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ABSTRACTS

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INDICATORS OF MINE SOIL RECOVERY. J. Anderson and P.D. Stahl, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071-3354

As the nation's leading producer of coal, Wyoming has thousands of acres of soil that are affected by surface mining each year. In the year 2000 alone, over 330 million tons of coal was surface mined in Wyoming. Although topsoils are removed from mine sites and stockpiled for protection to be later redeposited, soil organisms including plants, animals and microorganisms are negatively impacted by surface mining activities. Microorganisms in soils play important roles in organic matter decomposition, nutrient cycling, and vegetation reestablishment, as well as soil development and stabilization. The response of soil microorganisms to disturbance and their recovery during reclamation of surface mine sites is not well understood, yet extremely important to sustainable mine land reclamation. The objective of this study was to examine the recovery of soil microorganisms and ecosystem processes they control by analyzing a chronosequence of nine different aged reclamation sites (ranging in age from 2 to 32 years since reclamation was initiated) and adjacent undisturbed sites on the Dave Johnson Coal Mine located in Central Wyoming. Results indicate that the soil microbial community may take much longer than 30 years to recover to native undisturbed levels. Even though the plant community may recover in terms of biomass production and surface cover within twenty years or less, amounts of soil microbial biomass carbon were only approximately half of that found in adjacent undisturbed soils. Concentrations of organic matter in reclaimed soils, however, appear to increase to levels above that found in adjacent undisturbed soils.

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CONSIDERATIONS FOR USING A SALT AND TRACE ELEMENT LADEN DRAINAGE WATER. G. Banuelos, USDA-ARS, Fresno, CA

Accumulation of trace element oxyanions in soils and drainage waters threaten the sustainability of irrigated agriculture in arid environments. Concern about certain oxyanions (i.e., Se, B, As, Mo, U, and V) increased following the discovery of Se toxicosis in wildfowl at the Kesterson Wildlife Refuge in central California. The finding of significant concentrations of trace elements in drainage waters of central California again raises a concern for potential impacts on waterfowl, fish, wildlife, public health, and agriculture, as this water is collected, discharged, and sometimes reused. Hence, long-term disposal options for the drainage water are not only complicated by the presence of Se, but also by other trace elements. Unless today's growers stop importing irrigation waters into regions where soils are principal sources of oxyanions, drainage waters enriched with increasing trace element concentrations pose environmental hazards to the agricultural ecosystem.

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FATE OF PERSISTENT HERBICIDES IN FEEDSTOCKS AND COMPOST. D. Bezdicek, M. Fauci, D. Caldwell, and R. Finch, Departments of Crop and Soil Sciences and Animal Sciences, Washington State University, Pullman, WA, 99164-6420

Composting organic materials has a sanitizing effect on weeds, disease organisms, and pesticides. Unfortunately, composts made from feed stocks treated with clopyralid may be injurious to legumes, tomatoes, potatoes and sunflower at levels of 10 parts per billion (ppb) or less. Clopyralid is a chlorinated pyridinecarboxylate that functions as a plant growth regulator and is the active ingredient in over 30 products used for control of annual and perennial weeds in crop production and in turf. Typical symptoms include leaf cupping, loss of apical dominance, failure of trifoliate leaves to develop, and prevention of fruit set. Clopyralid-contaminated compost from grass clippings was noted in 1999 at nurseries in Spokane WA, in 2000 at Pennsylvania State University, in 2001 at Washington State University from grass hay, and in 2002 in California. Studies are underway to further identify composting conditions and management options to enhance herbicide breakdown. Over the past year, clopyralid levels in feed stocks and compost decreased at WSU in Pullman and at the Spokane facility, but are not at low enough levels for sale to the public. Persistence studies of clopyralid in grass clippings have been conducted at WSU-Puyallup and with contaminated hay at WSU in Pullman. At Pullman, concentration of clopyralid increased during 100 days of composting because the loss of compost mass exceeded the degradation rate of clopyralid. The Washington State Department of Agriculture has initiated draft rules to regulate clopyralid-containing products in the lawn and turf industries where feedstocks may reach compost facilities.

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QUANTIFYING SOIL CARBON SEQUESTRATION DUE TO THE APPLICATION OF CONSERVATION PRACTICES IN IOWA, INDIANA AND NEBRASKA. J. Brenner, K. Paustian, K. Killian, P. Smith, J. Schuler, USDA-Natural Resources Conservation Service, Information Technology Center, 2150 Centre Avenue, Bldg. A, Fort Collins, CO 80526-1891, Natural Resource Ecology Laboratory and Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO 80523-1499

Land managers have long known the importance of soil organic matter in maintaining the productivity and sustainability of agricultural land. More recently, interest has developed in the potential for using conservation practices that increase stocks of carbon in soil organic matter and vegetation to sequester C and mitigate increasing atmospheric CO_2. To help answer these questions, studies using the Century Soil Organic Matter Model were done in all 284 counties in Iowa, Indiana and Nebraska. Existing soil, climate, land use databases, long-term experiments and a new county level management survey were used to provide inputs for the Century model. We show how local land mangers were able to provide previously unavailable historical and land use details needed to refine the model to the sub-county scale. Century SOM estimates for the soils and crop/tillage combinations now available in the CarbOn Management Evaluation Tool (COMET) databases for each state.

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SOIL MOISTURE CONTENT EFFECTS ON ELECTROMAGNETIC METER (EM38) READINGS. J. Brummer, G. Cardon and T. Gates, U. S. Bureau of Reclamation, D8570, Denver, CO 80025-0007 and Departments of Soil and Crop Sciences and Civil Engineering, Colorado State University, Ft. Collins, CO 80523

During the Arkansas river valley investigations Reclamation soil scientists and Colorado State University(CSU) researchers have observed very significant increases in EM38 meter readings in recently irrigated checks when compared to immediately adjacent checks not yet irrigated.

In response to these observations this research studied the effect of declining soil moisture content on EM38 meter readings at 73 staked sites in an irrigated alfalfa field during a 32 day irrigation cycle. The findings of this research indicate that the EM38 readings declined in a linear fashion from field capacity to near wilting point. No significant differences in the reading declinination slopes were noted between sites with an Ece of about 1 ds/m verses a site with an ECe of nearly 5ds/m. This research also indicates that immediately following irrigation and before soil drainout the EM38 readings decline quite rapidly in a non linear manner. Some but not all of the irrigated/ nonirrigated check reading differences can be explained by the rapid elevation of the readings just following an irrigation event.

