Rocky Mountain Water Environment Association/Biosolids Committee
Mining, Forest and Land Restoration Symposium
July 17-19, 2000/Denver, Colorado

Reclamation of Semi-Arid Rangeland with Biosolids: Fifteen Years of Research at Albuquerque, New Mexico

J. Steven Glass
Technical Programs Manager
City of Albuquerque
4201 Second Street SW
Albuquerque, NM 87105

Introduction

Faced with anticipated stringent federal regulation of biosolids disposal and with the imminent loss of their leased biosolids disposal area near the municipal landfill, the Albuquerque Wastewater Utility Division beginning in 1985 participated in a program of joint research with the US Forest Service Rocky Mountain Forest and Range Experiment Station, examining the potential for using anaerobically digested, dewatered biosolids as an organic soil amendment for degraded semi-arid southwestern rangeland. The USFS motivation for participation in the research came from their mission to mitigate severe erosion resulting from destructive grazing practices in the Rio Puerco Watershed northwest of Albuquerque, considered by experts to be the single largest source of sediment pollution reaching the Rio Grande via runoff through the Rio Puerco.

Initial greenhouse experiments established the value of municipal biosolids as a source of nutrients and moisture retentive mulch to support the growth of native forage grasses, with the consequent effect of reduced erosion. The need for in situ studies was clearly indicated.

Upper Rio Puerco Watershed Plot Studies

In 1985, a plot study was installed on Upper Rio Puerco watershed land managed by the US Bureau of Land Management and leased to private cattle owner. Biosolids from the Albuquerque Southside Water Reclamation Plant were applied to the surface of replicate10x60 foot plots of rangeland at rates of 5, 10, 20 and 40 dry tons per acre. Importantly, the biosolids were applied without tilling, to avoid damage to existing vegetation.

USFS monitoring of soils, vegetation and microbial populations over succeeding growing seasons established that surface-applied municipal biosolids enhanced the overall nutrient status of the treated plots. Figure 1 illustrates the effect of surface-applied biosolids on measured soil nitrate content over a period of eight years after

treatment (1). Although soil nitrate had declined noticeably after eight growing seasons, increased soil nutrient levels remained correlated with biosolids application rate.

Figure 2 shows the response of native range vegetation to surface-applied biosolids in the Upper Rio Puerco Plot Studies. Percent foliar cover on plots treated with surface-applied biosolids was greater than foliar cover on untreated plots even eight years after treatment (2). Based on observed vegetation responses, the maximum recommended biosolids application rate was set at 20 dry tons/acre, to avoid any potential for approaching minimum phytotoxic levels of certain inorganic micronutrients, most notably copper, in soils treated with biosolids (2). Importantly, a 1991 study established that no biosolids associated heavy metals were detected at phytotoxic levels in treated soil, even at the highest biosolids application rate (3).

