based on detection of increasing, self-reproducing colonies at pre-selected monitoring sites within each species recovery area for a 5-year period. Monitoring sites will be selected in areas of known live snail collections from the past 15 years and generally represent the outer most boundaries of the recovery area for each species. Standards for habitat conditions would be based on state (Idaho) water quality standards for cold-water biota including annual water temperatures that average below 18^{o} Celsius (C) (64.4^{o} Fahrenheit (F)); dissolved oxygen concentrations greater than 6 parts per million; and pH levels that are within the range of 6.5 to 9.5 milligrams/liter (mg/L)[1]."

Specific to the Banbury Springs limpet:

- The recovery areas and monitoring sites for the Banbury Springs lanx (limpet) are tributary cold-water spring complexes to the Snake River between river kilometer (RKM) 941.5 to 948.8 (river mile (RM) 584.8 to 589.9):
  1) at Banbury Springs RKM 948 (RM 589),
  2) at Box Canyon Springs RKM 947 (RM 588), and
  3) at Thousand Springs RKM 941 (RM 584).

- Suitable habitats will include well-oxygenated, clear, cold (15-16^{o}C (59-61^{o} F)) water on boulder or cobble substrate.

[1] The 1995 Recovery Plan incorrectly defines pH as milligrams per liter (mg/L). pH is defined as a measurement of the hydrogen ion concentration in an aqueous solution.

Status of Recovery Criteria

Banbury Springs limpets are known from 4 populations in the Snake River and its tributaries: Briggs Springs, Banbury Springs, Box Canyon Springs, and Thousand Springs (Figure 1). While all known populations of Banbury Springs limpets are self-reproducing, annual monitoring density data collected at the 4 populations indicates 3 of the 4 populations are declining, with the smallest population (Thousand Springs) increasing in 2017 for the first time since monitoring began. This increase at Thousand Springs is likely in response to conservation actions carried out by the Service and its partners in 2016 (see Section 2.3.1.2). It is important to note that monitoring only provides an index of population density and trends, and not population or range-wide abundance estimates, though it does provide information sufficient to assess whether recovery criteria are being met. Therefore, because 3 populations are declining and only 1 is increasing, the demographic criterion for this species has not been met.

pH data collected at the 4 springs occupied by the Banbury Springs limpet indicate values are within the range of 6.5 to 9.5 mg/L identified in the Recovery Plan (USFWS 2015-2017). We do not have information indicating that dissolved oxygen concentrations at the occupied springs are less than the 6 parts per million identified in the Recovery Plan.

Since the completion of the recovery plan in 1995, we have learned more about this species, including where it is found, and its habitat requirements. The recovery area and monitoring sites listed in the recovery criteria include 3 of the 4 known cold-water spring complexes (Banbury Springs, Box Canyon Springs, and Thousand Springs) known to be occupied by the species in 1995, but does not include the population at Briggs Springs that was discovered after the recovery plan was approved. Briggs Springs is also the outer most boundary of the 4 known populations along the Snake River at approximately RKM 949 (RM 590). Therefore the existing recovery criteria of "Monitoring sites will be selected in areas of known live snail collections from the past 15 years and generally represent the outer most boundaries of the recovery area for each species." is not up to date with the addition of Briggs Springs.

While the recovery plan identifies aspects of suitable habitat for the species, we do not believe it encompasses all habitat requirements we now consider to be necessary. Long-term water temperature data collected at 1 spring occupied by the Banbury Springs limpet (Box Canyon Springs) indicates that water temperatures are not meeting water temperature recovery criteria (15-16ºC (59-61º F)) identified in the recovery plan during certain times of the year (see Figure 2). Therefore, these recovery plan criteria may need to be revised to objectively capture water temperatures that appear to be tolerated by the Banbury Springs limpet.

We have documented increasing nutrients such as nitrates occurring in the 4 known occupied spring complexes that are likely affecting the species and its habitat. While it is unknown what direct effects nitrates have on the Banbury Springs lanx, they are known to have negative impacts on invertebrate species when their concentrations increase past certain thresholds (Camargo *et al.* 2005, p. 1255). In addition, increasing nitrate concentrations may be driving macrophyte presence (Mebane *et al.* 2013, p. 154) at several springs occupied by the Banbury Springs limpet, which prefer clean cobble to boulder habitat relatively free of macrophytes.

In addition, the maintenance of sufficient volumes of spring water to maintain suitable habitat conditions for the Banbury Springs limpet is not adequately captured in the existing recovery criteria for the species. As discussed in further detail below, several occupied springs are undergoing long-term declines in spring discharge (Figures 6 and 7). This can affect suitable habitat availability for the species.

Given our expanded knowledge of the species range and habitat requirements since completion of the recovery plan in 1995, we recommend that the recovery criteria be revised to include our current knowledge for the Banbury Springs limpet.

Figure 1: Banbury Springs limpet (lanx) occupied springs: Briggs Springs, Banbury Springs, Box Canyon Springs, and Thousand Springs.

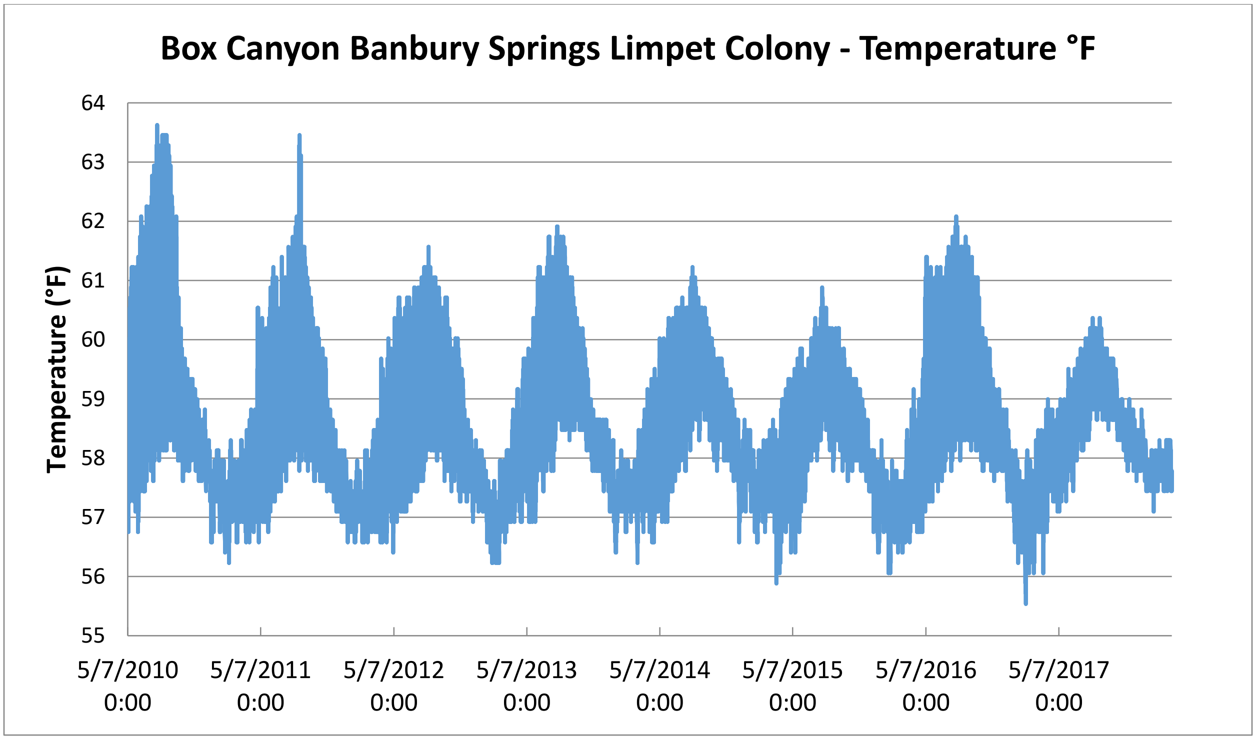


Figure 2: 2010-2017 water temperature (°F) data collected at Box Canyon Springs where it is occupied by the Banbury Springs limpet. Data collected by the USFWS with Onset® HOBO Pendent® water temperature data loggers.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Biological and life history information for the Banbury Springs limpet continues to be lacking in several key areas, including knowledge about biology and life history of the species, and sensitivity to water quality parameters. Due to the Banbury Springs limpet's restricted distribution, along with limited resources, experimental investigations of biology or life history have not been carried out on the species. Without this species specific information, it can be difficult to assess the severity of certain threats to the species, such as direct and indirect impacts from degraded water quality. Additional information on biology and life history would allow for more effective conservation actions.

Limited examinations of Banbury Springs limpet have been conducted in the field, along with comparisons to closely related species, such as *Fisherola nuttalli* (Frest and Johannes 1992, p. 31) which is found in Idaho's large rivers, primarily the Snake and Salmon Rivers and some of those rivers' tributaries (Lysne 2009, p. 13). Below is a summary of known biology and life history information for the Banbury Springs limpet.

The Banbury Springs limpet is distinguished by a conical shell with a sub central apex, and ranges in length from 2.4 to 7.1 millimeters (mm), 1.0 to 4.3 mm in height, and 1.9 to 6.0 mm in width (U.S. Fish and Wildlife Service (USFWS) 1995, p. 12). They are known to occur in large, undisturbed springs containing cold, clear, and well oxygenated water where they avoid areas with large, attached plants or areas with fluctuating water levels and are generally absent from turbid environments (Frest and Johannes 1992, p. 28). They likely feed on periphyton (which has not been verified through stomach content analysis) and occur primarily on the lateral sides of rocks, but not in contact with the sediment (Frest and Johannes 1992, pp. 27-29). Limpets move very little[2] and reside in localized populations. As specialized respiratory organs are lacking, limpets are particularly sensitive to fluctuations in dissolved oxygen that can lead to mortality (Baker 1925 *in* Frest and Johannes 1992, p. 27).

The Banbury Springs limpet lays eggs within subhemispherical capsules that are < 1.5 mm, with no more than 6 eggs within each capsule. It is likely oviposition (egg deposition) takes place approximately 1 month after copulation, with eggs having been seen from April through June, and hatchlings encountered from May through July. Young of the year are likely sexually mature by late fall to early winter. A large die off of adults (90-95%) likely occurs at approximately the same time as egg laying. A one year life span is expected for the majority of individuals in a population (Frest and Johannes 1992, pp. 31-32). The Banbury Springs limpet is assigned to the family Lymnaeidae, a family in which all known members are hermaphroditic, where individuals have both male and female sexual parts, and can reproduce both sexually and asexually.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

We lack detailed demographic information, along with historical abundance and distribution, for the Banbury Springs limpet. Based on annual monitoring for the Banbury Springs limpet, densities for the species have ranged from 1.3 to almost 100 individuals/meter^2 (m^2) (Lysne in litt. 2008; USFWS 2011-2017), with densities closer to 40/ m^2 being more typical historically (Frest and Johannes 1992, p. 30). A rangewide monitoring approach was implemented in 2012, allowing us to assess the species' status with population density trend information that has been gathered since the last 5-year review in 2006.