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RAPID MEASUREMENT OF SOIL WATER HYSTERESIS. G.L. Butters, Department of Soil and Crop Sciences, Colorado State University, Ft. Collins, CO. 80523

Soil hydraulic properties are fundamental to describing soil water flow and retention in a broad array of applications. The importance of accounting for the wetting vs. draining directional dependence of moisture retention (2(h))and hydraulic conductivity (K(h)) functions is widely recognized but the measurement of hysteresis is usually tedious and difficult. A continuous flow method is described which allows very rapid and accurate measurement of K(h) and 2(h) including hysteresis. The method employs simultaneous tensiometry and water flow measurements which are easily automated. The analysis uses a combination of direct Darcian analysis and numerical inversion of Richards equation for estimation of the hydraulic properties. This combination allows for estimation K(h) and 2(h) over the entire tensiometer range of measurement while retaining the physical significance of the hydraulic parameter estimates. The main branches and scanning curves of K(h) and 2(h) can be assessed very rapidly, typically in less than a day of experimental effort. Illustrative results are shown for both re-packed soil and structured field soil. The approach described is ideal for the general assessment of hydraulic properties or when a time series is needed to monitor changes in properties that might occur due to reconsolidation, microbial activity, or water quality changes.

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SOIL CARBON SPATIAL VARIATION IN A 63 HA LOW PRODUCTIVITY AMAZON PASTURE. C.E.P. Cerri, M. Bernoux, R.l. Victoria, J. M. Mellilo, C.C. Cerri, K. Paustian, Centro de Energia Nuclear na Agricultura (CENA), Universidade de Sao Paulo, CP.96. 13400-970 Piracicaba, SP, Brazil, Institut de Recherche pour le Développement (IRD), URO41-SeqC, at CENA, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, Massachusetts, Natural Resource Ecology Laboratory, Colorado State University, Ft Collins, CO 80523

The present study investigates the soil carbon (C) spatial variation in a 63 ha pasture area located at Nova Vida Ranch, Rondonia, Brazil. A regular 25 m grid was used for collecting a total of 2,955 soil samples at the 0 to10, 10 to 20 and 20 to 30 cm layers. Conventional statistical methods and geostatistics were performed in order to analyze soil carbon spatial dependence. Mean, standard deviation, skewness, and kurtosis for all measured data were evaluated. All variograms generally were well structured with a relatively large nugget effect. Soil C semivariograms were best fitted by spherical models. Two types of validation ("Jackknife" or cross-validation and external validation) were conducted, indicating a lack of bias for the used prediction models. Models were used to interpolate the values at unmeasured locations using block kriging. Data from the 3 layers were overlaid using Geographic Information System (GIS), generating maps. Within these maps we defined areas containing a degree of homogeneity in soil carbon content, used to selected specific locations to install an experiment of pasture rehabilitation and carbon sequestration.

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GRASSLANDS AND GREENHOUSE GASES: MANAGEMENT, FLUXES, AND MITIGATION. R.T. Conant, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523-1499

Grasslands and grazer-dominated systems cover more than 20% of the terrestrial surface of the earth and contribute significantly to greenhouse gas (GHG) uptake and emission. Gaseous C and N exchange between grazing lands and the atmosphere are strongly influenced by management; management activities can lead to net sequestration of GHGs, reduction of emissions, or increased net emissions. This poster reviews the ways in which management can impact GHG fluxes in three ecosystems representative of broadly occurring grazing lands in the U.S.: mesic pasture, semiarid grassland, and desert shrubland. Mesic pastureland is found in the Eastern, Southern, and extreme Western US. Management practices such as grazing intensity and duration, fertilization, and species composition can strongly influence GHG fluxes, but little is known about the distribution of various management practices. Management in semiarid grasslands is typically confined to native species, but grazing management and, occasionally, irrigation or fertilization, can impact GHG fluxes. Grazing management is particularly important since grazing impacts not only production and C inputs to the soil, but species composition as well. Desert shrublands are similar to semiarid grasslands in that grazing is the primary means of management. Woody shrub encroachment into areas that were formerly dominated by grass species is not fully understood, but impacts on soil and vegetation carbon pools can be substantial. Reviewing the impacts of pertinent management practices for each of these types of ecosystem helps identify means by which GHG fluxes from grazing lands can be reduced by altering management practices.

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THE ROLE OF MICROBIAL DIVERSITY IN MAINTENANCE OF SOIL QUALITY. D.E. Crowley, Department of Environmental Sciences, University of California, Riverside, CA 92521

One of the revolutions in modern microbiology has been the discovery of the true extent of microbial diversity in nature. It is now estimated that there are millions of bacterial species, and DNA based methods have shown that any given environment may contain thousands of bacterial species that organize into discrete communities. These communities are highly dynamic in relation to environmental variables that occur in a given habitat, and microbial diversity is hypothesized to play a key role in the resilience of biological processes that occur over a range of environmental conditions. However, there are still formidable problems in using DNA signatures as a diagnostic tool for monitoring ecosystem health. Many different interchangeable sets of bacterial species can apparently carry out the same functions, and there is often little relationship between 16S rDNA taxonomy and function. Another dilemma is the statistical problem that is encountered when comparing DNA signatures from different treatments.

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HIGH-VALUE MANURE USES IMPROVE SOIL QUALITY AND PROTECT WATER QUALITY. J.G. Davis, G.L. Vlaming, R.J. Zimmerman, Department of Soil and Crop Sciences, Colorado State University, Fort Collins CO 80523-1170

Concentration of livestock production facilities in river basins often leads to contamination of shallow alluvial aquifers and reservoirs with nitrogen and phosphorus. Due to the low perceived value of manure, it is usually not economical to transport it more than 8 km. Our hypothesis is that when manure is used for higher value uses, economical transport distances will rise, and soil quality will be improved, while also protecting water quality. We are evaluating this hypothesis on two specific high-value manure uses: restoration of eroded land and organic farming. We applied manure and composted manure at varying rates on two sites for each of these studies. Manure application increased crop yield, soil organic matter, and soil P on both eroded soils. Aggregate stability and infiltration rate were also measured, with insignificant results. Manure application to organic orchards reduced soil pH, while increasing organic matter content. In addition, manuring increased soil NO_3-N, NH_4-N, P, K, Zn, Mg, and B levels. Compost was applied at lower rates and was less effective than manure application. We are in the process of evaluating soil physical and microbial properties on these sites, and will be working with an economist to help us quantify the value of manure for these high-value uses and its subsequent affordable hauling distance. In addition, we will be starting a project on composted manure use on turf in 2003, as an additional high-value use for manure.

