5 MONITORING REPORT:
BRUNEAU HOT-SPRING SPRINGSNAIL
(PYRGULOPSIS BRUNEAUENSIS)

by
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Bruneau Hot-spring Springsnail (*Pyrgulopsis bruneauensis*)

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Table of Contents

List of Figures

List of Tables

SUMMARY

This report presents the 1995 monitoring results from four sites near the Indian Bathtub that contain, or have contained, populations of the Bruneau Hot-spring Springsnail (*Pyrgulopsis bruneauensis*). Three of these sites were monitored in 1990 and 1991 by Mladenka (1992), in 1992 by Robinson et al. (1992), in 1993 by Royer and Minshall (1993), and in 1994 by Varricchione and Minshall (1995a). An additional seep at Site 3 (New Seep) was included in the 1994 and 1995 springsnail monitoring efforts.

Springsnail populations were reduced drastically in Hot Creek (Site 1) by a major runoff event in July 1992 and have since failed to recover (Royer and Minshall 1993). There is no evidence to suggest that springsnails have recolonized Hot Creek since July 1992. It is recommended that experiments be conducted to assess the potential for successful transplantation of springsnails to Hot Creek (Site 1). Habitat improvement and spring-flow augmentation in the local area are also recommended.

Population fluctuations at the Sites 2 and 3 (Original and New Seeps) may be related to temperature variability. Temperatures at Site 2 were fairly stable. Temperatures at Site 3 were often below 24°C and may have affected local springsnail reproductive success. Both Sites 2 and 3 (Original Seep) maintained springsnail densities similar to those in previous years. Densities at Site 3 (New Seep) were more variable. In 1994 and 1995 small numbers of living springsnails were observed under an orange periphyton matrix growing upon certain portions of the spring rockfaces. These areas were not used in springsnail density monitoring, but they may be habitat for significant numbers of *P. bruneauensis*. Low spring-water flows at Sites 2 and 3 may result in a lack of protection for springsnails from extreme air temperatures. Maintenance of

adequate spring-flow appears to be the most important factor for assuring the success of springsnail populations at Sites 2 and 3 (Original and New Seeps).

INTRODUCTION

The springsnail *Pyrgulopsis bruneauensis* is an endemic species inhabiting a complex of related hot springs near the Bruneau River south of Mountain Home, Idaho. The snail's habitat has diminished considerably in recent years because of agricultural-related groundwater mining in the area. As a consequence, the snail became an endangered species on January 25, 1993. This listing was challenged and, on December 14, 1993, the U.S. District Court for the District of Idaho set aside the final rule listing the springsnail as an endangered species. On June 29, 1995, the U. S. Court of Appeals for the Ninth Circuit granted interim reinstatement of the springsnail as an endangered species.

Hershler (1990) provided a complete taxonomic description of *P. bruneauensis*. Mladenka (1992) focused on the life history of *P. bruneauensis*, providing the groundwork on which this monitoring study is based. Mladenka (1992) found only two studies addressing the biology of *P. bruneauensis*: Taylor (1982) described the taxonomy of the snail, and Fritchman (1985) studied its reproduction in the laboratory.

Mladenka (1992) found temperature to be important in the distribution of *P. bruneauensis*, with reproduction possible at temperatures between 24° - 35°C. Snail growth was retarded at cooler temperatures (<24°C). In addition, he showed sexual maturity to occur in two months; the sex ratio was 1:1. The snails showed little preference for current or substrata type. Mladenka (1992) noted that the snail population may have declined by 50% from earlier estimates of abundance, and by 100% in local areas such as the Indian Bathtub and Hot Creek. Gut analyses were performed on two Hot Creek fish taxa, *Gambusia* and *Tilapia*. The analyses showed that the diets of these two taxa consisted of organic matter and insects, but not of *P. bruneauensis* springsnails (Varricchione and Minshall 1995b). This report presents the continued biomonitoring of Mladenka's (1992) study sites through November 1995.

METHODS

Site Description

Mladenka (1992) described in detail the three original springsnail study sites (1, 2, and 3 Original Seep). Figure 1 shows the locations of the three study sites with respect to the Bruneau River. Figure 2a shows a map view of Site 1 at Hot Creek and an adjacent rockface seep. Figures 2b and 2c show front views of the hot-spring study areas (Sites 2 and 3 respectively). Royer and Minshall (1993) recommended that the Site 3 location be divided into two sub-sites: the Original Seep (right side) and a New Seep (left side) (Fig. 2c). These two seeps are approximately 4 m apart from each other and each "seep" has a distinct spring-flow. Their populations were monitored separately during 1994 and 1995. Site 2 is also composed of two "seeps", but their population data were combined to remain consistent with previous monitoring reports (Fig. 2b). The purpose of the division of Site 3 was to allow the 1994 and 1995 Original Seep data to remain consistent with data from previous years and to allow for the inclusion of a recently discovered springsnail population into monitoring efforts.

Both spring-rockface and stream habitats were examined for *P. bruneauensis* at Site 1, while only spring-rockface habitats were monitored at Sites 2, 3, and 3 New Seep. "Spring-flow-

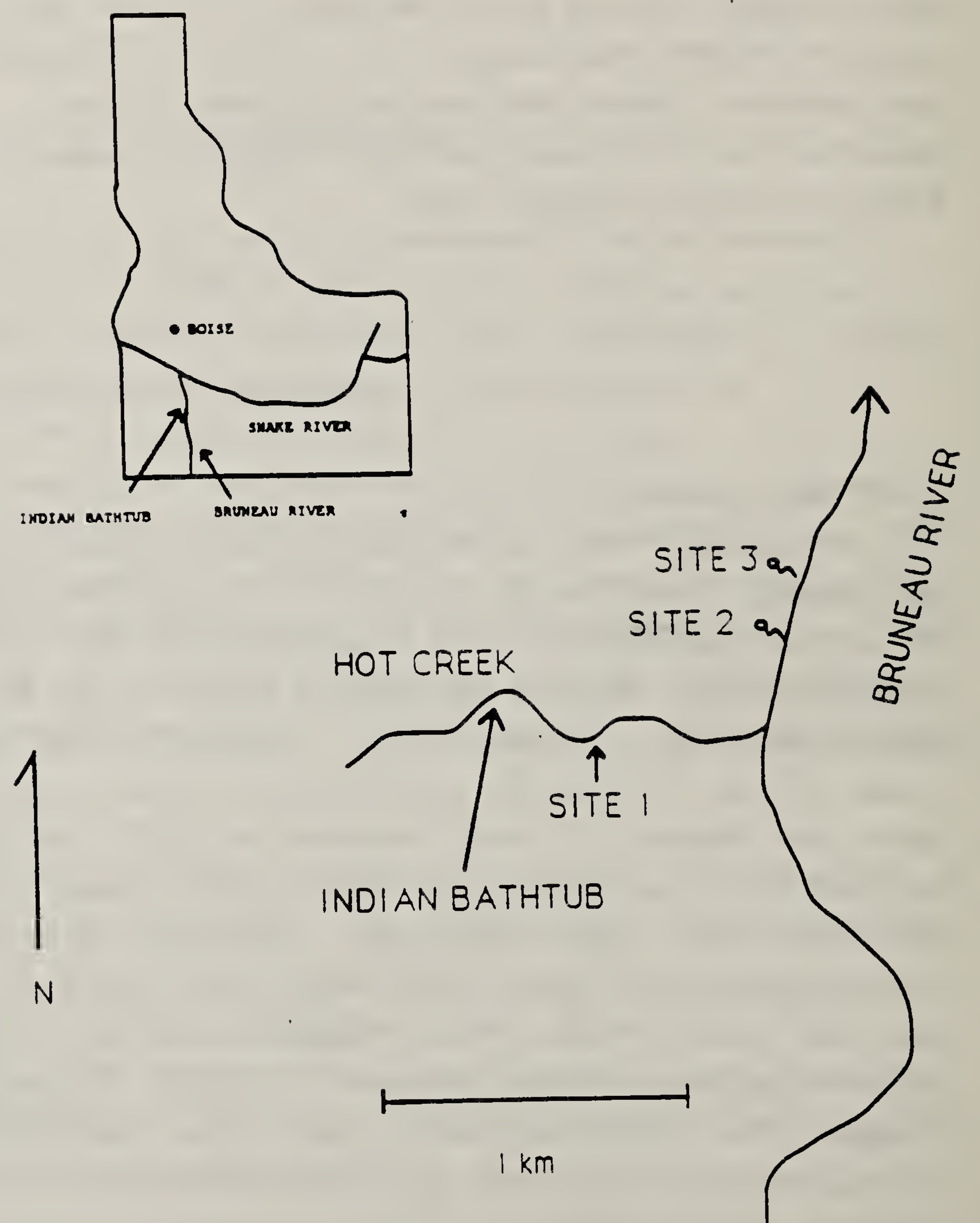

Figure 1. Map showing the locations of the Bruneau hot-spring springsnail study sites. The flow of water between Indian Bathtub and about 100 m upstream of Site 1 is primarily subsurface flow. (Reprinted from Mladenka 1992).

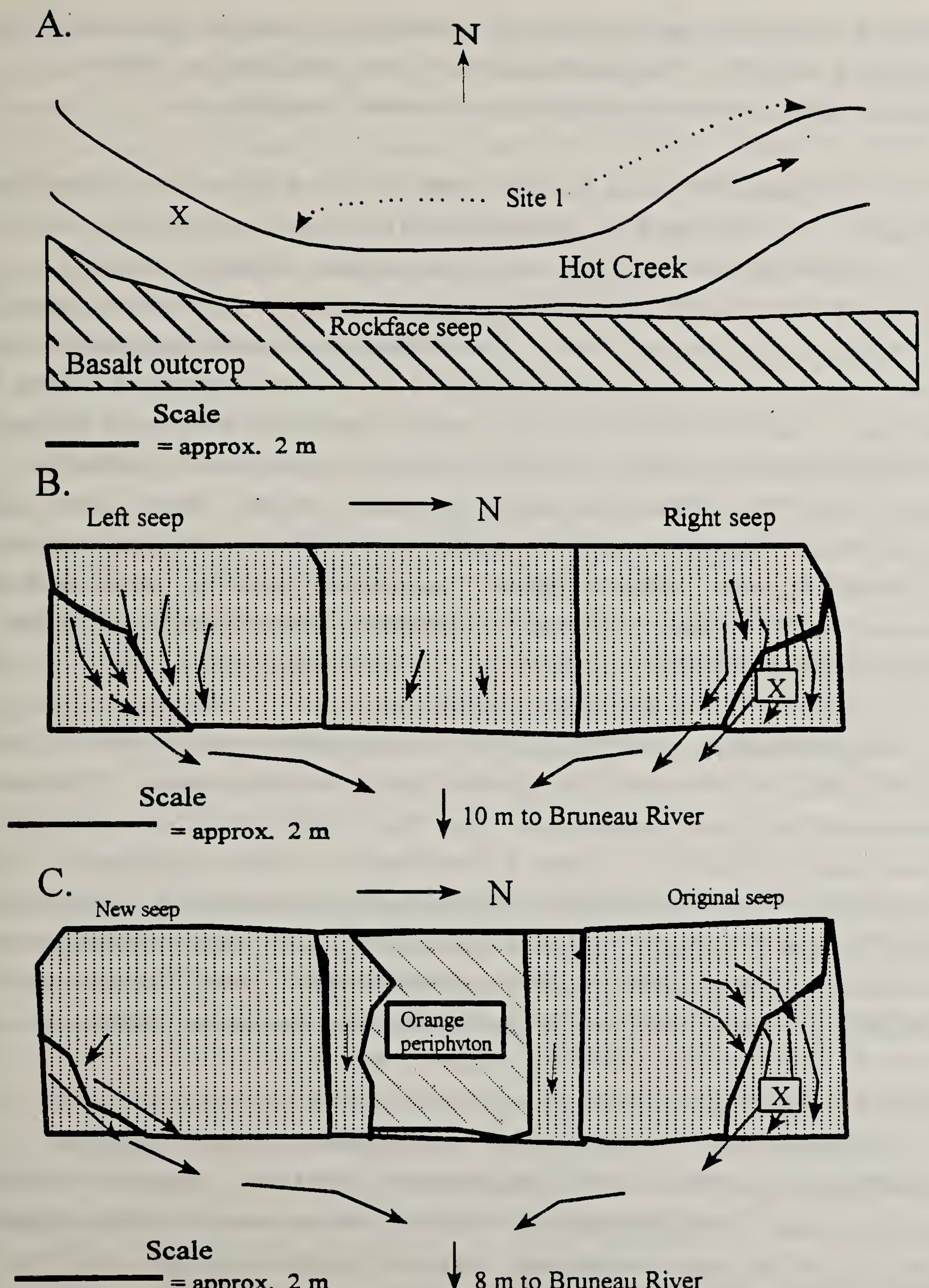

Figure 2. Temperature data logger locations for each of the study sites. Data loggers are represented by "x". A. Map view of Site 1 (Hot Creek). B. Front view of Site 2 rockface. C. Front view of Site 3 rockface (Original and New Seeps). Features are not drawn to scale.

covered rockface" was defined as rockface covered by a thin layer of running water. "Wetted-rockface" was defined as moist rockface adjacent to spring-flow-covered rockface.

