

ENVIRONMENTAL ASSESSMENT  
FOR  
ACID DEPOSITION ON POTHOLE ORGANISMS  
ARCHES NATIONAL PARK  
AND  
GRAND RESOURCE AREA,  
BUREAU OF LAND MANAGEMENT

## Background

Acid deposition has not been considered a threat to arid lands in the past, primarily because there is little rainfall, thus little acid rain, and also because soils have a high buffering capacity to neutralize what acid does fall. Better understanding of the dynamics of pollutant fallout has revealed that these assumptions are probably invalid. Acidic particles do not fall out of the atmosphere only during precipitation events. In deserts, the accumulation of dry deposition of acidic particles may be very significant. Upon wetting, these particles may form a more concentrated solution than the precipitation itself. In addition, certain systems in deserts may be more sensitive to acid deposition than others, and thus while damage is not readily visible, significant reductions in certain ecosystem functions may be occurring. Rainfall in the arid West has been measured with very low pH's: 4.36, Green River, Utah, 4.21, Bryce Canyon National Park, Utah, 3.84, Mesa Verde National Park, Colorado.

A research project to study the effects of acid deposition on pothole organisms has been proposed by Resource Management, South East Group, National Park Service. This research would be conducted on pools in Arches National Park and on Grand Resource Area, Bureau of Land Management lands in the Sand Flats area.

Potholes, depressions in bedrock, are small discrete ecosystems that often contain unique organisms, not found in other aquatic systems. Although pools on the Colorado Plateau are in rocks with fairly high  $\text{CaCO}_3$  content, pothole water apparently has low alkalinities (Graham, unpublished data), and thus is not well buffered against acid deposition. These pools are good systems to study impacts of acid deposition in arid systems because they are thought to be more sensitive than ground and surface waters, or soils, which are all buffered.

Amphibians, snails, and some crustaceans have been shown to be susceptible to reduced pH levels in other systems (Bruce Bury, USFWS, personal communication; West, 1980; Anon, 1983), and related species are found in these potholes. The objectives of the proposed research are to determine sensitivities of macroinvertebrates and amphibians in potholes to reduced pH levels, and to determine whether any species are sensitive enough to act as biomonitors of increases in acid deposition and their impacts.

## Description of the environment

The potholes proposed for study are found in Arches National Park (T25S R21E, Sec. 24), and in the Grand Resource Area, BLM (T25S R21E, Sec. 34, and T25S R22E, Sec. 31) near Moab, Utah. These potholes are formed in Navajo Sandstone, and are situated on the tops of narrow fins. Navajo Sandstone is cemented primarily with  $\text{CaCO}_3$ . Little is known about the chemistry of these pools (c.f.

Dodson 1937). Alkalinity tests of pothole water have shown very low buffering capacities (Graham unpubl. data), but the rock may provide a reservoir of  $\text{CaCO}_3$  buffer by dissolving into the pothole water when pH is reduced.

Potholes on the Colorado Plateau contain a diverse array of microinvertebrate animals. The species present in any one pool are apparently determined primarily by pool longevity and/or predation (Dodson 1937). Species composition varies between pools, but the following list of invertebrate groups are found in potholes in the study areas:

- Notonectidae--backswimmers
- Corixidae--water boatmen
- Dytiscidae--diving beetles
- Ceratopogonidae--no-see-um gnats
- Chironomidae--midges
- Gerridae--water striders
- Ostracoda--clam shrimp
- Conchostraca--clam shrimp
- Notostraca--tadpole shrimp
- Anostraca--fairy shrimp
- Cladocera--water fleas
- Gastropoda--snails

Activity in the pools varies seasonally. Snow melt and spring rains fill the pools, and some pothole species hatch, break dormancy, or immigrate to the pools at this time (e.g., no-see-ums, many aquatic insects, fairy shrimp, ostracods). During the hot, dry months of May and July, the pools are usually dry and don't refill until the monsoonal thunderstorms begin in late July. Many of the same species are found in both spring and summer pools, but there appear to be some that are usually limited to one season or the other. Ostracods are very abundant in spring, but rare or absent in summer. Tadpole shrimp generally have the opposite pattern, except when spring weather is very warm, and eggs may hatch in May if there is water in the pools.

