2002-2003 Synopsis of Research

Title: Springs in peril: Have changes in groundwater input affected Oklahoma springs?

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Congressional District: 4th District

Descriptors: spring discharge, spring fauna, Oklahoma crayfish

Problem and research objectives:

Problem. Groundwater is an extremely important commodity to Oklahoma, with heavy use by agriculture, industry, municipalities, and private landowners. Groundwater is also critical for wildlife and for maintaining the high-quality outdoors environment of Oklahoma, especially through the influence of groundwater on springs and on stream flows.

Springs, by definition, are the locations where groundwater emerges and becomes surface water. As a habitat, springs share the characteristics of both underground waters (nearly constant temperatures and water flow, and low oxygen concentration) and surface waters (light and algal growth, inputs of dead plant material, and the water-air interface which allows gas exchange and colonization by flying insects). Typically, springs have a characteristic fauna that may include certain fishes and a predominance of non-flying invertebrates, such as snails and flatworms.

The extensive use of groundwater in Oklahoma and surrounding states may reduce water levels in some Oklahoma aquifers, with consequent partial or complete dewatering of the associated springs. In fact, springs provide an excellent point to monitor quantitative and qualitative changes in groundwater resources. Such reduction in spring flows may adversely affect the plants and animals living in spring, especially those species that are spring specialists. The flow of streams associated with springs may also be adversely affected by groundwater use.

Recently, there have been two proposed large-scale water sales projects in Oklahoma. Although neither sale has gone through, both are still possible and these potential sales highlight the growing value of Oklahoma water. The first sale would involve water extracted from southeastern Oklahoma and sold to Texas. Although the sale would involve only surface stream flow, the interaction between streams and groundwater could also affect alluvial aquifers (= aquifers associated with streams and rivers).

The second proposed water sale would involve the direct extraction of groundwater from the Arbuckle-Simpson aquifer, a process that would almost certainly affect the springs and spring-fed streams in this area. These streams and springs are used by local municipalities and have very high recreational value.

Original objectives: This research will addresses (1) the flow status of springs in Oklahoma, and (2) the effects of altered flow rates on spring biota. Discharge data and invertebrate surveys from 50 springs collected in 1981-1982 (existing data from a previous OWRRI project; Matthews et al.1983) and in 2001-2002 (this project) are being used to assess changes in groundwater discharge into springs and indicate how any changes may affect the invertebrate fauna of springs.

Specific objectives of the project are:

A. Estimate the extent of groundwater flow changes into springs throughout Oklahoma.
B. Determine if changes in spring conditions over the past 20 years have affected spring invertebrate communities.
C. Determine whether some types or locations of springs are more susceptible to flow reduction than other springs.
D. Identify possible indicator species that either appear or disappear in flow-impacted springs.
E. Increase the knowledge base of the biodiversity and distribution of spring-dwelling invertebrates.
F. Train one graduate student to work on the springs of Oklahoma.
G. 'Re-use' data from the project by adding data to the OBS database, to be used, for example, in future research projects by external researchers.
H. Disseminate information and results in a final report, by developing a project website, presenting results at one or more meetings, and writing one manuscript.

Added objectives. In addition to sampling invertebrates at each spring, fish were collected, when present. Fish were collected in the 1981-1982 study and their inclusion in this study adds to the information gained about changes in the biota over the 20-year period. Fish were not included in the original proposal because there was insufficient time to obtain the required approval for research involving vertebrates by the University of Oklahoma. Approval has since been obtained.

Additionally, the study was expanded to include about 20 additional springs, with emphasis on sampling springs that were in areas underrepresented in the original 50 springs study. Also, because spring-owner questionnaires were found to be a good method of indicating possible flow changes over time, questionnaires were sent to a large number of spring owners.

Methodology

The study hinges on the comparison of two datasets of spring surveys, one collected in 1981-1982 and the other collected in 2001. In order to have comparable surveys, the methods used in the 2001 springs survey closely followed those of the previous survey. Descriptions of the methods used in the 1981-1982 surveys are found in the final project report (Matthews et al. 1983), manuscripts (Matthew et al. 1985), and in the field notes from the project.