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SIMULATED AFFECTS OF NITROGEN FERTILIZER, CULTIVATION, AND STUBBLE REMOVAL ON NET GREENHOUSE GAS FLUXES. S.J. Del Grosso, W.J. Parton, D.S. Ojima and A.R. Mosier, Natural Resource Ecology Lab, Colorado State University, Fort Collins CO 80523

The DAYCENT ecosystem model was used to investigate the effects of fertilization levels, tillage practice, and stubble removal on net greenhouse gas fluxes (GHGnet), grain yields, and N leaching. Soil CO_2 fluxes, the CO_2-C equivalents of N_2O and CH_4 fluxes, and the CO_2 emissions associated with N fertilizer production were summed to calculate GHGnet. DAYCENT uses inputs of daily maximum/minimum temperature and precipitation, soil properties, and land management to simulate plant growth, NPP allocation, SOM decomposition, nitrification, denitrification, and CH_4 oxidation in soils. Comparisons of model results with field data show that DAYCENT simulates NPP, SOM, N_2O emissions, and CH_4 uptake reasonably well. Climate, soil texture, and land management data for corn and soybean cropping in the U.S. corn belt were used to drive the model. Simulations suggest that N_2O emissions and N leaching increase substantially at fertilization levels greater than ~200 kg/ha. N leaching and NO_x losses were higher in sandy loam compared to clay loam soil while N_2O losses were similar. Reduced tillage resulted in C sequestration in soil but also increased N leaching. N_2O emissions were not very sensitive to tillage practice.

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INTERACTIONS BETWEEN SALINITY AND ONION PRODUCTION PRACTICES IN THE ARKANSAS VALLEY, COLORADO. O.C. Doss, M.E. Bartolo, J.G. Davis, G.E. Cardon, Department of Soil and Crop Sciences, Colorado State University, Ft. Collins, CO 80523-1170

Crops differ in their ability to tolerate salinity. In the Arkansas Valley, high-value crops are of particular concern due to their sensitivity to saline soils and degraded water quality. Onions have a relatively low salinity tolerance compared to other crops. Variety and irrigation experiments were conducted in 2000 and 2001 to evaluate the response of onions to soil salinity. The first experiment investigated three rates of magnesium sulfate applied to five onion varieties. The second experiment compared the impact of furrow and drip irrigation on yield and salt distribution. Yields were measured from each plot and graded by size. In both years, Colorado 6 and Vision varieties had the highest total marketable weight. However, Colorado 6 had the greatest cull weight in 2000. In 2001, the magnesium sulfate application rates were doubled in order to increase the probability of achieving a yield reduction among salt treatments. Redwing and Daytona had the greatest cull weight in 2001. Salinity levels had no effect on the yield or grade, but varieties were significantly different in both 2000 and 2001. The irrigation experiment data demonstrated patterns of salt distribution in both years. The drip irrigation application showed trends of higher ECe in the furrow and lower ECe in the middle of the bed (44" centers). The furrow irrigation salt distribution results were the inverse of the drip irrigation results. However, due to water quality and quantity pressures in the Arkansas Valley, drip irrigation is a promising alternative.

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FIELD SCALE MONITORING AND MODELING OF SALINITY AND WATERLOGGING IN THE LOWER ARKANSAS RIVER BASIN OF COLORADO. L. Garcia, Department of Civil Engineering, Colorado State University, Ft. Collins, CO 80523

The results of a project studying the spatial and temporal variation of salinity at the field scale in the Lower Arkansas River Basin in Colorado will be presented. The focus of this research effort is to collect field-level data and develop models to evaluate the temporal and spatial variability of salinity (soil and water) and to develop modeling tools that can be used to evaluate the impact of soil and water salinity on crop production. The same tools are being used to evaluate alternative strategies to improve crop yields at the field scale. The presentation will show the data collected, the computer tools that have been developed which include animations showing the temporal and spatial variation of different parameters. A field-scale model has been developed and calibrated to estimate the impact of soil and water salinity on crop yield. Based on the field-scale data that has been collected, a new set of equations for predicting soil salinity have been developed and will also be presented.

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REDUCTION/CATION EXCHANGE MODEL OF THE COINCIDENT RELEASE OF MANGANESE AND TRACE METALS FOLLOWING SOIL REDUCTION. C.H. Green, D.M. Heil, G.E. Cardon, Department of Soil and Crop Sciences, Plant Science Building, Colorado State University, Fort Collins, CO 80523

This research was conducted to determine the impact of reducing conditions on the solubility of manganese and other trace metals over an 84-hour time period. In the Alamosa River basin, Mn is of particular concern because it consistently exceeds water quality standards. Soil columns were saturated with water from which EH, pH and soluble metal concentrations were measured at 12-hour intervals. A critical Eh had to be reached before Mn-oxide dissolution would occur. Increases in the soluble concentrations of Zn and Ni were greater than expected based on the dissolution of metal-bearing Mn- oxides in the soil. The changes in the concentrations of divalent cations (Ca, Mg) and trace metals (Sr, Zn, Ni) were consistent with a cation exchange model. Although cation exchange models do not account for the effects of pH on metal release, this did not limit the application of a model to our data because both the pH and EH of our soil columns remained at a nearly constant value between 24 and 84 hours for the Mogote and La Jara soils. Cation exchange reactions appear to have an important influence on the changes in the solubility of Mn and other trace metals under reducing conditions for these soils.

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RESEARCH REQUIREMENTS FOR APPLYING SOIL QUALITY TO SUSTAINABLE LAND MANAGEMENT. Jeffrey E. Herrick, USDA-ARS Jornada Experimental Range, MSC 3JER, NMSU, Box 30003, Las Cruces, NM 88003.

During the past 10 years the term "soil quality" has been increasingly used by soil scientists to communicate our dry, dusty conclusions to an increasingly urbanized and disinterested public. Rather than debating the merits of a concept that has already been widely adopted, the objective of this paper is to discuss a possible strategy and research requirements for using soil quality to increase the probability that future generations will have at least as many land use options as we have today. Application of the soil quality concept is frequently limited by the lack of data demonstrating causal relationships between soil quality indicators and sustainability. Specifically, assessment and monitoring protocols are required that reflect risk of, and resistance and resilience to, degradation. Research is required to improve our understanding of the relative importance of frequently interacting soil properties and processes for both degradation and recovery. Application of the soil quality concept is further limited by the fact that the range of limiting values for these properties and processes is usually poorly defined, particularly when two or more interacting processes are involved. Research is required to design and populate a new generation of reference databases, and to develop the tools necessary to both interpret and assess the quality of the data they contain. The paper will conclude with a brief discussion of thresholds and a consideration of the relationship between economic and ecological sustainability.

