Preface to special section on Fifty Years of Research and Data Collection: U.S. Department of Agriculture Walnut Gulch Experimental Watershed

M. Susan Moran,[1] William E. Emmerich,[1] David C. Goodrich,[1] Philip Heilman,[1] Chandra D. Holifield Collins,[1] Timothy O. Keefer,[1] Mark A. Nearing,[1] Mary H. Nichols,[1] Kenneth G. Renard,[1] Russell L. Scott,[1] John R. Smith,[1] Jeffry J. Stone,[1] Carl L. Unkrich,[1] and Jason Wong[1]

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[1] This special section of *Water Resources Research* and the associated Web site (http://www.tucson.ars.ag.gov/dap/) describe 50 years of data collection and the most recent research results at the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) Walnut Gulch Experimental Watershed (WGEW) in southeast Arizona. The goal of this compilation is to encourage cooperative, interdisciplinary studies of semiarid ecohydrology at WGEW based on continuing long-term measurements of soils, vegetation, hydrology, and climate.

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1. Introduction

[2] To understand the complex ecohydrology of semiarid regions, it is necessary to have long-term information on soils, vegetation, hydrology, and climate at a given location. Such data have been collected for decades as part of interdisciplinary experiments at the U.S. Department of Agriculture (USDA) Walnut Gulch Experimental Watershed (WGEW) operated by the USDA Agricultural Research Service (ARS) Southwest Watershed Research Center (SWRC) in southeast Arizona USA. WGEW is one of the most intensively instrumented semiarid experimental watersheds in the world, with a 10- to 100-year record of abiotic and biotic measurements and photographs. The task of making these data available to scientists and the public on an interactive Web site was daunting. Because measurements have been made continuously for over 50 years, the WGEW data set includes measurements made with both primitive and advanced sensors, and with data recording, collection and archiving technologies ranging from paper tapes to radiotelemetry.

[3] In association with the 50th anniversary of the establishment of WGEW, SWRC scientists committed to a Data Access Project (DAP) with the goal to promote analyses and interpretations of historic and current WGEW data by improving data access. The initial DAP objective was to provide Web-based access to continuous, quality-checked measurements of precipitation and runoff from over 125 gauging stations in WGEW. After a 2-year all-staff effort, this objective was met in 2003 with the development of the SWRC Web site (http://www.tucson.ars.ag.gov/dap/). Soon thereafter, DAP was expanded to put WGEW sediment, meteorological, soil moisture, vegetation, CO_2 and water flux, and geographic information system (GIS) data on line (Table 1) and to publish metadata for all WGEW long-term measurements along with the latest research results.

[4] The publication of this special section of *Water Resources Research* and the establishment of the AGU-approved Web site (http://www.tucson.ars.ag.gov/dap/) mark a milestone in the ongoing WGEW DAP [*Nichols and Anson*, 2008]. In 2008, there are over 20 manuscripts providing WGEW history, metadata, data access and recent results of WGEW data analysis. This special section is part of an AGU commitment to make high-quality data available for research by publishing metadata and approving Web sites. The goal of this *Water Resources Research* special section and the associated Web site is to encourage cooperative studies of semiarid ecohydrology on WGEW.

2. Description of WGEW

[5] WGEW is part of the USDA ARS Watershed Program in which fourteen ARS research centers are operating over 100 long-term research watersheds. WGEW is one of two ARS experimental watersheds on western rangelands and is the only one on southwest semiarid rangelands. The 150-km^2 watershed is located in the transition zone between the Sonoran and Chihuahuan deserts (31°43′N, 110°41′W) in southeast Arizona, surrounding the historical town of Tombstone. WGEW elevation ranges from 1220 to 1950 m, with desert shrubs dominating the lower two thirds of the watershed and desert grasses dominating the upper one third.

[6] The climate at WGEW is classified as semiarid, with mean annual temperature at Tombstone of 17.7°C and mean annual precipitation of 312 mm. The precipitation regime is dominated by the North American Monsoon with about 60% of the annual total coming during July, August and September. Summer events are localized short-duration,

[1]Southwest Watershed Research Center, Agricultural Research Service, United States Department of Agriculture, Tucson, Arizona, USA.

Table 1. WGEW Long-Term Measurements of Hydrology, Climate, and Vegetation[a]

Data	Instrumentation	Record	Reference
Precipitation	Current network of 88 gauges	1953 to present	*Goodrich et al.* [2008a]
Runoff	30 instrumented watersheds	26 to 47 years and continuing	*Stone et al.* [2008]
Sediment	7 instrumented watersheds and 10 stock tanks	Early 1960s to present	*Nichols et al.* [2008]
Standard meteorological measurements	Automated weather stations at Lucky Hills and Kendall watersheds, and Tombstone headquarters	1990 to present	*Keefer et al.* [2008a]
Soil moisture and temperature (multiple depths)	Sensors at Lucky Hills and Kendall watersheds	1996 to present	*Keefer et al.* [2008a]
	Sensors at 19 locations in WGEW	2003 to present	
Vegetation	Permanent transects at 13 to 55 sites across WGEW	1967, 1994, 1999, 2005, and continuing	*Skirvin et al.* [2008]
CO_2 and H_2O flux	Bowen ratio stations at Lucky Hills and Kendall watersheds	1997 to present	*Emmerich and Verdugo* [2008a]
Satellite- and aircraft-based images of WGEW	Multiple sensors in the optical and microwave spectrum	1984 to present	*Moran et al.* [2008]
GIS layers: soils, geology, geomorphology, vegetation, ecological sites, and more	NA	Current state	*Heilman et al.* [2008]

[a]Most data are available at SWRC Web site (http://www.tucson.ars.ag.gov/dap/). NA denotes not applicable.

high-intensity convective thunderstorms and winter storms are generally slower moving, frontal systems. Virtually all runoff is generated by summer thunderstorm precipitation and runoff volumes and peak flow rates vary greatly with area and on an annual basis.