Study quadrats were established at each site for monitoring purposes. To estimate *P. bruneauensis* size-distribution and density-fluctuation inside a study quadrat, a meter stick (baseline) was positioned flush against the rockface and parallel to direction of spring-flow. Ten transects, each perpendicular to the meter stick, were established at 10 cm intervals along the baseline. Random number lists, generated in the Stream Ecology Center laboratory using Quattro Pro for Windows v.6 software (Novell Inc.) on a Packard Bell computer (Model 1166), were used to determine random rockface-sampling locations for springsnail size- and density- monitoring. The random numbers were used to determine the distance across a transect each sample would be taken or monitored.

Environmental conditions were measured or monitored at the study quadrat (± 1 m) of each site on a monthly basis. These parameters included discharge (for Hot Creek (Site 1) and the hot-springs (Sites 2, 3, and 3 New Seep)), water chemistry, water temperature, food availability (periphyton abundance), and stream habitat (Site 1 only). Stream substrate size and embeddedness data were obtained from a 50-m reach of Hot Creek (Site 1 ± 25 m) beginning in June 1995 to be continued on an annual basis.

Size Distribution

To determine if the Site 1 springsnail population was recovering from previous flood events, arbitrary spring-rockface locations and creek substrata within a 50-m reach of Hot Creek (Site 1 ± 25 m) were examined, without magnification, for the presence of *P. bruneauensis*.

Within the sampling quadrats at Sites 2, 3, and 3 New Seep, springsnails were washed from random locations into a petri dish using streams of water squeezed from a squirt bottle. The sizes of the snails were determined on site using a Bausch and Lomb dissecting microscope. The microscope ocular was marked with 0.14 mm units (under 7x magnification). Snail lengths were rounded to the nearest 0.14 mm unit (i.e. a snail whose length was 8.8 units long was noted as being in the 9-unit, or 1.26 mm-, size class). Sample size was 100 for both sites 2 and 3. Beginning in 1994, Site 3 was subdivided into the Original Seep (n=50) and the New Seep (n=50).

Population Fluctuations

Density was not measured at Site 1 because springsnails have not been found there since flooding events that occurred in July 1992. Springsnail density was measured at the rockface sites (Sites 2, 3, and 3 New Seep). Densities were estimated as the number of springsnails present within the circumference of a petri dish (9 cm diameter) at 10 random locations within the sampling quadrat. Densities were reported as the number of snails per m^2. A small Garrity flashlight (2 AA batteries, PR 104 bulb) was used to help distinguish the snails from the dark rockface.

Discharge, Temperature, and Water Chemistry Fluctuations

Stream water velocities were measured across a permanent transect at Site 1 (Hot Creek) using a small Ott C-2 current meter. This transect was moved slightly upstream or downstream (1 or 2 m) if the instream vegetation was too thick. Stream discharge was determined using the methods described in Platts et al. (1983). Spring-flow and wetted-rockface estimates at the rockface study quadrats adjacent to Site 1 were not possible because of the overgrowth of rockface vegetation.

The amount of potential snail habitat at the other study quadrats was estimated by establishing a horizontal transect across each quadrat at the 50% height mark. The amount of the transect which crossed over spring-flow-covered- or wetted-rockface was measured. These values were compared with the length of the transect to obtain estimates of the percentage of the quadrat area covered by spring-flow and the percentage of the quadrat rockface that was wet.

Because of frequent breakage or loss associated with using maximum/minimum thermometers in earlier monitoring years, miniature temperature data loggers were used at all sites during and after 1994. Internal sensor loggers (Onset Hobo-Temp HTI-05+37) were used from 18 February 1994 to 26 September 1994, and then were replaced with external sensor data loggers (Onset StowAway-Temp STEB02-05+37) on 26 September 1994. Data loggers were downloaded and relaunched approximately every three months, in the laboratory, using LogBook for Stowaway v.0.98 software (Onset Instrument Corp.) on a Packard Bell computer (Model 1166).

Figure 2a shows the location of the temperature data logger submersed in Hot Creek. The logger was located 2 m upstream of Site 1 to reduce the potential for vandalism (riparian vegetation was closer to the streambank in this location). A rockface groundwater seep adjacent to Hot Creek at Site 1 had been previously known to support a population of *P. bruneauensis*. Currently, this seep is overgrown with grasses which prevent the observation of springsnails that may still exist on the rockface. Figures 2b and 2c show the locations of the temperature data loggers at Site 2 and Site 3 respectively. These temperature loggers were not completely submersed because the groundwater seeping from these areas was very shallow (approximately 1-2 cm). Instead, these data loggers were placed in small pools of groundwater that formed at the base of the seeps. The data loggers had a temperature sensor housed in the bottom part of its protective case. The lower portion of the unit was submersed in the hot-spring water. These data loggers were hidden by cobble substrate to reduce the potential for vandalism.

Water chemistry parameters were measured for all the study sites. pH was measured, in the field, using an Orion pH meter (Model 290A). The pH meter, which automatically compensated for temperature, was calibrated to standard solutions (Orion pH 7.00 and pH 10.01 buffer solutions). Conductivity (μS/cm) was measured, in the field, using an Orion conductivity meter (Model 126), which automatically compensated for temperature and standardized the values to 20°C. Water samples, for all sites, were collected in 250-ml plastic bottles, kept on ice until returning to the laboratory, and then frozen until processed. In the laboratory, samples were thawed at room temperature. Once thawed, samples were shaken by hand (approximately 10 sec) to resuspend any solids. Alkalinity and hardness of the water samples were determined using procedures described in Standard Methods for the Examination of Water and Wastewater (APHA, 1992).

Periphyton Levels

Periphyton samples were taken from rock substrata that were collected within 1 m of the study quadrats. For each sample, a modified syringe tube (3.14 cm^2) was placed on top of the substrate. Closed-cell foam, attached to the base of the modified syringe tube, formed a seal between the tube and the substrate to prevent the loss of periphyton samples. Approximately 5 ml of spring or creek water was added to the tube to create a slurry. A modified toothbrush was used to dislodge periphyton from the rock, and a dropper was used extract the periphyton slurry from the tube. The periphyton slurry was concentrated onto Whatman GF/F glass microfibre filters placed in a Nalgene filter holder (Nalge No. 310-4000). A Nalgene hand vacuum pump (Nalge No. 6131-0010) was used to create the suction necessary to remove the water from the slurry. Periphyton samples were placed on ice, returned to the laboratory, and kept frozen until processed. In the laboratory, periphyton filters were analyzed for the presence of chlorophyll *a* (corrected for the presence of phaeophytin *a*) on a Gilford Instruments spectrophotometer (Model 2600) using procedures described in Standard Methods for the Examination of Water and Wastewater

(APHA, 1992). Methanol was substituted for acetone as the solvent used in the analyses (Marker et al. 1980). Chlorophyll *a*, an indicator of the presence of algal organisms, was expressed as mg chlorophyll *a* per m^2.

The remaining periphyton material from each sample was used in the determination of algal biomass (expressed as g ash-free dry mass (AFDM) per m^2). The material was dried at 50°C for 24 h, cooled to ambient temperature in a desiccator, weighed on a Sauter balance (Model AR1014) to the nearest 10^{-4}g, ashed in a muffle furnace at 550°C for a minimum of 3 h, rehydrated, redried at 50°C, cooled to ambient temperature in a desiccator, and then reweighed. The difference in weights equaled the AFDM of the sample.

Habitat Assessment at Hot Creek

Beginning in March 1995, stream habitat assessment at Hot Creek (Site 1) was conducted monthly using the Idaho Department of Health and Welfare's Habitat Assessment Field Data Sheet for lowland streams (Appendix A; Robinson and Minshall 1995). The parameters assessed included bottom substrate/instream cover, pool substrate characterization, pool variability, canopy covering, channel alteration, deposition, channel sinuosity, lower bank channel capacity, upper bank stability, bank vegetation protection, streamside cover, and riparian vegetative zone width. Also, 100 random measurements of substrate size and embeddedness were made in Hot Creek on an annual basis within a 50-m reach of Hot Creek (Site 1 $\pm$ 25 m). Future changes in these habitat parameters should reflect recovery from prior land use activities and recovery from earlier flooding and sediment deposition events in Hot Creek. Changes in these parameters, with time, should also reflect changes that may result from any habitat improvements that may be conducted.

RESULTS

The following results section presents the Bruneau Hot-spring Springsnail population and habitat monitoring data recorded for 1990 through 1995, with an emphasis on 1995. Springsnail population data are shown first. This data includes population size distribution (Fig. 3a-f) and population density fluctuations (Fig. 4) for Sites 1, 2, 3, and 3 New Seep. Springsnail habitat data from the Hot Creek (Site 1) and rockface (Sites 2, 3, and 3 New Seep) sites are shown. This data includes discharge and maximum temperatures (Hot Creek (Site 1) only; Fig. 5), estimated spring rockface habitat (Sites 2, 3, and 3 New Seep; Table 1), maximum and minimum temperatures (Fig. 6), water chemistry (Fig. 7), periphyton (food resource) fluctuations (Figs. 8 and 9), and streambed particle size and embeddedness distribution (Hot Creek (Site 1); Fig. 10).

Size Distribution

Snail size structure was monitored at the three study sites: Site 1 (Hot Creek), Site 2 (upper spring rockface), and Site 3 (lower spring rockface) (Mladenka 1992). As suggested by Royer and Minshall (1993), a new seep at the southern edge of Site 3 was included in the monitoring for 1994 and 1995. Figures 3a-f illustrate the monthly size distributions for Sites 1, 2, and 3 (Original and New Seep) since 16 February 1990. Snails smaller than 1 mm in size were arbitrarily designated as juveniles.

Site 1 (Hot Creek)

Site 1 (Hot Creek) population was reduced to nearly zero in July 1992 and has yet to recover as of October 1995.