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CARBON SEQUESTRATION IN CROPLANDS – SOME THOUGHTS FROM A CANADIAN PERSPECTIVE. H.H. Janzen, Agriculture and Agri-Food Canada, Lethbridge, Alberta

The CO_2 concentration in the atmosphere is now more than 30% above pre-industrial levels and is increasing quickly, largely because of human activities. One way proposed to abate these increases is to store more carbon in cropland soils. This approach – 'carbon sequestration'– has many benefits besides CO_2 mitigation, but some questions remain. Some that we are wrestling with in Canadian agroecosystems include: How do rates of carbon (C) gain vary among combinations of soils, climates, management system? How does history of management affect C accrual? What kind of C are we storing? Can we reliably measure the C increases when (and if) they occur? Will we need to apply more nutrients to support the C gain? What is the effect of C-sequestering practices on net, 'whole-farm' greenhouse gas emissions? What are the links between C sequestration in croplands and the C cycle in other ecosystems? In this paper, I will probe some of these questions and offer some examples of approaches and initial findings from Canadian studies.

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VARIATION OF FRAGIPAN DEPTH, ABOVE-GROUND BIOMASS, AND SOIL CARBON IN A SMALL GRASS WATERSHED. J. Johnson-Maynard, K. Umiker, and P. McDaniel, Soil Science Division, University of Idaho, Moscow, Id 83844-2339

It is well known that surface topography influences the distribution of soils and vegetation across landscapes, mostly through its control on water redistribution. Subsurface water-restrictive horizons such as Fragipans also influence the local hydrologic cycle. Despite the importance of these features, their influence on biomass production and carbon distribution is not well understood. Our objective is to develop relationships between subsurface morphology and C movement at the subwatershed scale. The study site is a 1.7-ha subwatershed located in the eastern Palouse region of northern Idaho. The catchment is instrumented with wells to monitor perched water tables that develop in the winter and spring. A digital elevation model was created in Arc-View. Biomass was measured at points throughout the watershed. The depth to fragipan ranges from 29 to 118 cm and does not correspond to surface topography. Comparison of the variation of depth to fragipan and standing biomass shows that areas with deep fragipans have higher biomass levels. The relationship between fragipan depth and biomass ($r = 0.33$) was much stronger than that between slope and biomass ($r = 0.07$) and aspect and biomass ($r = -0.09$). Standing biomass and A horizon depth was not related to the compound topographic index. Preliminary data indicate that fragipan characteristics may be the best predictor of C accumulation in the watershed. Linkages between hydrologic data and C distribution within the watershed will be discussed. This data may be useful in refining C cycling models for use in areas where water restrictive horizons are present.

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GEOCHEMICAL PROPERTIES OF THREE SERPENTINE SOILS: PRESIDIO, CA. Matthew J. LaForce, Jim Neiss, and Carolyn Domrose, San Francisco State University, Department of Geosciences, 1600 Holloway Ave, TH 509, San Francisco, Ca 94132-4163

In California, serpentine/ultramafic habitats comprise approximately 2860 km2 of land surface. One unique serpentine habitat is found at Inspiration Point in the Presidio of San Francisco, California. Here, serpentine prairie plant species such as the federally endangered Presidio clarkia (Clarkia franciscana) and the federally threatened Marin dwarf flax (Hesperolinon congestum) will be reintroduced as part of an extensive restoration project. Thus, in order to ensure the successful restoration of threatened endemic plant species it is critical to understand pre- and post-forestation soil geochemical characteristics. Accordingly, this project evaluated differences between Ca/Mg ratios, exchangeable cations, pH, available nutrients, and total heavy metal content at three adjacent Inspiration Point field sites (serpentine prairie, deforested site (1995), and forested canopy). A one-way ANOVA post-hoc (Tukey) test was utilized to determine differences between the sites. The range of values detected were as follows: Ca/Mg ratios (0.09-1.94), exchangeable cations-- Cr (0.0-0.47 mg/kg), Ni (0.0-1.6 mg/kg), Mn (1.0-32.4 mg/kg), pH (4.87-6.89), NO3 (1.4–4.0 mg/kg), and total heavy metal concentrations Cr (320-2,540 mg/kg), Ni (109-1,965 mg/kg), Pb (18-100 mg/kg), and Zn (66-118 mg/kg). An analysis of variance revealed significant differences ($P < 0.05$) between the Ca/Mg ratios, pH, extractable Cr, and total heavy metal concentrations between the forested and non-forested sites. Thus, as a result of past land management practices changes in serpentine soil characteristics exist which may inhibit future habitat restoration and endangered plant re-vegetation projects proposed at the Presidio.

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IRON AVAILABILITY FROM BIOSOLID AND ACID AMENDED CALCAREOUS SOILS.

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The chemical reaction dynamics of alkaline-calcareous soils of the southwest U.S. are largely responsible for iron (Fe) deficiency chlorosis of many plants grown on such soils. A substantial acreage of grain sorghum crop [*Sorghum bicolor* (L.) Moench] grown in this region suffers from insufficient levels of plant available Fe. Greenhouse and field experiments were conducted to characterize methods for correction of this Fe availability anomaly. Two typical grain sorghum producing soils with this nutritional problem include the Clareville clay loam (Pachic Argiustoll) and the Orelia sandy clay loam (Typic Ochraqualf). Municipal solid sewage sludge was tested at several rates ranging from 5 g kg^{-1} to 25 g kg^{-1} while field experiments were conducted with acid and non-acid chelated materials. Most Fe deficiency chlorosis on leaves was eliminated with 15 g sludge kg $soil^{-1}$ on Clareville soil and 25 g sludge kg $soil^{-1}$ on the Orelia. Sorghum grown on both Fe deficient soils showed response in dry matter and tissue Fe concentration to applications of dried sewage sludge. With the Clareville soil, 10 g kg^{-1} was required to reach maximum growth and 12.5 g kg^{-1} for peak tissue Fe content. On the slightly finer textured Orelia soil, maximum dry matter and Fe content were reached at the 25 g kg^{-1} rate. Plant tissue Fe levels on Clareville soil (less chlorotic sorghum) were considerably higher and varied more widely with treatment than those observed in sorghum on Orelia soil which required 25 g kg^{-1} to elevate plant tissue Fe above the critical range. Additional studies under field conditions on the same soils, showed industrial grade H_2SO4 performed equally to Fe - EDDHA in the initial year of testing. Residual effects from H_2SO4 produced significantly higher grain yields of sorghum in the second year while Fe - EDDHA showed no increase. In summary, availability of Fe from municipal biosolids corrected the Fe deficiency problem on sorghum. Also, pH depression using industrial sulfuric acid improved the bioavailability of indigenous soil Fe to sorghum grown on these soils.

