EVALUATING PECAN WATER USE THROUGH REMOTE SENSING

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Poster Abstract 1

Pecans are a major agricultural crop in New Mexico. Currently there are more than 30,000 acres of pecan in the Mesilla Valley consuming more than one third of the annual diversion. The hundreds of pecan orchards scattered across the Valley consist of various field sizes and various stages of tree growth. The variability in field size, as well as the stage of growth, affects the amount of water which is applied, as well as the amount of water actually consumed by the crop. Remote sensing technology is being used to identify pecan orchards and calculate the spatial and temporal variability of pecan tree evapotranspiration (ET). The spatial distribution of pecan ET is used to identify current water use, irrigation efficiency, and the maximum possible water use and yield by pecan orchards once the young orchards reach full maturity.

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CHARACTERIZATION OF ARSENIC IN THE SOILS OF THE MIMBRES WATERSHED UTILIZING REMOTE SENSING AND GIS TECHNIQUES

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Poster Abstract 2

Chronic low-level exposure to arsenic (As) has been found to increase health risks for cancer, skin lesions, and numerous other illnesses. In January 2006, the EPA lowered the As drinking water limit to 10 ppb. This new standard has affected many New Mexico wells and brought the topic of arsenic contamination to the forefront. Arsenic in the soils of New Mexico has received far less attention. In a study performed by WRRI, As in soils irrigated with water containing arsenic was investigated. This study concluded that As accumulated within the soil profile and estimated that greater than 80% of the arsenic in irrigation water is retained in the fields. Since the EPA standard only applies to drinking water it is feasible that water now unsuitable for drinking will be utilized for irrigation. In this study, soils of the Mimbres watershed will be analyzed for As concentration using X-Ray Fluorescence. In addition to As concentrations, a number of other metals/metalloids will be measured. These data, in combination with other soil properties such as texture, pH, slope, etc., will be entered into a geodatabase along with soil classification for analysis. As we characterize the soils known to be in close proximity to As deposits, this study will allow us to look for patterns of As accumulation with respect to several different factors including the concentrations of other elements such as Al, Fe, and P; soil type and texture; pH; and slope.

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INFLUENCE OF INDUSTRIAL WASTEWATER ON SOIL PHYSICAL AND HYDRAULIC PROPERTIES IN THE CHIHUAHUAN DESERT

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Poster Abstract 3

Few studies of land application wastewater treatment systems provide information about the effects of effluent on soil physical and hydraulic properties. Soil hydraulic properties, especially the amount of water passing through and that retained in the soil matrix, strongly influence soil chemical properties such as salinity and sodicity, which influence plant growth.

Four treatments were chosen for this study: a control plot (NMSU-Control) that receives rainfall only, a plot receiving secondary industrial effluent irrigation based on shrub water demand (NMSU-Irrigated), a plot receiving programmed irrigation based on effluent availability (City of Las Cruces-Irrigated), and a plot receiving primary effluent from a local cheese processing factory (Cheese Factory-Irrigated).

Soil cores were taken at 5-10 cm depth. Four replications were made at 3 different sites (i.e. bare ground or inter-shrub and creosote and mesquite shrubs) for a total of 12 samples per treatment. However, 4 replications were made at only 2 different sites (i.e. bare ground and saltbush) in Cheese Factory-Irrigated. Parameters measured from soil cores included bulk density, saturated hydraulic conductivity, texture, and soil moisture characteristics.

A one-way ANOVA showed no differences in soil texture among treatments. NMSU-Irrigated retained higher soil moisture compared to other irrigation treatments and NMSU-Control for suctions < 5 bar. In NMSU-Control, NMSU-Irrigated and City of Las Cruces-Irrigated, bare ground sites retained higher soil moisture at the same suction compared to vegetation sites (i.e. creosote and mesquite). These differences may be correlated with the electrical conductivity and sodium adsorption ratio of the soil.

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RIPARIAN EVAPOTRANSPIRATION (ET) ESTIMATES ON THE MIDDLE RIO GRANDE USING REMOTE SENSING

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Poster Abstract 4

There is an urgent need for an accurate method to estimate evapotranspiration (ET) of the riparian region of the Middle Rio Grande in an effort to evaluate the impact of saltcedar removal and its management, to balance the water budget, and to better manage the river. One missing component of the hydrologic budget of the Middle Rio Grande is a better estimation of regional riparian ET. Many studies have focused on measuring ET of individual riparian vegetation. However, the riparian vegetation on the Middle Rio Grande varies in density, species, and spatial variation in climate, soil type, and depth to groundwater. Due to this variability, ET will also vary from one location to another. It is obvious that in order to get more accurate measurements, many sampling points are needed, thus making the process very expensive and complicated. An alternative solution, which is also cost-effective, is by using remote sensing technology to estimate regional ET.

Regional ET of the Middle Rio Grande using REEM (Regional ET Estimation Model) developed at New Mexico State University is presented. Satellite data combined with climate data and localized flux (ET) measurements at Bosque del Apache National Wildlife Refuge near Socorro, New Mexico are used to calculate and map regional ET. The results from this study will be used to evaluate and quantify the hydrologic impact of saltcedar removal and management at the refuge.