Site 2 (Upper Spring Rockface)

This population has maintained a relatively constant size structure through most of the years (Fig. 3a-f). Populations early in 1993 (Fig. 3d) and early in 1994 (Fig. 3e) were skewed towards the juvenile size classes. For the remainder of 1994 and

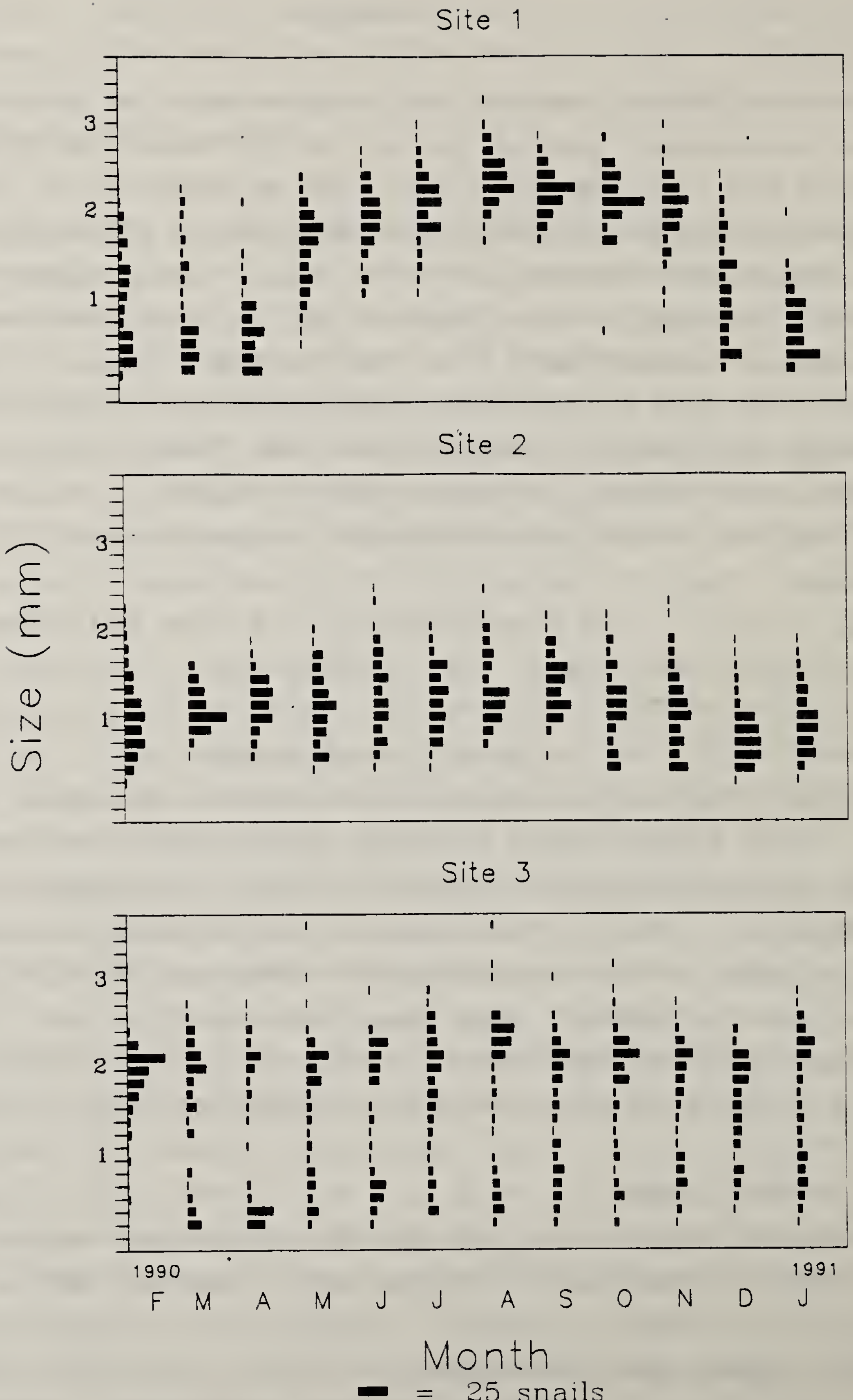

Figure 3a. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes (n=100 for each sample).

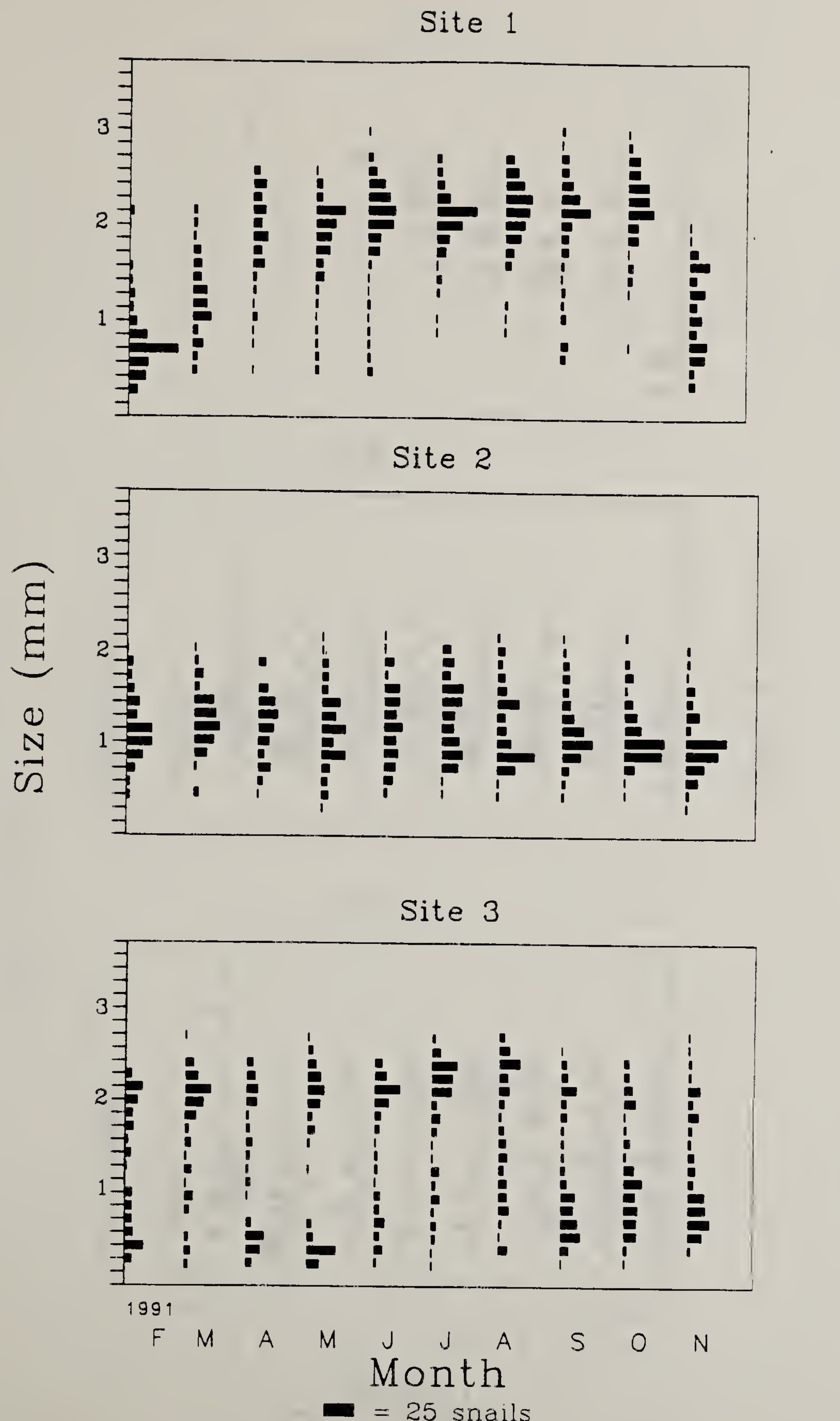

Figure 3b. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes (n=100 for each sample).

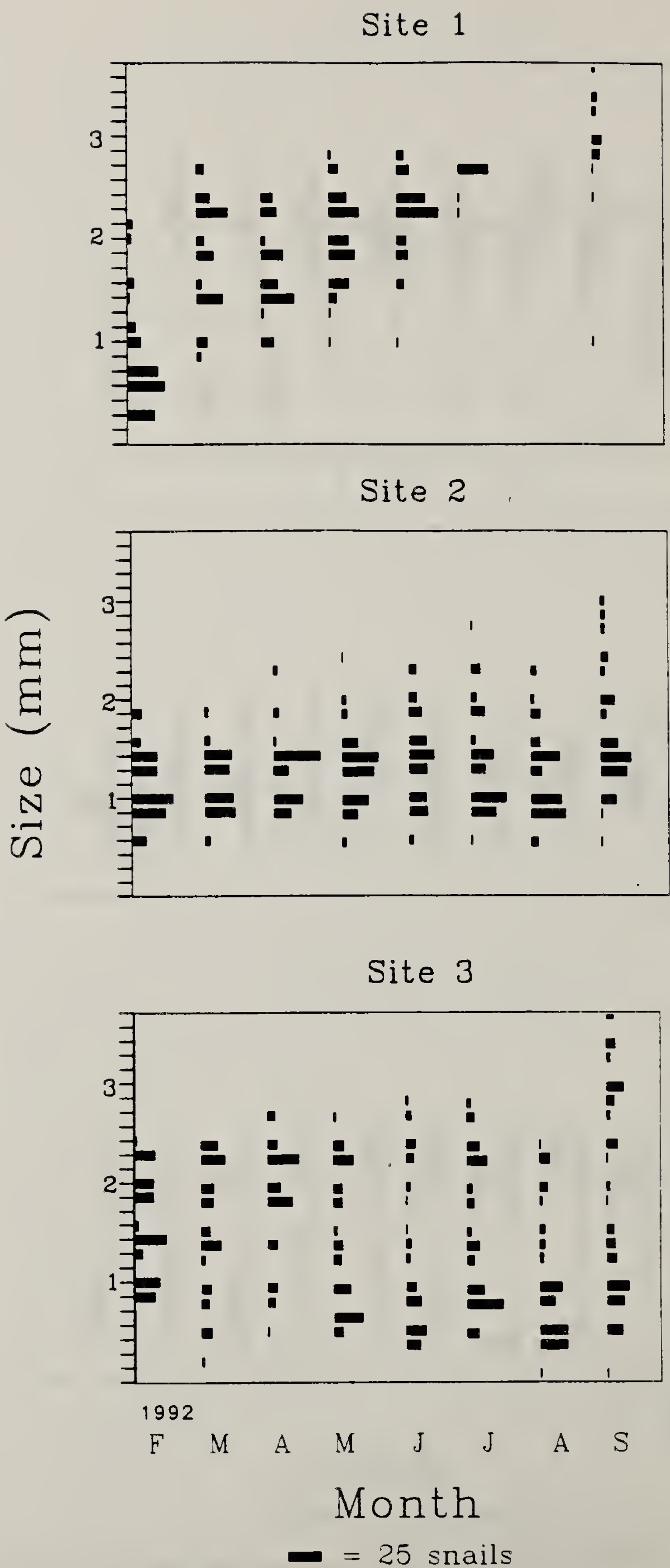

Figure 3c. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes (n=100 for each sample).

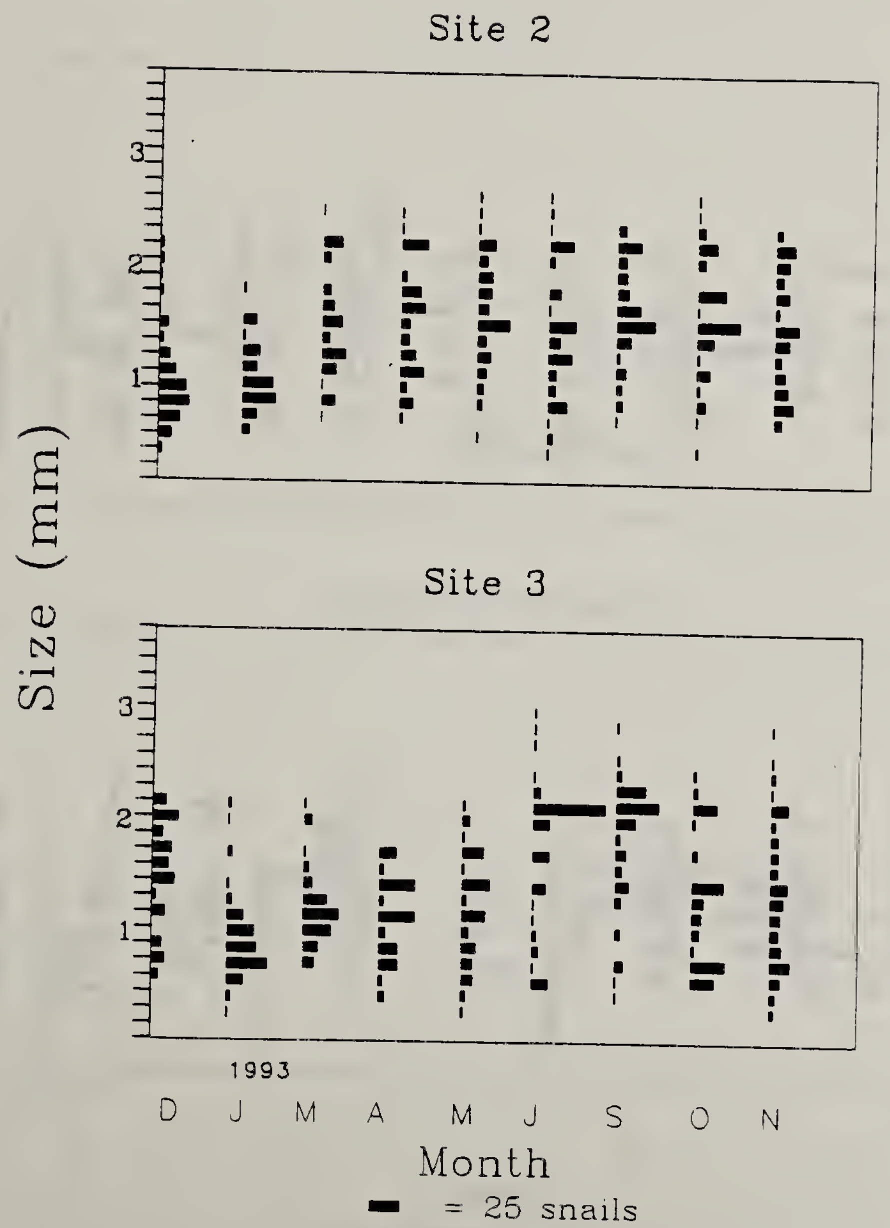

Figure 3d. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classess (n=100 for each sample).