Annual monitoring has been conducted at 3 of the populations since 2012 (Box Canyon Springs, Thousand Springs, and Briggs Springs), while annual monitoring has been conducted at Banbury Springs since 2008 (with no monitoring occurring in 2009 and 2010). The objectives of this annual monitoring are to determine presence/absence at the 4 known colonies on an annual basis, and collect information sufficient to monitor population density trends on an annual basis at representative locations within the 4 populations (USFWS 2017, p. 4). This monitoring approach is feasible and should provide us with enough information to document whether recovery criteria are being met. Besides Thousand Springs, we do not monitor within the entire populations at the other 3 springs given difficult access conditions (water too swift and deep that

[2] Frest and Johannes (1992, p. 29) stated that the Banbury Springs limpet "may cover a radius of only a few centimeters from its place of origin per day. Specimens at both Thousand Springs Preserve and Banbury Springs have been observed occupying essentially the same position for weeks; some at Banbury Springs definitely occupy the same rock for months."

is unsafe for monitoring, vegetation restrictions, etc.), and to limit monitoring related activities and the potential for negative impacts to the species (wading through occupied habitat has the potential to harm individual limpets). Therefore, our monitoring approach provides information sufficient to track recovery criteria status as stated above, but is sensitive to the species extreme rarity and susceptibility to human disturbance.

The following colony-specific status information is taken from annual monitoring reports from 2008, 2011-2017 (Lysne in litt. 2008, USFWS 2011- 2017).

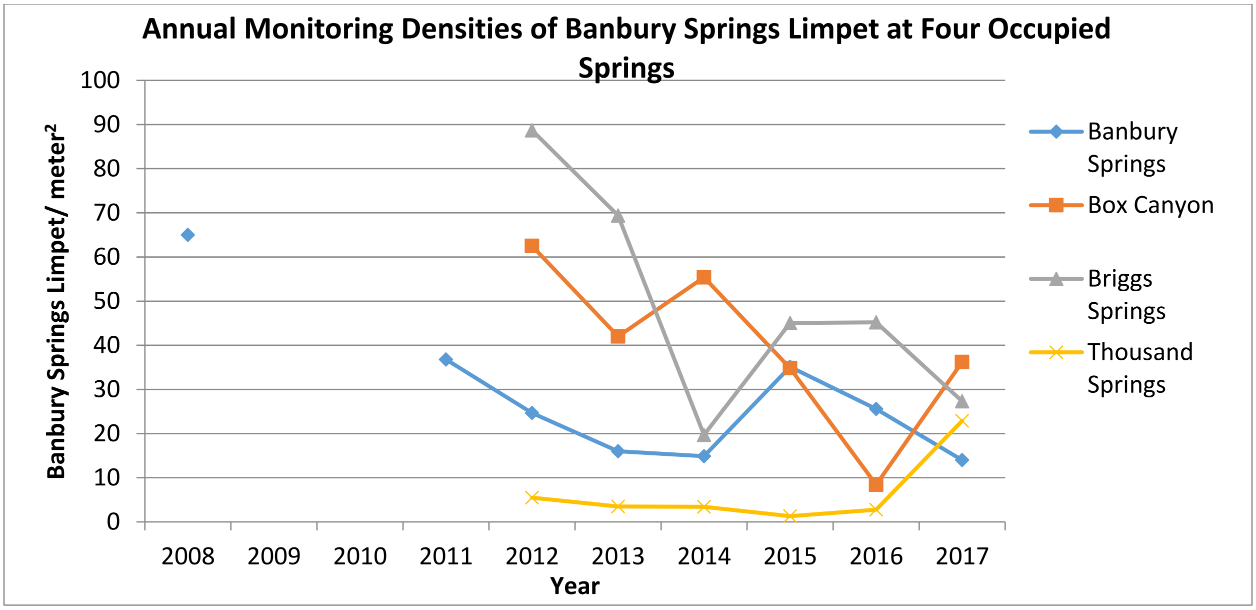


Figure 3: Banbury Springs limpet annual density findings at the 4 known populations, from 2008 through 2017. Monitoring was not carried out in 2009 and 2010, while in 2008 and 2011, monitoring was only carried out at Banbury Springs.

Banbury Springs

Of the 4 known Banbury Springs limpet populations, Banbury Springs has been monitored the longest (2008 and 2011-2017). In 2008, an 80 m^2 monitoring site was established in the highest known density location within this population. Within this monitoring site, 15-20 0.25 m^2 plots are placed on the stream bottom and the number of limpets are counted within each plot utilizing a benthic viewer (aquascope). Utilizing these counts, density findings are extrapolated to 1 and 80 m^2 respectively[3].

This population has undergone a decline in density from 2008 to 2014 from 65 to 15 limpets/m^2, briefly increased in 2015 to 35 limpets/m^2, but then declined to 14 limpets/m^2 in 2017 (Figure 3). Extrapolating these density findings to the entire 80 m^2 site results in an estimated average

[3] While limpets surveyed through an aquascope are not as readily detectable as those surveyed via the cobble count method, this monitoring approach at Banbury Springs continues to be utilized given the long-term and consistent data set. In addition, 2-3 independent observers are utilized for monitoring at Banbury Springs to increase limpet detection ability and minimize the number of limpets that may be missed by surveyors (USFWS 2017, p. 6).

sampling area population ranging from a high of 5,235 in 2008 to a low 1,120 individuals in 2017. It is important to remember that these estimates do not include limpets that occur outside of the 80 m^2 monitoring site. In addition, the 80 m^2 monitoring site does not provide habitat of uniform quality; observations suggest 40-71 percent has been made up of unsuitable macrophyte beds since monitoring began in 2008. Given the uneven distribution patterns and densities of limpets at Banbury Springs, and the effects macrophyte beds have on suitable habitat availability for the species (see Section 2.3.2), it is difficult to obtain a confident population estimate for this entire population.

Box Canyon Springs
At Box Canyon Springs, the cobble count method is utilized to monitor Banbury Springs limpets, where cobbles are randomly selected, the number of limpets on each cobble are counted, and then a measurement of available surface area is estimated for each cobble[4]. Results are then summarized and extrapolated to limpets/m^2. Average density has ranged from a high of 63 limpets/m^2 in 2012 to a low of 8.43 limpets/m^2 in 2016 within the sampling area (Figure 3). Annual monitoring results indicate this population is declining, though it is important to remember that these results do not include limpets found outside of the monitoring site, and therefore a confident population estimate for the entire population cannot be calculated.

Briggs Springs
At Briggs Springs, the cobble count method is utilized to monitor Banbury Springs limpets at two locations, where cobbles are randomly selected, the number of limpets on each cobble are counted, and then a measurement of available surface area is estimated for each cobble. The upper monitoring location is just below U.S. Geological Survey (USGS) streamflow gage No. 13095175, while the lower monitoring site is below a diversion that diverts water to an aquaculture facility. At the upper site, average density has ranged from a low of 32.2 limpets/m^2 in 2014 to a high of 127.9 limpets/m^2 in 2012. Densities have been generally lower at the lower site, ranging from a low of 5.7 limpets/m^2 in 2012 to a high of 73 limpets/m^2 in 2013 (Figure 4). When combined, both locations have declined since monitoring began in 2012 (Figure 3), though it is important to remember that these results do not include limpets found outside of the monitoring sites, and therefore a confident population estimate for the entire population cannot be calculated.

[4] The cobble count method at Box Canyon, Briggs Springs, and Thousand Springs is utilized for monitoring purposes as opposed to the monitoring plot method at Banbury Springs, given limpets are more readily detectable when all sides of the cobbles can be visually inspected at a relatively close range.

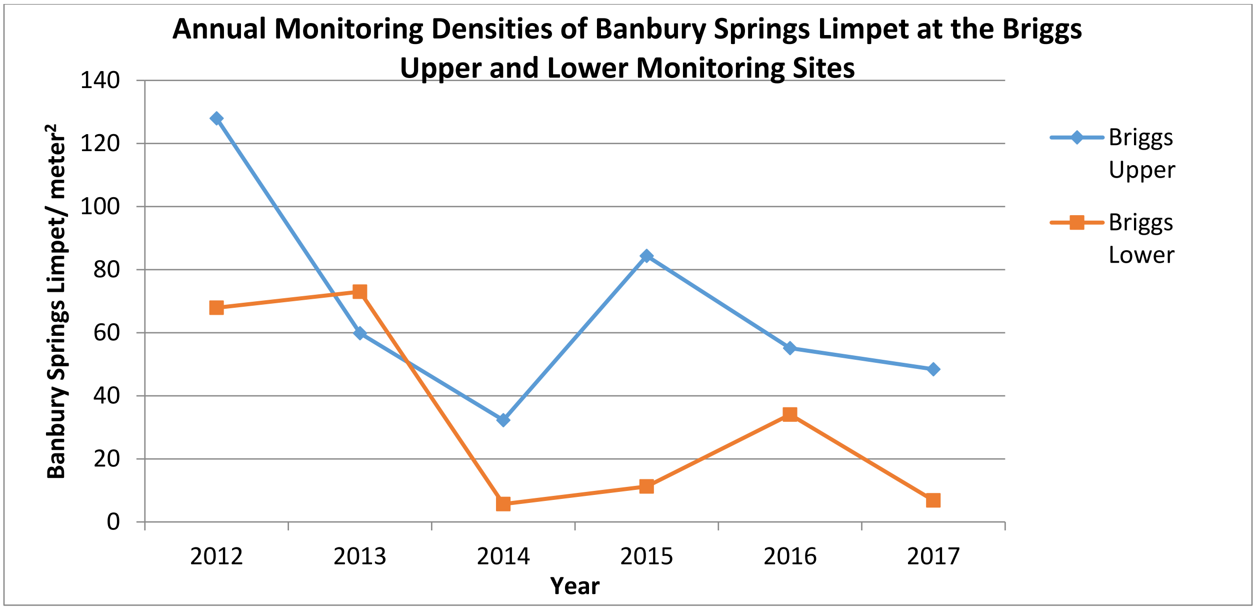


Figure 4: Banbury Springs limpet annual density findings at the upper and lower Briggs Springs monitoring sites, from 2012 through 2017.