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THE IMPORTANCE OF MODELING BASIN FILL AND BEDROCK AQUIFERS IN A REGIONAL GROUND WATER FLOW MODEL OF THE MIMBRES BASIN, SOUTHWESTERN NEW MEXICO

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Poster Abstract 5

We constructed a finite-difference ground-water flow model of the Mimbres Basin that represents basin fill and bedrock aquifers in four layers, with a total thickness of 2,500 ft. Modeling bedrock and basin fill allowed us to model interactions between the two aquifers and between the Mimbres River and the aquifers, recharge distribution, and effects of pumping from the bedrock (municipal and mining) and basin fill (municipal and irrigation). Basin-fill horizontal hydraulic conductivity (Kh) values range from 0.02 to 25 ft/d, and bedrock Kh values range from 0.0015 to 0.1 ft/d. The 32-mile perennial reach of the Mimbres River, modeled using the MODFLOW stream package, flows over bedrock and then extends several miles across basin fill. Steady-state calibrated areal recharge rates for bedrock zones range from <0.05 to 0.5 in./yr depending on elevation, slope, and degree of fracturing. Steady-state calibrated mountain-front recharge rates along arroyos in bedrock and basin fill range from <0.05 in./yr along the perimeter of the West Potrillo Mountains to >5 in./yr in the streambed of the Mimbres River near Deming. Steady-state calibration statistics, based on 989 target heads with a range of 3,342 ft, include a residual mean of 23 ft and an absolute residual mean of 45 ft. Model results indicate that basin-fill recharge from the Mimbres River creates a hydraulic barrier that separates regional drawdown effects from pumping in the northern and southern parts of the Basin. Model results also show that historic basin-wide pumping has had little effect on flow in the Mimbres River.

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DIRECT CONTACT MEMBRANE DISTILLATION FOR BRACKISH WATER DESALINATION: COMPARISON OF FLAT SHEET MEMBRANE AND HOLLOW FIBER MEMBRANE MODULES

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Poster Abstract 6

The objective of this research is to determine the efficiency of a membrane distillation process using both flat and hollow fiber membrane modules for brackish water desalination through experimental and process modeling studies. Hot feed and cold deionized water were introduced counter-currently through the flat sheet membrane module with an average operating temperature difference of 60°C. The pure water vapor from the hot feed passes through a hydrophobic membrane and condenses and produces pure water. To achieve better water flux and efficiency, a hollow fiber membrane module had been implemented. An experiment of direct contact membrane distillation using a hollow fiber membrane module was done to purify brackish water. The hollow fiber membrane is much more efficient when compared to the flat sheet membrane. The salt rejection rate here was near about 99%. This method was also used for removal of arsenic and nitrate salts from brackish water with removal efficiency over 99% on average. A preliminary theoretical modeling of heat and mass transfer phenomena associated with the process was also performed. The modeling results were compared with experimental results to check the consistency of the data obtained in this process. The calculated and experimentally obtained mass flux with operating temperature showed a similar behavior. A simple economical analysis of the membrane distillation process was carried out to assess the feasibility of applying the membrane distillation process for brackish water desalination. As this process can purify high saline water and remove hazardous dissolved salts at a very low cost, it will become an important separation process for water treatment in the near future.

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“DIVINING" AN IRRIGATION SCHEDULE USING SOIL MOISTURE STATUS

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Poster Abstract 7

In southeastern New Mexico, as well as the arid western U.S., it has become apparent that water conservation measures are needed to offset water loss due to drought and the increased demand of population growth. Water conservation programs are being implemented in domestic and agricultural arenas to increase overall irrigation efficiencies by monitoring soil moisture infiltration, storage, and depletion. Monitoring soil moisture accumulation and migration is an extremely important irrigation management procedure used to determine the optimal irrigation application schedule for individual soil textures and crops. A Sentek “Diviner 2000" that utilizes high frequency domain reflectometry was used to monitor soil moisture status in 10-cm increments under alfalfa, corn, cotton, chile, and pecans in the Pecos River Valley. An awareness by farmers of the soil moisture status with depth has helped avoid moisture stress during critical periods of crop development. It has also demonstrated climate and texture impacts on soil moisture depletion and affords opportunities for delaying water application. The system has also demonstrated unique differences between gravity fed irrigation systems and pressurized systems. Optimizing crop production by understanding relationships that exist between water consumption, nutrient uptake, and lengths of seasonal growth to maturation, among others, is an ongoing economic concern to irrigators in southeastern New Mexico.

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CONTROLLING FACTORS OF EVAPOTRANSPIRATION IN THE MIDDLE RIO GRANDE BASIN

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Poster Abstract 8

Evapotranspiration is a significant component of a water budget in any given watershed, especially in an arid climate. There are many environmental components that act as controls on this process, and they may vary from one region to the next. The Middle Rio Grande Basin offers an assortment of environments in which to study these interactions. Over the past several years, ET and other micrometeorological and hydrologic data have been collected in several locations along the Middle Rio Grande using eddy covariance systems. This data is helping us to better understand the unique relationships between ET and these different environmental factors. This is especially important in this arid region since large stretches of the Middle Rio Grande are bordered by forests of invasive species, such as salt cedar, which are believed to lose more water through transpiration than native ones. Both factor analyses and stepwise GLM's have been run on the data collected from the eddy covariance towers between 2000 and 2005 in order to determine unique interrelationships between the ET, groundwater depth, and micrometeorology as well as distinctive events brought on by anomalies such as monsoon events, drought, and flooding. The stepwise GLM's show a strong connection between ET and sensible heat flux and net radiation, both components already used in the energy balance used to determine ET. The effects of anomalous events on ET are more clearly seen using more simple analysis techniques or by direct comparison.

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U.S. – MEXICO GEOSPATIAL DATABASE BASED ON AQUIFER BOUNDARIES

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Poster Abstract 9

The need for international collaboration along the U.S. – Mexico border is fundamental in respect to environmental aspects of the region. A bi-national database based on mutually shared water basins was implemented by the New Mexico Water Resources Research Institute (NMWRRI) and the Geographic Information Center at Universidad Autónoma de Ciudad Juárez (UACJGIS).

