

Assessing biological effects of natural gas drilling on headwater streams in the Fayetteville Shale region.

Project Summary

There are approximately 1330 producing natural gas wells within the Fayetteville Shale region of Arkansas and new wells continue to be installed. Few studies have examined how the drilling process affects sedimentation and aquatic biota in this region. We propose to quantify and characterize sediments in streams that drain land with a high density of permitted locations (>10) versus those that drain land with few to no gas permits (<4). We will pair streams by geographic location and % land cover for a total of 6 pairs across the Fayetteville Shale region. Sediment, algal biomass and primary production, invertebrates, and fishes will be measured in spring 2010 in each stream to determine the community composition and possible changes in composition occurring from activities associated with gas wells. **Our data will provide baseline biological surveys of 12 headwater streams, the amount and composition of benthic and suspended sediment, and effects of sediment associated with drilling activities on sensitive aquatic biota, such as the speckled pocketbook mussel and Yellow cheek darter.**

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Budget Summary:

Total amount requested for **one** sampling season: \$65,324 (**OR** total for **two** seasons: \$121,211)

Matching funds (UCA/UA/TNC) for **one** sampling season: \$102,379 (**OR** total for **two** seasons: \$127,697)

Total project amount for **one** season: \$167,703 (**OR** total for **two** seasons: \$248,908)

Funding priorities addressed by proposal: Our project will assess the effects of natural gas drilling on biota in headwater streams by measuring sediments, primary production, invertebrates, and fish in headwaters with low or no permitted gas wells versus those with a high density of newly constructed active wells (>10). We will address 2 priorities listed under the Arkansas Wildlife Management Plan:

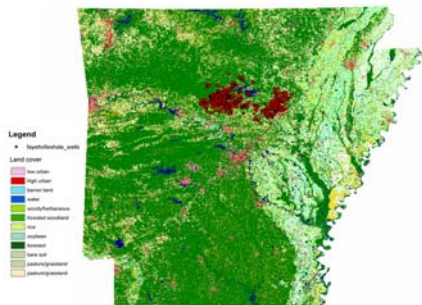
1. **Implement conservation actions and monitoring in the Fayetteville Shale area**
2. **Survey headwater aquatic biodiversity. Reduce anthropogenic impacts to headwater streams and cave recharge areas.**

Project Goals and Objectives: We will inventory and assess the aquatic biota in 12 headwater streams, 6 with high and 6 with low densities of newly constructed active wells. Headwater streams comprise over 90% of the total stream miles of Arkansas's river networks, providing critical habitats for sensitive invertebrates, salamanders, and fishes. Many land uses threaten the biological health of headwaters including agriculture, logging, and drilling for natural gas. Therefore, headwater streams are listed as ecosystems of concern under the AWAP and species of concern inhabit some of these streams. The installation and implementation of gas wells has the potential to dramatically increase sedimentation to headwater streams by increasing road and ditch densities; clearing vegetation around gas pad, pipeline, and compressor sites; and more directly from impacts associated with temporary and/or permanent stream/riparian intersection and alteration from road crossing, pipeline, and reservoir construction (Fig. 1). This sediment has the potential to smother biota and alter the community structure of the headwaters.



Fig. 1. Sedimentation from installation and maintenance of natural gas wells. A) Stream trenching for laying pipe under a small stream; b) ditch and fill activities along the riparian corridor of a stream; and C) slope clearing of vegetation to lay pipe for gas distribution, D) compressor sites, roads, and E) gas wells. Photos courtesy of Lindsey Lewis, USFWS

Region & Study Site Location: Our study sites will be located in the Fayetteville-Shale region of central Arkansas in 12, 2nd-order headwater streams (Fig.2).



Study Design and Methods: The study design is a paired stream approach that will allow for an experimental block design to increase our ability to detect biological differences due to sedimentation from drilling and minimize differences due to geographic location, local geology, differences in hydrology, and precipitation. We will determine suitable paired stream locations by determining catchment area and calculating land cover above each sampling reach using the Arc Hydro extension

Fig. 2: 2006 Arkansas land use and land cover data with producing wells in Fayetteville Shale region (red dots).

in ArcMap (Fig. 3, Table 1). In each stream, we will ground-truth, conduct habitat assessments, and then delineate a 200 meter stream segment to sample in replicate. Our sampling will include 6 streams from the Little Red River drainage and 6 from the Cadron drainage.