Thousand Springs
At Thousand Springs, the cobble count method is utilized to monitor Banbury Springs limpets, where cobbles are randomly selected, the number of limpets on each cobble are counted, and then a measurement of available surface area is estimated for each cobble[5]. As opposed to the other populations, the Thousand Springs population is the smallest population that historically occupied an area of 12-14 m^2 (129 to 151 square feet (ft^2); Frest and Johannes 1992, p. 26). Recently, most individuals are confined to an area < 2 m^2 (22 ft^2; Hopper in litt. 2016). Therefore, cobbles are selected for monitoring purposes from all occupied habitat within the Thousand Springs population, though it is unlikely all limpets are detected.

Given the consistently low densities of limpets found at Thousand Springs, and the small area occupied compared to historical records (Frest and Johannes 1992, p. 27), the Service determined that genetic bottle-necking and inbreeding, as well as demographic stochasticity, could lead this population to be extirpated (Hopper in litt. 2016). Therefore in 2016, the Service and partners implemented a translocation of Banbury Springs limpets from Banbury Springs into Thousand Springs. Nineteen limpets were translocated given it was believed this amount would limit negative impacts from the loss of individuals to the donor Banbury Springs population, while ensuring enough individuals were introduced to contribute genetic material to the Thousand Springs population. Translocated limpets were individually marked with a waterproof marker to assess post-translocation survivorship. Twelve of the 19 marked limpets were found alive 9 days after being translocated. Assessing survivorship of translocated limpets beyond 9 days was difficult as the marking utilized on the limpets started to fade, though these results indicate a majority of the 19 individuals survived the initial translocation into Thousand Springs (USFWS 2016, pp. 16-17).

[5] Unlike the other 3 occupied springs, snorkeling is utilized at Thousand Springs to limit wading through occupied habitat, which minimizes monitoring related impacts to the species.

Following the translocation, the Service carried out a macrophyte removal effort by hand during the summer of 2016 (USFWS 2016, p. 16; see Section 2.3.2.1 (Macrophytes) for a description of macrophyte effects to Banbury Springs limpet habitat). Follow-up surveys in 2017 showed densities increased to approximately 23 limpets/m^2 (USFWS 2017, p. 14), which was much greater than the second greatest density of 6 limpets/m^2 in 2012 (Figure 3). One item to note is that in 2017 the least amount of cobble area was surveyed since monitoring began, which may partially attribute to the much higher density findings that year (USFWS 2017, p. 14-15). It is likely the small cobble area surveyed in 2017 was due to less cobbles surveyed and those cobbles being smaller in size (USFWS 2017, p. 14). While no additional translocations have been carried out at Thousand Springs, additional macrophyte removal efforts were carried out by hand in 2017 to maintain and provide additional suitable habitat at this location (USFWS 2017, Appendix I).

Figure 5: Occupied Banbury Springs limpet habitat cleared of macrophytes, with macrophytes remaining in the upper right portion of the photo.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

There continues to be limited information available regarding genetic variation among the 4 known populations of the Banbury Springs limpet. While Clark (2007) and Campbell *et al.* (2017) examined the taxonomic status of the Banbury Springs limpet using genetic characters, data collected showed virtually no variation at the intrapopulation level. Examination of other genetic markers, such as allozymes or microsatellites, is needed to better understand genetic variation among the 4 populations (Clark 2007, p. 4).

2.3.1.4 Taxonomic classification or changes in nomenclature:

Though not formally described at the time of its listing under the Endangered Species Act, the Banbury Springs limpet was identified as a unique species with a highly restricted range, found in springs derived from a single aquifer system (Eastern Snake Plain Aquifer (ESPA)) that feeds the middle reaches of the Snake River in Idaho. At the time of its discovery by Dr. T. Frest in 1988, the Banbury Springs limpet was placed in the genus *Lanx*, with a temporary assignment of *Lanx* (n.) sp. as a congener with two other species, *L. patelloides* and *L. alta* (Campbell *et al.* 2017, entire). Earlier works had also recognized *Walkerola* as a genus within the Lancinae, but it is now recognized as a synonym of, or subgenus within *Lanx*. The more wide-spread giant Columbia River limpet (*Fisherola nuttallii*) is recognized as a monotypic genus within the subfamily Lancinae (Campbell *et al.* 2017, entire).

An unpublished genetic and morphological analysis by Clark (2007, entire) supported the Banbury Springs limpet as a unique species and suggested a level of differentiation that might warrant the erection of a separate genus. Despite this work, the species remained undescribed until a recent, more thorough investigation by Campbell and others (2017, entire) was conducted analyzing genetic sequences from four DNA regions from samples of the three described lancine species as well as samples from the 4 known populations of Banbury Springs limpet. Comparisons with other members of the subfamily also included morphological differences in the shell, shape and location of the columnar musculature, and genitalia, all of which support Clark's (2007) earlier taxonomic analysis and placement of Banbury Springs limpet within its own genus. The new genus, *Idaholanx*, describes the species' endemicity within the state of Idaho.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

The Banbury Springs limpet is found within portions of 4 large spring complexes that discharge ESPA water into the middle-Snake River (Mid-Snake) in the Thousand Springs Area: Briggs Springs, Banbury Springs, Box Canyon Springs, and Thousand Springs. The species is still found at the four springs as described in the previous 5-year status review (USFWS 2006, pp. 8-11; USFWS 2017, entire), with each population remaining as isolated as they did at the time of the previous 5-year status review completed in 2006.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

The Banbury Springs limpet is solely reliant on springs that discharge from the ESPA, which underlies an area of the Eastern Snake River Plain, Idaho and is approximately 274 kilometers (km) (170 miles (mi)) long and 97 km (60 mi) wide (Garabedian 1992, entire). Most groundwater in the ESPA moves horizontally through interflow zones in Quarternary basalt, while moving vertically in recharge and discharge areas along joints and interfingering edges of basalt flows (Garabedian 1992, p. F1). Studies indicate the basalt may exceed several thousand feet in thickness, though along the margins of the plain, sand and gravel several hundred feet thick transmit large volumes of water (Garabedian 1992, p. F1). Water moves relatively fast through the ESPA, up to 1,767 meters (m)/day (5,800 feet (ft)/day) in certain areas (Idaho Department of Water Resources (IDWR) 2014, p. 56).

As further described below in section 2.3.2, the amount, distribution, and suitability of occupied springs for the Banbury Springs limpet have been impacted. Wetted habitat availability changes within years due to withdrawals and other factors, while long-term declines in spring discharges continue. In addition, nutrients such as nitrates are increasing at the 4 occupied springs, which likely leads to macrophytes limiting suitable habitat for the species. All of these factors have led to impacts to habitat or ecosystem conditions upon which the species relies.

2.3.1.7 Other: NA

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat Modification
The Banbury Springs limpet continues to be impacted by structures and diversions as described in the 2006 5-Year Status Review for the species (USFWS 2006, p. 8-11); all 4 springs have been impacted by habitat modification and curtailment due to hydroelectric development, water withdrawals, and/or diversions.

Additional or updates of existing factors affecting habitat availability or the range for the species are described below.

Groundwater
The Banbury Springs limpet is solely reliant on springs that discharge from the ESPA; adequate quantity and quality of these spring outflows is critical to the long-term persistence of the species. Groundwater quantity and quality factors may affect the Banbury Springs limpet through direct impacts to the species, such as to dissolved oxygen availability (Baker 1925, p. 148), exposure to fine sediment that may affect the ability of the species to breathe through its vascularized mantle (Reed *et al.* 1989, entire), along with contaminants that may be toxic. Groundwater quantity and quality can also impact suitable habitat that the Banbury Springs limpet is dependent upon. An update of the factors affecting groundwater quantity and quality, along with recently implemented or ongoing conservation measures that may affect groundwater quantity and quality in relation to the Banbury Springs limpet and its habitat, are described below.

Groundwater Quantity
As noted above, the Banbury Springs limpet is reliant on springs of adequate quantity that discharge from the ESPA. Current estimates of surface and groundwater use for Idaho are approximately 17.2 billion gallons per day, with irrigation for agricultural and horticultural uses

accounting for about 80 percent of this total (Maupin *et al.* 2014, pp. 10, 25-26). Idaho ranks number 2 in the country (below California) in total irrigation water withdrawals, which includes both surface and groundwater (Maupin *et al.* 2014, p. 10). This trend in the state is directly relevant to the Banbury Springs limpet. Over a 95-year period of recordkeeping, spring flows from the ESPA contributed between 30-85 percent of flow in the Snake River at King Hill (Richards *et al.* 2006, pp. 84, 85). Between the turn of the last century (est. 1900) and the 1950's, irrigation water was moved from rivers and streams with the use of surface conveyance canals. Seepage from these canals into the fractured basalt resulted in recharge of the ESPA and corresponding increases in spring discharge (Kjelstrom 1992, entire). Based on analyses reported by Richards and others (2006, p. 84), and Ondrechen (in litt. 2004), spring discharges in the early 2000's may have been 15 percent greater than they were in the early 1900's. However, spring discharges began a sharp decline with the increased use of groundwater for irrigation, and a corresponding decrease in flood irrigation due to the use of center pivot sprinklers, which contribute little to groundwater recharge (Ondrechen in litt. 2004; University of Idaho in litt. 2007). These large withdrawals, along with a decrease in incidental recharge, drought, and changes in cropping patterns, have been documented to be contributing to the depletion of the overall ground water storage in the ESPA (IDWR 2016, p. 7; University of Idaho in litt. 2007).

Spring flow reductions appear to be having short and long-term effects to the Banbury Springs limpet by limiting wetted suitable habitat availability (Figures 6, 7, and 8). In addition to long-term declines in spring discharges, spring flows change within years, with annual peak flows occurring around November 1 and annual low flows around May 1 (Richards *et al.* 2006, p. 88; Schorzman *et al*. 2009. p. iv). Annual changes in flow are primarily due to groundwater pumping for agricultural purposes and natural spring recharge (Clark *et al.* 1998, p. 2). Given the species is reliant on wetted habitat, areas that are dewatered become unsuitable for the species. As spring flows seasonally decline, limpets must move and stay in the remaining wetted habitat to survive. While Banbury Springs limpets appear to be able to recolonize habitat that is dewatered during certain times of the year (limpets are detected in wetted habitat that is dry during other times of the year), we do not know at what point this continued seasonal dewatering will affect Banbury Springs limpet populations to the point where they cannot persist.