A GIS (geographic information system) was employed to construct the database of digital layers that were distributed between both institutions via the new generation of Internet 2. Included are typical base map layers such as roads, populated places, geopolitical divisions and legal boundaries of both countries. Also included are layers of particular bi-national interest such as rivers, geology, soils, vegetation, land use, landownership, wells, and landfills. The data is made readily accessible as an interactive map under an ArcIMS environment. Users will easily be able to manipulate the map to their needs by performing queries, turning layers on and off, and performing other useful operations such as printing a map or buffering a region of interest. The data will be served by both NMWRRI and UACJ which will provide users with the ability to view the data in both English and Spanish languages. The geographic database of the Mimbres basin was produced as a prototype for the development of a larger bi-national database funded by the Hewlett Foundation. The Mesilla basin will include data layers similar to the Mimbres database and will be incorporated into the larger database that will eventually encompass the entire New Mexico – Chihuahua border region.

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WATER-RESOURCES VITAL-SIGN MONITORING IN THE NATIONAL PARK SERVICE CHIHUAHUAN DESERT INVENTORY AND MONITORING NETWORK, NEW MEXICO AND TEXAS

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Poster Abstract 10

The Chihuahuan Desert Inventory and Monitoring Network (CHDN) is responsible for the inventory and monitoring of natural resources within Amistad National Recreation Area, Big Bend National Park, Carlsbad Caverns National Park, Fort Davis National Historic Site, Guadalupe Mountains National Park, Rio Grande Wild and Scenic River, and White Sands National Monument. Monitored resources within CHDN include surface- and ground-water quantity and quality.

Proposed water-resources monitoring requires identification of parameters that serve as vital signs reflecting the conditions of water resources within CHDN. The goals of vital-sign monitoring include: 1) determining the status of and trends in water resources, 2) providing early warning of the development of atypical hydrologic conditions, 3) improving understanding of the dynamic nature and condition of hydrologic systems, 4) providing data to meet legal mandates, and 5) providing a means to measure progress toward performance goals. Important water-resources vital signs identified by CHDN include: 1) Surface-water quality as determined by temperature, pH, specific conductance, turbidity, abundance of bacteria, abundance and diversity of aquatic macroinvertebrates, and concentrations of dissolved inorganic constituents, dissolved oxygen, and nutrients; 2) rates and frequencies of surface-water discharge; 3) sediment load and chemical composition; 4) lake and reservoir levels; 5) ground-water quality as determined by temperature, pH, specific conductance, and concentrations of dissolved inorganic constituents; and 6) ground-water levels. The CHDN water-resources vital-sign monitoring program is being designed to complement and benefit from monitoring efforts by the U.S. Geological Survey, the New Mexico Office of the State Engineer, the Texas Commission on Environmental Quality, the Texas Water Development Board, and the International Boundary and Water Commission.

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TIME-SERIES MODEL OF MONTHLY STREAMFLOW: RIO GRANDE AT AMERICAN DIVERSION DAM, EL PASO, TEXAS

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Poster Abstract 11

The City of El Paso, Texas takes surface water from the Rio Grande for treatment during the summer months when water is released upstream from Elephant Butte Dam. River flows dwindle to consist of mainly agricultural drain and ground water return flows in the winter months. El Paso Water Utilities (EPWU) has initiated a project to determine if adequate flows exist to justify advanced treatment of winter return flows for Municipal and Industrial use. Time series analyses of monthly flows for the Rio Grande above American Diversion Dam are performed for the periods of 1951-1978 and 1979-2003. A comparison of the models of the two time periods is looked at and the results are discussed. The development of adequate Autoregressive Integrated Moving Average (ARIMA) models of the time series is discussed. Autocorrelation structures, such as the Autocorrelation Function (ACF), are used to identify appropriate orders of differencing. Diagnostic checks and an evaluation of back forecasted values are also used to determine the adequacy of each model for forecasting future streamflows. The uses and implications of such models for surface water treatment plant operations and management are also discussed.

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ASSESSMENT OF ARSENIC AND OTHER GROUNDWATER IMPAIRMENTS IN THE GALLINAS WATERSHED, LAS VEGAS, NEW MEXICO

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Poster Abstract 12

The Gallinas River is the primary source of water for Las Vegas, NM (population 18,000), providing 95% of its domestic water supply. Water quality studies show that the river contains elevated concentrations of arsenic (0.039 mg/L) during periods of elevated flow (1.98m^3/s). This exceeds the US EPA drinking water standard of 0.010 mg/L. Total recoverable arsenic in water samples is strongly correlated with total suspended solids (R2 = 0.98) and was determined to originate from Permian and Cretaceous shales that underlie a large area (>50%) of the Gallinas Watershed. There is concern that these arsenic-bearing units could impair groundwater. There are approximately forty domestic well users in the upper watershed and hundreds more in the eastern plains. Groundwater quality data does not exist for these wells. Groundwater was sampled from 12 wells throughout the watershed to address impairment of domestic, agriculture, and stock water supplies in the Gallinas Watershed caused by arsenic, uranium, hardness, pH, nitrate, and fecal coliform bacteria as pollutants. Arsenic concentrations throughout the study area were consistently low (< 2.5 ug/l). Mean arsenic concentrations were significantly higher ($p<0.05$) at lower elevations (1,900 to 2,100 m) compared to higher elevations (2,100 to 2,600 feet) with 0.05 and 0.60 ug/L, respectively. Mean electrical conductivity exhibited the same trend with 289 and 1,300 uS/cm. Uranium values were consistently low throughout the watershed (0.16 to 7.9 ug/l). There was no significant trend for nitrate, hardness, alkalinity, pH, dissolved oxygen, and fecal coliform. Despite the low concentrations of dissolved arsenic and uranium in the study area, it is important to understand the mechanisms related to their mobilization and transport. A similar terrain with slightly different conditions (pH, redox chemistry, source material) could result in very different behavior of natural contaminants. Further research is needed to determine the effects of changes in pH on the sorption or desorption of arsenic and uranium.