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LINKING HYDROLOGIC AND PEDOLOGIC PROCESSES IN CATCHMENT-SCALE STUDIES. P. McDaniel[1], J. Boll, A.T. O'Geen, E. Brooks. Soil Science Division and Dept. of Biological and Agricultural Engineering, University of Idaho, Moscow, ID 83844-2339

Soils with hydraulically restrictive subsoils are extensive in parts of northern Idaho and eastern Washington, and exert a strong influence on local hydrological processes. We initiated several catchment-scale studies to assess the links between pedologic and hydrologic processes in this region. Shallow wells, redox electrodes, tensiometers, time-domain reflectometry probes, and a flume for measuring surface outflow were installed in a small 1.7-ha catchment. Four years of monitoring data have identified several key hydrological processes operating in this landscape. A spatially extensive, near-surface perched water table forms above the fragipan and is typically present from late November until May. This perched water table level rises and falls with only a 4-5% change in soil moisture content, and is present at or near the soil surface on several occasions during the winter and early spring. Bypass flow in A horizons occurs when perched water tables are near the surface, and this is responsible for the most-rapid movement observed with applied tracers. As much as 89% of incident precipitation may be exiting the catchment hillslopes as subsurface lateral flow. Despite the fact that the catchment has permanent grass cover and high infiltration rates, significant surface runoff is generated when soils become saturated during periods of heavy rainfall or snow melt. Finally, automated deep piezometers indicate the presence of multiple seasonal perched water tables associated with a vertical sequence of paleosols.

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SOIL-WATER-PLANT RELATIONS OF RANGE LANDS: "I" MEASUREMENT TECHNIQUES AND RELATED CONCEPTS. R.F. Miller Department of Geography, University of Denver and U.S. Geological Survey, Denver, CO.

Water Relations of Range Lands, have been investigated since 1957. The same techniques have been used to obtain data, but the concepts used to evaluate the data have evolved over time. Plant cover is defined along permanent transects. Soils are sampled with an auger in decimeter depth increments. Measurements of bulk density, water content, and water potential are defined for each decimeter depth increment. In-situ water potential was defined from the equilibrium water content of filter papers enclosed with the soil. Filter papers were calibrated using data, for papers equilibrated in contact with soil for a week at 20 C^o. These measurements are used to define lines for each depth increment that compares the log10 of the water potential to water content as mm/dm. Water potential is defined as either the Log10 of the -g/cm^3 or –Kpa levels of potential. Moisture characteristics are approximated by extending lines from the 105.75 g/cm^3 or 104.75 Kpa level of potential on the Y axis of a graph through a data point representing the water content and water potential for a decimeter depth increment. This modeling approach is based on numerous regression relationships comparing in-situ water content to the log10 of the potential. In-situ water content and potential values measures over the range from maximum to minimum levels of wetness, are used to define levels of energy vegetation must progressively exert to desorb water from the soil as consecutive molecular layers of water are extracted and levels of water potential double. Available on CDs.

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THE EFFECTS OF INTERSEEDED ALFALFA ON NATIVE RANGELAND SOILS. M.C. Mortenson and G.E. Schuman, USDA-ARS, High Plains Grasslands Research Station, 8408 Hildreth Rd. Cheyenne, WY. 82009

Rising atmospheric CO_2 concentration impacts on global climate change have spurred research in the field of soil carbon sequestration. Rangeland soils, generally nitrogen and water deficient, have shown potential as a sink for carbon through management practices and plant community improvement. Introducing leguminous, nitrogen fixing plants can increase available nitrogen for the native plant community, which will also increase plant water-use-efficiency. This study evaluated the effects of interseeding rangelands with yellow-flowered alfalfa (*Medicago sativa* ssp. *falcata*) on soil quality, soil carbon storage, and forage production and quality. The Smith Ranch in northwestern South Dakota has been interseeding 'falcata', which is drought and grazing tolerant, for over 40 years and sites were chosen that were interseeded in 1998, 1987 and 1965. Data shows that in addition to increasing forage production by 42, 143, and 68% for the 1998, 1987 and 1965 sites, protein content of native plants was increased on the interseeded sites by 8 to 33% compared to adjacent control areas, varying by species. Soil carbon in the top 1 m depth increased 4, 8, and 17% for the 1998, 1987 and 1965 interseeded soils compared to the controls, resulting in the addition of 4.8, 9.1 and 11.8 Mg C ha^{-1} of carbon per hectare. Since there are 161 Mha of rangelands, much of which lies in the Great Plains, the practice of interseeding, where adaptable, would significantly increase carbon storage in the soil and improve forage production and quality.

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ANALYSIS OF BACTERIAL COMMUNITY STRUCTURAL CHANGES IN A CHRONOSEQUENCE OF SITES RECLAIMED FOLLOWING DRASTIC SOIL DISTURBANCE. D.L. Mummey and P.D. Stahl, Department of Renewable Resources, University of Wyoming, Laramie, WY 82070-3354

Little data is available about how bacterial communities respond to drastic soil disturbance. In this study we evaluate the effects of drastic disturbance associated with surface mining on soil bacterial community structure. Differences in the bacterial diversity in soils reclaimed between two and twenty years after disturbance and adjacent undisturbed soils were examined using 16S ribosomal DNA sequence and terminal restriction fragment length polymorphism (TRFLP) analyses. On the basis of the presence or absence of specific ribotypes, cluster and similarity analyses of TRFLP data indicated three distinct bacterial populations associated with undisturbed sites, sites reclaimed for over two years, and sites reclaimed less than two years. However, analysis of the relative abundance each ribotype over all sites indicated that undisturbed and older reclaimed sites share many of the same predominant ribotypes, despite large differences in microbial biomass, SOM, and nutrient status. These results suggest that, even though relatively large differences exist between ribotypes of undisturbed and all reclaimed soils, many of the most abundant members of undisturbed soil communities have reestablished on older reclaimed soils. Phylogenetic analysis indicated that the majority of 16S rDNA sequences obtained from all sites are from bacterial lineages for which no cultivated isolates are available, including a new potentially division-level group previously known from only three clones obtained in two different studies of Arizona soils. Phylogenetic analysis of 16S rDNA sequences from newly reclaimed sites indicate that members of a little know and highly divergent Actinobacteria subdivision (Rubrobacter Group 3) are in high abundance.

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MICROBIAL BIOMARKERS AS AN INDICATOR OF ECOSYSTEM RECOVERY FOLLOWING SURFACE MINE RECLAMATION. D.L. Mummey, P.D. Stahl and J.S. Buyer, Department of Renewable Resources, University of Wyoming, Laramie, WY 82070-3354 and USDA-ARS, Sustainable Agricultural Systems Laboratory, Beltsville, MD 20705

Increased disturbance of terrestrial ecosystems in recent years for purposes of mineral extraction has created interest in development and optimization of reclamation methodologies for these lands. Currently, criteria for judging surface mine reclamation success, or progress toward reclamation goals, predominantly rely on aboveground indicators that fail to account for the abundance and composition of soil microbiota, an essential aspect of soil health. To test the utility of fatty acid methyl ester (FAME) biomarkers as indicators of reclamation progress, FAME bacterial, fungal, and total biomass biomarkers extracted from soil of surface mine reclamation sites of different ages and an adjacent undisturbed site were compared with other indicators of reclamation progress and ecosystem stability. Our results indicate that FAME microbial biomarkers and soil organic matter (SOM) contents were greatly impacted by disturbance. Discriminant analysis of FAME bacterial, fungal and total microbial biomass biomarkers, although clearly able to discriminate between disturbed and undisturbed ecosystems, indicated a trend towards the undisturbed condition with reclamation age. The ratio of FAME bacterial to fungal biomarkers reflected changes in other indicators of soil health (SOM, inorganic N concentration), suggesting that this ratio is a useful indicator of reclamation progress.