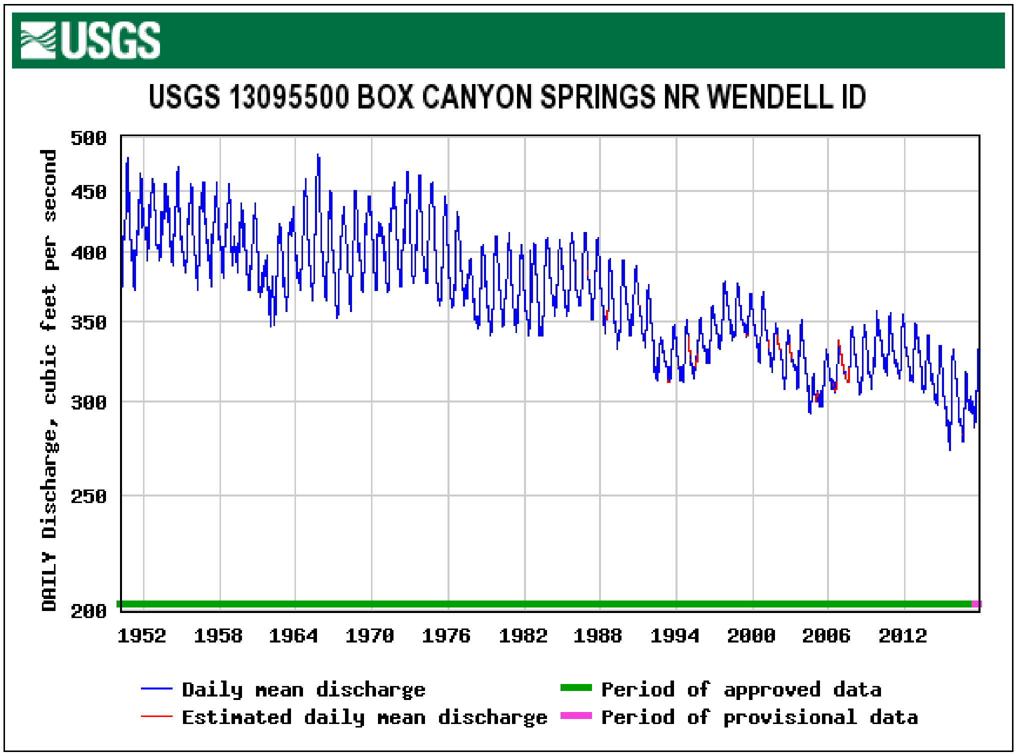


Figure 6: Spring discharge from approximately 1951 to 2017 at Box Canyon, Idaho measured at U.S. Geological Survey stream gage 13095500.

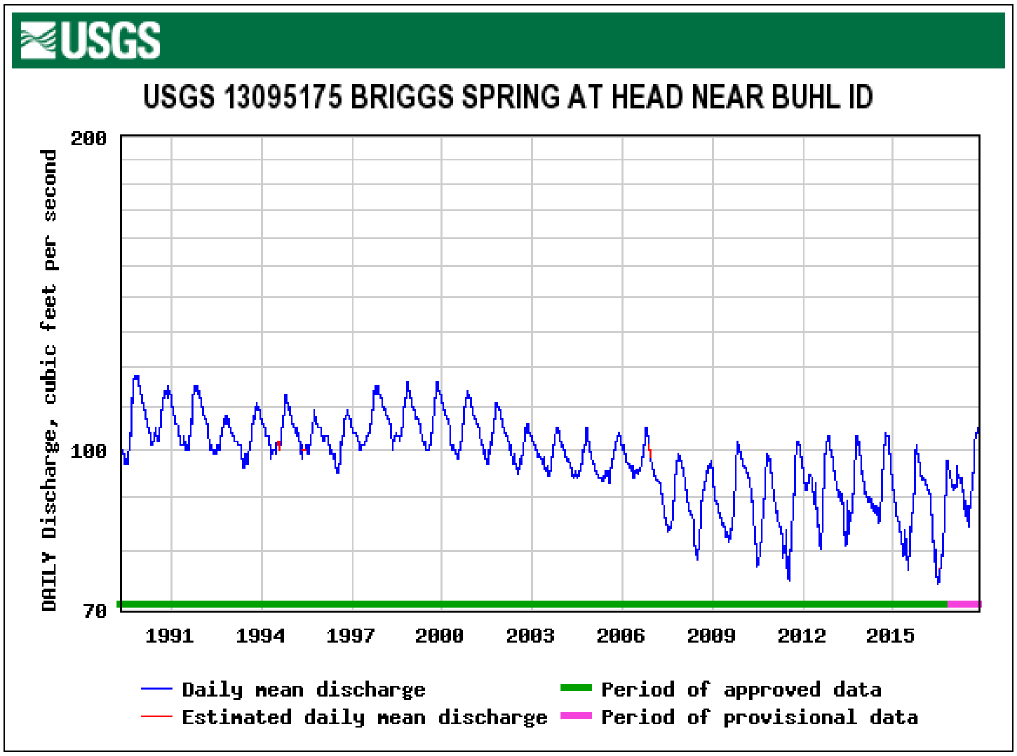


Figure 7: Spring discharge from approximately 1992 to 2017 at Briggs Springs, Idaho, measured at U.S. Geological Survey stream gage 13095175.

Figure 8: Within year spring flow changes at an occupied Banbury Springs limpet population in Box Canyon, Idaho. The above photographs illustrate a documented 22.5-cm change in stream stage from July 2011 to February 2012 (USFWS 2012, pp. 14-15).

Inter-annual spring flows at select Banbury Springs limpet populations (Box Canyon and Briggs Springs) continue to decline as described in the previous 5-year status review (IDWR 2016, p. 11; USFWS 2006, pp. 12-14; Figures 6 and 7). In Box Canyon, the limpet population is located below a water diversion for an aquaculture facility, which has a water right to divert 300 cubic feet per second (cfs) of Box Canyon water. As measured at the USGS gage upstream of this water diversion (gage 13095500), spring flow through Box Canyon dropped below 300 cfs multiple times since 2004 (Figure 6). Banbury Springs limpets continue to occupy this area, indicating there is additional spring discharges below the diversion that maintains habitat for the species during low flow periods (USFWS 2017, pp. 12-13). At Briggs Springs, spring flows continue to decline, though there appears to be greater variation in within year spring flows starting in approximately 2007 (Figure 7). Unlike Box Canyon, the Banbury Springs limpet at Briggs Springs occurs both above and below existing water diversions. The Service monitors a lower Briggs Springs site, which is directly below a water diversion for an aquaculture facility. This site has undergone some of the largest declines in density monitoring (a 95% decline in 2014) findings (Figure 4), which is partly attributable to the periodic dewatering of this section of occupied habitat to the point where it becomes unsuitable for the Banbury Springs limpet during certain periods of the year (USFWS 2014, pp. 19-22).

<u>Groundwater Quality</u>

In addition to groundwater quantity, groundwater quality is important to the long-term persistence of the Banbury Springs limpet. There are 2 ground water flow systems affecting or adjacent to the springs occupied by the Banbury Springs limpet; the local aquifer and regional aquifer (Baldwin *et al.* 2006, p. 20; Skinner and Rupert 2012, p. 4; Figure 9). The Banbury Springs limpet is found in springs that originate from the regional aquifer system, though Briggs

Springs is close to the delineation zone for these 2 aquifers (Baldwin *et al.* 2006, p. 28). The regional aquifer is characterized by low specific conductance, along with low total dissolved solids and lower nitrate concentrations compared to water quality in the local aquifer system (Baldwin *et al.* 2006, p. 66).

While there are known effects from degraded water quality on invertebrates in general, it is largely unknown what direct and long-term effects degraded water quality, and related pollutants, have on the Banbury Springs limpet. For example, nitrates, which is a nutrient of increasing concern in springs occupied by the Banbury Springs limpet, can have a wide range of adverse effects and ecological risks to aquatic invertebrates and their habitats (Camargo *et al.* 2005, entire). Below is an update regarding sources and trends of key nutrients in the ESPA, along with potential impacts to habitat availability from increasing macrohpytes to the Banbury Springs limpet.

Nutrient Sources

Over 23,310 square kilometers (km^2) (9,000 square miles (mi^2)) of irrigated land are located within the Snake River drainage or that of its tributaries (Johnson *et al.* in litt. 2013). Most of the crops grown in this area are subject to modern agricultural practices which include the use of herbicides, insecticides, fungicides, and fertilizers; a proportion of which make their way into the Snake River via irrigation return flows and through ground water recharge (Clark *et al.* 1998, p. 2). Clark *et al.* (1998, p. 17) found the largest amounts of pesticides to be present in wells adjacent to agricultural areas around the Snake River between Burley and Hagerman, which are also the locations with the highest frequencies and concentrations of nitrates in ground water. Nitrogen input in the mid-Snake region of south-central Idaho is greatest from fertilizer use, followed by cattle manure, and lastly atmospheric deposition (Skinner and Rupert 2012, p. 4). Dissolved nitrate from nitrogen input is readily transported to groundwater because of the well-drained soils and fractured basaltic substrates in the mid-Snake region, and persists after reaching the ESPA because the highly oxic groundwater prevents denitrification (Skinner and Rupert 2012, p. 4). The presence of nitrates and other agrochemical contaminants in the groundwater (Holloway *et al.* 2004, pp. 4-6; Carlson and Atlakson 2006, pp. 3-5; Schorzman *et al.* 2009, pp. 9-19) illustrates the pathway through which these agricultural contaminants can reach the habitats of the Banbury Springs limpet and other sensitive species living within the aquifer springs.

Concentrated Animal Feeding Operations (CAFO) have increased substantially in south central Idaho overlaying the ESPA near occupied Banbury Springs limpet springs (Gooding, Jerome, and Lincoln Counties). From 2006 through 2016, total cattle numbers in these counties increased from an estimated 456,500 to 579,000 head (both dairy and beef combined; U.S. Department of Agriculture in litt. 2017). The close proximity of CAFOs and other intensive agricultural practices on the adjacent canyon rim (Figure 9) illustrate the immediacy of potential agricultural-related influences on spring habitats occupied by the Banbury Springs limpet. Nitrogen input from cattle related operations has been identified as a major contributor to water quality degradation in surface waters, groundwater, and springs in southern Idaho (Clark *et al.* 1998, p. 19; Bahr and Carlson 2000, p. 2; Schorzman *et al.* 2009, p. 19; Skinner and Rupert 2012, p. 4).