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RAPID DETECTION OF HUMAN FECAL CONTAMINATION USING SIGA AS AN INDICATOR

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Poster Abstract 13

Water contaminated with human fecal matter can be a significant public health concern especially in areas with limited water resources used for consumption and irrigation. The objective of this study is to determine the feasibility of using human secretory (sIgA) as an indicator of human fecal contamination in water sources such as raw sewage and ground water to determine if concentrations of sIgA can be detected with a high degree of certainty and reliability in contaminated water. For ground water samples, 10L of water were collected and spiked with a 200ng/mL concentration of human sIgA. The sample was then concentrated to 200mL using an ultra-filtration method. Eight 1:10 dilutions were placed on a 96 well ELISA (colorimetric assay, which uses passive absorption of antibody to antigen) plate to determine the recovery efficiency of the method. The percent recoveries for the spike challenges performed on ground water were 50.2%. For the raw sewage, a 1mL sample was collected, diluted (eight 1:10 dilutions), and plated to detect sIgA present before being processed at wastewater treatment facilities. Once it was determined that sIgA was found in 75% of the samples taken, tests were preformed to determine the efficiency of recovery using an ultra-filtration method. The raw sewage samples were concentrated to 50mL from a 1L sample, and ELISA was preformed. The efficiency of recovery of ultra-filtration methods for raw sewage was 45.5%. A sIgA assay used for the detection of human fecal contamination proves to be an efficient, rapid, and cost effective procedure.

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ONE-DIMENSIONAL INVERSE MODELING OF WELL WATER AND GRAYWATER FLOW AND SALT TRANSPORT IN A LOAM SAND SOIL COLUMN

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Poster Abstract 14

This paper presents preliminary results of inverse simulation of hydraulic parameters of gray water and well water flow in a loamy sand soil column and transport of salts to assess the salt accumulation in the soil using the HYDRUS-1D software package. Initial estimates of the optimized soil hydraulic parameters are provided, and parameters to be optimized were specified. Initial estimates of water flow parameters were assigned. Then, the parameters were modified using trial-and-error approach to fit simulated curves to the observed moisture content data measured by three sensors installed at 15.2, 30.5, and 45.7 cm from top down. Only data from the top two sensors (the first from top and the middle one) were used due to effects of boundary conditions in the lowest sensor data. Results of "best" fit of simulated and observed data showed good agreement in the first part of the first sensor's curve and the first and the last portion of the middle sensor's data. The flow model with optimized hydraulic parameter estimation was then used as the base for the transport model to simulate salt movement inside the column. Results of transport simulation showed that the predicted concentrations of Na+ and Cl- in the leachate, as well as in the selected observation points along the soil profile, were not unusual during the two week period of simulation. No significant changes in sodium concentration were noticed. Results agreed well with estimated values of sodium adsorption ratio (SAR) with an average 3.74 for a 2 percent compost-treated soil.

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ANALYZING THE EFFECT OF IRRIGATION ON RIO GRANDE CHEMISTRY: A SITE STUDY IN LEMITAR, NM

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Poster Abstract 15

In order to better understand the effect of agriculture on the water quality of the Rio Grande, a representative site (a farm in Lemitar, NM) was chosen. Samples were analyzed both before irrigation (from a nearby canal) and after (from a well sampling the shallow groundwater). Concentrations of major ions are higher in the groundwater samples, most likely due to chemical reactions occurring in the soil. Calcite, dolomite, and gypsum have been identified as probable reactive mineral phases. NETPATH, a computer program that calculates a geochemical mass-balance between initial and final waters, was utilized to generate possible reaction combinations. The program yielded nine possible combinations which each quantify subsurface reactions. The most plausible of which unites the dissolution of dolomite and calcite with ion exchange reactions where carbon dioxide is available. In addition, a water-balance calculation revealed a fifty percent loss of irrigation water to evapotranspiration. Further, a simplified solute burden calculation seems to indicate the irrigation process discharges an additional: 1154 kg/yr calcium, 426 kg/yr magnesium, 906 kg/yr sodium, 1758 kg/yr sulfate, 5773 kg/yr bicarbonate and 408 kg/yr chloride to the Rio Grande.

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DROUGHT TOLERANCE OF BLUEBONNETS

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Poster Abstract 16

Previous research has shown the potential use of *Lupinus havardii* (Big Bend bluebonnet) in the cut flower industry. However, little information exists on the drought tolerance of this species. A greenhouse study was conducted to characterize the growth and cut flower production in response to drought stress. Five soil moisture content treatments were created by watering the plants to container capacity, allowing them to dry to a predetermined volumetric soil moisture content (33%, 25%, 20%, 15%, or 12%), and then re-watering to container capacity. Plants were grown in 10-L containers and drip-irrigated. Mature racemes (40 to 55 cm) were harvested weekly. After 9-week treatment, total cut flower yield did not differ in 33%, 25%, and 20% treatments but decreased in the other treatments. Growth index decreased in the range of 12 to 20%, while no difference was found between 25% and 33%. There was no difference in root: shoot ratio among treatments. Leaf SPAD readings, measured at the end of the experiment, were lower in the 15% and 12% treatments. Daily evapotranspiration (ET) decreased as soil moisture content decreased. In general, growth, cut flower yield, and dry weight of the plants in 15% and 12% decreased compared to the other treatments. For maximum growth and cut flower production, plants should be irrigated at soil moisture content of 25% or higher.