Figure 1. Upper Rio Puerco Watershed Plot Studies

Effect of Biosolids Application Rate on Soil Nitrate

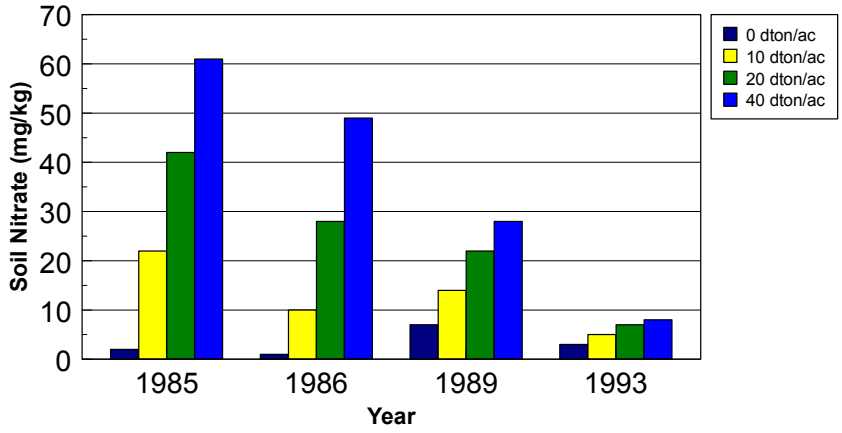
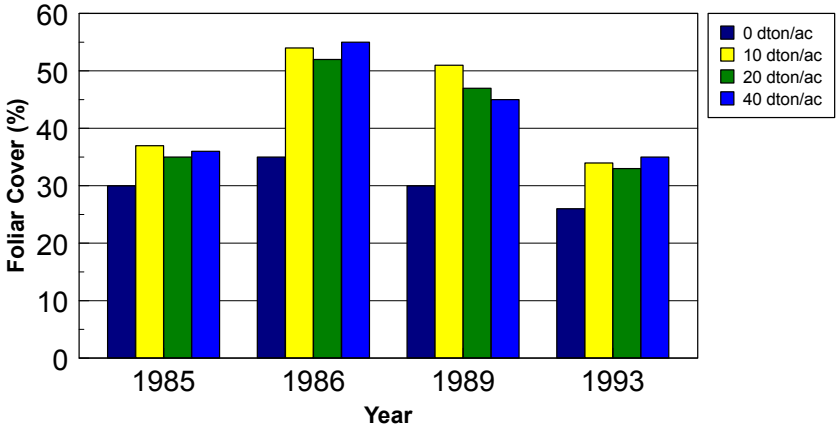


Figure 2. Upper Rio Puerco Watershed Plot Studies

Effect of Biosolids Application Rate on Foliar Cover



Further research established that biosolids application resulted in more robust soil microbial populations (4), and anecdotal evidence suggested that the treatment contributed to reduced numbers of nuisance plant species such as Broom Snakeweed.

Sevilleta Long-Term Ecological Research (LTER) Facility Plot Studies

Based on the results of the initial plot studies, the USFS and the City, in partnership with the US Fish and Wildlife Service and the New Mexico Water Resources Research Institute, in April 1991 installed a larger plot study within the boundaries of the Sevilleta National Wildlife Refuge, a USEPA Long-Term Ecological Research Facility, near the City of Socorro. Using a biosolids application rate of 20 dry tons per acre on replicate 10x30 foot plots located on sloping land (6% slope and 11% slope), the objective of this second series of experiments was to address the potential effect of surface-applied biosolids on the quality of water percolating into or running off of treated range soils. As with the preceding Upper Rio Puerco Watershed studies, disturbance of the soils and existing vegetation was minimal during biosolids application. Each plot was surrounded with flashing and covered tanks were placed at the downslope end of each test plot, then calibrated to allow determination of runoff volumes.

Unexpectedly, the Sevilleta study found that surface-applied biosolids virtually eliminated runoff from the treated plots, even when an intense thunderstorm event (approximately 40mm of precipitation over a 30 minute period) was simulated with an apparatus supplied by New Mexico State University (Table 1). Similar differences in runoff volumes were observed after natural storm events during the summer of 1991 (5).

Table 1. Sevilleta LTER Plot Studies
Effect of Biosolids Application on Precipitation Runoff

	% Precipitation Runoff	
	Control	**Treated**
6% slope, Rep 1	22%	1%
6% slope, Rep 2	28%	<1%
6% slope, Rep 3	10%	1%
11% slope, Rep 1	6%	<1%
11% slope, Rep 2	18%	1%
11% slope, Rep 3	24%	1%

Confirming results of precursor Upper Rio Puerco Watershed studies, surface application of biosolids at the Sevilleta LTER plots resulted in increased soil nitrate levels at depths up to 15cm (Figure 3). Moreover, no elevated levels of surface water contaminants or heavy metals were found in subsurface water, surface runoff or tissues from plants growing on treated plots, compared to untreated controls (5).