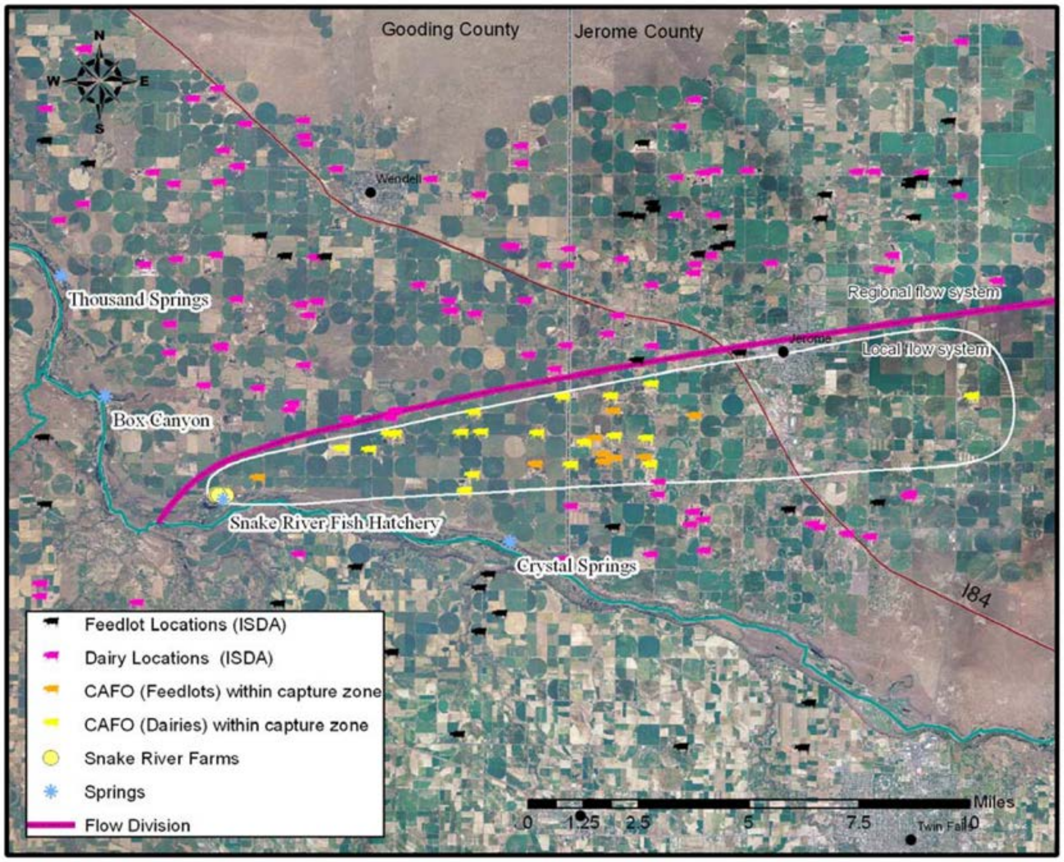


Figure 10. Land use east and hydraulically up-gradient of Snake River Farms using calculated one-year TOT capture zone.

Figure 9: Cattle feedlot and dairy locations within the range of the Banbury Springs limpet, which are found in portions of Thousand Springs and Box Canyon shown on this map. The red line is the approximate division between the regional and local aquifers and their contributions to springs and the Snake River. Map courtesy of Schorzman *et al.* (2009, p. 18).

The human population has also grown within southern Idaho. For example, from 2006 through 2011, the human population in Gooding, Jerome, and Lincoln Counties in southern Idaho grew 15 percent (U.S. Census Bureau in litt. 2013), with the city of Twin Falls growing by 20 percent from 2000 to 2010 (City of Twin Falls Data in litt. 2013). Sewage treatment facilities from these municipalities have permitted National Pollutant Discharge Elimination System discharges of nutrients, ammonia, suspended solids, organic matter, and industrial wastes into the Snake River (Clark *et al.* 1998, p. 7; U.S. Environmental Protection Agency (USEPA) 2002, pp. 4-19). Other nonpoint discharges from urban areas, such as parking lot run-off and urban-use pesticides (Clark *et al.* 1998, p. 7), do not undergo treatment but can be reasonably expected to make their way into the Snake River and/or its tributaries. Although urban run-off likely contributes to declines in water quality in the Snake River, it is not considered to be a major source of pollutants (Clark *et al.* 1998, p. 19).

Pesticides have been widely detected in groundwater in the Snake River Plain, but concentrations have been found to be generally below human-health benchmarks (Frans *et al.* 2012, p. 44). The most common pesticide compounds detected included atrazine and its degradate (a compound from the breakdown of a parent pesticide), deethylatrazine, along with simazine, hexazinone, metribuzin, diuron, prometon, metolachlor, *p,p'* – DDE, dieldrin, 2-4-D, and alachlor (Frans *et al.* 2012, p. 42). Schorzman *et al.* (2009; pp. 13-15,19) detected personal care products and pharmaceuticals (PCPP), all of which were below levels that create a human health concern, within certain springs originating from the local aquifer in southern Gooding County. PCPPs detected include sulfamethoxazole (animal and human antimicrobial compound), caffeine, DEET (insect repellent), and carbamazepine (anti-seizure medication). While the detection of these PCPPs does not identify a point source of pollution, it does indicate that they are detectable in southern Gooding County spring discharge and that a pathway exists for these and other constituents (Schorzman *et al.* 2009, p. 15) to potentially impact the Banbury Springs limpet or its habitat.

Nutrient Trends

More recent reports and data indicate that nitrate concentrations continue to increase in groundwater in the mid-Snake region (Frans *et al.* 2012, pp. 35-38; Skinner and Rupert 2012, p. 2) and in springs originating from both the local and regional aquifer (Figure 10; Schorzman *et al.* 2009, p. 10; Frans *et al.* 2012, pp. 35-38). While a trend analysis performed by IDWR between 2 time periods (2002 to 2006, and 2007 to 2011) showed decreasing groundwater nitrate trends in the Twin Falls Nitrate Priority Area (IDWR 2013, p. 30), data of nitrate data collected at the 4 springs occupied by the Banbury Springs limpet indicate an upward trend (Figure 10; Idaho Power Company 2017, p. 232; Frans *et al.* 2012, pp. 35-38). While nitrate concentrations in springs have been increasing over the longer-term, there are also within year variations in these concentrations (Figure 10; Baldwin *et al.* 2006, pp. 59-60; Schorzman *et al.* 2009, p. 10). The highest nitrate concentrations within the local and regional aquifers occur in the fall from September to December, with the lowest nitrate concentrations occurring in the spring and early summer from April to June. It is believed that the peak nitrate concentrations coincide with the lag time between summer irrigation and travel time to the spring, and that any nitrogen remaining in the soil after the growing season is transported to the aquifer in the same year if sufficient soil moisture is available given the well-drained soils and fractured basalt (Baldwin *et al.* 2006, p. 59; Schorzman *et al.* 2009, p. 10; Skinner and Rupert 2012, p. 4).

Within springs occupied by the Banbury Springs limpet, nitrate concentrations are generally highest in Briggs Springs (Figure 10). As noted above, Briggs Springs is the population located closest to the delineation zone between the local and regional aquifer. Nitrate concentrations decrease as the location of occupied springs proceeds downstream along the Snake River, until the lowest nitrate concentrations are typically found at Thousand Springs (Figure 10; Baldwin *et al.* 2006, p. 66).

In response to declining groundwater quality in parts of the mid-Snake region, the USGS National Water Quality Assessment (NAWQA) program conducted an investigation into increasing nitrate concentrations in this area (Skinner and Rupert 2012, p. 2). They modeled simulations in the change of nitrate concentrations in groundwater over time in response to three nitrogen input scenarios: 1) nitrogen levels fixed at 2008 levels, 2) nitrogen input increased from 2008 to 2028 at the same rate of increase as the average rate of increase from 1998 through 2008, and 3) nitrogen input related to agriculture completely halted, with only atmospheric nitrogen remaining (Skinner and Rupert 2012, p. 3).

Model results indicate that even when nitrogen input is held constant (scenario 1), groundwater nitrate concentrations are projected to increase for 10 to 50 years after 2008 by as much as 2 to 4 mg/L in many areas, with concentrations reaching or exceeding 10 mg/L in certain areas (Skinner and Rupert 2012, p. 27). It is important to keep in mind that this model provides a regional projection of nitrates, and should not be applied at the site specific level, such as those springs occupied by the Banbury Springs limpet (Skinner in litt. 2018). Regardless, it projects that nitrates will continue to increase in the ESPA in the mid-Snake area over the next 50 years, even when nitrogen inputs are held constant to 2008 levels, possibly leading to increased detrimental effects to the Banbury Springs limpet and the habitat it depends upon. This supports existing water quality monitoring data described earlier showing a continued increasing trend of nitrates in the ESPA and outflowing springs.

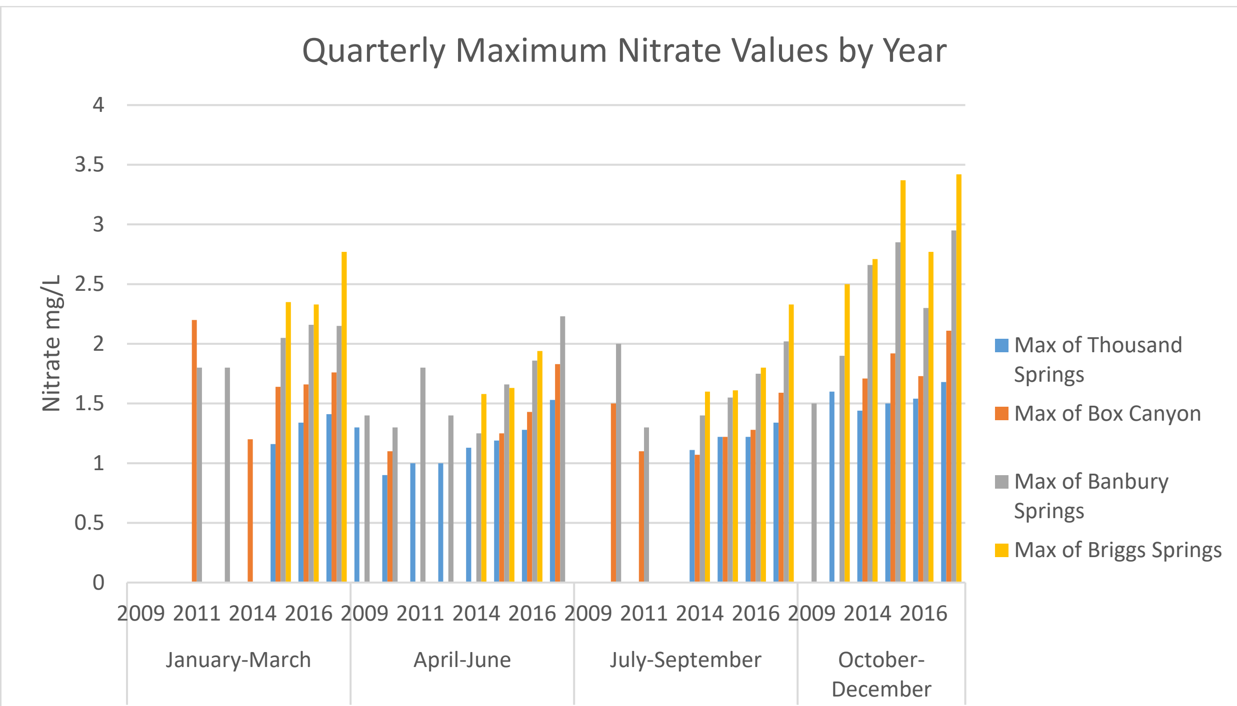


Figure 10: Quarterly maximum nitrate (mg/L) values from 2009-2017 at 4 occupied Banbury Springs limpet populations in southern Idaho. Data collected by the U.S. Fish and Wildlife Service and the Idaho Power Company.