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SALT TOLERANCE OF BLUEBONNETS

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Poster Abstract 17

Use of recycled water to irrigate urban landscapes and nursery production may be inevitable as fresh water supplies are diminishing and the populations continue to grow in the arid and semiarid Southwestern U.S. *Lupinus havardii* (Big Bend Bluebonnet) has a potential use in the cut flower industry, and *L. texensis* is a popular bedding plant. However, little information is available on the relative salt tolerance of these species. A greenhouse study was conducted to characterize the growth response of these two species to salt stress by growing them in 10-L containers and drip irrigating with synthesized saline solution at electrical conductivity (EC) levels of 1.6, 3.7, 5.7, 7.6, and 9.4 dS/m. After 11 weeks of treatment, *L. texensis* were visually acceptable when irrigated at EC of up to 7.6 dS/m, although shoot growth was reduced and plants became more compact as EC increased. All plants survived at 7.6 dS/m, while only 15% did at 9.4 dS/m. In contrast, *L. havardii* had leaf injury at 5.7 dS/m. No plants survived at 9.4 dS/m, and only 7% plants survived at 7.6 dS/m. In addition, growth of *L. havardii* was significantly reduced and plants were shorter at elevated salinity levels. Cut flower yield of *L. havardii* decreased at salinity level greater than 3.7 dS/m. However, no difference in cut flower yield was observed between the control and 3.7 dS/m, although shoot growth was reduced. Overall, *L. texensis* was more tolerant than *L. havardii*.

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LINEAR MODELING OF THE RESPONSE OF GROUNDWATER LEVEL TO RIVER FLOW IN THE MIDDLE RIO GRANDE BOSQUE, 2005

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Poster Abstract 18

In 1993, the Bosque Biological Management Report provided an integrated overview of the Middle Rio Grande Bosque's (MRGB) structure and function, stressing the region's dependence on river water. A key issue addressed in the report is the connection between river water and groundwater.

The U.S. Forest Service, in partnership with the University of New Mexico, has installed and maintained a series of approximately 50 groundwater monitoring wells in the MRGB, stretching from Albuquerque to the Bosque del Apache. Each well is equipped with a logging pressure transducer that samples every fifteen minutes. In addition, the U.S. Geological Survey provides high quality daily mean discharge records for the Rio Grande at a number of gaging stations.

Here we select 3 wells, one each in Albuquerque, Los Lunas, and Bosque del Apache. We produce daily means of each well's record for 2005 and divide the record by month. We then identify the river gage closest to each well with no intervening diversion dam.

To assess the hydrological reactivity of MRGB groundwater to river water, we use a linear model of the response of groundwater levels to river discharge for the entire year of 2005, and month-by-month, comparing the resulting R^2 and P values.

All of the examined sites lie between the river and canals. Future work will include canal water level and distance from well to canal and well to river as model parameters to study the MRGB's groundwater response to its human and natural environment.

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WIND PROFILE IN A PECAN ORCHARD, DOÑA ANA COUNTY, NEW MEXICO

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Poster Abstract 19

The structural roughness of pecan trees, open space between the rows, and the fetch distance from the edge of the orchard are known to affect the vertical wind profile within the canopy and thus affect evapotranspiration rates. This study investigated the vertical profile of horizontal wind velocity in a pecan orchard in Doña Ana County, New Mexico.

Vertical profiles of horizontal wind velocities in and above a pecan orchard that was 50 ft (15.24 m) tall using multiple anemometers was measured on days of year 202, 208, 209, 210, and 216, (7/21, 7/27, 7/28, 7/29, and 8/4 of 2005) respectively. Using a graphical method, the zero plane displacement (d), roughness length (zo), friction velocity (u*) and the shearing stress (ô) were determined. Results indicated a logarithmic wind profile similar to that of short crops.

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DAILY SALTCEDAR EVAPOTRANSPIRATION RATES MEASURED AT BOSQUE DEL APACHE NATIONAL WILDLIFE REFUGE

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Poster Abstract 20

Evapotranspiration from saltcedar (riparian vegetation) is considered one of the larger components of outflow in the Middle Rio Grande hydrologic budget and also one of the least understood. Saltcedar ET was measured using the south saltcedar tower OPEC system in 2005. Eddy covariance technique was used in the energy balance to measure sensible heat. Latent heat (LE) in terms of equivalent depth of water or ET was calculated as a residual from the energy balance. The ET was measured during 346 days of data collection at south saltcedar tower, but the primary focus was during the growing season (April 11 - November 14). The ET measured during the growing season was 1181 mm (3.9 ft) and during the whole year (346 days) was about 1392 mm (4.6 ft). Depth to water table ranged from about 80 cm to 500 cm (3 ft - 16.4 ft). The study site was flooded from mid-April through mid-July.