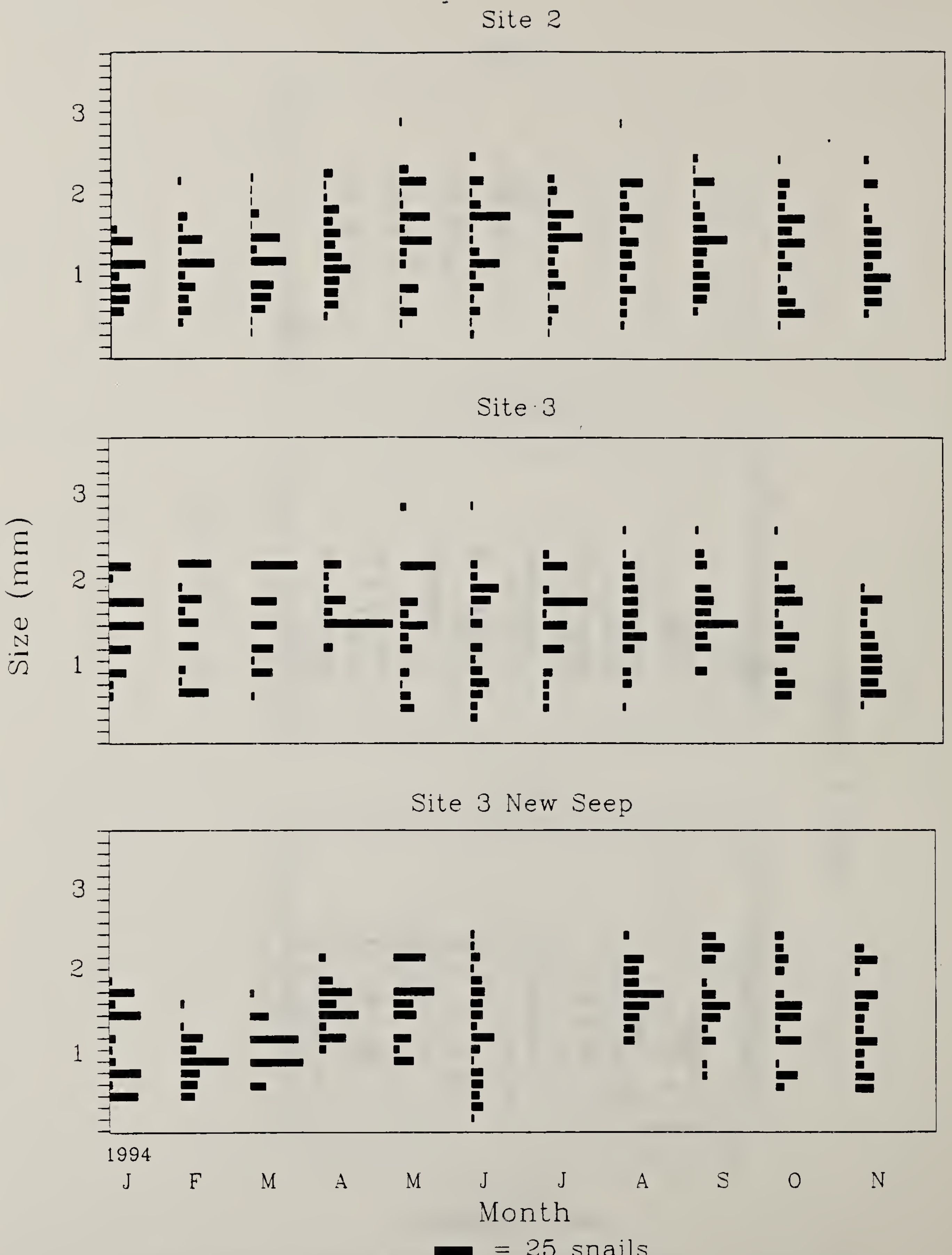

Figure 3e. Size histograms for the Bruneau Springsnail study sites.. Horizontal tick marks represent 0.14mm size classes (n=100 for Site 2 and n=50 for Site 3 and Site 3 New Seep).

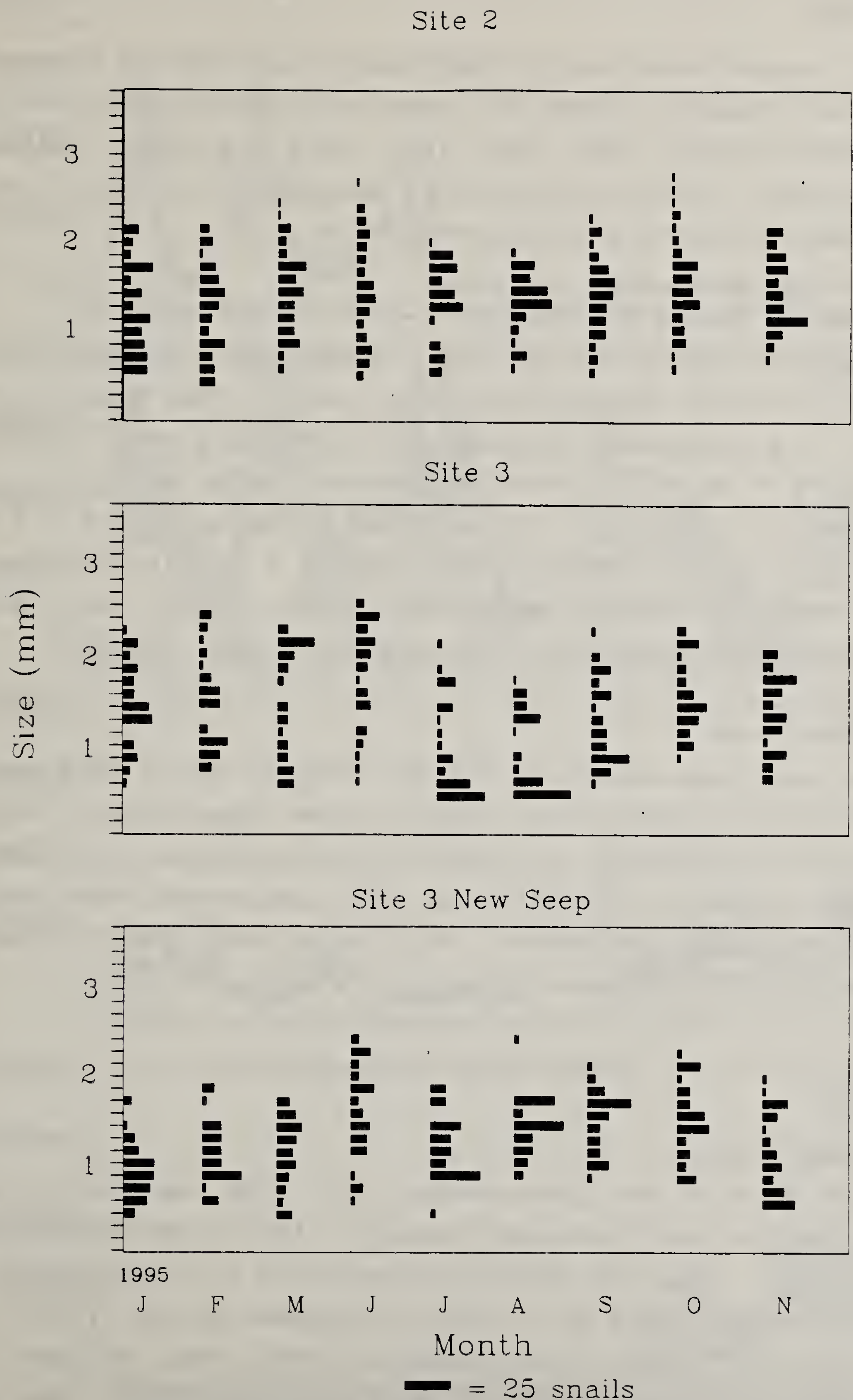

Figure 3f. Size histograms for the Bruneau Springsnail study sites. Horizontal tick marks represent 0.14mm size classes (n=100 for Site 2 and n=50 for Site 3 and Site 3 New Seep).

for 1995, snails were evenly distributed between the 0.5 mm and 2.0 mm size classes, except for some more pronounced juvenile recruitment in early 1995 (Fig. 3f). Data for 1993, 1994, and 1995 revealed a relative absence of adults in the 2 to 3 mm size classes compared with previous monitoring.

Site 3 (Lower Spring Rockface)

The snail population at Site 3 displayed a bimodal distribution until January 1993 (Fig. 3a-d). For most of 1994 and 1995, the population displayed a relatively even distribution across the 0.5 mm to 2.0 mm size classes. Most of the recruitment for 1994 and 1995 appeared to occur during the summer months (Fig. 3e-f). Snails larger than 2.0 mm were recorded in greater densities during the summer months of 1993 (Fig. 3d) than during the summer months of 1994 and 1995 (Fig. 3e-f).

Site 3 (New Seep)

The snail population at the new seep in early 1994 and 1995 were comprised primarily of juvenile size class snails (Fig. 3e-f). As 1994 progressed, the populations appeared to become more evenly distributed (Fig. 3e). As 1995 progressed, the population appeared to age as one cohort, with relatively little juvenile recruitment until November (Fig. 3f).

Population Fluctuations

Site 1 (Hot Creek)

Storm flow in Hot Creek during July 1992 resulted in major channel scouring and sediment loading. Indian Bathtub was filled with sediment. The Hot Creek population of *P. bruneauensis* was reduced to nearly zero as a result (Robinson et al. 1992). Snails were not found in Hot Creek in 1993, 1994, or 1995. It is likely that *P. bruneauensis* has been extirpated from this site (Fig. 4; Royer and Minshall 1993). A stream side refugia that had retained snails (<10 individuals) in the past (Robinson et al. 1992) continued to do so in 1993. Royer and Minshall (1993)