<u>Macrophytes</u>

Macrophytes are photosynthetic organisms usually growing with their roots in the soil, above which is a layer of water (Jones *et al.* 2012, p. 1006). Macrophytes tend to spread by vegetative growth, forming stands which are relatively homogeneous (Jones *et al.* 2012, p. 1007). Two primary nutrients associated with plant growth, and of interest in freshwater systems, are nitrogen and phosphorus (Smith 1996, p. 300). Mebane *et al.* (2013, p. 154) found that total nitrogen[6] in water and sediment, along with loosely sorbed phosphorus (to take up and hold, as by absorption or adsorption) within streams was positively correlated with macrophyte biomass at both spring-fed and runoff dominated springs in southern Idaho.

In addition to nutrient availability, macrophyte abundance increases in streams with low and stable flows, such as spring-fed streams occupied by the Banbury Springs limpet (Mebane *et al.* 2013, p. 152). Macrophytes in turn can increase the retention of fine sediments by reducing water velocity, which can lead to changes in stream bed composition (Jones *et al.* 2012, p. 1006). These stream bed composition changes can further increase macrophytes when fine sediments are more nutrient rich than the natural river bed (Jones *et al.* 2012, p. 1006). Therefore, once macrophytes become established within suitable streams, they can initiate a positive feedback where their presence can lead to larger beds of macrophytes on beds of finer sediment (Jones *et al.* 2012, entire; Gurnell 2014, entire).

The Banbury Springs limpet prefers areas free of macrophytes and fine sediments, such as cobbles and boulders (Frest and Johannes 1992, p. 29; Lysne in litt. 2008; USFWS 2013, pp. 38-41). Macrophytes (ex. *Stuckenia pectinata*) are limiting suitable habitat availability for the Banbury Springs limpet at several sites, notably Banbury Springs and Thousand Springs (USFWS 2017, p. 18). Empirical evidence indicating whether increasing macrophyte presence is an increasing threat is lacking. Experimental studies conducted by the Service have documented Banbury Springs limpets recolonizing previously unsuitable habitat that had been cleared of macrophytes and fine sediments 5 months earlier (USFWS 2013, pp. 38-41). Utilizing this information, the Service and partners employed macrophyte removal efforts at Thousand Springs, in conjunction with a translocation effort, in an attempt to increase this declining population (USFWS 2016, pp. 16-20). Results post macrophyte removal indicate this population is likely positively responding to this conservation action (USFWS 2017, p.14). Given the Banbury Springs limpet resides in spring-fed streams that are susceptible to macrophyte development, and that nutrients such as nitrates that can increase macrophytes are increasing in these springs, macrophyte expansion is a potentially increasing threat that should be monitored closely.

<u>Aquifer Recharge</u>

The state of Idaho is attempting to stabilize ESPA levels by implementing water conservation measures, including managed (artificial) aquifer recharge, that are identified in the 2010 Comprehensive Aquifer Management Plan (CAMP; IWRB 2009, entire). The long-term aquifer recharge target identified in the CAMP is 150,000 to 250,000 acre feet (af) per year (IWRB 2009, p. 4; IWRB in litt. 2017). Due to the high water year during the 2016/2017 recharge season (October 25, 2016 to July 7, 2017), the Idaho Water Resource Board was able recharge over 310,000 af, surpassing their annual goal of 250,000 af (IWRB in litt. 2017).

The effects of managed aquifer recharge on groundwater quality depends largely on the quality of source water (Norvitch *et al.* 1969, p. 26), with the potential for relatively unpolluted water to improve groundwater quality by diluting contaminants (Norvitch *et al.* 1969, p. 30). Alternatively, groundwater quality could be degraded by managed aquifer recharge if pollution plumes move to areas in the aquifer where they are not wanted (National Research Council 1994,

[6] Total nitrogen is the sum of nitrate, nitrite, organic nitrogen, and ammonia.

p. 33). Furthermore, cooler recharge water could affect groundwater mixing, with colder, more dense and viscous recharge water sinking to lower levels and moving more slowly within the aquifer (Norvitch *et al.* 1969, p. 31).

If managed aquifer recharge actions, coupled with other conservation measures being concurrently undertaken, are successful at stabilizing ESPA levels, this can be a positive conservation outcome for the Banbury Springs limpet. If groundwater quality is compromised due to managed aquifer recharge efforts, impacts to the Banbury Springs limpet may be negative. It is unknown at this time if managed aquifer recharge, along with other water conservation measures identified in the CAMP, will affect groundwater quantity or quality for the Banbury Springs limpet.

In summary, existing water control structures identified in the 2006 5-year status review continue to limit coldwater spring flow into Banbury Springs limpet habitat. In addition, ESPA spring flow continues to decline, further impacting habitat availability for the species in the short and long-term. Degraded water quality in terms of increasing nutrients, such as nitrates, affect springs and may be leading to increased beds of macrophytes, which Banbury Springs limpets generally avoid. Conservation measures have been implemented by the state of Idaho to address these declining flows, but it is unknown at this time if they will affect suitable spring flows the species is dependent upon.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Currently there is no new information that leads us to believe that overutilization of the Banbury Springs limpet for commercial or recreational purposes is a threat. Collections for scientific or educational purposes is regulated by the Service through issuance of Section 10(a)(1)(A) recovery permits. Existing permits are limited, and we do not anticipate an increased demand in future requests to collect this species.

2.3.2.3 Disease or predation:

Currently there is no new information regarding the threat of disease or predation to the continued existence of the Banbury Springs limpet. We believe that disease is not likely to affect the species unless an unknown pathogen is transmitted via a non-native vector. The effect of predation is unknown on the species, though crayfish and fish, which are known predators of snails (USFWS 2006, p. 18), continue to co-occur with the Banbury Springs limpet. We have no information which leads us to believe that native or non-native predators are affecting the Banbury Springs limpet.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

<u>Surface and Groundwater Management</u>

Water Quantity Regulations

The Idaho Department of Water Resources (IDWR) manages water in the state of Idaho. Among the IDWR's responsibilities is the development of the state Water Plan (Water Plan) (IWRB

2012, entire). The Water Plan outlines objectives for the conservation, development, management, and optimum use of all unappropriated waters in the state. One of these objectives is to ‘‘maintain, and where possible enhance water quality and water-related habitats’’ (IWRB 2012, p. 6). It is the intent of the Water Plan that any water savings realized by conservation or improved efficiencies is appropriated to other beneficial uses (e.g., agriculture, hydropower, or fish and wildlife).

The Water Plan also states that the capacity of water storage, flood control, and flow regulation on the Snake River is insufficient for future beneficial uses (IWRB 2012, p. 55) and further states that construction of new reservoirs, enlargement of existing reservoirs, and development of off-stream storage sites may be necessary to meet future demands (IWRB 2012, p. 19). Given the non-protected status of the Snake River where springs occupied by Banbury Springs limpet enter the river, there exists no assurances that future development of water resource projects will not further inundate occupied springs, deplete groundwater, or negatively impact habitat or water quality upon which the species depends.

The IDWR and other state agencies have created additional regulatory mechanisms that limit future surface and ground water development in the ESPA, including the continuation of various moratoria on new consumptive water rights, and the designation of Water Management Districts (Caswell in litt. 2007). The state is attempting to stabilize aquifer levels and enhance cold water spring outflows from the ESPA by implementing water conservation measures identified in the Comprehensive Aquifer Management Plan (CAMP) for this area (IWRB 2009, entire). The long-term objective of the CAMP is to incrementally achieve a net ESPA water budget of 600,000 acre feet annually by the year 2030 through a mix of management strategies, including managed aquifer recharge, ground-to-surface water conversions, demand reduction strategies, and weather modification (IWRB 2013, p. 3).

While managed aquifer recharge may reduce the rate of groundwater depletion in the ESPA, it also may affect ESPA groundwater quality if measures are not taken to ensure water utilized for recharge purposes is relatively clean. Overall, since adoption of the CAMP, progress is being made towards strategy implementation (IWRB 2013, p. 3; CH2M 2016, p. 1; IWRB in litt. 2017), although it is unknown at this time to determine if these strategies will be effective at reducing and reversing the rate of groundwater depletion in the ESPA and whether long-term declines in springs occupied by Banbury Springs limpets are halted or reversed. Ongoing monitoring of CAMP efforts (IWRB in litt. 2017), along with spring discharge data at existing USGS stream gages, should provide the information needed for future assessments of whether implementing the CAMP water conservation measures stabilize and increase ESPA spring outflows.

The state of Idaho signed an order on November 4, 2016 creating a Ground Water Management Area (GWMA) for the ESPA region (IDWR 2016, entire). A designated GWMA is defined as a “ground water basin or part thereof that the Director (IDWR) determines may be approaching the condition of not having sufficient ground water to provide a reasonably safe supply for irrigation and other uses in the basin under current or projected rates of withdrawal” (IDWR 2016, pp. 18-19). Idaho Code § 42-233b authorizes the Director of the IDWR to designate GWMAs and approve associated ground water management plans that provides “for managing effects of ground water withdrawals on the aquifer… and on any other hydraulically connected sources of water" (IDWR 2016, p. 18). Ground water users that comply with an approved GWMA plan, which has not been developed for the ESPA region, "shall not be subject to administration on a time priority basis" if the Director determines the ground water supply is insufficient to meet demands within the GWMA (IDWR 2016, p. 18). Given the recent GWMA designation for the ESPA, it is too soon to determine if it will successfully address the long-term goal of addressing the decline in ESPA spring flows that the Banbury Springs limpet is reliant upon, though this designation is a positive step towards that goal.