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SOIL MICROBIOLOGICAL PROPERTIES 20 YEARS AFTER SURFACE MINE RECLAMATION: SPATIAL ANALYSIS OF RECLAIMED AND UNDISTURBED SITES. D.L. Mummey, P.D. Stahl, and J.S. Buyer, Department of Renewable Resources, University of Wyoming, Laramie, WY 82070-3354 and USDA- ARS, Sustainable Agricultural Systems Laboratory, Beltsville, MD 20705

Spatial characteristics of soil microbial community structure and selected soil chemical factors were analyzed in soil surrounding bunchgrass and A. tridentata (Wyoming big sagebrush) plants in sites reclaimed after surface mining and adjacent undisturbed sites in Wyoming. Microbial biomass C (MBC) and fatty acid methyl ester (FAME) biomarkers for total biomass, bacteria, and fungi were used as indicators of soil microbial community abundance and structure. In reclaimed soil total FAME biomarkers, MBC and soil organic matter (SOM) were significantly less than in undisturbed soils. In contrast to undisturbed soils, FAME biomarkers and MBC of reclaimed soils exhibited spatial correlation up to 42 cm. Reclaimed soils also exhibited localized enrichment of bacterial, fungal, and total microbial biomass, as well as depletion of inorganic N concentrations, around plant bases (< 10 cm), suggesting relatively poor soil exploration by roots and microorganisms compared to the undisturbed ecosystem. Strong spatial stratification of undisturbed SOM and soil NH_4^+ pools was found with highest concentrations on the leeward side of shrubs, likely due to localized changes in microclimate and plant litter deposition. This indicates that shrub cover plays a central role in regulating ecological processes, such as moisture capture and C and N mineralization and immobilization, and establishment of site heterogeneity, which has important implications for reclamation.

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LIKELY IMPACTS OF COAL BED METHANE WATER DISPOSAL STRATEGIES ON SOIL SALINITY IN THE POWDER RIVER BASIN, WYOMING. L.C. Munn, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071-3354.

Projected development of coal bed methane (CBM) reserves in the Powder River Basin (PRB) of Wyoming involves surface disposal of large quantities (a projected maximum of 450,000 acre-feet) of water annually. Water quality in terms of salinity and sodicity varies widely over the basin with electrical conductivity values of 500 ΅S/cm to greater than 3000 ΅S/cm and sodium adsorption ratios of 0.5 to greater than 50. Water quality is in general best in the southeastern portion of the PRB (south of Gillette) and salinity and sodicity levels in CBM product water are generally higher in the west and northern portions of the Basin (Buffalo to Sheridan and Decker, Montana). Proposed disposal by surface discharge as flood and sprinkler irrigation, and with atomizers will result in salinity accumulations which exceed historic rates in upland soils in the Powder River Basin. This has implications for vegetation stability and future hydrologic characteristics of the watersheds. Pre-CBM development, soils in the PRB were largely non-saline and non-sodic Aridisols, Entisols, Mollisols and Alfisols. Salt and sodium accumulation in upland soils were dominated by soil parent material and landscape position effects. Salt accumulation in soils of saline playas was tied to geologic parent material and the size and vegetative characteristics of the playa watersheds. Water disposal to facilitate CBM development will result in additions of soluble salts and sodium to soils in new patterns not closely tied to historic patterns of soil genesis. Similar rates/practices of water disposal will produce varied effects based on geologic water characteristics.

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KINETICS OF PYRITE OXIDATION, B. Noecker, K.J. Reddy, T. Brown, Department of Renewable Resources, University of Wyoming, Laramie, WY 782071-3354 and Western Research Institute, Laramie, WY 82072

Pollutants generated by the oxidation of sulfide minerals in mine wastes are by far the most threatening environmental issue we face today. Acid Mine Drainage (AMD) is the term used to describe low pH, metal contaminated waters that develop as a direct result of pyrite (FeS_2) oxidation. At the present time millions of acres of land devoted to mineral extraction are affected by AMD problems throughout the world. Many remediation strategies have focused on preventing AMD through the use of bactericides or mine sealing and treating AMD through chemical means. The reaction steps of pyrite oxidation proposed by Singer and Stumm suggests the rate-determining step of pyrite dissociation is the oxidation of Fe^{+2} to Fe^{+3}. Initially the oxidizing agent is O_2, but once the dissociation of pyrite is initiated, the cycle is perpetuated, as Fe^{+3} becomes the oxidizing agent of the system. Experiments to better understand the oxidation/ reduction kinetics of pyrite in an oxidation/reduction potential (ORP) control unit have been conducted to address the possibility of controlling a systems redox potential (Eh) with a buffered pH (using the carbonate system) and a reducing agent (increases e^- activity). Eh (in volts) = 59.2pe with pe = -log (e^-). The relationship pe + pH can be used to describe the expected speciation with respect to the mineral in equilibrium with the system. By maintaining a constant pH and decreasing the pe (increasing e^- activity), Fe^{+3} reduces to Fe^{+2} by the reaction $Fe^{+3} + e^- \rightleftharpoons Fe^{+2}$ ( ) $G^o r$ = -74.32 kJ/mol and log K^o = 13.02). Developing the ratio of Fe^{+2}/Fe^{+3} expected in a system with pyrite oxidation, through an Eh range of –400 mV (reduced) to 400 mV (oxidized) will allow for direct comparison by species and total Iron to those ratios and totals observed when reducing agents are applied to a system with a buffered pH and pyrite oxidation.