Vegetative responses to biosolids treatment in the Sevilleta study, illustrated in Figure 4, differed from those observed during the preceding Upper Rio Puerco plot studies. Researchers attributed the apparent decrease in percent foliar cover observed during

the fall of 1991 to physical masking of plant material by the surface-applied biosolids, so that they were not counted by the line-intercept transect method used. Copious rain that fell during the winter of 1991 and spring of 1992 contributed to an increase in foliar cover, and the vegetation response was considerably greater on treated plots than on untreated plots. However, a dry summer in 1992 erased the springtime gains, reducing vegetation to levels even lower than those seen prior to treatment. The latter observation points up the crucial role of precipitation in rangeland restoration, irrespective of the presence or absence of biosolids (5). Subsequent visual assessments of the Sevilleta LTER plots indicated increasing vegetative cover on the treated plots in successive growing seasons.

San Luis, NM Demonstration Project

In late 1993, with grant funding provided by the USEPA Office of Municipal Pollution Control, the USFS and the City, in partnership with the US Bureau of Land Management and the New Mexico Environment Department, conducted a moderate-scale demonstration of semi-arid rangeland rejuvenation using municipal biosolids. A 130-acre watershed, adjacent to the site of the original plot studies and leased by the same cattle owner, was divided along a natural drainage channel into a treated half and a control half. Using a slurry spreader purchased by the USBLM, biosolids transported to the location, 60 miles northeast of Albuquerque, were spread at 10 dry tons per acre over 65 acres between October 1993 and September 1994. Spreading operations were conducted such that disturbances to existing soils and vegetation were minimized.

The effort required coordination of efforts by Albuquerque management and operations personnel, the private biosolids transportation contractor, USBLM land managers, USFS researchers and state regulators. Important lessons were learned through the demonstration project about the financial, logistical and interagency coordination requirements of large-scale application of the biosolids rangeland restoration technology (6).

Scientific monitoring at the demonstration site between 1994 and 1996 confirmed the value of surface-applied biosolids for increasing soil nutrient levels. In Figure 5, soil nitrate levels are shown to be significantly higher in treated soils, at two sampling depths, for the two years following biosolids application. Besides nitrogen compounds, statistically significant treatment-related effects were documented for phosphorus, sodium, magnesium, and molybdenum (7). As with previous studies, no heavy metals approached phytotoxic concentrations in biosolids-treated soils.

Vegetation monitoring during the San Luis Demonstration Project included specific assessments of foliar densities for various classes of plants, to more clearly define the deleterious effect of biosolids treatment on undesirable species in the Upper Rio Puerco Plot Study. As shown in Figure 6, biosolids application had a generally stimulatory effect on the desirable grasses and forbs, but had an apparently suppressive effect on the less desirable shrubs (7).

A particularly undesirable member of the shrub class is Broom Snakeweed and, as shown in Figure 7, this species showed a significant continuing decline in density,

relative to the untreated control, for three growing seasons after biosolids application (7).

Production-Scale Implementation Project

The City of Albuquerque, with the support of the New Mexico Environment Department Ground Water Protection Bureau, is currently negotiating an agreement with a local cattle owner under which 6,700 acres of public and private rangeland will be used in a coordinated program of low-impact biosolids application and sustainable grazing practices. Under the draft memorandum of agreement, Black Cattle Ranch, LLC will offer 4,500 acres of leased rangeland for surface application of Albuquerque biosolids (at 20 dry tons/acre) in exchange for grazing access to 1,200 acres of rangeland held in trust by the Albuquerque Open Space Division. Albuquerque biosolids, after anaerobic digestion and mechanical dewatering, meet US Environmental Protection Agency requirements (8) for exceptional quality pollutant concentrations (40CFR503.13, Table 3) and for Class B pathogens control (40CFR503.32). Appropriate site access restriction measures will be taken, as stipulated in 40CFR503.14.