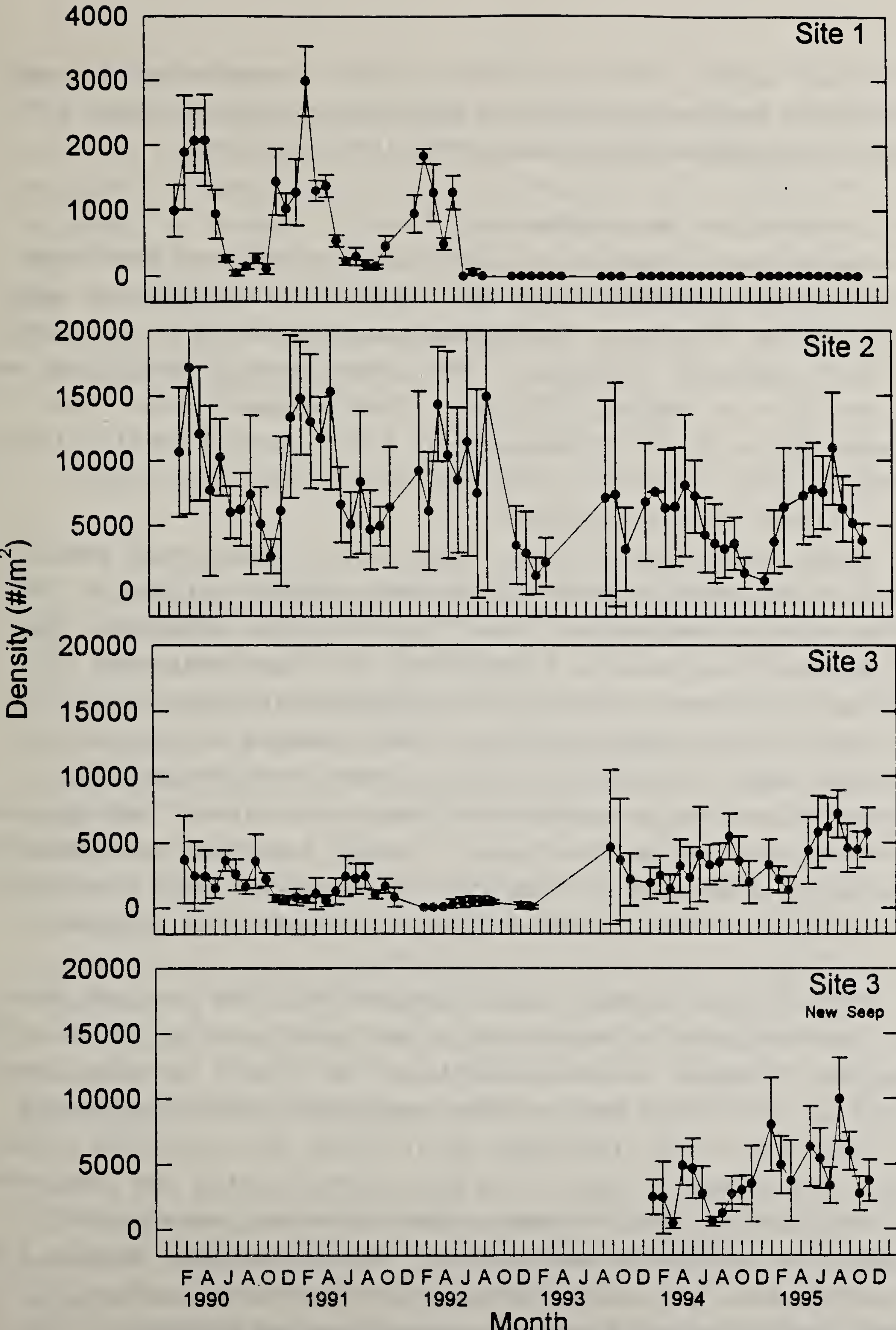

Figure 4. Mean density of the Bruneau Springsnail at the four study sites. Error bars represent one standard deviation from the mean. Note the different Y-axis for Site 1.

noted that in May 1993 this refugia became overgrown with dense terrestrial vegetation which has persisted through October 1995, preventing observations during 1993, 1994, and 1995.

Site 2 (Upper Spring Rockface)

The snail population at Site 2 in 1995 had peak densities during the warm summer months and low densities during the cold winter months (Fig. 4). The highest density for Site 2 in 1995 was 10937 snails/m^2 in August. The lowest density for Site 2 was 750 snails/m^2 in January (Fig. 4). Given adequate water flow, the population of *P. bruneauensis* at Site 2 should remain viable.

Site 3 (lower spring rockface)

Royer and Minshall (1993) found increases in snail density (and an associated increase in spatial variability) due to the inclusion of a new seep at Site 3 in population estimates (Fig. 4). At their suggestion, these sites have been monitored separately in order to distinguish differential population fluctuations occurring over time. The rockface at Site 3 (Original Seep) maintained a thick, orange moss/periphyton matrix. This complex appeared to reduce springsnail populations on these parts of the rockfaces. A small number of springsnails were observed beneath this matrix. The rockface area covered by this complex was not included in density monitoring efforts.

In 1995, the highest snail population at the original Site 3 was 7148 snails/m^2 in August while the lowest population was 1358 snails/m^2 in March. Water temperatures at Site 3 (Original Seep) tended to be low and the rockface completely froze over during the 1991/1992 winter (Robinson et al. 1992) and 1992/1993 winter (Royer and Minshall 1993). Ice also formed during the 1993/1994 and 1994/1995 winters. Fluctuations in density were probably a response to changes in temperature. To potentially increase the *P. bruneauensis* population at Site 3, enhanced water flow, sufficient to maintain optimal temperature and habitat conditions, is necessary.

Site 3 (New Seep)

Snail populations at Site 3 (New Seep) varied greatly in 1994 and 1995 (Fig. 4). The highest density, 9936 snails/m^2, was recorded in August and the lowest density, 2716 snails/m^2, was recorded in October. Site 3 (New Seep) does not provide a substantial rockface area suitable for snail growth because of the large amount of shading, low groundwater flow, and the presence of an orange moss/periphyton complex on certain locations of the rockface.

Discharge, Temperature, and Water Chemistry Fluctuations

Site 1 (Hot Creek)

Discharge dropped dramatically after the channel scouring and sediment loading in July 1992. Discharge after the start of 1993 fluctuated greatly, probably as a result of precipitation (Fig. 5). Reduced discharge in Hot Creek resulted in higher maximum water temperatures for 1992 (Mladenka 1992). This relationship did not hold as strongly for 1993, 1994, and 1995 (Fig. 5). In 1994, both minimum (31°C) and maximum temperatures (36°C) were recorded in May (Fig. 6). This was most likely occurred when the height of the water in Hot Creek dropped and the top of the temperature logger case (internal sensor) became exposed to air until remedied on the next monitoring date. Temperatures remained very constant, roughly 32-34°C for all of 1995. (Fig. 6). There was no significant change in water chemistry at Site 1 during 1995, except for a slight decrease in hardness and alkalinity from 1994 to 1995 (Fig. 7).

Site 2

At Site 2, most of the rockface habitat (both the wetted area and the area covered by flow) was reduced by about 5% between September and November 1995 (Table 1). The wetted area for the right seep at Site 2 was reduced by 20% between September and November 1995. Site 2 had relatively constant temperatures

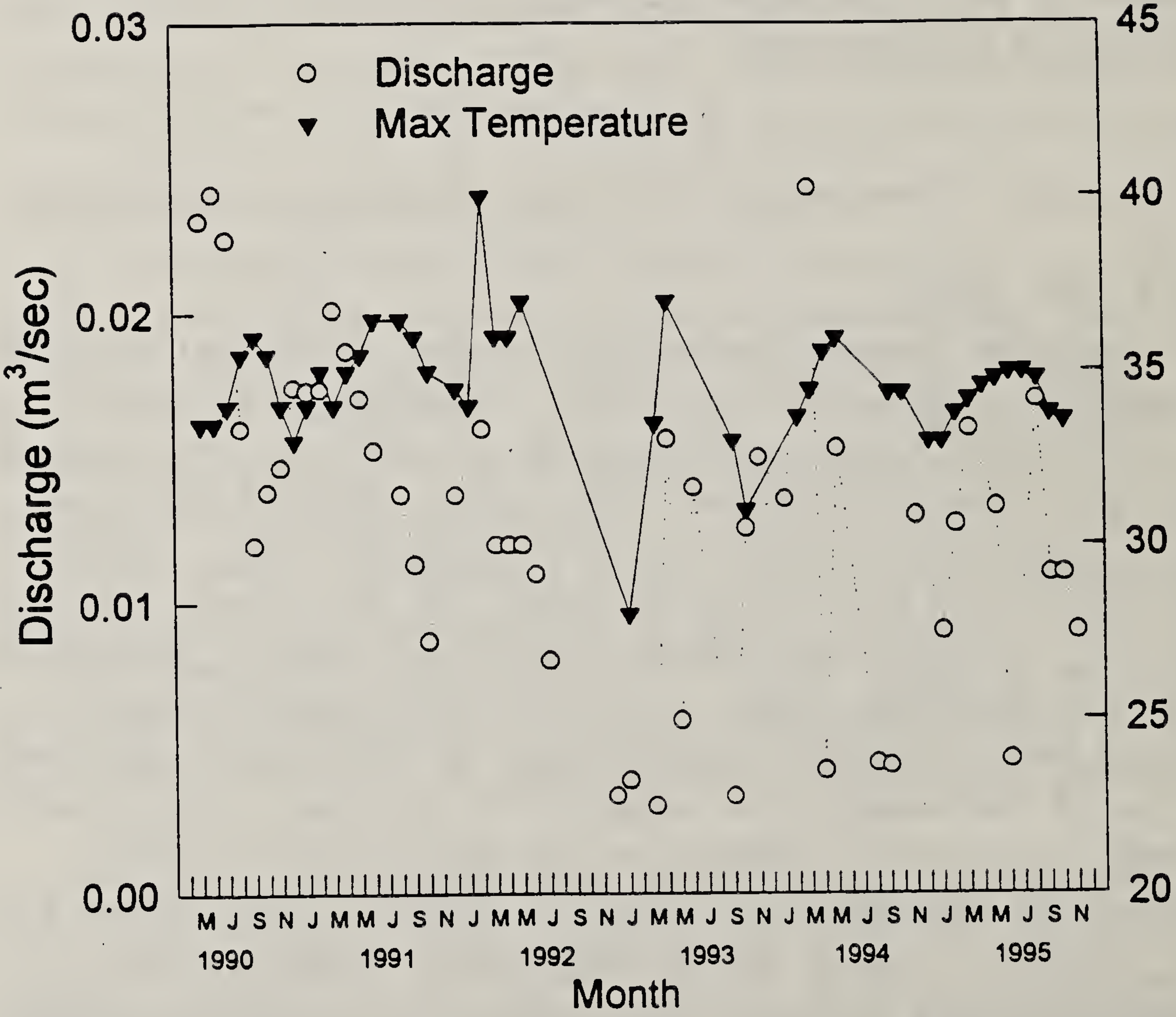

Figure 5. Discharge and maximum water temperatures for Site 1 (Hot Creek).

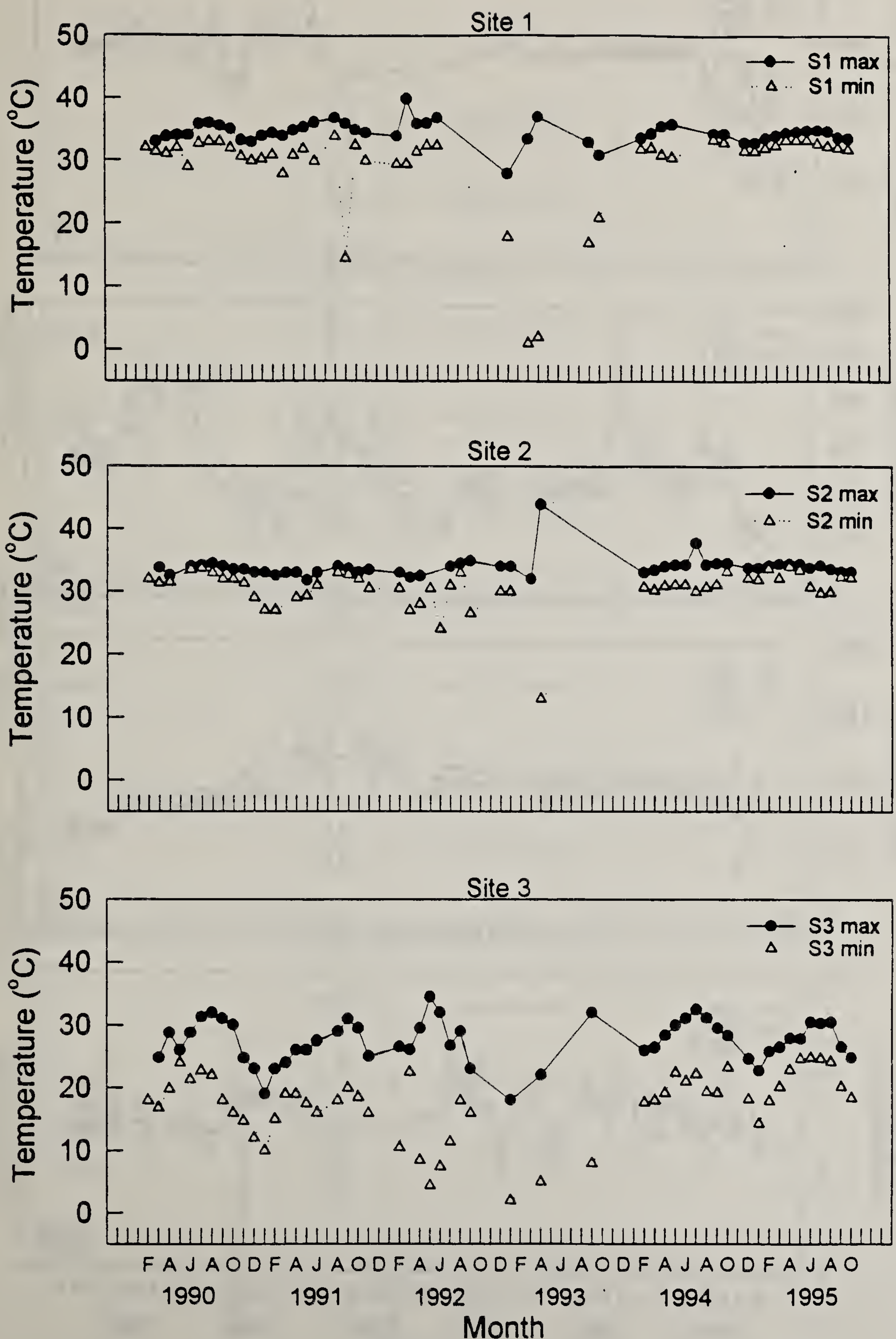

Figure 6. Maximum and minimum water temperatures for the Bruneau Hot Springs study sites.