Water Quality Regulations

State and federal laws are responsible for safeguarding the water quality criteria required by the Banbury Springs limpet and its habitat. In Idaho, ground water is protected by state laws regulating activities that either directly or indirectly affect ground water quality (Idaho Department of Environmental Quality (IDEQ) in litt. 2014). Important ground water quality protection legislation in Idaho includes: Environmental Protection and Health Act (Title 39, Chapter 1, Sections 102, 120, 126); Health and Safety: Aquifer Protection Districts (Title 39, Chapter 5); Local Land Use Planning Act (Title 67, Chapter 65, Section 37); and, Ground Water Quality Protection Act of 1989 (Title 39, Chapter 1). Three Idaho agencies have specific statutory responsibilities regarding ground water quality: the IDEQ coordinates and administers ground water quality protection programs for the state, the IDWR maintains the natural resource Geographic Information System (GIS) for the state and collecting baseline data for the state's water resources, and the Idaho State Department of Agriculture regulates the use of pesticides and fertilizers and licenses operators (IDEQ in litt. 2014).

In accordance with the Environmental Protection and Health Act, the Idaho Ground Water Quality Rule (IDAPA 58.01.11) was promulgated in 1996 and requires for protection of ground water quality through water quality standards and an aquifer categorization process (IDEQ in litt. 2014). The Primary Constituent Standards (numerical ground water quality standards) are based on protection of human health. Given the effects of these ground water standards in the Idaho Ground Water Quality Rule on the Banbury Springs limpet are largely unstudied, it is unknown if they are sufficient for protection of the species.

Various state-managed water quality programs are being implemented within the range of the Banbury Springs limpet. These programs are tiered off the 1972 Clean Water Act (CWA), which requires states to establish water-quality standards that provide for (1) the protection and propagation of fish, shellfish, and wildlife, and (2) recreation in and on the water. As required by the CWA, Idaho has established water-quality standards (e.g., for water temperature and dissolved oxygen) for the protection of cold-water biota (e.g., salmonids) in many reaches of the Snake River. The CWA also specifies that states must include an antidegradation policy in their water quality regulations that protects water-body uses and high quality waters. Idaho's antidegradation policy, updated in the state's 1993 triennial review, is detailed in their Water Quality Standards (IDEQ NA, pp. 15-16).

While point source pollution regulations are enforceable through the CWA, nonpoint source water pollution is primarily addressed through non-regulatory means under the CWA (USEPA in litt. 2013a). The IDEQ works closely with the USEPA to manage point and non-point sources of pollution to water bodies of the state through the National Pollutant Discharge Elimination System program under the CWA. The USEPA continues to retain authority for the issuance of permits through the National Pollutant Discharge Elimination System, though an application has been submitted to USEPA to transfer that authority to the IDEQ (IDEQ in litt. 2016). IDEQ expects to phase in full implementation of the Idaho Pollutant Discharge System Program by 2022. There are approximately 115 permitted aquaculture facilities in the Idaho, with nearly 70% of those operating in the Magic Valley and discharging into the Snake River or its tributaries (IDEQ in litt. 2018). While 3 of the 4 springs occupied by Banbury Springs limpets have diversions that may affect the species, none are directly exposed to aquaculture waste discharges.

Under Section 303(d) of the CWA, states are required to develop lists of impaired waters not meeting state water quality standards (USEPA in litt. 2013b). Waters that do not meet water-quality standards due to point and non-point sources of pollution are listed on USEPA's 303(d) list of impaired water bodies. In water bodies that are currently not meeting water quality standards, the TMDL approach applies pollution-control strategies through several of the following programs: State Agricultural Water Quality Program, Clean Water Act section 401 Certification, USBLM Resource Management plans, the State Water Plan, and local ordinances. While TMDLs do not directly address groundwater, protection of surface water may improve/conserve groundwater quality that the Banbury Springs limpet is dependent upon.

<u>State Invertebrate Species Regulations</u>

There has been no change in state regulations regarding the protection of invertebrates since the time of the 1992 listing of the Banbury Springs limpet. The Idaho Department of Fish and Game (IDFG), under Idaho Code section 36-103, is mandated to preserve, protect, perpetuate, and manage all wildlife. However, these regulations do not extend protection to invertebrate species. In 2017, Idaho finalized the 2015 Idaho State Wildlife Action Plan (SWAP; IDFG 2017, entire), which is a conservation strategy for the state's species of greatest conservation need (SGCN). As part of the SWAP, the Banbury Springs limpet is defined as a Tier 1 species in the state's list of SGCN (IDFG 2017, p. xvi), though there is no regulatory authority associated with this designation. In summary, there are no state regulations in place that are specific to the Banbury Springs limpet; therefore state invertebrate species regulations for the Banbury Springs limpet continue to be inadequate.

There are no assurances that current regulations and policies will protect the Banbury Springs limpet and its habitat from effects to declines in groundwater quantity and quality. While there are no known water development projects within the range of the Banbury Springs limpet, future development projects would be a concern if they impacted the remaining occupied springs within the species' range. Conservation measures in the ESPA CAMP have been developed and implemented, but it is too early to determine if they can stabilize ESPA water levels and/or if they will adversely affect groundwater quality. The same can be said of the newly formed ESPA GWMA – it is too soon to determine if this effort will stabilize and reverse declining spring flows the Banbury Springs limpet is reliant upon. While federal and state regulations exist regarding groundwater and surface water quality, it is unknown if they are protective enough for the Banbury Springs limpet given its requirements of undisturbed springs containing cold, clear, and well oxygenated water where they avoid areas with large, attached plants or areas with fluctuating water levels and are generally absent from turbid environments. Lastly, there continues to be no state regulations in place providing protection to invertebrate species such as the Banbury Springs limpet.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Invasive Species

Certain researchers have suggested that the New Zealand mudsnail competes with native species for food and/or space (Kerans *et al.* 2005, pp. 135, 136; Hinson 2006, p. 41) and can dominate ecosystem nutrient and energy flow (Hall *et al.* 2003, p. 411). Research has shown that New Zealand mudsnails influence the growth of sympatric freshwater snails (Richards 2004, entire) and can displace native species (Hall *et al.* 2003, entire). Competition from the New Zealand mudsnail was shown to negatively impact growth rates of the Bliss Rapids snail (*Taylorconcha serpenticola;* a federally listed snail co-occurring with the Banbury Springs limpet), under experimental conditions (Richards 2004, pp. 117-118). In enclosure experiments, increasing New Zealand mudsnail densities also resulted in lower Bliss Rapids snail densities (Richards 2004, pp. 117-118).

Although the New Zealand mudsnail can tolerate various water velocities, they appear to reach their highest densities in slower moving waters (Richards *et al.* 2001, pp. 378, 389), unlike the Banbury Springs limpet. In addition, the New Zealand mudsnail appears to flourish in Snake River reaches under a variety of environmental conditions, including low dissolved oxygen and on substrates of mud or silt, but it is also found at high densities in some cold-water spring tributaries to the Snake River (e.g. up to 500,000 snails/m^2 (46,500/ ft^2) at Banbury Springs; Richards *et al.* 2001, p. 375). The Banbury Springs limpet is found on gravel to cobble habitat in areas of flowing water, and not found in areas of non-flowing systems composed of mud or silt. Regardless, there is overlap among the species as they have been found to be co-occurring. While there are potential impacts from the New Zealand mudsnail on the Banbury Springs limpet, they have been co-occurring for over 20 years, and there is no data to document a direct negative impact to the limpet.

Climate Change

Changes in temperature, precipitation, and streamflow patterns from a changing climate could be detrimental to the Banbury Springs limpet The average mean-annual air temperature in the Columbia River Basin (CRB) has increased by approximately 1.1 ^{o}C since the late 1800s (U.S. Bureau of Reclamation (USBR) 2016, p. 24). By 2039, mean annual air temperatures in the CRB are projected to increase by between 1.1 ^{o}C (Brekke *et al.* 2010, p. 25) and 1.3 ^{o}C (Rupp *et al.* 2017, Table 1 on p. 1788) compared to an historical baseline of 1970-1999. The largest temperature increases throughout the CRB are projected to occur in the upper Snake River basin (USRB; USBR 2016: pp. 34-35 main report). Snow and rain that falls on the USRB supply the Snake River and the ESPA. For an area encompassing the USRB minus the central Idaho mountains, Petersen *et al.* (2017, pp. 10, and 15-17) projected an annual mean temperature increase between 2.5 ^{o}C to 2.94 ^{o}C, and a mean summer temperature increase of approximately 3.3 ^{o}C, for the period 2040-2069 compared to a historical period of 1950-2005. In addition, models project an increase in the frequency and intensity of extreme weather events such as heat waves and heavy precipitation (Mote *et al.* 2013, pp. 37 and 46).

Precipitation projections vary more widely than temperatures and extreme events, with most showing increased cool season precipitation (winter & early spring) and decreased warm season precipitation (USBR 2016, pp. 34-35 main report; Mote *et al.* 2013, pp. 32-36). An annual mean increase in precipitation is projected in the CRB of 1% (range -5 to 6%), with seasonal changes showing a winter increase of 3% (range -14 to +13%), and a summer decrease of -5% (range -21 to +7%) (Rupp *et al.* 2017, p. 1788, Table 1). Projected increases in winter precipitation will likely not be sufficient to offset the effects of strong regional warming that would lead to earlier snowmelt (prior to April 1) or to more winter precipitation falling as rain instead of snow (Mote *et al.* 2005, p. 47). Compared to baseline (1980-2009) total annual runoff above Brownlee Reservoir will increase (USBR 2016, Appendix A, p. 29), but negative trends in April 1 snow water equivalent (Ashfaq *et al.* 2013, entire; Hamlet *et al.* 2013, Fig. 7, left panel, p. 404) combined with earlier and higher peak runoff (USBR 2016, pp. 56-58) will affect seasonal flows. For the period 2010-2039, Snake River summer flows above Brownlee Reservoir are projected to be between approximately 6 to 30% lower in July, 6 to 25% lower in August, 2 to 14% lower in September, and 1.5 to 12% lower in October compared to the historical period 1980-2009 (USBR 2016 Appendix A, p. 6; Figure 3.13, p. 31). Projected reduced streamflow in the warm season leads to less natural flow water rights available for irrigation. Less available natural water right flow increases water users' reliance on stored water contracts as opposed to instream flow rights to meet irrigation and other needs (USBR 2016: p. 16 of Appendix B). Compounding the demand for water are the increases in temperature, drought intensity, and growing season projected for the USRB, which will reduce soil moisture availability and increase evapotranspiration from crops, leading to potential water shortages and heightened reliance on groundwater from the ESPA (USBR 2016, pp. 46, 59 and 70).