Scientific objectives of the production-scale project are to monitor and explore the relationships between sustainable grazing practices and biosolids-mediated semi-arid rangeland restoration. The City of Albuquerque, with authorization from the NM Environment Department Groundwater Protection Bureau, will track and report biosolids application rates and perform annual soil and water monitoring. Independent grazing and veterinary specialists have been retained by Black Cattle Ranch, LLC to provide ongoing assessments of animal and vegetation health.

As a project endorsed by Albuquerque Mayor Jim Baca's Sustainability Initiative, the proposed public-private partnership will establish operating parameters for long-term arrangements that will enhance the productivity of semi-arid rangeland while providing for safe, beneficial use of municipal biosolids. It is anticipated that biosolids application will begin in late 2000 or early 2001.

Figure 3. Sevilleta LTER Plot Studies
Effect of Biosolids Application on Soil Nitrate Levels

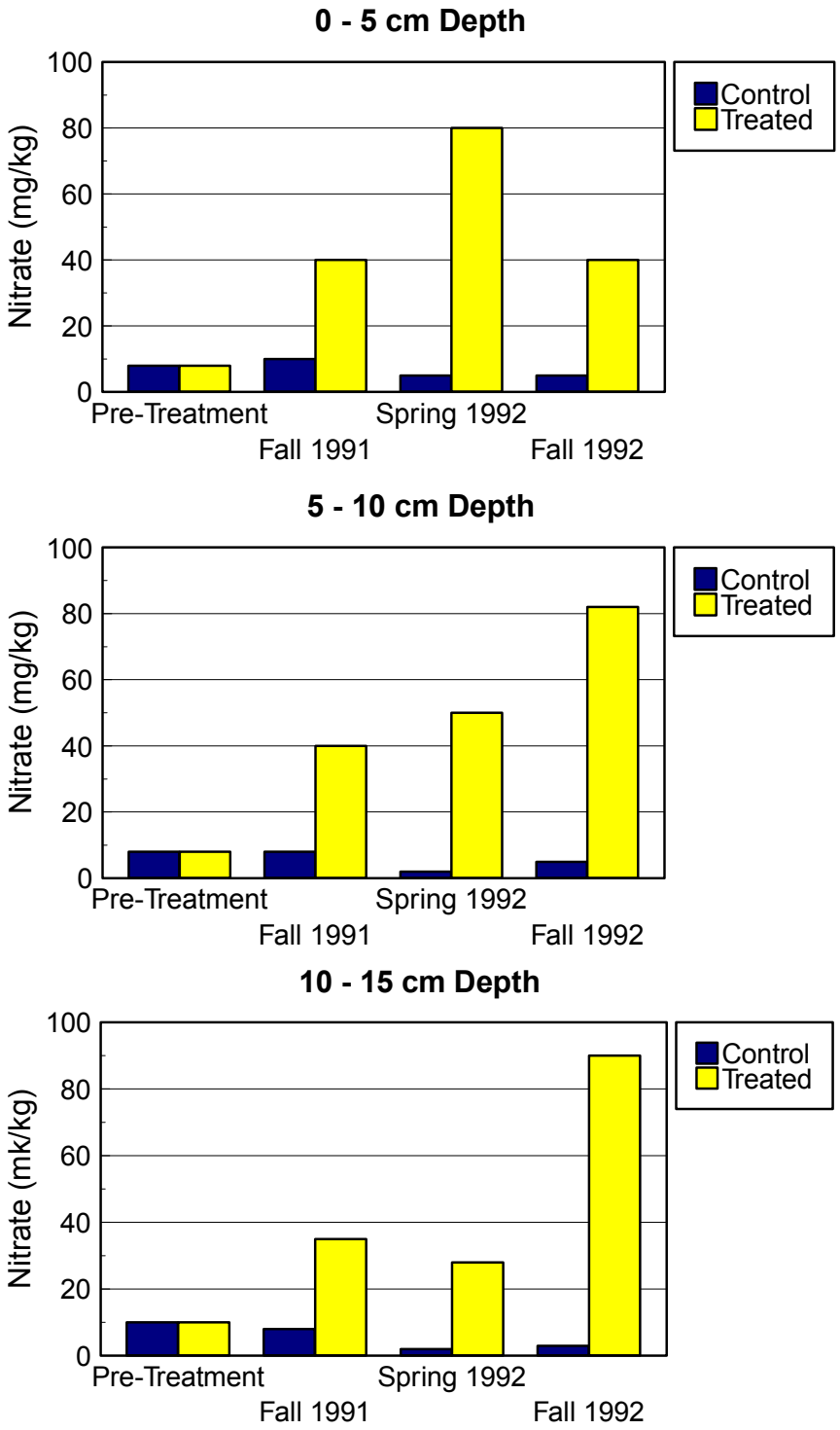


Figure 4. Sevilletta LTER Plot Studies