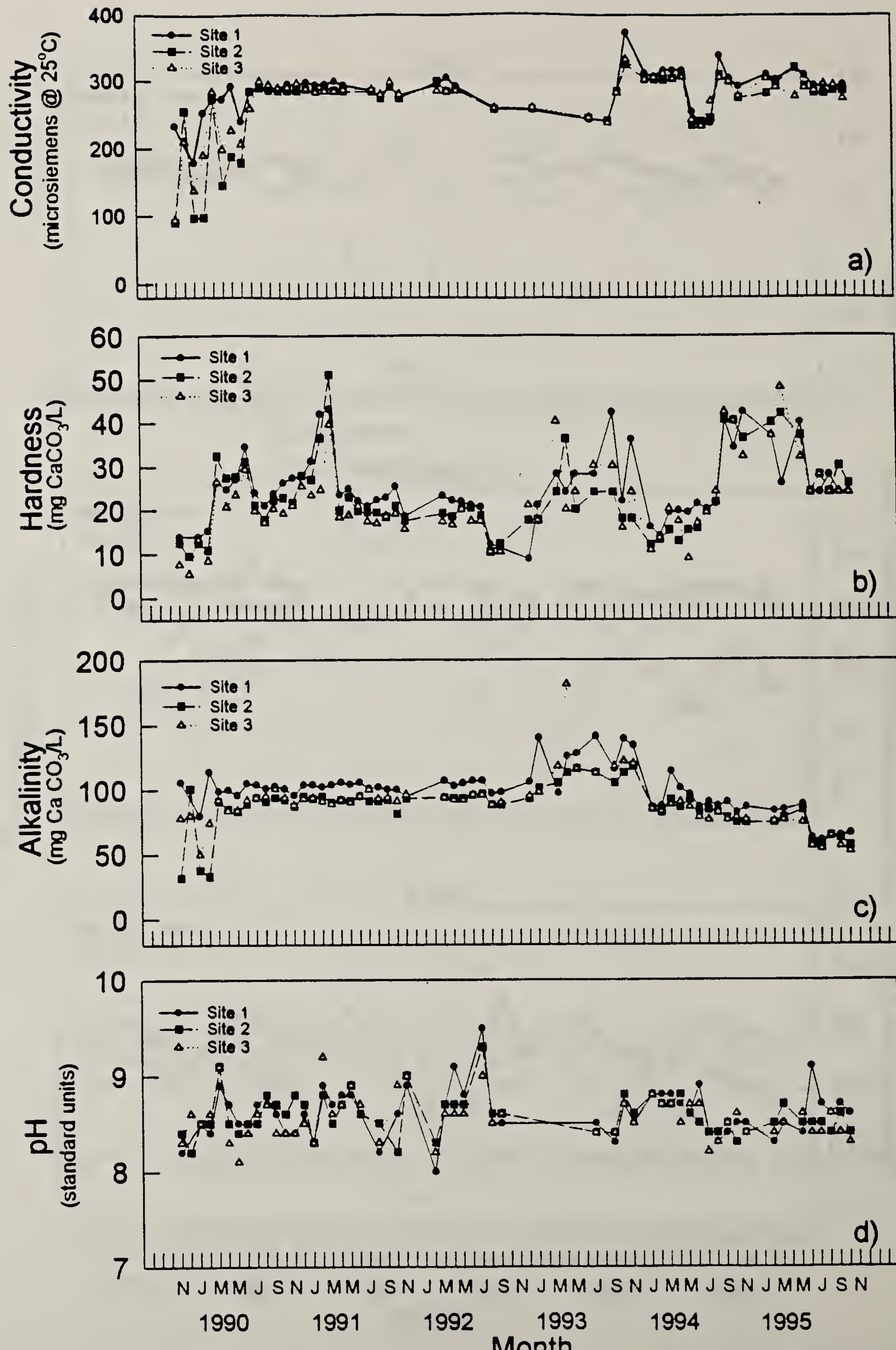

Figure 7. Conductivity (a), hardness (b), alkalinity (c), and pH (d) for the Bruneau Hot Springs study sites.

Table 1. Springsnail habitat availability at the spring sites (Sites 2, 3, and 3 New Seep). The rockface area monitored is given in parentheses.

Date	Percent Rockface Covered By Flow				Percent Wetted Rockface			
	Site 2		Site 3		Site 2		Site 3	
	Left Seep (1.3 x 1.0m)	Right Seep (1.7 x 1.0m)	New Seep (1.0 x 0.4m)	Right Seep (1.6 x 1.0m)	Left Seep (1.3 x 1.0m)	Right Seep (1.7 x 1.0m)	New Seep (1.0 x 0.4m)	Right Seep (1.6 x 1.0m)
9/95	25	10	10	10	95	80	100	95
10/95	20	10	15	10	90	75	95	95
11/95	20	5	10	5	90	60	95	100

Table 2. Habitat assessment scores for Site 1 (Hot Creek).

Date	Bottom Substrate	Pool Substrate	Pool Variability	Canopy Cover	Channel Alteration	Deposition	Channel Sinuosity	Channel Capacity	Bank Stability	Bank Vegetation	Streamside Cover	Riparian Width	Total Score	Percent of Maximum
Maximum score possible:	20	20	20	20	15	15	15	15	10	10	10	10	180	100
3/95	4	5	5	16	12	2	10	9	8	8	6	5	90	50
5/95	4	5	5	16	12	2	10	9	8	8	8	5	92	51
6/95	4	5	5	15	12	2	10	9	9	9	5	5	90	50
7/95	4	5	5	14	12	2	10	9	9	10	5	5	90	50
8/95	4	5	5	14	12	2	10	9	9	10	5	5	90	50
9/95	4	5	5	14	12	2	10	9	9	10	5	5	90	50
10/95	4	5	5	15	12	2	10	9	9	10	5	5	91	51
11/95	4	5	5	15	12	2	10	9	9	9	6	5	91	51

during 1995 (Fig. 6). Minimum temperatures (30°C) were recorded in July. Maximum temperatures remained about (32°C). There was no significant change in water chemistry from previous years, except for a slight decrease in hardness and alkalinity from 1994 to 1995 (Fig. 7).

Site 3

At Site 3, neither rockface-area-wetted nor rockface-area-covered-by-flow habitat changed substantially between September and November 1995 (Table 1). Site 3 displayed the greatest variation in temperature among the monitoring sites. This probably was due to the low flows of water at this site, and because of the lack of an adequate flow of water in which to effectively place the data logger. However, each time the logger was replaced (Fig. 6), attempts were made to position the logger in the same exact location. External sensor data gathered in 1995 appeared to be more precise than the internal sensor data obtained for February through September 1994. Water temperatures ranged from 14°C in January to 30°C in June 1995. It is probable that snails were restricted to certain habitats at this site because of low temperatures and the formation of ice on the rockface during winter.

Periphyton Levels

Site 1 (Hot Creek)

In 1995, chlorophyll a and ash-free dry mass (AFDM) values were greatest during the late summer months (Figs. 8, 9). The highest value for chlorophyll a, 259 mg/m^2, was found in July, and the lowest value, 29 mg/m^2, was found in October. The highest value for AFDM, 40 g/m^2, was found in July, and the lowest value, 6.1 g/m^2 was found in March. This trend is consistent with the seasonal changes in Hot Creek's periphyton community observed during previous years. Except for some high chlorophyll a and AFDM values between mid-1992 and mid-1993, periphyton communities did not appear to be greatly affected by

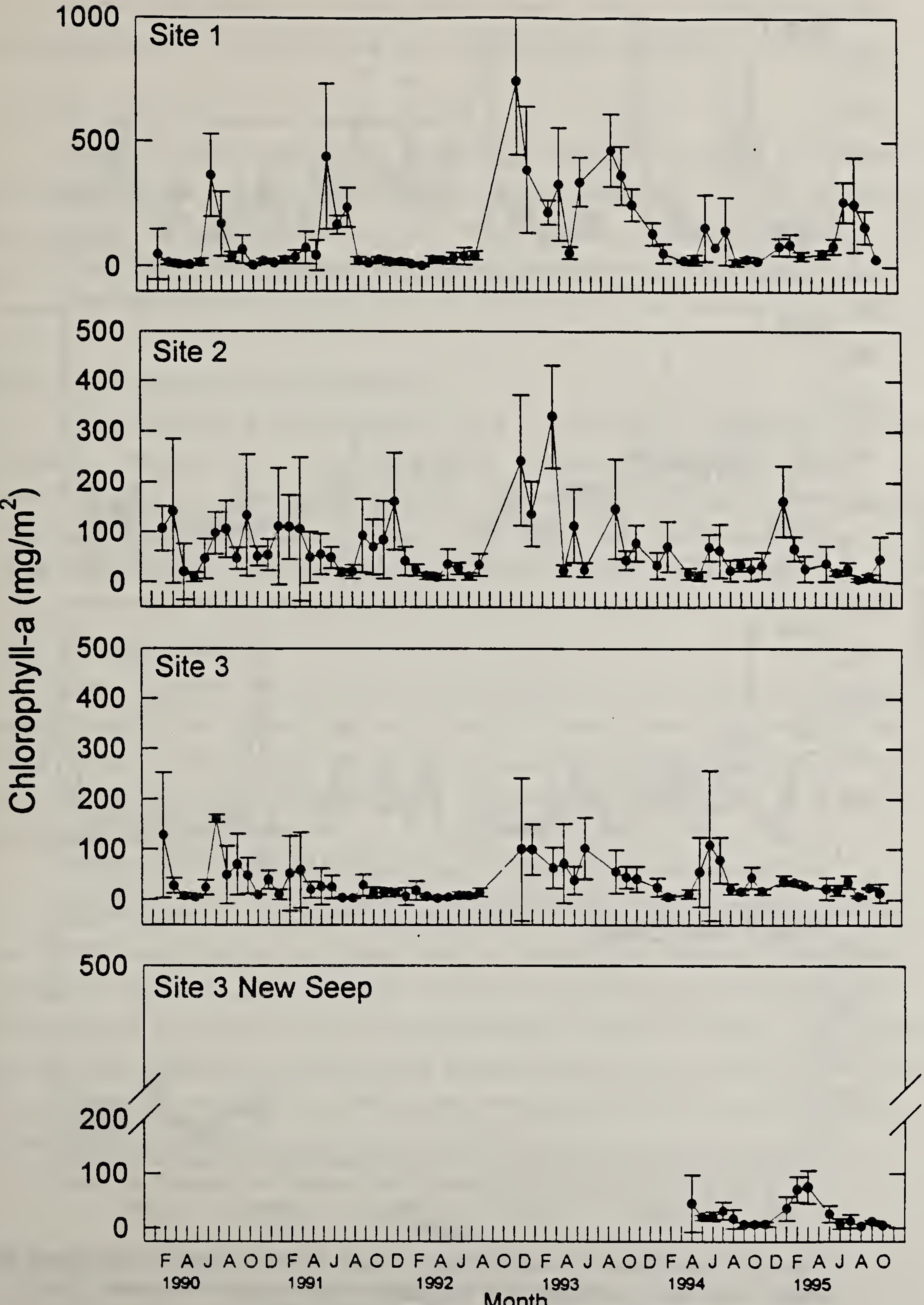

Figure 8. Chlorophyll-a values for the Bruneau Springsnail study sites. Error bars represent one standard deviation from the mean. (n=5 for Sites 1 and 2; n=3 for Site 3 and Site 3 New Seep).