Potholes provide a number of links between aquatic and terrestrial ecosystems. Amphibians, especially Spadefoot and Red-Spotted Toads, use these pools for development of tadpoles. Many insects also pass through their nymphal or larval stages in potholes, most notable no-see-ums, and some mosquitoes. The young forms provide food for other pothole inhabitants (e.g., tadpole shrimp), and the adults are eaten by terrestrial animals (e.g., Gnatcatchers and other birds, lizards, toads, and terrestrial insects). Potholes also trap wind-blown organic debris originating on land. Decomposition in the warm, moist environment of a pothole is much quicker than on dry land. Thus, recycling time of nutrients is shortened. Reintroduction of nutrients to terrestrial systems is via predation and development from aquatic young to terrestrial adults as mentioned above. Potholes are important water sources for terrestrial animals such as desert bighorn, mule deer, coyote, mountain lion, etc.

## Proposed Action

The proposed study would examine potholes in Navajo sandstone, along the Colorado River in Arches National Park and in Grand Resource Area northeast of Mead. A total of 45 pools of comparable size and community composition are needed for the study (see Table 1). Criteria for selecting pools for study include the following:

1. Pools must be small enough that manipulations can be performed easily, and a reasonable estimate of population sizes can be made for species selected for study.
2. There must be a sufficient number of comparable pools to allow for adequate replication to validate statistical assumptions.
3. "Key" species (see below) selected for study must be abundant in the pools.
4. Pools should be in remote and/or relatively inaccessible areas to reduce impacts on study from humans, and impacts on humans from the study.

Eighteen pools in Arches fit the criteria set for selecting acceptable pools. There are no readily accessible, comparable pools in Navajo Sandstone in Canyonlands. The General Superintendent of the South East Group, National Park Service requested that the Grand Resource Area Manager, Bureau of Land Management allow study and manipulation of 27 potholes (20 during summer 1988, and 7 during spring) 1989 in the Sand Flats area in order to have enough pools to conduct the proposed research. The Grand Resource Area Manager has agreed to this cooperative land use, pending completion and acceptance of this environmental assessment, and a Finding of No Significant Impact.

Pools to be included in this study will be selected from the 45 Grand Resource Area and 44 Arches potholes. Pools will be matched as closely as possible for volume (v), surface area (a), a/v ratios, and macroinvertebrate fauna. Average pool volume of pools to be used in the study will be approximately 3500L (900 gal).

The study proposes three field experimental manipulations, which would be applied in summer 1988, or spring 1989. If additional funding is available, a second year of study is recommended.

All potential study pools will be measured, and their surface areas, volumes, and a/v ratios estimated, using either cylinder or pyramid models. Species composition of macroinvertebrates of each pool will also be determined. In pools that are selected for study (using the criteria listed above), abundances of "key" species will be estimated by sampling the water column and pool bottom. "Key" species will be selected based on the following criteria:

1. The species is present in all pools selected for study.
2. They are conspicuous (e.g., large and mobile) enough to easily quantify.
3. They are "important" to functioning of pothole ecosystems, at least from a subjective assessment, based on abundance, guild and functional group assignments, and observed interactions with other species in the pools.
4. Species known to be sensitive to reduced pH levels will be used when possible.

For experiment one, a total of 35 pools are needed. Five pools will be used as control pools, and both summer and spring experiments will be compared to these five pools. The other 30 pools will be split into two seasons, spring pools and summer pools (see Table 1). Within each seasonal set of pools, sulfuric acid ( $H_2SO_4$ ) will be added to lower the pH to 5.5, 5.0 or 4.5; five pools will be acidified to each pH level. Selected macroinvertebrate species populations will be estimated in each pool and comparisons among treatments will be made of spp. composition, population size, and where possible developmental progress.