Field sites. The 50 spring sites were originally selected because they had enough flow to be used as a water supply (with a few exceptions), were good sites for monitoring particular aquifers, and had landowner permission for privately owned sites. The 50 sites are located in 29 Oklahoma counties (Figure 1) and in 8 aquifers.

As in the earlier survey, springs were surveyed during the summer. Data and samples collected at each spring included:

- A description of the spring site. This description included a diagram of the spring, directions to re-locate the site, GPS readings, and information on local land use, alterations to the spring, and the vegetation in and near the spring.
- Measurement of several physical and chemical parameters: including, pH; water temperature; conductivity; water widths, depths, and velocities. Discharge (the quantity of water flow per time, as liters per second) was calculated from the last three variables.
- Sampling for aquatic invertebrates. Qualitative sampling followed the 1981-1982 sampling protocol and included dip-netting, picking organisms off stones, and collecting leaf packs, which were preserved and later searched for invertebrates in the laboratory. Additionally, 3 to 6 core samples (diameter = 10.2 cm) were collected at each site. Invertebrate samples were preserved in 70% ethyl alcohol.
- Sampling for fish. Springs were seined with a fine-meshed (3 mm openings) seine and representatives of each species caught were preserved in 10% formaldehyde. The majority of captured fish were released.

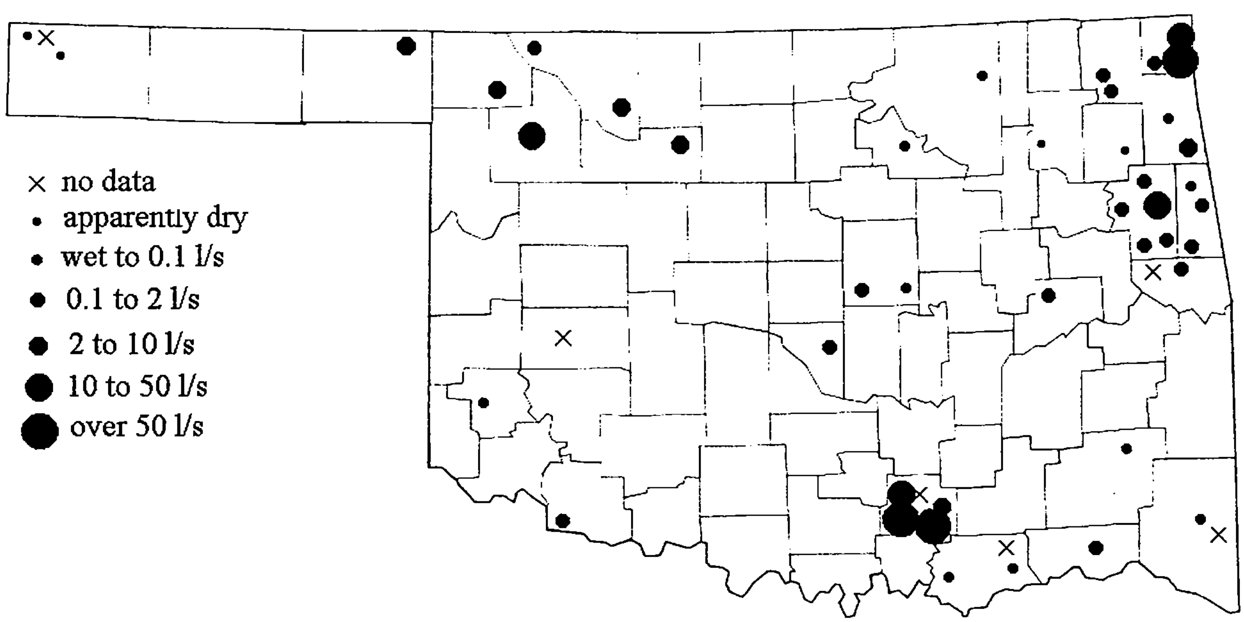

Figure 1. Location of the 50 springs sampled in 1981-82 and in 2001. The calculated discharge of each spring during the 2001 sampling is indicated by the symbol marking each spring (see legend).