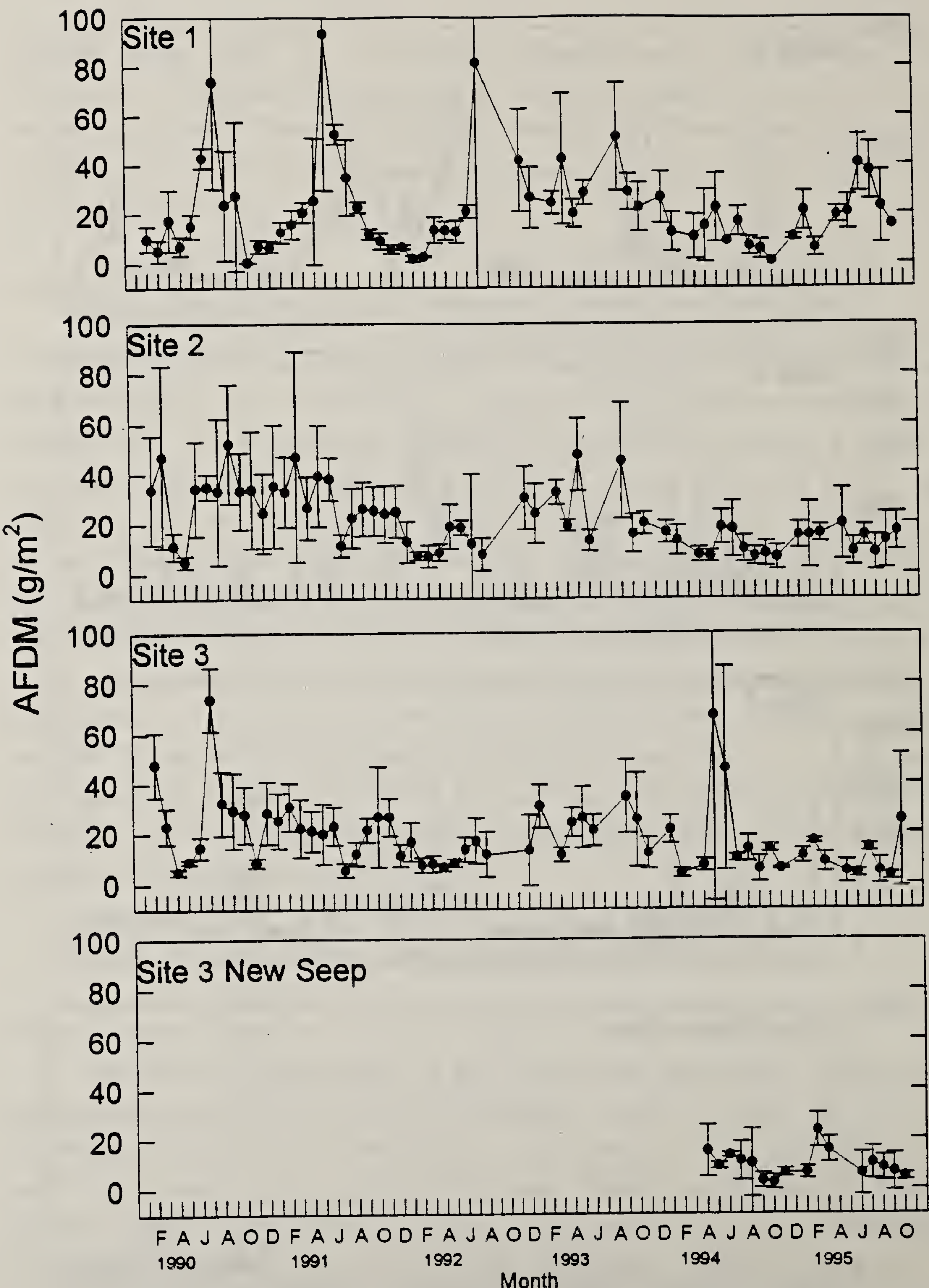

Figure 9. Ash-free dry mass (AFDM) values for the Bruneau Springsnail study sites. Error bars represent one standard deviation from the mean. (n=5 for Sites 1 and 2; n=3 for Site 3 and Site 3 New Seep).

the presence or absence of *P. bruneauensis* in Hot Creek.

Site 2 (Upper Spring Rockface)

During 1995, the highest value for chlorophyll a at Site 2, 161 mg/m^2, was found in January, and the lowest value, 5.1 mg/m^2, was found in August (Fig. 8). The highest value for AFDM, 19 g/m^2, was found in March, while the lowest value, 8 g/m^2 was found in August (Fig. 9).

Site 3 (Lower Spring Rockface)

Chlorophyll a values for Site 3 reached its highest value in January (259 mg/m^2) and its lowest value in August (6 mg/m^2) for 1995 (Fig. 8). The highest value for AFDM, 25 g/m^2, was found in October, and the lowest value, 2.8 g/m^2 was found in September (Fig. 9).

Site 3 (New Seep)

The highest value for chlorophyll a, 75 mg/m^2, was found in March, and the lowest value, 3 mg/m^2, was found in August for Site 3 New Seep (Fig. 8). The highest value for AFDM, 23 g/m^2, was found in February, and the lowest value, 5 g/m^2 was found in October (Fig. 9).

Chlorophyll a and AFDM values did not vary as much during the 1995 monitoring as they did in previous years. The food resource supply appears not to be a limiting factor for the growth and survival of the springsnail populations. Variations in the chlorophyll a and AFDM measurements may be a reflection of the patchy distribution of food resources within each of the sites.

CONDITIONS AT INDIAN BATHTUB AND HOT CREEK

The most recent examination of the Indian Bathtub portion of Hot Creek (September 1995) found only a small amount of groundwater seeping from the Bathtub rockface. The water from this sinks below the ground surface and reemerges about 200 m "downstream" (Fig. 1). At Site 1 (approximately 300 m) the discharge of Hot Creek ranged between 0.005 and 0.02 m^3/sec during 1995 (Fig. 5). The small rockface/spring outlet adjacent to the creek at Site 1 has a small trickle of water which seeps down the rockface (Fig. 2a). This small spring-flow area was overgrown by dense grasses during 1995.

A flood in the summer of 1991 contributed much silt, sand, and gravel to Hot Creek. In particular, Indian Bathtub was reduced to less than one-half its size before the flood because of sediment addition. Available habitat in the immediate vicinity of Indian Bathtub was reduced because of this and other sedimentation events. Another flood occurred in July 1992 which substantially altered and scoured the channel of Hot Creek. This event filled in the remainder of Indian Bathtub. Due to these events, it appears that *P. bruneauensis* has been extirpated from Indian Bathtub and Hot Creek (Royer and Minshall 1993). Continued monitoring during 1994 and 1995 failed to locate any springsnails either in Hot Creek at Site 1 (Fig. 4) or on the adjacent rockface seep.

Using the Idaho Department of Health and Welfare Habitat Assessment Field Data Sheet for lowland streams (Appendix A), habitat assessment scores were obtained on a monthly basis for Hot Creek. During 1995 substrate quality did not vary much with time (Table 2). Vegetation parameters (canopy cover, bank vegetation, and streamside cover) varied seasonally, as expected (Table 2). The riparian community appeared to offer a reasonable amount of shade and streambank stability, but these habitat characteristics were offset by Hot Creek's poor channel morphology and substrate composition. In July 1995 Kelly Sant revisited the monitoring sites. He noted that there had been an increase in vegetative cover at all the sites since he had been monitoring in 1992. At Site 1 the riparian vegetation has been slowly increasing in ground cover since the removal of cattle grazing in the Hot Creek area. The streambank cover does not appear to affect stream periphyton growth and so food resource availability does not appear be a limiting factor to springsnail recolonization of Hot Creek. Chlorophyll a values in 1994 and 1995 fluctuated within the range of values that was measured between 1990 and 1993 (years when springsnails were present at Site 1).

The primary obstacle to the return of *P. bruneauensis* to Hot Creek appears to be a lack of significant recolonization. If any recolonization has occurred already, it has not yet resulted in a substantial population size based upon examinations of Site 1 stream substrate. A number of factors may be reducing the chances for successful recolonization. These factors may include unsuitable substrate type, predatory fish, weak migration abilities, and a lack of an upstream colonization source.

The stream bottom at Site 1 was described as originally having areas of large cobbles which became embedded as a result of cattle grazing (Mladenka 1992). Flooding events in 1992 deposited additional loads of sediment. Substrate analysis in Hot Creek (Fig. 10) showed that >90% of the substrate particles were <100 mm and >50% were <6 mm. Approximately 50% of Hot Creek's substrate was >50% embedded (Fig. 10). Laboratory experiments have indicated that springsnails do not prefer large substrate sizes to small substrate sizes (Mladenka 1992). However, *P. bruneauensis* springsnails need hard surfaces for depositing eggs (large cobble and snail shells are two possibilities). Also, different communities of periphyton tend to colonize and thrive on different types of substrate. An altered substrate composition may reduce the chances for

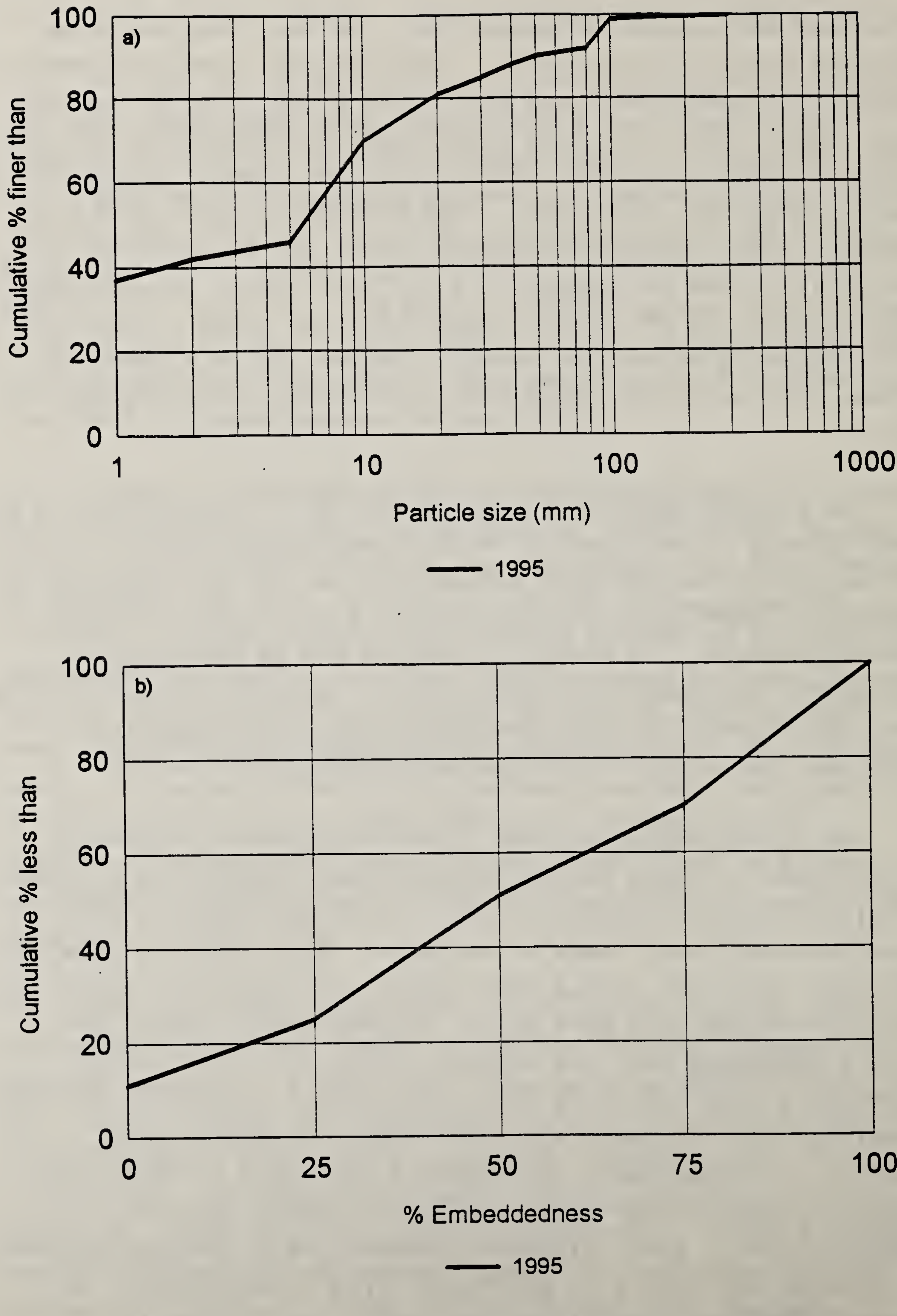

Figure 10. Particle size (a) and embeddedness (b) distributions for Hot Creek (Site 1) for 1995.

springsnail survival by affecting oviposition success and food quality (Mladenka 1992).

