Continuation: Assessing physical, chemical, and biological effects before, after, and during gas well construction in headwater streams on Gulf Mountain Wildlife Management Area.

We propose to continue to quantify potential changes in water quality and aquatic biota of headwater streams in the Gulf Mountain WMA from natural gas drilling. Further, we will relate water quality and sediment quantity and composition to possible changes in aquatic biota in streams draining catchments with wells in the Gulf Mountain WMA to those that use questionable best management practices (BMPs) in 3 catchments nearby. We have sampled headwater streams in Gulf Mountain in autumn 2009, spring 2010, autumn 2010, are funded to sample spring 2011. Two well pads have been built on Gulf WMA and several more are proposed for 2011. We are requesting funds for 1 additional year of funding to continue to study headwaters in Gulf Mountain Wildlife Management Area.

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Total amount of project cost: $217,849
Total amount of SWG money requested: $146,857
Amount and source of matching funds or inkind services: $76,507

Project Statement (pages 2 to 4):

Project need: Natural gas development is occurring at an unprecedented rate that will impact over 20 U.S. states**.** Our past data indicate cumulative effects of gas development on stream water quality in regions where management practices during well development are uncertain (Figure 1). We will continue to address the potential effects of natural gas development on headwater streams in north-central Arkansas' Fayetteville Shale gas play (Appendix 1). If funded, we will be able to complete a 3rd year of sampling (see Appendix 2) as well as monitor streams as the gas development proceeds on Gulf Mountain Wildlife Management Area (WMA). In addition to addressing a pressing emerging issue, data collected on water levels, species distributions, and abundance over multiple years with varying hydrologic regimes at several sites will contribute to our understanding on the critical flow needs of species of concern.

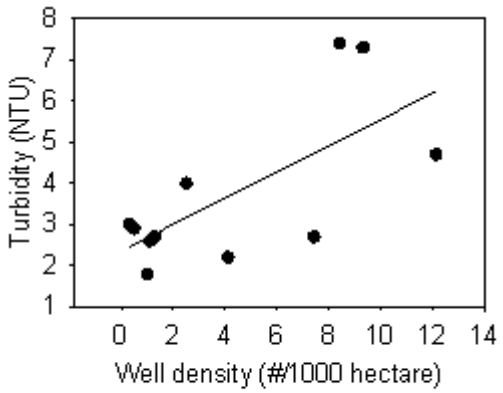


Figure 1. Stream water turbidity increased with an increase in well density within the catchment during high flow in February 2010.

Objectives – Sampling will occur from autumn 2011 to autumn 2012. We will sample variables outlined below twice a year, unless noted otherwise, in spring and in autumn or early winter (see Timeline as appendix 2 below).

Our primary objective is to quantify potential alterations in water quality in headwater streams in Gulf Mtn WMA. We began sampling these streams in autumn 2009 and have sampled twice a year since. We will not continue sampling all of the 11 streams off Gulf Mountain. Instead, we will retain 3 sample sites near Gulf Mtn located in catchments with high well density and variable BMP implementation. The biological data from these sites will be used as a comparison to parallel data collected in the Gulf Mountain headwater streams. Our study is also complementary to Haggard et al. who are quantifying changes in water quality in the South Fork of the Little Red River (SFLRR). These two projects combined will provide a long term quantitative analysis of effects of natural gas development to surface waters in the Fayetteville shale. We will continue to use these data to inform resource managers and concerned citizens of potential threats from gas well development.

Study Design and Methods: We are using before-after-control-impact factorial analysis to detect changes in chosen biological attributes following drilling. In addition, a suite of multivariate statistics will be used to further examine effects from pipe line, road, and reservoir densities on biological communities within the stream catchments. Sites have been chosen based on catchment size, land use land cover, and well density. All sites have now been ground-truthed and stream segments delineated for sampling. See the timeline for a summary of data already collected and projected sampling that will occur if funded. We will add the collection of stream water level to our suite of metrics to address how changing hydrology relates to species distributions and water quality. Entrekin and Evans-White will use a portion of their proposed supply money to purchase 10 PlantCam cameras and 10 staff gages to record hourly water levels (~$ 1000.00).