Experiment two will attempt to determine whether ambient rain pH's are inhibiting egg hatching of crustaceans in summer pools. In order to do this 50L of distilled water will be added to each of ten small, dry potholes, and the species that appear will be identified and quantified. These results will be compared to population levels and species composition of similar pools that have filled with rain water.

After the ten distilled water pools have been quantified and observed for a week, five of the pools will have sulfuric acid added to lower the pH to 4.5 for the third experiment. Changes in population sizes and/or species composition between the five control and five treatment pools will be monitored and compared.

Water chemistry will be analyzed for a variety of chemical and physical parameters periodically during the study. Samples will be collected and sent to Los Alamos National Labs for analysis. Comparisons between acidified and control pools will be made on chemical constituents, as well as analysis of rainwater for potential sources of these chemicals (e.g., coal-fired power plants, automobile exhaust, etc.).

A progress report will be prepared after each field season, and final results will be presented in a technical report, and papers submitted to refereed scientific journals.

## Alternatives to the Proposed Action

### A. No Action

Do not perform the research.

### B. Reduced number of replications

The number of replicates for each treatment could be reduced to four or three.

### C. Reduce number of treatments

Fewer pH levels could be used in the study.

## Environmental Consequences of the Proposed Action and Alternatives

### A. Proposed Action

Because almost nothing is known about pothole ecology, the impacts of reduced pH on these systems is unknown, thus, the need for the study. We suspect that some species may be sensitive enough to affect phenology, (i.e. developmental timing and reproduction), and perhaps survivability. These may or may not be among the species chosen to monitor in this study. To try to cover this possibility, at least qualitative descriptions of all the species in each pool will be made at the beginning and end of the study.

Adding  $H_2SO_4$  to some pools could have an impact on wildlife using the pools. EPA water standards allow pH's from 5-9 in human water systems, and 4.4-8.4 is given as the range of pH's tolerated by most fish (Ricketts et. al 1964). Lemonade has a pH of 2.8, almost 100 times as strong an acid as the most acidic treatment in this study. The source of the  $H^+$  ions does not affect the strength of the acid, only the concentration (i.e., abundance) of the ions. Thus, relative to pH (i.e.,  $H^+$  ion concentration), lemonade is 100 times as corrosive as the 4.5 treatment of this study. The quantity of  $H_2SO_4$  needed to lower the pH from near 7 to 4.5 will not introduce enough sulfate ions ( $SO_4^{2-}$ ) to exceed drinking water standards (Ricketts et. al 1964). Because of small sizes of the treated pools, the abundance of larger pools, which will hold water longer, and thus probably be used more by wildlife, and the short time water will be in the treated pools, it is doubtful that any significant damage to wildlife will occur.

The pools to be studied in Arches are in a remote area with very little human visitation. BLM potholes are on fins near the Slickrock Bike Trail, but access from the trail to these fins is very difficult, and there is little evidence that many people encounter these pools.

Possible exposures of people to acidified pool water will probably be minimal since the pools are small and shallow and less inviting to drink or swim in than other, adjacent pools. To

minimize possible conflicts, small signs will be placed in each pool, warning that the pool is being used in a scientific study and has been acidified. The signs will be placed in the potholes rather than up on the rock because the signs themselves would probably draw attention to the area.

Because almost nothing is known about pothole ecology, and interactions between potholes and the surrounding terrestrial ecosystems, this research will make a significant contribution to our knowledge of pothole ecology, and baseline conditions in potholes on public lands. If, as hypothesized, pothole inhabitants are sensitive to reduced pH levels, this study could also provide guidelines for monitoring potholes and pothole indicator species for changes in acid deposition in lieu of expensive air quality monitoring stations.

The results of this study could have applications at least across the Colorado Plateau, and perhaps in much of the rest of the arid Southwest as well. The added understanding to be gained from this study about basic and applied ecology of potholes outweighs the potential impacts to the potholes to be studied.

#### B. No Action

Under this alternative, no additional basic or applied knowledge of pothole ecology will be gained. No alterations of pothole ecosystems will be made, thus there will be no impacts to potholes.