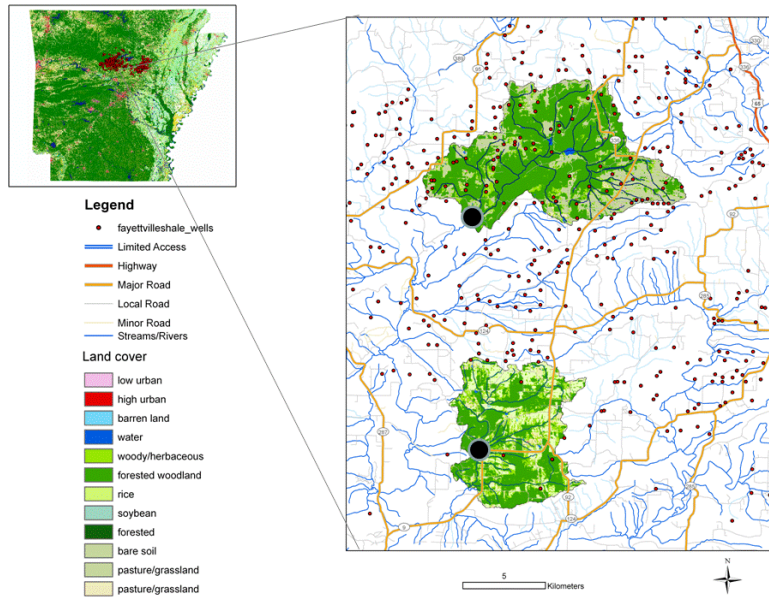


Fig. 3: Example of site selection showing paired high and low density catchments. Potential study reach locations are shown as black dots.

Table 1. Percent land cover in each of the catchments in Fig. 3 using 2006 Arkansas land use and land cover data.

Catchment	Urban	Water	Herb/woody	Woodland	grasses (warm)	grasses (cool)
Low well	2	0	20	50	23	4
High well	2	1	9	63	24	1

We will quantify the following variables in Spring 2010 (or Spring and Autumn 2010):

1. Ten benthic and suspended sediment samples from each stream reach at high and low flow. Benthic sediments will be sampled using a corer, collecting a known volume of slurry subsample, and filtered in the laboratory. Suspended sediments will be sampled using portable automated sequential water samplers and filtered in the laboratory. Sediment content (organic vs. inorganic fractions) and volume will be quantified.
2. Five to 10 benthic invertebrate samples will be collected in each stream reach within each representative habitat using a 250 µm mesh Hess sampler. Invertebrates will be collected, preserved in ethanol, enumerated, identified, and biomass will be estimated. Invertebrate richness, diversity, density, and biomass will be determined for each stream at base flows only.
3. Fish will be sampled at base flows with triple pass electro-fishing. Fish taxa richness, density, and biomass will be quantified. Fish that cannot be identified in the field will be preserved in 10% formalin and taken to the laboratory. Individual fish will be identified and weight and length measurements recorded.

4. Periphyton biomass and primary production: Five to 10 cobbles will be collected in each stream reach within each representative habitat, stored on ice, and analyzed for chlorophyll *a* and ash-free dry mass in the laboratory. Whole-system metabolism (i.e., gross primary production, community respiration, net ecosystem production) will be measured in each study stream by determining diel dissolved oxygen patterns using multi-parameter sondes equipped with temperature, conductivity, optical DO, and turbidity sensors and conservative gas and solute releases to estimate re-aeration. Photosynthetically-active radiation will be monitored using Odyssey light loggers at each stream reach during metabolism estimates. Water samples will be collected and analyzed for total nitrogen and total phosphorus on a Lachat rapid flow analyzer before and after metabolism estimates.