Approach

1. Five benthic sediment samples from each of 10 stream reaches at low flow.

Benthic sediments will be sampled using a corer, collecting a known volume of slurry subsample, and filtered in the laboratory. Sediment content (organic vs. inorganic fractions) and volume will be quantified (following methods outlined by Wallace et al. 2006). (PI Entrekin) (1 year x 2 sampling dates x 10 stream reaches x 5 cores=100 total samples)

2. Two siphon samplers have been placed at each of the 10 study sites to capture suspended sediments during high flows. One set of samplers is set 10 cm above base flow and the other is set 30 cm above base flow. We aim to sample 2 storms per season, including summer and winter, although total number of storms that will occur varies greatly. Ideally, we will sample 1 year x 2 storms x 4 seasons x 2 samplers per stream reach x 10 stream reaches=160 total samples).

3. Ten 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, life history traits, and biomass will be determined for each stream at base flows only (Entrekin et al. 2007). (PI Entrekin) (1 year x 2 sampling dates x 10 stream reaches x 10 cores=200 total samples). Entrekin is requesting $42,637 for invertebrate and sediment collection (Approach 1-3) and analysis including 10% towards indirect costs and she will provide $22,622 as match from unrecovered indirects and salary.
Total Cost=$65,595; SWG= $42,637; Match=$22,958

4. 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. (PI G and R Adams). Adams' are requesting $41,096 for project collection and analysis including 10% towards indirect costs and $22,622 as match from unrecovered indirects and salary.
Total Cost=$63,224; SWG= $41,096; Match=$22,128

5. Periphyton will be measured on 10 cobbles in each stream reach within each representative habitat, stored on ice, and analyzed for chlorophyll *a* and ash-free dry mass in the laboratory twice annually (2 sampling dates x 10 reaches x 10 cobbles = 200 total samples). Whole-system metabolism (i.e., gross primary production, community respiration, net ecosystem production) will be measured in each study stream at the same time that periphyton cobbles are collected by determining diel dissolved oxygen patterns using multi-parameter sondes equipped with temperature and dissolved oxygen probes (2 sampling dates x 10 reaches = 20 total samples). Water samples will be collected when primary production is being measured and analyzed for total dissolved inorganic nitrogen (NO_3+NO_2-N + NH_4), soluble reactive phosphorus, and total phosphorus (TP) on a Lachat rapid flow analyzer (2 sampling dates x 10 reaches = 20 total samples per chemistry type, 80 total samples). We will also analyze (TP) on storm flow samples collected in the siphon samplers. The number of these samples will depend upon storm events (Evans-White). Metabolism, periphyton, and dissolved nutrient analysis will require $47,582 including 10% for indirect costs and $23,053 in match from salary and unrecovered indirect costs.
Total Cost=$70,635; SWG= $47,582; Match=$23,053

5. Water column water samples will be collected from each of the 10 study sites 12 times per year for a total of 120 samples that will be analyzed for conductivity, turbidity, dissolved trace elements (e.g., arsenic, copper, cadmium, calcium, chromium, iron, magnesium, manganese, zinc) using inductively coupled plasma optical emissions spectrometry (ICP–OES). In addition, 3 sediment samples from each of the 10 streams will be collected and analyzed from storm samples collected by siphon samples. Sediments will be extracted using a Mehlich III method and analyzed on a separate ICP in the Agricultural Diagnostic Lab to detect Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, P, S, and Zn. The University of Arkansas Water Quality Research Lab (Haggard) will be responsible for this component of the study. Trace element water chemistry will require $6720 (120 samples x $56 per sample), $300 (30 total samples) for sediment extraction and analysis, travel will be $1200, and $822 for 10% indirect costs and $4,868 in match from salary and unrecovered indirect costs.
Total Cost=$13,910; SWG= $9,042; Match=$4,868

7. Each catchment will have a characterization of the land cover, well densities, and unpaved roads identifying total length, density, and hydrologic proximity to streams. Gas infrastructure will be quantified in each catchment as total length of gas pipelines, their proximity to streams, the number of well pads, and their proximity to the stream. In addition, stream bank sediment sources and sinks will be estimated from the site of sampling collection. These spatial data will be used to assist in the interpretation of the biological and sediment data. Ethan Inlander and Daniel Millican (The Nature Conservancy) will be responsible for this objective and it will require $5,850 for salary plus $650 for indirects of 23% and they will match $3500 as salary and unrecovered indirect costs.
Total Cost=$10,000; SWG= 6,500; Match=$3,500

Location of Work - Study site locations in Gulf Mountain Wildlife Management Area located in Vanburen County and Arkansas. See Appendix 1 for map of study site locations.