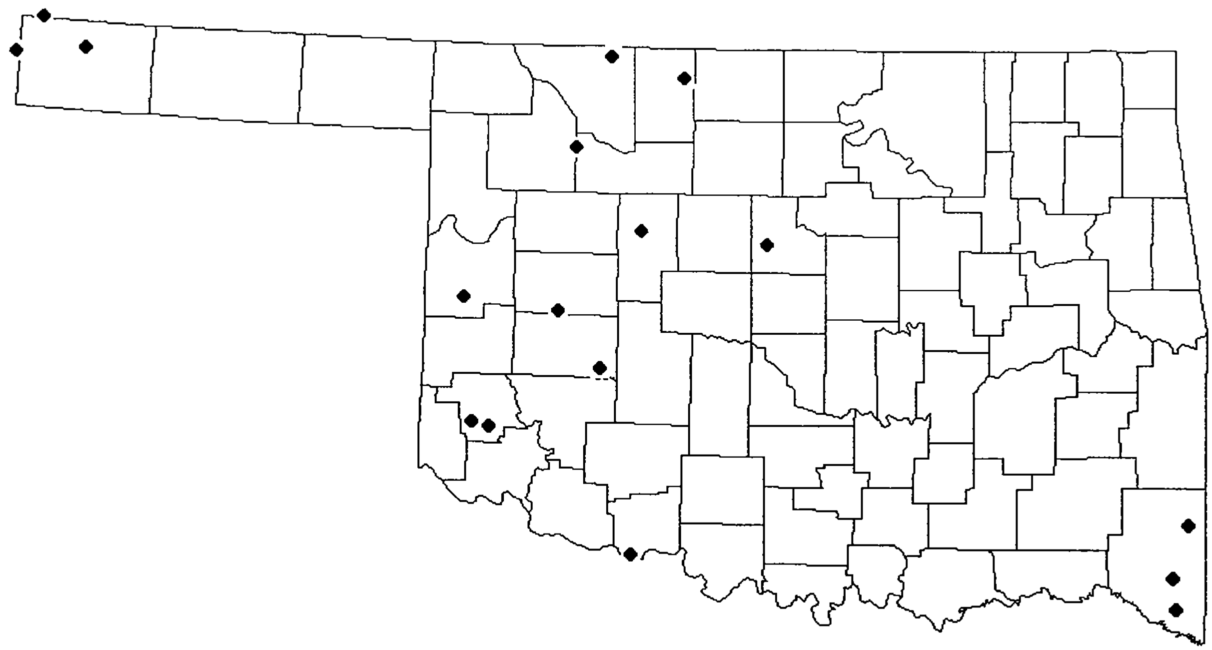

Figure 2. Location of 24 springs sampled in 2002-3. Some of the indicated locations are pairs of nearby springs.

Laboratory processing of biological samples. Fish samples were rinsed of formaldehyde, identified by Dr William Matthews (Curator of Fishes, Sam Noble Oklahoma Museum of Natural History, University of Oklahoma), and transferred to 70% ethyl alcohol. The fish samples will be deposited in the fish collection at the SNOMNH.

Invertebrates in the invertebrate samples have been sorted from the substrates and divided into broad taxonomic categories. Chironomids and crayfish are mostly identified and identification of other invertebrates is on going.

Questionnaires. Owner questionnaires were used to identify springs whose flow patterns had altered over time. Questionnaires were not completed for all sites, especially sites on public lands. Some questionnaires were of little value because owners had recently purchased the property or were not very familiar with their spring.

Principal Findings and Significance

1. Data on spring flows and changes in flow between 1981 and 2001 were reported in the 2001-2 annual report and are not repeated here.

2. Changes in spring flow over time were accessed for an additional 35 spring locations using questionnaires (no previous flow data were available for these locations). Of these springs, owners reported reductions in flow at 4 locations; no change was reported at 25 locations and owners did not know at 6 locations. Reductions in flow were associated

with increased groundwater use for irrigation (2 spring locations) and siltation of the spring (2 spring locations) by their owners.

3. The four springs with reduced flow were primarily alluvial springs (in Cimarron, Custer, Greer and Woods Counties), although the Greer and Woods County sites may have been associated with bedrock aquifers (Dog Creek Shale & Blaine Gypsum Aquifer and Cedar Hills Sandstone Aquifer, respectively). This supports last year's finding that alluvial aquifers sometimes have flow-impacted springs.