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ASSESSMENT OF HYDROLOGIC PROCESSES ACROSS MULTIPLE SCALES IN SOIL/PALEOSOL SEQUENCES USING ENVIRONMENTAL TRACERS. A. O'Geen and P. McDaniel, Soil Science Division, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339

Thick loess deposits of the Palouse region in eastern Washington and northern Idaho consist of multiple buried paleosols. Ground water recharge mechanisms and rates through this deep regolith are poorly understood. To assess water movement, pore-water Cl^- and $\delta^{18}O$ distributions were measured to 6-m depths in three catchments representing a climosequence across the Basin. Vertical facies between dense and soft horizons coincide with variations in [Cl^-]. In the eastern Basin, pore water [Cl^-] ranged from 15 to 150 mg/L and increased with depth. In addition, shifts in isotopic signature of oxygen in pore water coincide with Cl-rich horizons, and suggest long pore water residence times. In contrast, [Cl^-] in the central and western Basin ranges from 1 to 15 mg/L and changes little with depth. $\delta^{18}O$ distributions are similar to contemporary precipitation. Tracer profiles illustrate three hydrostratigraphic units in the Basin: 1) uplands with homogeneous regolith that has short pore-water residence times; 2) uplands with heterogeneous regolith that has long pore-water residence times; and 3) valleys with heterogeneous regolith that display dynamic hydrology. Regional relationships between deep regolith and surface soils were established in order to use the SSURGO database to estimate the spatial extent of each hydrostratigraphic unit. The degree of paleosol development mimics that of contemporary sola across the climosequence. Results indicate that recharge is less than 1.4 cm yr^{-1} in the eastern Basin where precipitation is greatest and regolith is heterogeneous. Recharge increases to 4.1 cm yr^{-1} in the western and central Basin where regolith is homogeneous.

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AGRICULTURE AND GREENHOUSE GAS MITIGATION: AN OVERVIEW. K. Paustian, Department of Soil and Crop Sciences and Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO 80523

The issue of greenhouse gases (GHGs) and global warming is by now familiar to most people, although not necessarily where agriculture fits in. Recently, increased attention has been focused the potential for agriculture to reduce GHG emissions. All three of the major GHGs, carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4), are important for agriculture. For each of these GHGs, there are significant mitigation opportunities within agriculture. Agricultural carbon sequestration is based on the use of practices that can increase soil carbon, such as reduced and no-till (i.e., conservation tillage), conservation buffers and reserves, cover crops, improved crop rotations. For N_2O and CH_4, a variety of practices are possible to reduce emissions. For nitrous oxide, the key is to reduce the amount of nitrogen cycling through the soil while still meeting plant nutrient needs. Reducing methane from livestock is possible through improving the diet, nutrition and food assimilation of the animals. Improved manure management, especially via methane capture and use as biofuel, has considerable potential. Among the most important features of agricultural greenhouse gas mitigation strategies are the many ancillary benefits that exist. Practices that enhance soil C sequestration will improve the quality and fertility of soils, improve wildlife habitat, help reduce erosion and improve air, soil and water quality.

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MANAGEMENT ZONES FOR VARIABLE RATE NITROGEN APPLICATION IN IRRIGATED CORN. T.M. Shaver, R. Khosla, D.G Westfall, and W.J. Gangloff, Dept. of Soil and Crop Sciences, Colorado State University, Fort Collins, CO. 80523.

Spatial variability of soil characteristics across landscapes can create large variations in crop yield and potential problems with nitrogen (N) management. Although crop producers admit that soil variability exists, it is rarely if ever accounted for in N management practices. Precision agriculture practices are showing promise in N management by maintaining yields with lower N applications while minimizing environmental impact. One such practice is delineating Site-Specific Management Zones (SSMZ) on farm-fields into regions of high, medium, and low productivity based on inherent soil properties. These SSMZ receive optimum levels of N based on their yield potential (i.e. high levels of N to areas of high productivity). Additionally, optimum application of N on SSMZ decreases N leaching potential. This study was conducted in 2000 in North Eastern Colorado in a continuous corn (Zea Mays L.) cropping system under furrow irrigation.

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STABILIZATION MECHANISMS OF PROTECTED VERSUS UNPROTECTED SOIL ORGANIC MATTER: IMPLICATIONS FOR C-SATURATION OF SOILS. J. Six, C. Stewart, R. Conant, E.A. Paul and K. Paustian, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA and Michigan State University, East Lansing, MI.

The relationship between soil structure and the ability of soil to stabilize organic matter (SOM) is a key element in soil C dynamics that has either been overlooked or treated in a cursory fashion when developing SOM models. This paper reviews current knowledge of SOM dynamics within the framework of a new conceptual model. We distinguish SOM that is protected against decomposition by various mechanisms from that which is not protected from decomposition. Quantification, characteristics, and responses to changes in land use or land management are described for two measures of SOM we defined as unprotected – light fraction OM and coarse particulate organic matter (> 250 ∶m sized POM). Similarly, methods of quantification and characteristics of three SOM pools defined as protected are discussed. Soil organic matter can be physically stabilized, or protected from decomposition, through (micro)-aggregation or intimate association with silt and clay particles and can be biochemically stabilized through the formation of recalcitrant SOM compounds. Our conclusions are illustrated in a conceptual model that differs from most SOM models in that the model state variables are measurable SOM pools. The conceptual model suggests that physical characteristics inherent to soils define the maximum physical protective capacity of soil that limits increases in SOM (i.e., C sequestration) with increased OM inputs.

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GETTING PAID TO STORE CARBON: MARKET ISSUES. G. Smith, EcoLands Program, Environmental Resources Trust, Seattle, WA

Farmers are interested in getting paid to store carbon in their soil. This opportunity arises from commitments to reduce net greenhouse gas emissions. Soil carbon increases come from removing the greenhouse gas carbon dioxide from the atmosphere. Current sequestration projects will inform future rules. Soil sinks may not be permanent, but emitters need to "close the account books" on annual emission tallies. Rental of sequestration-instead of sale of offsets-solves this problem. A variety of conditions are needed for a market in soil carbon offsets to exist. Key elements needed for a market include the abilities to quantify and own offsets. Soil carbon offsets can be quantified by many methods. The trade-off between increasing the reliability of measurements versus decreasing the cost of measurement must be negotiated by the buyer and seller. Measuring larger projects generally reduces per-ton measurement costs. NRCS or consultants could operate benchmark measurement systems. RC&Ds, coops, and farmer associations can aggregate offsets from many farms. At this time, revenues per acre per year are modest.

