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INFLUENCE OF METAL CONCENTRATIONS AND pH ON THE TOXICITY OF CONTAMINATED FLOODPLAIN SOILS, GRANT-KOHRS RANCH N.H.S., MONTANA

Concentrations of metals in sediments and soils deposited along the floodplain of the Clark Fork River, within the boundaries of the Grant-Kohrs Ranch National Historic Site, have exceeded those typically found in uncontaminated soils. Upstream mining and smelting along the Clark Fork River in the Deer Lodge Valley, Montana, have produced substantial quantities of waste materials that have been deposited throughout the watershed. As a result, portions of the Deer Lodge Valley, including the Grant-Kohrs Ranch, have received National Priority List Designation under the Comprehensive Environmental Response, Compensation, and Liability Act. These contaminated substances continue to be released, and seem to be preventing the germination and establishment of critical riparian plant species. *Slickens*, bare spots devoid of all vegetation, occur frequently in the floodplain along the Clark Fork River. Using a series of plant germination tests, pH measurements, and metals analyses performed on soils collected from the Grant-Kohrs Ranch, we investigated the influence of metal concentrations and pH on the toxicity of floodplain soils along the Clark Fork River. We have shown that pH seems to exert substantial control over the toxicity of metals in the floodplain soils of the Grant-Kohrs Ranch:

- During the reconnaissance survey, August 1993, total soil metal concentrations along a transect across two slickens on both sides of the Clark Fork River were found to correlate poorly with the presence of nonvegetated slicken areas. Low pH, however, was found to exist in all slicken soils along the transect.
- When each metal was considered individually, total soil metal concentrations were higher in the reference site

samples for 68.6% of seven slicken-reference pairs collected during July 1994. The results of a seed germination test using barnyard grass, *Echinochloa crusgalli*, and soil pH measurements on the slicken-reference pairs correlate well with the presence of nonvegetated slicken areas.

- Metals analyses of soils collected along a transect across one slicken boundary during July 1994 show that the highest total metal concentrations are not always associated with the nonvegetated slicken samples. In fact, total concentrations of arsenic, cadmium, copper, and zinc decrease from the first sample outside to the first sample inside the slicken. Arsenic concentrations show a monotonic pattern of decrease along the transect, moving into the slicken. Although pH values do not show a monotonic response, a grouping of values is evident. All slicken sites have acidic pH values (pH 4.4 to pH 4.9), and all nonslicken sites have more neutral pH values (pH 5.8 to pH 6.1). Results of a one-way analysis of variance performed on transect design seed germination data show significant differences ($P < 0.0001$) in the emergence of *E. crusgalli* seeds, with decreasing emergence along the transect from outside to inside the slicken.
- Results of germination tests performed on pH manipulated soils show that neither uncontaminated, acidic artificial soils (pH = 3.8); nor contaminated, pH-neutralized slicken soils (pH = 6.55) are sufficient to elicit an acutely toxic effect on the emergence of *E. crusgalli* seeds. Instead, both low pH and the presence of elevated concentrations of heavy metals are necessary to cause the phytotoxic response.

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