1. Budget summary
Complete the project budget summary form below.

Budget Category	State Wildlife Grant Funds (Federal)	Cash Match (Non-Federal)	In-Kind Match (Non-Federal)	Total Project Cost
Salaries	103,464.00	-	76,507.00	179,971.00
Contract Services	7,020.00	-	-	7,020.00
Supplies and Materials	10,750.00	-	-	10,750.00
Travel	7,200.00	-	-	7,200.00
Equipment	-	-	-	-
Indirect Costs	12,908.00	-		12,908.00
TOTAL	146,857.00	-	76,507.00	217,849.00

-

Qualifications of assembled research group:

Sally Entrekin is an aquatic ecologist often studying 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 morphology, physiology, life history, genetics, and ecology of invertebrates and fishes on which she has published. 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.

Chris Davidson is an endangered species biologist with the United States Fish and Wildlife Service. He has national lead on recovery of the federally endangered speckled pocketbook and monitors the activity of natural gas activities in the Little Red River watershed, including authorizing BMPs. He will act in an advisory role to find study sites, gain access to private lands, and disseminate our research results.

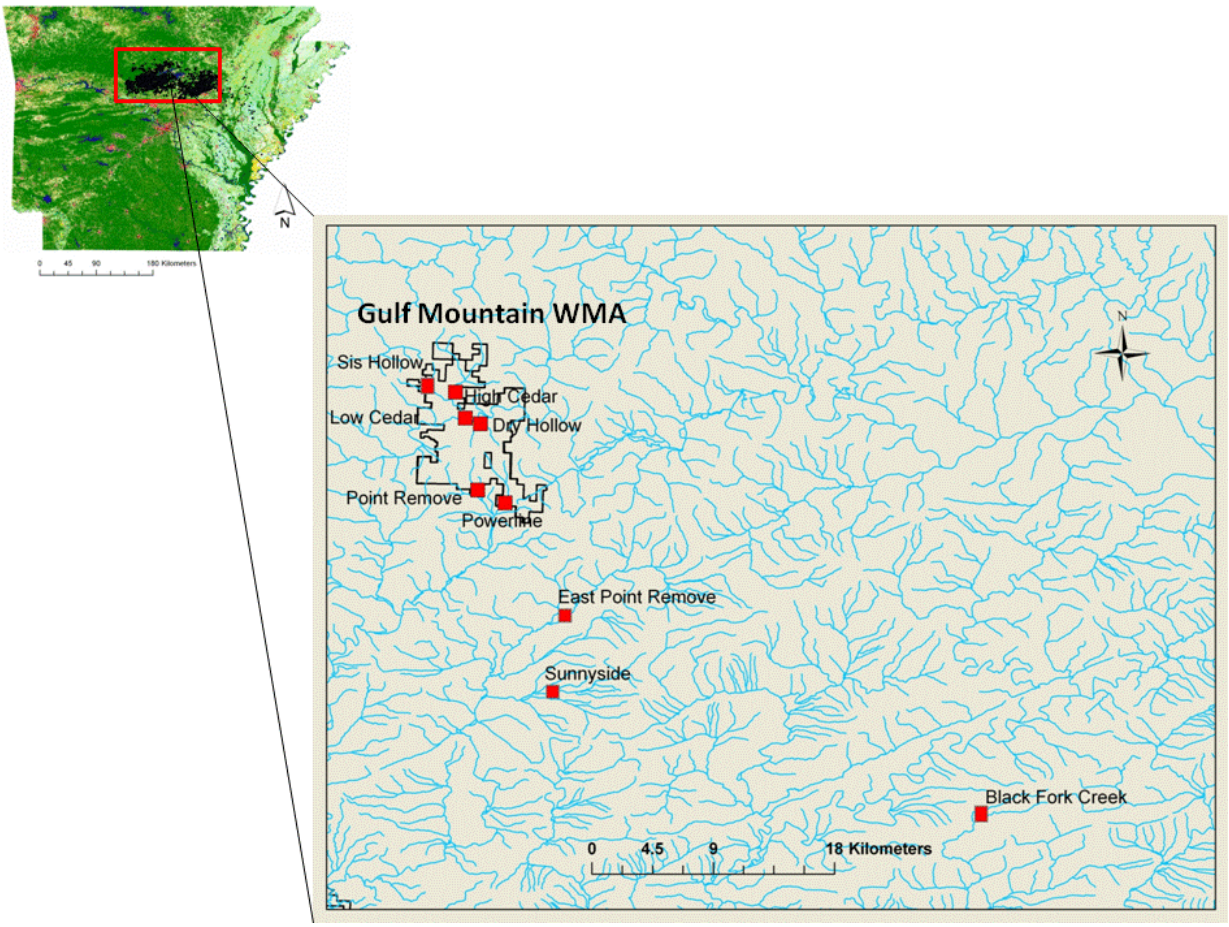
Lindsey Lewis is a biologist with the United States Fish and Wildlife Service. Among his many duties, he monitors the activity of well drillers in the state of Arkansas. He will act in an advisory role to help us find study locations, gain access to private lands, and help disseminate our research results.