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EVAPOTRANSPIRATION ESTIMATES BASED ON STANDARDIZED EQUATION REFERENCED TO GRASS USING NEW MEXICO WEATHER STATION DATA

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Poster Abstract 21

Computation of reference ET using a standardized method has been proposed by the Committee of the Environmental and Water Resources Institute of American Society of Civil Engineers. The proposed method sets a benchmark equation that standardizes the calculation of ETref and improves transferability of crop coefficients (Kc=ETactual/ETref). The standardized equation requires meteorological data from local weather stations, such as wind speed, relative humidity, air temperature and solar radiation. However, this method also requires stringent conditions at the location of weather stations. These conditions assume a dense reference crop, well-watered, free of disease, of a specific height and fetch distance. Many weather stations in New Mexico do not meet these requirements. Evapotranspiration referenced to grass (ETo) using meteorological data from two weather stations located in New Mexico for years 2002 through 2005 was investigated. One weather station was surrounded by agricultural crops and the other surrounded by seasonal riparian shrubs. The ETo followed a similar trend from year to year with slight variations at both sites. Monthly ETo ranged from about 50 mm in December to a maximum of 250 mm in June at both weather stations.

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SOIL CHEMISTRY OF AREAS OCCUPIED BY SALTCEDAR (TAMARIX SPP.) AT THE ELEPHANT BUTTE DELTA, NEW MEXICO

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Poster Abstract 22

Soil chemistry of areas occupied by saltcedar at the Elephant Butte Delta was studied. The study site included non-treated and herbicide-treated saltcedar. At the treated site saltcedar was dead but still standing. At each site four areas were selected randomly to collect soil samples for laboratory analysis and also to measure conductivity, dissolved solids, and temperature. Preliminary results from both field measurements and the laboratory analysis indicated that there is more salt in the untreated saltcedar site than the treated saltcedar site. The soils in this were slightly alkaline (pH of 7.3 to 7.4). The salinity (EC) levels in the untreated site decreased as the leaves senesced but then increased as the leaves decomposed. Recent measurements show that after bud break in non-treated site, the EC continues to increase. There was no indication of sodium related problems at both sites (SAR <13).

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EVAPORATION ESTIMATION AT ELEPHANT BUTTE RESERVOIR USING SKIN TEMPERATURE AND MICROMETEOROLOGICAL DATA ABOVE THE WATER SURFACE

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Poster Abstract 23

Evaporation from shallow and deep water depths of Elephant Butte Reservoir was measured from January 1 through April 30, 2006. Skin temperature of water was measured using an infrared thermocouple. Micrometeorological data such as wind speed, relative humidity, air temperature, and barometric pressure were measured. Using the measured data, evaporation was then calculated using the bulk-aerodynamic method. A class "A" evaporation pan was also used to measure evaporation at the northern end of the reservoir. Evaporation using the bulk-aerodynamic method ranged from 0.44 to15 mm and from pan measurements ranged from 0.25 to 13 mm, respectively, during the period of measurement.

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DETERMINATION OF HEAT STORAGE RATE IN MATURE PECAN ORCHARD, NEW MEXICO

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Poster Abstract 24

Thermal storage rate (G, W/m²; G = Gair + Gveg + Gsoil) of a vegetated surface is normally considered insignificant in energy budget methods commonly used to estimate evapotranspiration (ET) of dense grown agricultural crops or riparian vegetation. The assumption is that G is small when compared to other energies such as net radiation, sensible heat, and latent heat in the energy budget.

This project investigated the thermal storage in a mature pecan orchard which is considered to have a higher biomass than crops and attempted to determine if it is significant in the daily energy balance. A single air temperature above the canopy was used to estimate Gveg (biomass storage rate) and Gair (air layer storage rate), while Gsoil (soil storage rate) was measured using a soil heat flux plate. The Gair and Gveg are considered linear functions of the time change of the index temperature (T). The greatest variation between 24-hour Gsoil and G was about 0.63 MJ/m². Therefore, the effect of Gair and Gveg towards ET calculations is very small and could be ignored in the energy balance equation.

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THE IMPACTS OF LAND USE CHANGE ON WATER RESOURCES AND TRADITIONAL ACEQUIA CULTURE IN NORTH CENTRAL NEW MEXICO

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Poster Abstract 25

Rural areas throughout the western United States are undergoing rapid and far-reaching land use changes that impact water management, riparian ecosystems, and traditional cultures. Impacts to water resource use and management include: potential overdraft of groundwater resources, surface water quality impacts, potential groundwater contamination risks due to increased numbers of single household septic systems, and changes in the distribution of water supplies from agricultural to municipal and industrial uses. In northern New Mexico, the acequia irrigation system has been used for centuries, and related cultural values are at risk due to increasing urbanization pressures and potential impacts on actual water use, water quality, and riparian vegetation along the rivers and irrigation ditches. GIS and aerial photography interpretation techniques were used to generate land use change maps for the years 1997 and 1962 to assess the impacts of water resources in Alcalde, New Mexico, a small agricultural community located along the Upper Rio Grande. In examining the cultural values associated with the acequia way of rural life, we implemented a written survey that incorporated questions regarding the above issues. The land use maps depicted water resources use and management changes – risks to groundwater, changes in acequia management and water use, and riparian ecosystem impacts. This project is well suited to provide local and state planning programs with constructive methods for further research and is also applicable to other western states with similar challenges.

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ARID-LAND SOIL AMENDED WITH INDUSTRIAL BYPRODUCTS: IMPACT ON STRUCTURE AND CHEMISTRY

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Poster Abstract 26

Two coal combustion power plants in the Four Corners region consume approximately 14.5 million metric tons of coal per year, generating substantial coal combustion byproducts (CCBs) in the form of ash and flue gas desulfurization materials. Additionally, the municipalities of Farmington, Aztec, Bloomfield, Durango, and Shiprock generate considerable amounts of sewage sludge waste (biosolids) through secondary and tertiary waste water treatment. Both CCBs and biosolids are currently landfilled – products that may have agricultural utilization potential.