Measurable products: We will survey and assess the biological community of 12 headwater streams throughout the Fayetteville Shale region. We will provide baseline data on the productivity of the streams and measure invertebrate and fish density and diversity in these headwater streams. In addition, we will quantify the amount of sedimentation and the effects of high-density permit locations on biological communities in these headwater streams. Products will include:

- Baseline data on periphyton biomass, primary production, and invertebrate and fish diversity, density, and biomass in 12 headwater streams with varying levels of permit densities and landuse in understudied habitats.
- Provide management recommendations for minimizing sedimentation that may occur from drilling activities.
- Provide data to alert land managers to potential effects of sedimentation from gas drilling on species of concern.
- Submission of at least 3 peer-reviewed scientific publications addressing the effects of natural gas drilling on biota in Arkansas.

Partnerships: University of Central Arkansas biologists and chemists will be working in collaboration with the United States Fish and Wildlife Service, The Nature Conservancy, and the University of Arkansas, Fayetteville. Collectively, the partnership will provide a diversity of knowledge relevant to the project, equipment needed to carry out research objectives, and people located in close proximity to the study locations.

Budget: Proposed total for sampling in Spring 2010

	Total	UCA/UA (Match)	SWG
Salary/benefits	61011	35004	26007
Operating expenses			
Equipment	71196	53068	18128
Travel	10000	5000	5000
Supplies	7000	0	7000
Other*	3250	0	3250
Subtotal	152457	93072	59385
Indirect (10%)	15246	9307	5939
Totals	167703	102379	65324

This table represents costs for Spring 2010 sampling only. With an additional \$55,887, primarily for graduate student stipends, we could also sample in autumn 2010 for a total SWG request of \$121,211.

* Other includes publication fees and meeting registration fees.

Qualifications of University of Central Arkansas to carry out this project

University of Central Arkansas has a location ideal for this multi-investigator project and has been involved in biological research in the area for many years. UCA has a strong Environmental Science Program to train undergraduate students, who will be central to this effort, as well as a graduate program in biology. In addition, the chemistry department has analytical equipment. The collaboration with the University of Arkansas Fayetteville and The Nature Conservancy will provide additional analytical support for water quality analysis, mass spectrometry, and graduate student involvement through Michelle Evans-White's laboratory, GIS analysis, spatial statistics, and additional biological experience in the Fayetteville Shale region.

Sally Entrekin has a background in aquatic ecology that has focused on food web and organic matter dynamics in headwater streams on which she has published. Her responsibilities on this project will include project organization, mentoring of an undergraduate and graduate student to investigate organic matter dynamics and invertebrate community structure.

Ginny Adams research has focused on the conservation of sensitive and endangered species in relation to anthropogenic disturbance. She is an expert in cave and spring ecology and has studied morphology, physiology, life history, genetics, and ecology of invertebrates and fishes on which she has several scientific papers. Her responsibilities on this project will include mentoring of undergraduate and graduate students in fish collection and identification.

Reid Adams research has focused on physiology and ecology of freshwater fishes and invertebrates in large river systems and has several papers relevant papers on these subjects. He will contribute his broad experience on the ecology of streams and rivers in this region. His responsibilities on this project will include mentoring of undergraduate and graduate students in fish collection and identification.

Michelle Evans-White research and scientific publications have focused on roles of animals in organic matter and nutrient dynamics in stream ecosystems and how anthropogenic factors may alter species functional roles. Her responsibilities on this project will be monitoring whole-stream metabolism, water chemistry (including storm sampling), and providing analytical support to faculty at UCA.

Lindsey Lewis is a biologist with the United States Fish and Wildlife Service. Among his many duties, he monitors the activity of well drillers in the state of Arkansas. He will act in an advisory role to help us find study locations, gain access to private lands, and help disseminate our research results.

Karen Steelman has a great deal of experience with radiocarbon dating and stable isotope analysis and will aid in the characterization of the organic and inorganic content of sediments. She will mentor undergraduate students in field, as well as with laboratory sampling and processing.

Ethan Inlander is a professional geographer and project manager with over 15 years experience applying geospatial technologies and analyses to land management and conservation issues. His emphases include watershed modeling, riparian mapping and conservation prioritization. His responsibilities on this project will be to provide input on GIS modeling and landscape characterization.

Daniel Millican is an aquatic ecologist with experience in identification of species-environment relationships using multivariate analyses. His responsibilities on this project will be to provide advice on biological and landscape sampling design, and on using statistical analyses to identify landuse influences on biological characteristics.