#### C. Reduce number of replications

The statistical validity of the study could be questioned with fewer replicates. The variability between potholes is large, and five replicates may not be enough to account for this variability. Some information would be obtained during the study, but the scientific significance of the results would be more questionable. Under this alternative, fewer potholes would be manipulated, reducing the environmental impacts of the study.

#### D. Reduce number of treatments

Fewer treatment pH levels could be used, but again there would be a significant loss of information. The pH levels chosen are in the critical range of pH's known to affect aquatic invertebrates in other systems (West 1980, L. Hansen personal communication). They are also in the range of precipitation pH's this area is currently receiving (NADP reports 1982-1987). Reducing the number of treatment pH levels could obscure the relationships between  $H^+$  ion concentration and impacts on pothole inhabitants. For example, if only 3.5 and 4.5 pH levels are studied, there is a 100 fold difference in  $H^+$  ion concentration between the two treatments. Subtle impacts, such as changes in reproductive effort may begin at pH levels between the two treatment levels, but they would not be apparent if only these two pH levels were studied. This alternative would affect only 10, or 20 potholes if only one or two experimental pH level(s) is used respectively.

### Mitigations:

Because the exact impacts of acidification are unknown, mitigative measures should try to cover the most severe impacts, e.g., elimination of all or most of the species living in the pool prior to acidification. Equivalent sized samples of sediment from each pothole to be studied (both control and experimental pools) will be collected and stored to be used to "reseed" the pools if acidification has drastic impacts on the fauna. Removal of sediment could have an impact on the numbers of organisms that can hatch in the pool, and thus affect the population estimates for each pool. Taking equal quantities of sediment will reduce this problem, as will removing sediment from control as well as treatment pools. Less than 0.1% of the estimated sediment volume will be removed. It is anticipated that the number of potential organisms in each sample will be less than the experimental error of the population estimates, and thus there should be no effect on population estimates. Basins will be neutralized with  $\text{CaCO}_3$  at the end of the project, to prevent continued acidification with future precipitation. The pools will be monitored periodically for a year after neutralization to document spp. composition and abundances relative to control pools.

### Decision Record

#### Proposed Decision

It is recommended that the proposed alternative be adopted in its entirety; including all proposed mitigation measures. The benefits of the proposed study outweigh the environmental impacts of the experimental manipulations. The knowledge gained from the study will greatly aid our understanding of the unique ecosystems and communities found in potholes, and will provide guidelines for using pothole species as biomonitors of acid deposition. The benefits from this research far outweigh the environmental impacts of manipulating the potholes.

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Superintendent, Southeast Utah Group  
National Park Service

#### Literature Cited

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- Dodson, S. I. 1937. Animal assemblages in temporary desert rock pools: aspects of the ecology of Dasyhelea sublettei (Diptera: Ceratopogonidae). J. N. Am. Benthol. Soc. 6:65-71.
- Ricketts, T., S. Kunkle, and M. Flora. 1984. A Resource Manager's guide to water quality criteria. Training document for NPS Water Resources Training Course. NPS Water Quality Laboratory, Fort Collins, Co.
- West, S. 1980. Acid from Heaven. Science News 117:76-78.

Table 1. Experimental design for study of acid deposition impacts on potholes. Numbers in each cell represent number of replicate pools needed for study.

Experiment 1: Acidification of rainwater in pools.

Factor 1: Season of treatment

| Factor 2:<br>pH level | Summer 1988 | Spring 1989 |
|-----------------------|-------------|-------------|
| Control               | 5*          |             |
| 3.5                   | 5*          | 5*          |
| 5.0                   | 5           | 5 (2*)      |
| 4.5                   | 5           | 5           |

Experiment 3: Acidification of distilled water pools.

|         |        |
|---------|--------|
| Control | pH 4.5 |
| 5*      | 5*     |

\*Indicates number of pools in Grand Resource Area needed for each treatment. Other pools are in Arches National Park.