Nearby is the Navajo Agricultural Products Industry (NAPI), a large commercial farm operating 600 automatic center pivot irrigation systems on 31,000 ha of farmland. The soils are generally sandy to sandy loam with limited water-holding capacity, low inherent nutrient status, and elevated pH. CCBs and biosolids may increase water-holding capacity and contribute to the pool of micronutrients available for plant uptake. Environmental impact must also be considered

This project was designed to complement ongoing studies to examine potential benefits of soil physical properties by measuring water-holding capacity and saturated hydraulic conductivity of biosolid and CCB-amended soils. This study was a collaborative project with New Mexico State University, NAPI, the Arizona Public Service (APS) Four Corners Power Plant and the City of Albuquerque. The demonstration of environmentally sound management strategies for applying biosolids and CCBs to agricultural lands addresses regional and national priorities established by the U.S. Environmental Protection Agency, U.S. Department of Energy National Energy Technology Laboratory and the Combustion Byproducts Recycling Consortium for the increased utilization of these products.

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ANALYSIS OF PUMP TESTS ALONG THE LOWER SOUTH PLATTE RIVER, NORTHEASTERN COLORADO

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Poster Abstract 27

Well user groups near Sterling, northeastern Colorado, have proposed plans for augmentation of water supplies, which include recharge wells along the South Platte River designed to pump from the alluvial aquifer during the winter months when there is no priority call on the water rights. These wells are assumed to operate as direct diversions from the river. The pumped water is delivered to recharge ponds located at a distance from the river, where the ponded water infiltrates through the ground and flows back toward the river, offsetting out-of-priority depletions caused by irrigation season pumping.

Pumping tests were performed in Steib R-4 and Dinsdale R-1 recharge wells. This analysis describes our interpretation of the results. The goal of these tests was to investigate stream-aquifer interactions and to determine values of related parameters (including streambed conductance and aquifer hydraulic conductivity). These results will be used in development of unit replacement factors to determine timing and quantity of the water pumped from these recharge wells which is derived from the South Platte River losses, consistent with the terms of the related decrees.

Our analysis was based on Theis analysis, Hunt analysis, and a developed site-specific MODFLOW model that included the effects of evapotranspiration. Best-fit parameters were determined by matching drawdown as observed in nearby pumping wells and measured river losses. Hydrosphere's interpretation of the Steib and Dinsdale well tests indicate that the applicants should use a streambed conductance of 20 day-1 and 2.6 day-1, and hydraulic conductivity on the order of 400 and 200 ft/d, respectively.

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GRAY WATER REUSE TO CONSERVE FRESH WATER SOURCES

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Poster Abstract 28

As native fresh water sources are being depleted, new ways to irrigate crops and landscapes are a necessity. An excellent choice for an alternative water source is gray (laundry) water for a community such as the prison, where a vast amount of water is consumed with each wash cycle. For example, a total of 3,500 gallons of water are used daily. To test the reliability of using laundry water for irrigation, four plots of edible crops were planted. Two plots were irrigated with salty well water as a control, and the other two were irrigated with laundry water. Crops selected for this study were long green chilies, tomatoes, and bell peppers because they are very susceptible to the effects of salinity, and we felt that if these crops could grow with poor quality water, just about anything else would grow. Results showed that laundry water increased fruit yields and size, while the salty well water stunted plant and fruit size. Testing of fruits and irrigation water for pathogens showed no sign of pathogen contamination. This shows that the use of laundry water as a source of irrigation water is a safe and beneficial way to supplement water shortage for some communities.

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PUMP TESTS DESIGNED FOR INVESTIGATING SURFACE WATER – GROUNDWATER INTERACTIONS ALONG THE SOUTH PLATTE RIVER IN NORTHEAST COLORADO

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Poster Abstract 29

This paper describes pumping tests performed near Sterling, Colorado along the South Platte River with the goal of determining aquifer-stream interaction in that area and more specifically to determine the streambed conductance and aquifer hydraulic conductivity. Well users in northeastern Colorado have been proposing plans for augmenting water supplies that involve pumping water from wells very close to the South Platte River to recharge ponds located some distance away. The water (which is usually pumped in the winter when surface water supplies are generally unappropriated) delivered to the ponds infiltrates back into the alluvial aquifer and flows back toward the river; these accretions to the river are intended to offset out-of-priority depletions due to well pumping during the irrigation season. This recharge plan relies on the assumption that the water pumped from the "recharge well" is diverted directly from the river based on the proximity of the recharge well to the river. Two such tests were undertaken. The first test was conducted on the Steib farm and involved pumping a recharge well located 75 feet from the river at the rate of 2,700 gpm for a period of two days, with the pumped water transported to a recharge pond approximately one mile away via pipeline. The second test was undertaken on the Dinsdale farm, approximately 22 miles downstream from the first, and involved pumping a recharge well located 156 feet from the river at a rate of 1,500 gpm for 4 days. In both tests, river discharge was measured at three locations along the river (1000 ft upstream of the recharge well, immediately adjacent to the recharge well, and 1000 ft downstream of the recharge well), and groundwater levels were recorded in 7 observation wells laid out in a network in the vicinity of the pumped well.
* We would like to acknowledge the leading roles of Mary R. Halstead of the Colorado Division of Wildlife, Jon Altenhofen of the Northern Colorado Water Conservancy District, Bruce Kroeker, P.E. of TZA Water Engineers, and Calvin Miller, P.E. of Colorado State University in the planning and execution of these tests.