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THE POTENTIAL OF AGRICULTURAL SOILS TO SEQUESTER C AND ECONOMIC CONSEQUENCES. M. Sperow and K. Paustian, Natural Resource Ecology Lab, Colorado State University, Fort Collins, CO 80523

Agricultural soils represent a potential sink for reducing atmospheric carbon dioxide (CO_2) concentrations. We have estimated soil C sequestration on U.S. agricultural mineral soils (conterminous U.S. agricultural land only) using a modified version of the C emission/sink calculations in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Cropping practices and management activities on agricultural soils were estimated to sequester soil C at a rate of 17.1 Tg yr^{-1} for the period 1982 to 1997. Soil C sequestration on agricultural soils can be increased through wide-spread adoption of conservation tillage, elimination of bare summer fallow, inclusion of winter cover crops in annual crop rotations, and conversion of marginal cropland to perennial grass set-aside. These soil C enhancing activities have the potential of providing
additional soil C sequestration of 66 Tg yr^{-1} for twenty years. In addition, soil C emissions from crop production on organic soils were estimated at 6.1 Tg yr^{-1} during 1982-1997. These soil C emissions decrease the total CO_2 emission mitigation potential from agricultural soils. Elimination of crop production on organic soils may not generate increases in soil C, but could substantially reduce C emissions. We will present the biophysical potential of soil C increases and analyze the economic impact of adopting soil C enhancing activities, particularly conversion of cropland to set-aside, on mineral soils and elimination of crop production on organic soils. We estimate the level of reduced crop production and potential farm income loss, which represents the minimum value of soil C sequestration.

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ACCUMULATION OF ORGANIC CARBON IN RECLAIMED SURFACE COAL MINE SOILS IN WYOMING, P.D. Stahl, J.D. Anderson, D.L. Mummey and L.J. Ingram, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071-3354

The potential to sequester carbon and increase organic nutrient storage in disturbed soils, such as those presently being reclaimed after surface coal mining or those abandoned after surface coal mining (prior to passage of SMCRA in 1977), appears to be particularly great. Our data on organic matter accumulation in reclaimed soils at surface coal mines in Wyoming indicate that these soils are sequestering carbon at a rapid rate. Studies at a surface mine reclamation site near Hanna, WY indicates that over the past 15 years, surface (0-20 cm) soil organic matter content has increased from a low of 1.9% in 1983 to 3.2% in 1998. Undisturbed soil directly adjacent to the reclaimed site has a mean organic matter content of 2.6%. At a mine near Glenrock, WY, soil organic matter content at a site reclaimed in 1979 increased from an estimated low of 1.0% to a current level of 3.2%. Organic matter content of undisturbed soils adjacent to the reclaimed area range from 1.7 to 2.7%. In contrast to the elevated organic matter content, amounts of microbial biomass in reclaimed soils at both mines are lower than in nearby undisturbed soils (ca. 60% or less). Possible mechanisms explaining the accumulation of organic carbon in these soils will be discussed.

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QUALITY SOIL MANAGEMENT OR SOIL QUALITY MANAGEMENT: PERFORMANCE VS SEMANTICS. D.R. Upchurch and R.E. Sojka, USDA-ARS, Cropping System Research Laboratory, 3810 4th Street, Lubbock, TX 79415 and USDA-ARS, Northwest Irrigation and Soils Research Laboratory, 3793 North 3600 East, Kimberly, ID 83341

In the past 200 yr, soil science has used reductionist research to develop agricultural technologies that have unlocked the hidden potential of earth's natural systems to feed, clothe and provide raw materials to the human population of over 6 billion. The soil quality paradigm seeks to change that scientific approach, the nomenclature of soil science, and institutional priorities for soil management and research. The definition of soil quality is elusive and value-laden. Concerns exist for the paradigm's policy overtones, regional and taxonomic biases, failure to reconcile conceptual contradictions, as well as its ambiguous definitions that are confounded by countless circumstance-specific, function-dependent scenarios. The paradigm does not recognize or offer practical means to manage conflicting and often contradictory soil management requirements for the multiple functions of soil that occur simultaneously. Implementation of the concept has delivered low index ratings for many of the most economically productive and least subsidized US soils and agricultural sectors, and high ratings for soils and regions with some of the lowest economic return and greatest subsidization. The paradigm's focus on arbitrarily selected function assessment has diverted research and management resources from efforts aimed directly at developing improved management capable of solving existing identified and prioritized problems. We submit that over-arching, philosophically-driven indexing of soil status, as opposed to focused, specific soil status and property characterization, carries risks to the scientific assessment process, and to the scientist's role as a data interpreter and science mediator. Value intrusion in umbrella-style indices, erodes the individual manager's access to objective data to make decisions. We suggest emphasizing quality soil management rather than soil quality management as a professional and scientific goal.

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POTENTIAL IMPACTS AND ALTERNATIVES TO LAND APPLICATION OF COALBED METHANE PRODUCT WATER. G.F. Vance, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071-3354.

The Powder River Basin (PRB) in Wyoming and Montana has seen extensive coalbed methane (CBM) development over the past 10 years, with thousands of CBM wells in production and more than 50,000 total active wells projected within the next 10 years. During CBM production, large amounts of water are produced as coal seams are de-pressurized; most of this water is surface discharged to local streams and/or impoundments. Due to the quality of the product water, particularly its salinity and sodicity, CBM producers are required to obtain National Pollution Discharge Elimination System permits to surface discharge CBM waters into Tongue, Powder and Little Powder River Basins. Limitations on discharge permits has generated significant interest in alternative water disposal techniques. Land application of CBM product waters has been proposed as a method for water disposal; however, some of these waters have salinity and sodicity characteristics that may impact plant growth and/or soil chemical and physical properties. With the estimated production life of a CBM well at 10 to 20 years, there is great potential for CBM product water to cause salinization, sodicity, sedimentation, and erosion in affected lands and stream channels and tributaries. In addition, altered vegetative communities and wildlife habitats will result from the excess water, causing uncertainty in the sustainability of these ecosystems. The focus of this presentation will be on potential impacts CBM discharge waters may have on soil properties and vegetation, with alternative application methods currently being tested in the PRB, e.g., sprinkler systems, water cannons or atomizer units, also discussed.

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METAL CYCLING IN THE SEDIMENT PORE WATER OF LAKE COEUR D'ALENE, ID.

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Lake Coeur d'Alene is north Idaho's most popular recreational area however, it has become the major collecting bed for sediments enriched in As, Cd, Pb, and Zn from mining activities in the region. Diagenetic reactions within the sediment control metal solubility and contribute to the potential release of metals into the overlying water. Our objective is to develop a clear understanding of what factors control the release of metals into the water column and to predict the fate of metals affecting long-term water quality. Equilibrium samplers were placed in the sediment at the southern end of the lake to sample the interstitial water at four sites. Redox sensitive metals were measured using ICP to establish redox boundaries. Results indicate that at the time of sampling, the water column was oxic and that anoxic conditions were established at a depth of 5 cm in the sediment. Metal cycling is controlled by the high concentration of iron in the system, which encourages reductive dissolution, releasing arsenic into the sediment pore water. Iron concentrations increase with depth to 40 ppm. Arsenic concentrations reach 1.2 ppm at a depth of 15 cm. These data are to be used as input variables in a benthic flux model to predict metal mobilization/immobilization. Understanding metal cycling in sediment pore water has important implications for future water quality monitoring efforts on the lake as well as health concerns associated with the use of the lake.

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