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# **Potential Impacts of Global Warming on Water Resources: Lessons from the Upper Rio Grande Basin**

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The paper will discuss the use of climate projections from General Circulation Models to infer potential changes in available surface water in the upper Rio Grande basin. The upper Rio Grande basin refers to the basin from its headwaters in southern Colorado to its confluence with the Río Conchos immediately downstream of Presidio, Texas and Ojinaga, Chihuahua along the U.S.-Mexico border. This area is facing the multiple pressures of diminishing ground water, increasing soil salinity, deteriorating river ecosystems and rapid population growth. While public attention in the basin is focused on a current drought, proposed inter-basin water transfers, and over conflicts over planned transfers of surface water rights from agricultural use to municipal/industrial use, climate change may represent a more significant long-term issue as it has the potential of fundamentally altering land use/land cover patterns and significantly altering the supply of fresh water.

The flow of the upper Rio Grande is highly dependent on input from the mountainous headwaters in the Rockies. Snowpack in the higher elevations acts as a natural reservoir. This form of H<sub>2</sub>O storage has low albedo and, consequently, minimal evaporative loss. Downstream, numerous man-made reservoirs impound surface water for flood storage and for controlled release for irrigation purposes. Elephant Butte Reservoir, the largest of the basin's reservoirs, is located in southern New Mexico in the northern reach of the Chihuahuan Desert. When at capacity, this reservoir has surface area of 148 km<sup>2</sup>, evaporation loss from which is considerable. During the period from 1948 to 1995, evaporation pan data in the vicinity of Elephant Butte Reservoir averaged more than 280 cm annually.

A number of General Circulation Models (GCMs) have been developed for the purpose analyzing global warming trends based on projected increases in 'greenhouse gases' in the atmosphere. GCMs vary in their complexity, the most sophisticated of which attempt to integrate oceanic, atmospheric and biological components. GCMs divide the Earth's atmosphere into columnar grid structure creating a three-dimensional raster file. The magnitude of repetitive computations required to model global conditions over long time periods tax the ability of computers to process the information. Consequently, current generations of GCMs are relatively low-resolution and thus problematic to apply to individual river basins. Analysis of the output from GCMs is further confounded by significant differences, from one GCM to another, in projected future temperature ranges and precipitation.

Although fraught with uncertainty, several researchers assessed GCM output data, and their analyses suggest that impacts will become more exaggerated in downstream portions of western river basins. Reports from the Intergovernmental Panel on Climate Change indicate that surface air temperature increases in the arid regions of the western U.S. may be double global mean temperature increase, while precipitation may show a modest increase. The impact of these countervailing trends on streamflow varies with elevation: higher elevations in the upper Rio Grande basin are likely to experience a more rapid melt-off of snowpack, which may require new

reservoir construction or altered reservoir management; within the unaltered riverine habitat, altered timing of peak streamflows and lessened soil moisture and may impact aquatic and riparian communities; and, ecosystem adaptations throughout the basin may increase soil temperature and thereby contribute to increased evaporation. Projected temperature increases may have greatest impact in the lower portion of the river basin due to the increased evaporative loss from reservoirs and greater evapotranspiration from irrigated cropland. Basin-wide adaptive responses are needed.