4. The 2001 results indicated reduced flows in springs associated with the Ogallala Aquifer in Cimarron County. A second map series (Johnson 1983) indicates that the sampled Cimarron County sites are alluvial springs and are independent of the Ogallala Aquifer and, hence, no Ogallala springs in the Oklahoma panhandle were sampled. In contrast, 2 Ogallala-source springs were sampled in Roger Mills County and no evidence of reduced spring flow was found. Hence, this study showed no evidence of impacted flow of Ogallala aquifers in Oklahoma (although only 2 Ogallala-associated springs were sampled).

5. Of the 50 springs sampled in 1981 and 2001, 20 contained fish, 36 contained crayfish, and 10 contained neither fish nor crayfish. Of the additional 24 springs sampled in 2002-3, only three contained fish and eight contained crayfish. The additional 24 springs tended to have lower flow and be more western that the original set of 50 springs.

6. The occurrences of fish and crayfish were associated with flow. In the 50-springs dataset, mean flow of fish-containing springs was 34.6 L/s, mean flow of crayfish-containing springs was 14.4 L/s, and mean flow of springs with neither fish nor crayfish was 1.0 L/s.

7. Fish composition in springs was associated with the particular aquifer (the source of water) and with the contained watershed (the conduit of fish travel).

8. Eleven species of crayfish were collected in springs in 2001-3. This amounts to 41% of the known non-cave-dwelling crayfish species in the state. Crayfish were not identified in the 1981-2 study, so comparisons with the earlier dataset are limited.

9. Although the fish faunas in most springs changed little over between 1981 and 2001, a few springs had large changes. These changes were either (1) a reduction in diversity (or apparent loss of fish) that resulted from erosion/siltation, spring drying, or flow diversion or, less commonly, (2) an increase in diversity because of impoundment of the spring and fish stocking and colonization of the resultant pond.

Significance.
No evidence of recent reduced flow was found for the majority of the approximately 70 springs included in the 2-year study. Most springs with apparent reduced flows were associated with various alluvial aquifers, the Trinity Aquifer, or the Vamoosa Aquifer.

Possible reasons for reductions in spring flows include local increases in groundwater-based irrigation, direct modifications to the spring (e.g., construction of a forestry road over the spring), and land-use effects (e.g., farming and livestock operations resulting in siltation of the spring).

Springs in Oklahoma support a diverse group of organisms, including several species of fish, crayfish, and salamanders, and a variety of crustaceans and insects.

Based on the relationship between spring flows and fish presence, reduced flows in springs would likely result in reduced fish diversity and, if flow is sufficiently reduced, the loss of fish from affected springs.

References

Johnson, K. S. 1983. Maps showing principal ground-water resources and recharge areas of Oklahoma. Oklahoma State Department of Health.

Matthews, W. J., J. J. Hoover, and W. B. Milstead. 1983. The biota of Oklahoma springs: Natural biological monitoring of ground water quality. Misc. Publ. Oklahoma Water Research Institute, Oklahoma State University, Stillwater, Oklahoma. 64 pp.

Matthews, W. J., J. J. Hoover, and W. B. Milstead. 1985. Fishes of Oklahoma springs. Southwest Nat. 30:23-32.

Publications (2002-2003)

Articles Submitted to Refereed Scientific Journals

Taylor, Chris A., Shane N. Jones, and Elizabeth A. Bergey. In review. The crayfishes of Oklahoma revisited: new state records and checklist. Southwestern Naturalist.

Conference Presentations

Jones, Shane N., and Elizabeth A. Bergey. 2002. Spatial and temporal variation in the fauna of Oklahoma springs. Bulletin of the North American Benthological Society 19: 314-315.

Summary of students employed by the project

Category	Number	Discipline
Undergraduates	4	Environmental engineering, Microbiology & Zoology
Masters	3	Zoology
Ph.D.	0	
Post Doc	0	
Recent B.S. graduates*	2	Zoology
Total	9	

*summer employment after graduation only