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ORGANIZING WATER USERS ASSOCIATIONS AND GRANT IMPLEMENTATIONS IN THE POST-SOVIET REPUBLICS

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Poster Abstract 30

Starting in 1990, several Central Asian countries declared independence from the former Soviet Union. Overnight, the socioeconomic structure of these countries transformed from state sponsored socialist systems into capitalist systems. In several of these countries, the independence was followed by economic collapse and social unrest which resulted in the deterioration of the agricultural industry. Agriculture is the main source of income for these countries. The collapse of the irrigation systems combined with the lack of capital resulted in sharp reduction in agricultural production. The agricultural problem was exasperated by the disintegration of the large collective farms into small plots. The irrigation infrastructures that were originally managed by the government were now left unattended and looted. In 2004, Winrock International and New Mexico State University started a USAID sponsored project to form water users associations (WUAS) and rehabilitate the irrigation infrastructure in several Central Asian Countries. This poster discusses the tortuous process of forming WUAS and rehabilitating irrigation infrastructures in the chaotic post-soviet republics.

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DEGRADATION OF ARSENIC BEARING RESIDUALS IN A LANDFILL ENVIRONMENT DUE TO ANAEROBIC BACTERIA

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Poster Abstract 31

In January of 2001 the US EPA promulgated a new regulation for drinking water that reduces the maximum contaminant level (MCL) for arsenic (As) to 10 µg/L. This new standard will impact about 4,000 water utilities across the country, most of which rely upon ground water as their source of supply and therefore do not provide any current water treatment. The principal technologies for As treatment for small ground water utilities are adsorption onto metal oxide media and coagulation-precipitation using iron salts. All water treatment processes produce As bearing solid residuals (ABSR) that must be disposed of. A number of studies have been done which have found residuals from both adsorption processes and coagulation-precipitation processes are not hazardous as defined by the Toxicity Characteristic Leaching Procedure (TCLP). However, anaerobic bacteria present in a landfill may have the capability to reduce the solid ferric iron (Fe III) on which the As is adsorbed to soluble ferrous iron (Fe^{2+}). This reduction may cause As release beyond what is found during the TCLP. Cultures of Desulfovibrio desulfuricans, Shewanella putrefaciens, and a mixed culture from the Southside Water Reclamation Plant in Albuquerque, NM will be grown and exposed to the As bearing residuals under simulated landfill conditions. In addition to As release by iron reduction, sulfate reduction will be studied. Sulfate reduction will produce HS^- which may cause As stabilization as an AsS solid, hence causing As immobilization.

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ASSESSMENT OF WATER RESOURCE AVAILABILITY FOR OIL SHALE DEVELOPMENT IN THE WHITE RIVER BASIN

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Poster Abstract 32

Commercial prospects for oil shale development are under consideration in the Piceance Basin in Northwest Colorado. The hydrocarbon-rich Piceance Basin lies in a region with limited precipitation, where rivers must sustain water demands from municipal, industrial, and agricultural activities in addition to baseline environmental flows. Water resource competition would be augmented with the introduction of oil shale operations, which require approximately 3 barrels of water per barrel of oil produced.[1] This project aims to analyze the impact of climate variability on water availability for oil shale development in the Piceance Basin. Gauging data from the White River was used to perform three types of water availability analyses: (1) a time-series analysis to determine the duration and frequency of drought; (2) a Sequent Peak Algorithm (SPA) analysis of the reservoir storage capacity required to support uninterrupted oil shale operations; and (3) a drought return period analysis. In all analyses, three minimum streamflow thresholds were used to represent potential drought conditions for oil shale operations. Results indicate that streamflow in the White River will fall below all thresholds several times over a 100-year period of record. Findings thus demonstrate a need for water storage in a reservoir to ensure environmental flows during periods of drought. From the SPA analysis, a storage volume of 6,500 acre-ft is needed to sustain production of 250,000 barrels of oil per day. A storage volume of 15,500 acre-ft is needed to sustain production of 500,000 barrels of oil per day. Quantifying water shortcomings provides oil shale stakeholders with a basis to jointly assess how to minimize risks to oil shale operations while protecting instream flows. LA-UR-06-5321.

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[1] James T. Bartis et al., *Oil Shale Development in the United States* (Santa Monica: RAND Corporation, 2005), 15.

CHALLENGES IN PARAMETERIZING A LANDSCAPE EVOLUTION MODEL TO PREDICT 1000 YEARS OF EROSION AT A MESA-TOP WASTE REPOSITORY

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Poster Abstract 33

Low-level radioactive waste from operations at Los Alamos National Laboratory is currently being disposed in pits excavated into mesa-top repositories. One requirement for operation of the repositories is that no release of radioactive material will occur for up to 1000 years following closure of the repository. LANL is required to demonstrate that the repository can be successfully closed; including demonstrating that the waste pits will not be excavated by long term surface erosion processes. Here we describe the parameterization and application of the Siberia landscape evolution model in the optimization of the closure cap design for the Material Disposal Site G at LANL. The closure design is particularly challenging since some of the older waste pits are located near the edges of a slender finger mesa with complex topography. LANL scientists worked with the cap design engineer at URS in an iterative process to develop a stable design. In addition to design challenges, we faced significant challenges parameterizing the Siberia model for our site. Although we had multiple rainfall, runoff, and sediment data sets at a range of scales (plot, first order basin and watershed), these data were not complete enough to develop the relationships required to parameterize Siberia. The data did however provide a strong realty-check on rainfall-runoff and runoff-sediment yield relationships derived from the IRS9 and Hillslope Erosion (HEM) models respectively, which were ultimately used to develop parameter values for the fluvial erosion in Siberia. Diffusion was constrained by eye-balling a match between Siberia generated topography and the observed topography (field and ALSM data) at the heads of first order channels. Siberia runs that generated colluvial hollows (non-existent at this site) indicated that the diffusion coefficient was too high. LA-UR-04-6328.

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