Fish predation may be preventing any successful springsnail recolonization of Hot Creek. Gut content analysis found no evidence of springsnails being preyed upon by the Hot Creek fish *Gambusia* and *Tilapia*. The diets of the fish were found to consist of organic detritus, vegetative matter, and a small number of insects (Varricchione and Minshall 1995b). Still, this finding may be explained by a lack of any springsnails existing in the creek during 1995.

The continued lack of recolonization at Site 1 suggests that the springsnails do not have strong migratory capabilities. Because no springsnails have been observed upstream of Site 1 (including Indian Bathtub), there is probably a lack of an upstream recolonization source. Also, colonists deposited by visiting waterfowl probably encounter the same unfavorable conditions as mentioned above.

RECOMMENDATIONS

Temperature monitoring during 1994 and 1995 used one data logger per site (Fig. 2). During most of the monitoring period, the data logger at Site 1 (Hot Creek) was submersed in water. The temperature data, not surprisingly, remained fairly constant. The temperature data for the two rockface sites (Site 2 and especially Site 3) displayed a greater range between minimum and maximum temperatures. The low rockface seep flow and potential for the data loggers to be exposed to air temperatures may have confounded logger results. Future monitoring might require the excavation of small holes where the data loggers are currently located so that the rockface data loggers may be completely submersed in rockface seep water. Also, the addition of a temperature data logger to Site 3 New Seep would improve monitoring springsnail population responses to temperature fluctuations.

Springsnail population and habitat data collected to date indicate that immediate measures should be taken to rehabilitate the Indian Bathtub-Hot Creek area and restore the habitat conditions to at least those found prior to July 1992. This is the minimum effort required to restore the Bruneau Hot-spring Springsnail to Hot Creek. Habitat restoration would enable us to determine if the springsnail will repopulate naturally or if transplantation is necessary. A recolonization experiment also appears to be an important step for the recovery of *P. bruneauensis* in Hot Creek. Factors such as substrate quality and fish predation need to be evaluated as potential barriers to springsnail recolonization. A possible experiment might be to transplant springsnail-covered cobble from a rockface site to Hot Creek and exclude fish predators with mesh screens. Another possible experiment might be to transplant springsnails directly to Hot Creek substrate and exclude predators. Other experiments might include the addition of colonists without any exclusion devices. Another important step for the recovery of springsnails in the Hot Creek area will be to augment rockface seepage (which may be a consequence of reducing the intensity of groundwater mining in the surrounding area).

ACKNOWLEDGMENTS

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LITERATURE CITED

American Public Health Association. 1992. Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D.C.

Fritchman, H. K. 1985. The Bruneau hot spring snail: an unidentified, possibly endangered hydrobiid from Hot Creek and the Indian Bathtub, Owyhee Co., Idaho. Remarks on its biology. Unpublished report.

Hershler, R. 1990. *Pyrgulopsis bruneauensis*, a new springsnail (Gastropoda: Hydrobiidae) from the Snake River Plain, southern Idaho. Proc. Biol. Soc. Wash. 103: 803-814.

Marker, A. F. H., E. A. Nusch, H. Rai, and B. Riemann. 1980. The measurement of photosynthetic pigments in freshwaters and standardization of methods: conclusions and recommendations. Arch. Hydrobiol. Beih. (Ergebn. Limnol.) 14:91-106.

Mladenka, G. C. 1992. The ecological life history of the Bruneau hot springs snail (*Pyrgulopsis bruneauensis*). Unpublished M.Sc. Thesis, Idaho State University, Pocatello, Idaho.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertrebrates and fish. USEPA EPA/444/4-89-001.

Platts, W. S., W. F. Megahan, and G. W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Forest Service General Technical Report INT-138, 70 pages.

Ponder, W. F., R. Hershler, and B. Jenkins. 1989. An endemic radiation of hydrobiid snails from artesian springs in northern South Australia: their taxonomy, physiology, distribution, and anatomy. Malacologia 31:1-140.

Robinson, C. T. and G. W. Minshall. 1995. Biological metrics for regional biomonitoring and assessment of small streams in Idaho. Final report submitted to the Idaho Division of Environmental Quality, 119 pages.

Robinson, C. T., G. W. Minshall, and K. Sant. 1992. Annual Monitoring Report: Bruneau Hot Springs Snail (*Pyrgulopsis bruneauensis*). Prepared for the U.S. Bureau of Land Management, Boise, ID.

Royer, T. V. and G. W. Minshall. 1993. Annual Monitoring Report: Bruneau Hot Springsnail (*Pyrgulopsis bruneauensis*). Prepared for the U.S. Bureau of Land Management, Boise, ID.

Taylor, D. W. 1982. Status report on the Bruneau hot springs snail. Conducted for the U.S. Fish and Wildlife Service, Boise Office, Idaho.

Varricchione, J. T. and G. W. Minshall. 1995a. 1994 Monitoring Report: Bruneau Hot-spring Springsnail (*Pyrgulopsis bruneauensis*). Technical Bulletin 95-14 (June). 23p. (BLM-ID-PT-95-019-1150)

Varricchione, J. T. and G. W. Minshall. 1995b. Gut Content Analysis of Wild *Gambusia* and *Tilapia* in Hot Creek, Bruneau, Idaho. Technical Bulletin 95-16 (September). 5p. (BLM-ID-PT-95-023-1150)

Habitat Assessment, Glide/Pool Prevalence (modified after Plafkin et al., 1989).

Stream Name: ______________ Station: ______________ Date: ______________ Location Description: ______________

Idaho Department of Health and Welfare - Division of Environmental Quality
HABITAT ASSESSMENT FIELD DATA SHEET
GLIDE/POOL PREVALENCE

HABITAT PARAMETER	CATEGORY			
	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
1. Bottom substrate/ instream cover	Greater than 50% mix of rubble, gravel, submerged logs, undercut banks, or other stable habitat. 16-20 ___	30-50% mix of rubble, gravel, or other stable habitat. Adequate habitat. 11-15 ___	10-30% mix of rubble, gravel, or other stable habitat. Habitat availability less than desirable. 6-10 ___	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 0-5 ___
2. Pool substrate characterization	Mixture of substrate materials with gravel and firm sand prevalent, root mats and submerged vegetation common. 16-20 ___	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present. 11-15 ___	All mud or clay or channelized with sand bottom; little or no root mat; no submerged vegetation. 6-10 ___	Hard-pan clay or bedrock; no root mat or vegetation. 0-5 ___
3. Pool variability	Even mix of deep/shallow/ large/small pools present. 16-20 ___	Majority of pools large and deep; very few shallow. 11-15 ___	Shallow pools much more prevalent than deep pools. 6-10 ___	Majority of pools small and shallow or pools absent. 0-5 ___
4. Canopy cover (shading)	A mixture of conditions where some areas of water surface fully exposed to sunlight, and other receiving various degrees of filtered light. 16-20 ___	Covered by sparse canopy; entire water surface receiving filtered light. 11-15 ___	Completely covered by dense canopy; water surface completely shaded. OR nearly full sunlight reaching water surface. Shading limited to < 3 hours per day. 6-10 ___	Lack of canopy, full sunlight reaching water surface. 0-5 ___

Stream Name: ____________ Station: ____________ Date: ____________ Location Description: ____________

Idaho Department of Health and Welfare - Division of Environmental Quality
HABITAT ASSESSMENT FIELD DATA SHEET
GLIDE/POOL PREVALENCE

HABITAT PARAMETER	CATEGORY			
	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
5. Channel alteration	Little or no enlargement of islands or point bars, and/or no channelization. 12-15 ___	Some new increase in bar formation, mostly from coarse gravel; and/or some channelization present. 8-11 ___	Moderate deposition of new gravel, coarse sand on old and new bars; and/or embankments on both banks. 6-10 ___	Heavy deposits of fine material, increased bar development; and/or extensive channelization. 0-3 ___
6. Deposition	Less than 5 % of bottom affected; minor accumulation of coarse sand and pebbles as snags and submerged vegetation. 12-15 ___	5-30% affected; moderate accumulation of sand at snags and submerged vegetation. 8-11 ___	30-50% affected; major deposition of sand at snags and submerged vegetation; pools shallow, heavily silted. 4-7 ___	Channelized; mud, silt and/or sand in braided or nonbraided channels; pools almost absent due to deposition. 0-3 ___
7. Channel sinuosity	Instream channel length 3 to 4 times straight line distance. 12-15 ___	Instream channel length 2 to 3 times straight line distance. 8-11 ___	Instream channel length 1 to 2 times straight line distance. 4-7 ___	Channel straight; channelized waterway. 0-3 ___
8. Lower bank channel capacity	Overbank (lower) flows rare. Lower bank W/D ratio < 7. (Channel width divided by depth or height of lower bank.) 12-15 ___	Overbank (lower) flows occasional. W/D ratio: 8-15 8-11 ___	Overbank (lower) flows occasional. W/D ratio: 15-25 4-7 ___	Peak flows not contained or contained through channelization. W/D ratio > 25 0-3 ___

Stream Name: ______________________ Station: ______________________ Date: ______________ Location Description: ______________

Idaho Department of Health and Welfare - Division of Environmental Quality HABITAT ASSESSMENT FIELD DATA SHEET GLIDE/POOL PREVALENCE				
	CATEGORY			
HABITAT PARAMETER	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
9. Upper bank stability	Upper bank stable. No evidence of erosion or bank failures. Side slopes generally < 30°. Little potential for future problems. 9-10 ___	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40° on one bank. Slight potential in extreme floods. 6-8 ___	Moderately stable. Moderate frequency and size of erosional areas. Side slopes up to 60° on some banks. High erosion potential during extreme high flow. 3-5 ___	Unstable. Many eroded areas. "Raw" areas frequent along straight sections and bends. Side slopes 60° common. 0-2 ___
10. Bank vegetation protection	Over 90% of the streambank surfaces covered by vegetation. 9-10 ___	70-89% of the streambank surfaces covered by vegetation. 6-8 ___	50-79% of the streambank surfaces covered by vegetation. 3-5 ___	Less than 50% of the streambank surfaces covered by vegetation. 0-2 ___
OR Grazing or other disruptive pressure	Vegetative disruption minimal or not efficient. Almost all potential plant biomass at present stage of development remains. 9-10 ___	Disruption evident but not affecting community vigor. Vegetative use is moderate, and at least one-half of the potential plant biomass remains. 6-8 ___	Disruption obvious; some patches of bare soil or closely cropped vegetation present. Less than one half of the potential plant biomass remains. 3-5 ___	Disruption of streambank vegetation is very high. Vegetation has been removed to 2 inches or less in average stubble height. 0-2 ___

Stream Name: ______ Station: ______ Date: ______ Location Description: ______

Idaho Department of Health and Welfare - Division of Environmental Quality
HABITAT ASSESSMENT FIELD DATA SHEET
GLIDE/POOL PREVALENCE

HABITAT PARAMETER	CATEGORY			
	OPTIMAL	SUB-OPTIMAL	MARGINAL	POOR
11. Streamside cover	Dominant vegetation is shrub. 9-10 ___	Dominant vegetation is of tree form. 6-8 ___	Dominant vegetation is grass or forbes. 3-5 ___	Over 50% of the stream bank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 0-2 ___
12. Riparian vegetative zone width (least buffered side)	> 18 meters 9-10 ___	Between 12 and 18 meters. 6-8 ___	Between 6 and 12 meters. 3-5 ___	< 6 meters. 0-2 ___
Column Totals	___	___	___	___
Score				

Bureau of Land Management
Idaho State Office
3380 Americana Terrace
Boise, Idaho 83706

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