While responses of the ESPA to climate variability and change have yet to be formally evaluated, projected changes in air temperatures, form and timing of precipitation, and the frequency and intensity of extreme events (droughts and floods) all have the potential to affect groundwater quantity and quality. The direct impact of these changes on aquifer replenishment are unknown, with changes in snowmelt having the potential to reduce the seasonal duration and magnitude of natural recharge (Taylor *et al.* 2013, p. 323). A substantial portion of ESPA recharge comes from irrigation return flow (Lindholm 1996, p. 44); thus, the potential indirect effects of a changing climate may pose a greater threat than potential direct effects on groundwater through increasing water demand and land use changes. Projected increases in the frequency and intensity of droughts for the USRB over the latter half of the 21st century (USBR 2016, p. 46) could trigger a shift from agriculture to the expansion of municipal, industrial and commercial uses. Such a shift in land use may serve to further stress groundwater resources by reducing incidental recharge from irrigation return flow. Despite future uncertainties regarding water use and supply in light of climate change, the continued implementation of management actions outlined in the Comprehensive Aquifer Management Plan (IWRB 2009, entire) offers an opportunity to stabilize and improve spring flows, aquifer levels, and river flows across the Eastern Snake Plain. As part of this plan, in 2016/2017, the IWRB recharged over 310,000 ac ft to the ESPA (IWRB in litt. 2017). The development of additional managed aquifer recharge sites and necessary infrastructure to maximize delivery of recharge water provides a mechanism for taking advantage of future wet years and high flow events when surplus water may be available. However, it is unknown at this time if managed aquifer recharge will affect groundwater quantity or quality for the Banbury Springs limpet.

If temperature, precipitation, and streamflow patterns change as described in the climate projections above, indirect impacts could be detrimental to the Banbury Springs limpet resulting from spring flow reductions, increased flow variability, lower oxygen concentrations due to increased water temperatures, and contaminants in the groundwater becoming more concentrated with less water available during droughts to dilute them (USFWS 2006, pp. 11-17; Petersen *et al.* 2017, p. 38; Norvitch *et al.* 1969, p. 30). Other potential indirect effects from climate change may include an increasing prevalence of meltwater that is notably colder than winter spring discharge and carrying sediments overtopping the canyon rim and inundating spring complexes, as was evidenced during a heavy rain-on-snow event in 2017 (USFWS 2017, pp. 10-11). Further, the spring habitats supporting Banbury Springs limpet could be reduced during low summer flows by macrophyte productivity, which would benefit from nutrient enrichment and spring flow reductions (Mebane *et al.* 2013, pp. 143, 152; Jones *et al.* 2012, p. 1006).

Vulnerability to projected changes in snowmelt timing is probably highest in basins with the largest hydrologic response to warming and lowest management flexibility – that is, fully allocated, mid-elevation, temperature-sensitive, mixed rain-snow watersheds with existing conflicts among users of summer water, such as the USRB (Melillo *et al.* 2014, p. 491). The Snake River is a highly regulated river system that serves multiple uses, including, but not limited to, irrigation, hydropower, and aquaculture. Even though the Snake River is a highly managed riverine system, if summer streamflow decreases within the Snake River as the models and literature forecast, and groundwater flows decline due to continued depletion of the aquifer, there may be less water within the spring complexes themselves, especially as competition for this limited resource increases (Meyer *et al.* 1999, p. 1373).

With these projected changes, suitable habitat for the Banbury Springs limpet may become limited and the species may further contract its range. At the same time, in light of the ongoing conservation measures being implemented in the ESPA through the CAMP process, along with the uncertainty in how future ESPA water use practices will unfold (IDWR 2016, p. 17), which can greatly affect spring flow quantity and quality, it is difficult to determine the effects to groundwater quantity and quality within Banbury Springs limpet occupied springs. In short, there are too many unknowns at this point to confidently determine if future projected climate change effects are a factor affecting the habitats and range of the Banbury Springs limpet.

In summary for other natural or manmade factors, the New Zealand mudsnail continues to be found co-occurring with the Banbury Springs limpet. The limpet's preferred habitat of gravel to cobble habitat in areas of flowing water, but are not found in areas of non-flowing systems composed of mud or silt that is preferred by the mudsnail. While there are potential impacts from the New Zealand mudsnail on the Banbury Springs limpet, we do not have data to document a direct negative impact to the limpet at this time. While projected climate change may impact the Banbury Springs limpet and its habitat, given the ongoing conservation measures and uncertainty regarding future water use practices of the ESPA, it is uncertain at this point to determine if it is a threat affecting the species.

2.4 Synthesis

The endangered Banbury Springs limpet continues to be found in portions of 4 large spring complexes that discharge into the middle Snake River in south-central Idaho. High quality habitat is defined by undisturbed springs containing cold, clear, and well oxygenated water with cobble to boulder substrates. The species avoids turbid environments, fine sediments, areas with large, attached plants, or areas with fluctuating water levels. Recent monitoring data suggests 3 of the 4 populations are declining, but we do not have colony-wide population estimates. The smallest population (Thousand Springs) increased for the first time in 2017 since monitoring began, likely attributable to aggressive conservation efforts by the Service and its partners. While the Banbury Springs limpet was recently described as a monotypic genus through genetic and morphological data measurements, data allowing for a more in depth investigation of the genetic variation between the 4 known populations is lacking.

The primary factors continuing to affect the species include habitat modifications from existing water control structures and diversions, spring flow reduction, reduced groundwater quality, and inadequate regulatory mechanisms. Existing water control structures identified in the 2006 5-year status review continue to limit habitat coldwater spring flow availability for the Banbury Springs limpet. In addition, ESPA spring flows continue to decline, further impacting habitat availability for the species in the short and long-term. Degraded water quality in terms of increasing nutrients, such as nitrates, affect springs and may be leading to increased beds of macrophytes which Banbury Springs limpets avoid. While regulatory efforts to stabilize the ESPA have been implemented, it is too soon to determine if they will be effective, though ongoing monitoring of these stabilization efforts will provide information for future assessments. Therefore, existing regulatory mechanisms that oversee ESPA groundwater management may not be adequate to reverse the declining coldwater spring quantity and quality upon which the Banbury Springs limpet depends. While there are potential impacts from the New Zealand mudsnail on the Banbury Springs limpet, we do not have data to document a direct negative impact to the limpet at this time. Projected climate change may impact the Banbury Springs limpet and its habitat, though it is uncertain at this point to determine if it is a threat affecting the species. Lastly, because this species is restricted to portions of only 4 springs, future stochastic as well as anthropogenic disturbances could negatively impact the species. For these reasons, the Banbury Springs limpet remains appropriately designated as endangered.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist*:*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
__X_ No change is needed

3.2 New Recovery Priority Number: 4C

Brief Rationale: The Banbury Springs limpet was recently described as a monotypic genus (Campbell *et al.* 2017, entire). Recovery potential and degree of threat remain the same, and the limpet continues to be in conflict with development projects or other forms of economic activity. Therefore, we are revising the Recovery Priority Number from 5C to 4C.

3.3 Listing and Reclassification Priority Number, if reclassification is recommended

Reclassification (from Threatened to Endangered) Priority Number: ____
Reclassification (from Endangered to Threatened) Priority Number: ____
Delisting (Removal from list regardless of current classification) Priority Number: ____

Brief Rationale: N/A

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Revise Taxonomy in List of Endangered and Threatened Wildlife
While the Banbury Springs limpet is currently described as *Idaholanx fresti* (Campbell *et al.* 2017), it is still considered *Lanx* sp. (undescribed) under the List of Endangered and Threatened Wildlife in title 50 of the Code of Federal Regulations (50 CFR 17.11(h)). Therefore we recommend revising the List of Endangered and Threatened Wildlife to reflect its current description as *Idaholanx fresti*.

Revise Recovery Plan
We continue to recommend that the Snake River Aquatic Species Recovery Plan be updated and/or revised to include new information about the species and its threats that we have learned since the plan was completed in 1995 (see Section 2.2.3).

Monitoring
We recommend continued annual monitoring of the species in the 4 occupied spring complexes occupied by the Banbury Springs limpet. While this information is needed to assess the recovery status of the species, it also allows us to continually assess the need of other conservation actions, such as macrophyte control and translocation. In addition, we recommend more frequent monitoring of water quality and quantity at the 4 spring complexes. We also recommend implementing monitoring of macrophyte presence and trends at the 4 spring complexes to investigate whether macrophytes are increasing and further limiting suitable habitat availability for the species.

Continue Macrophyte Control as Needed
Based on past success, we have continued to implement macrophyte control measures at selected springs to increase suitable habitat for the species. These efforts have contributed to increasing density findings, along with providing additional habitat availability. We recommend continued macrophyte removal measures as needed.

Consider Future Translocations as Needed
In 2016, we translocated 19 individual Banbury Springs limpets into Thousand Springs from Banbury Springs. This effort, in conjunction with macrophyte control, likely led to an increased density finding for this population in 2017. Give this, we recommend implementing additional translocations as needed in the future. In addition, we also recommend serious consideration of translocating the species into protected coldwater spring habitats not occupied by the species.

Captive Propagation Program
We have initiated development of a captive propagation program plan for the species at the Hagerman National Fish Hatchery, in Hagerman, Idaho. The objectives of this effort are to provide Banbury Springs limpets in a controlled environment to carry out needed life history and genetic investigations (a recommendation in the 2006 5-Year Status Review; USFWS 2006, p. 21) and other needed research on the species. In addition, having a propagation program in place would also allow for re-establishment of wild populations should they become extirpated, help ensure we maintain genetic representation from each of the 4 populations, and allow for the establishment of other populations in appropriate, unoccupied habitats. We recommend

continuing working with the State of Idaho Department of Fish Game, who is scheduled to take over day-to-day management activities of the Hagerman National Fish Hatchery from the USFWS starting in October 2018 (Spokesman Review in litt. 2018).

Collaborative Conservation Effort for the Eastern Snake Plain Aquifer

Consider developing a collaborative effort with strategic partners towards conservation of springs occupied by the Banbury Springs limpet. For example, utilize the Banbury Springs limpet and co-occurring threatened Bliss Rapids snail as "canaries in the coal mine" to help monitor the overall health of the Eastern Snake Plain Aquifer.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Banbury Springs Limpet*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_✓_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: 4C

Review Conducted By: Greg Burak and Dave Hopper

FIELD OFFICE APPROVAL:

State Supervisor, Idaho Fish and Wildlife Office

Approve ____________________ Date 9/9/18