Finding of No Significant Impact  
Arches National park  
Environmental Assessment for Study on  
Impacts of Acid Deposition on Pothole Ecosystems

An environmental assessment was prepared to analyze the effects of acidifying 33 potholes in Arches National Park (T25S R21E, Sec. 24) and Grand Resource Area, Moab District, Bureau of Land Management (T25S R21E, Sec. 36, and T25S R22E, Sec. 31). The environmental assessment of the proposed action did not reveal any significant impact to natural resources. This project does not constitute a major federal action significantly affecting the quality of the human environment. An Environmental Impact Statement will not be prepared.

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Regional Director

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Date

Effects of acid deposition on the Colorado Plateau:  
acidification of potholes near Arches National Park, Utah

Temperature, pH, and alkalinity were measured three times, and macroinvertebrate populations and volume were estimated <sup>at least</sup> ~~once~~ <sup>most days</sup> in 12 potholes in Navajo Sandstone. Nine pools were acidified, three each to 5.5, 5.0, and 4.5. One set was acidified once each of three days, and the others two days. The pH returned to pre-acidification levels in all but one pool in less than 24 hours, but alkalinity was reduced. Data on macroinvertebrate populations have not been analyzed as yet, but mortality occurred in all treatments of four groups of crustaceans. Insect larvae and pupae were apparently more resistant to pH changes. *Lily*

Interactions of acid solutions with pothole  
sediments: changes in pH and alkalinity over time

Acidic solutions were added to sediments from potholes in Navajo Sandstone and quartz monzonite, and from a drainage impoundment (White Tank). Distilled water (pH 5.7), and  $H_2SO_4$  solutions of pH 5.0, 4.5, and 3.5 were used. pH of most solutions increased by a unit within one hour, and stabilized between 6.5 and 7.0 within five hours. White Tank > Navajo Sandstone > quartz monzonite in buffering capacity. The 3.5 solution stabilized at 4.25 and 5.84 (Navajo Sandstone, two trials), and 4.89 (quartz monzonite), and 6.44 (White Tank). Implications for acid deposition are discussed in terms of relative susceptibility of pothole systems in different rock types.



# United States Department of the Interior

NATIONAL PARK SERVICE  
ARCHES AND CANYONLANDS NATIONAL PARKS  
NATURAL BRIDGES NATIONAL MONUMENT  
MOAB, UTAH 84532



IN REPLY REFER TO:

N3615

17 August 1988

To: Area Manager, Grand Resource Area, Moab District,  
Bureau of Land Management

From: Superintendent, Southeast Utah Group

Subject: Environmental Assessment of proposed study:  
Ecology of potholes on the Colorado Plateau: effect of acid  
deposition on rock pool communities in Arches National Park,  
and Grand Resource Area, Bureau of Land Management.

This is a note explaining the apparent discrepancy between the number of study pools mentioned in the EA as opposed to the numbers we quoted to you two weeks ago. The original proposal was to study a total of 45 pools. Ten pools would be used for the distilled water experiments, and thirty five pools would be used for the acidification of rainwater experiments. Of the thirty five, five would be control pools, 15 would be acidified in summer 1988, and 15 would be acidified in spring 1989. I forgot about the spring treatments when I told you that we would only need a total of 30 pools, and that only 10-15 would be needed in Sand Flats.

In the past two weeks, we have been able to measure all available potholes in the Arches group, and estimate volumes, surface areas, and a/v ratios. Of the 44 pools present, only 18 fall within the wide range of volumes (1000-10,000L) that we believe we can study effectively (actually, we would prefer to concentrate on smaller pools, but there are not enough of them). So, of the 35 pools needed for experiment 1, 18 are available in Arches, leaving 17 needed in Sand Flats. Arches has very few small pools (<1000L) so the distilled water experiment needs to be done in Sand Flats as well, and ten pools are needed for that experiment. Thus, a total of 27 pools in the Sand Flats area are needed to adequately conduct this study. Of these, only 17 will be acidified (see Table 1 of the EA).

I hope this explains the difference in numbers I quoted to you, and those mentioned in the EA and the proposal. We appreciate very much your cooperation in this study, and I would like to extend an open invitation to you and any of your staff to accompany Tim Graham when he goes out to study these potholes, both in Grand Resource Area, and in Arches National Park.