Brian Haggard is an associate professor and the director of the Arkansas Water Resources Laboratory and has many years of experience analyzing sediments and water for contaminants. He will run suspended sediment samples at AWRC.

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.

Appendix 1: Study site locations on Gulf Mountain Wildlife Management Area in North-Central Arkansas.



GPS coordinates for Gulf Mtn Study sites

Location	Creek	Latitude	Longitude
Off Gulf Mtn	Black Fork	35.25	-92.31
Off Gulf Mtn	Hogan/Cove	35.38	-92.46
Off Gulf Mtn	Sunnyside	35.39	-92.62
Gulf Mtn	High Cedar	35.59	-92.68
Gulf Mtn	Powerline	35.51	-92.65
Gulf Mtn	Dry Hollow	35.57	-92.66
Gulf Mtn	East Point	35.52	-92.67
Gulf Mtn	Low Cedar	35.57	-92.67
Gulf Mtn	Sis Hollow	35.59	-92.70
Gulf Mtn	Point Remov	35.52	-92.67

GCS_North_American_1983

Datum: D_North_American_1983

Appendix 2: Summary of work accomplished and proposed work to be conducted.

Table 1. Proposed timeline for continued sampling on Gulf Mtn WMA.

	2009			2010			2011			2012			2013			2014		
Sample Collection	**Spring**	**Summer**	**Autumn**	**Spring**	**Summer**	**Autumn**	**Spring**	**Summer**	**Autumn**	**Spring**	**Summer**	**Autumn**	**Spring**	**Summer**	**Autumn**	**Spring**	**Summer**	**Autumn**
Gulf Mtn sediment			X	X		X	*		*	*		*	*		*	*		
All catchment/no-BMP sediment			X	X		X	*		*	*		*	*		*	*		
Gulf Mtn Periphyton and Metabolism			X	X			*		*	*		*	*		*	*		
All catchment/no-BMP Periphyton and Metabolism			X	X			*		*	*		*	*		*	*		
Gulf Mtn Invertebrates			X	X		X	*		*	*		*	*		*	*		
All catchment/no-BMP Invertebrates				X			*		*	*		*	*		*	*		
Gulf Mtn Fish			X	X		X	*		*	*		*	*		*	*		
All catchment/no-BMP Fish				X			*		*	*		*	*		*	*		
Sample processing/Data analysis																		
			Year 1			**Year 2**			**Year 3**			**Year 4**			**Year 5**			
x=completed			SWG 1			SWG 2			Submitted Preproposal			Continue if possible			Continue if possible			
*=projected to do		Report due	9/18/2011			9/18/2012												

Lower sites are reduced to 3 beginning in Autumn 2011