Effect of Biosolids Application on Foliar Cover

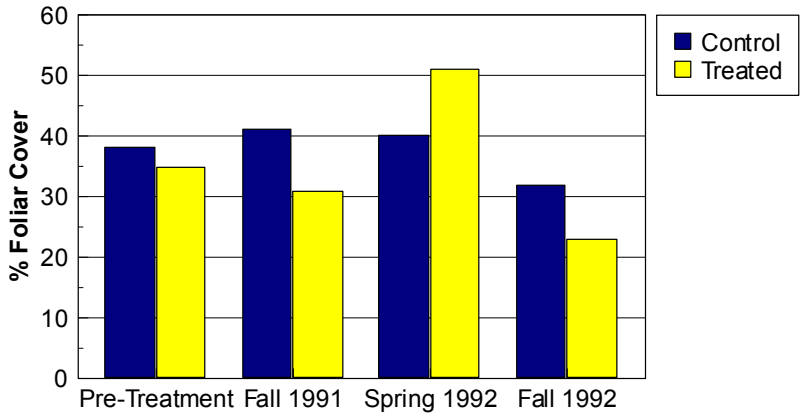


Figure 5. San Luis Demonstration Project

Effect of Biosolids Application on Soil Nitrate

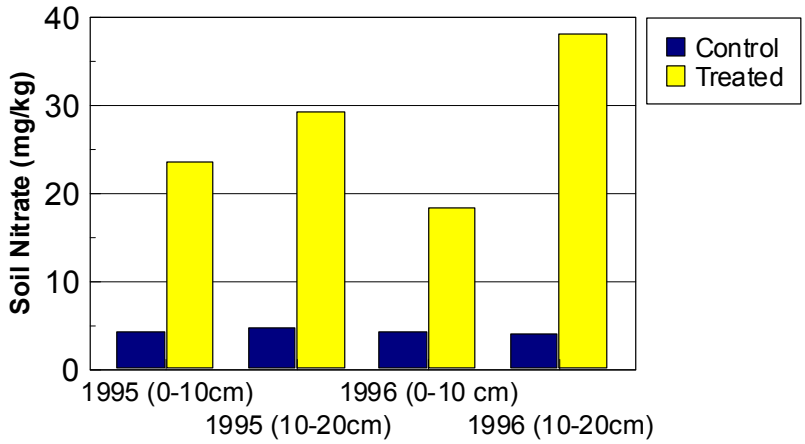


Figure 6. San Luis Demonstration Project

Effect of Biosolids Application on Vegetation Classes

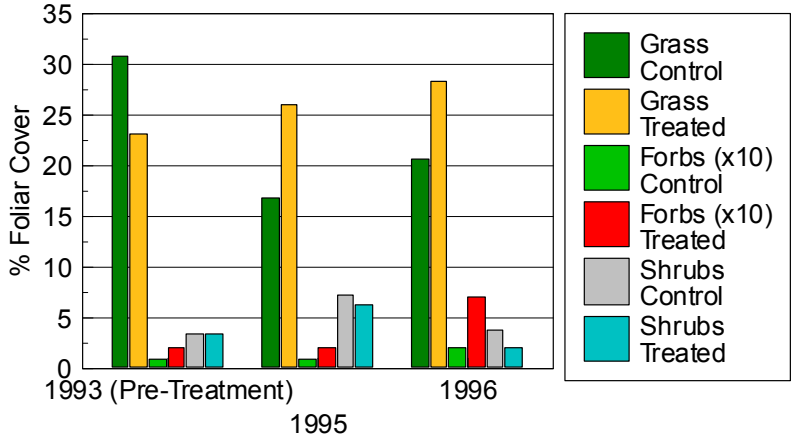
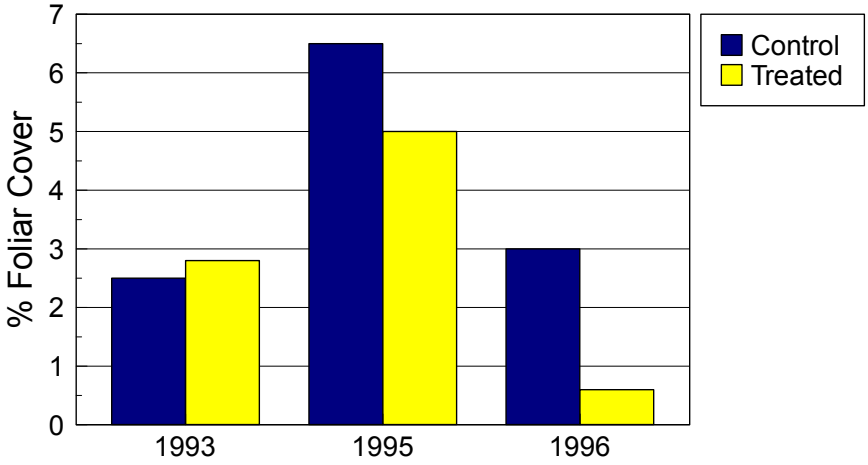


Figure 7. San Luis Demonstration Project

Effect of Biosolids Application on Broom Snakeweed Abundancer



References Cited

1. White, C.S, S.R. Loftin and R. Aguilar. 1997. Application of Biosolids to Degraded Semiarid Rangeland: Nine-Year Responses. J. Environmental Quality 26(6):1663-1671.

2. Loftin, S.R, R. Aguilar and P.R. Fresquez. 1995. Rangeland Restoration with Surface-Applied Biosolids: Effects on Soils and Vegetation of the Rio Puerco Watershed, Northcentral NM. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Albuquerque, NM.

3. Fresquez, P.R., R. Aguilar, R.E. Francis and E.F. Aldon. 1991. Heavy Metal Uptake by Blue Gramma Growing in a Degraded Semiarid Soil Amended with Sewage Sludge. Water, Air and Soil Pollution 57-58:903-912.

4. Fresquez, P.R. and G.L. Dennis. 1990. Composition of Fungal Groups Associated with Sewage Sludge Amended Grassland Soils. Arid Soil Research and Rehabilitation, 4:19-32.

5. Loftin, S.R. and R. Aguilar. May 1995. Rangeland Restoration with Surface-Applied Biosolids: Soils, Vegetation and Surface Hydrology at the Sevilleta National Wildlife Refuge, Central NM. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Albuquerque, NM.

6. Glass, J.S. and S.R. Loftin. August 1996. Management Scale Rangeland Reclamation with Municipal Biosolids: Logistical Considerations. Water Environment Federation Biosolids Specialty Conference, Denver, CO.

7. Loftin, S.R., R. Aguilar and J.S. Glass. July 1997. Management Scale Application of Biosolids to a Degraded Semiarid Grassland in New Mexico. Final Project Report, USEPA Grant Agreement CP996232-01-0, USDA Rocky Mountain Forest and Range Experiment Station, Albuquerque, NM.

8. US Environmental Protection Agency. February 1993. Standards for the Use or Disposal of Sewage Sludge; Final Rules. Code of Federal Regulations, Title 40, Part 503.