[7] Hydrometeorologic and soil erosion/sedimentation data are collected from over 125 instrumented installations on WGEW. Precipitation is measured with a network of 88 weighing-type recording rain gauges arranged in a grid throughout the watershed [*Goodrich et al.*, 2008a]. Various runoff measuring structures are used to measure runoff from watersheds ranging in area from 0.18 to 14,933 ha [*Stone et al.*, 2008]. These structures include broad-crested V notch weirs, H flumes, Santa Rita supercritical flumes, stock ponds, and Walnut Gulch supercritical flumes. Currently there are 8 small (0.18–5.91 ha) watersheds, 10 medium (35–160 ha) watersheds, and 10 large (227–14,933 ha) watersheds that are instrumented. Sediment from instrumented watersheds is monitored with automatic pump samplers or total load automatic traversing slot samplers (*Nichols et al.*, 2008). Meteorological, soil moisture and temperature and energy flux measurements are made at two vegetation/soil complexes [*Keefer et al.*, 2008a; *Emmerich and Verdugo*, 2008a]. Permanent vegetation plots and transects have been established across WGEW to evaluate the impacts of management practices and global change on vegetation [*Skirvin et al.*, 2008].

[8] In 2000, SWRC reinstrumented WGEW with electronic sensors and digital data-logging capability combined with radiotelemetry to allow remote data monitoring and transmission. On a daily basis, all locations are automatically and sequentially queried and data are transmitted to a dedicated computer at the Tombstone field office. Data are archived, used to generate daily reports and written to the Tucson SWRC network server. This reinstrumentation greatly enhances our research and cooperative capabilities as well as maintaining the viability of hydrologic data collection and long-term continuous record [*Keefer et al.*, 2008b].

[9] In addition to the long-term, high-quality hydrologic data collection, hundreds of satellite and aircraft spectral images of WGEW have been acquired [*Moran et al.*, 2008] and extensive geographic information system (GIS) databases are available [*Heilman et al.*, 2008]. As a result, WGEW was chosen as one of 15 core sites worldwide by the International Community Earth Observing System (CEOS) for satellite product validation and calibration; WGEW has been designated as a global fiducial site by the EPA for collection of periodic satellite images for the next 25 years; and WGEW is a key experimental site of the NSF Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) Science and Technology Center.

[10] The impact of long-term data collection and research at WGEW on the current understanding of semiarid hydrology is evident [*Renard et al.*, 2008]. For example, the temporally continuous, spatially extensive WGEW precipitation database was used to develop the first depth-area-intensity relationships for semiarid convective air mass thunderstorms. WGEW was the site of the first quantification of transmission loss in ephemeral channels. The development and application of important prediction models have been based on parameterization and validation with WGEW data. The WGEW Santa Rita flume with its traversing slot sampler is the first widely used technology to measure runoff and sediment transport in ephemeral streams. Experiments designed at WGEW with the rotating boom rainfall simulator have produced the world's largest database of plot scale rangeland hydrology and erosion.

3. Recent and Future Research at WGEW

[11] The research reported in this special section supports the well-founded assertion that multidecadal data sets are crucial to studies of ecosystem change. WGEW has both spatially and temporally extensive measurements of precipitation, runoff and sediment yield, leading to unique research opportunities in spatiotemporal scaling [*Garcia et al.*, 2008; *Goodrich et al.*, 2008b; *Nearing et al.*, 2007]. The issues affecting vegetation in WGEW are similar to those identified throughout the southwest United States and

semiarid regions around the world, including desertification, impacts of climate change and urbanization. The combination of both biotic and abiotic data at WGEW offer a unique opportunity to study these issues [*King et al.*, 2008; *Emmerich and Verdugo*, 2008b; *Holifield Collins et al.*, 2008]. The spatiotemporal coverage of hydrological and meteorological data with extensive remote sensing and GIS databases has facilitated modeling of WGEW processes [*Peters-Lidard et al.*, 2008; *Yatheendradas et al.*, 2008]. The extensive database and history of modeling described in this special section should encourage parameterization of watershed models at WGEW for the entire period of record.

[12] WGEW is particularly well situated for future research on important issues confronting the western United States and semiarid regions. In central WGEW, instrumentation was installed to monitor runoff from small urbanized, partially developed and undeveloped watersheds. Combined with the archive of satellite- and aircraft-based imagery, it is possible to study the hydrological impact of urbanization on semiarid rangelands. Instrumentation at proximal shrub- and grass-dominated watersheds in WGEW offers a unique opportunity to study the hydrologic processes at these disparate vegetation communities and apply this information to understanding the larger impacts of regional shrub encroachment. These are only a few examples of the future research direction at WGEW, building on the long-term, interdisciplinary data set that has been made available in this *Water Resources Research* special section and the associated AGU-approved Web site.

[13] The land comprising WGEW is under the ownership and control of federal agencies, state of Arizona, private landowners or leaseholders. The research activities and access to the field sites are arranged in cooperation with the appropriate federal and state agencies and the private landowners or leaseholders. SWRC has made an effort to facilitate research at WGEW by maintaining a publication list and distributing semiannual newsletters to summarize the latest research results (both are available on our Web site at http://www.tucson.ars.ag.gov). Specific information for potential collaborators can be found at the Web site http://www.tucson.ars.ag.gov/dap/.

[14] **Acknowledgments.** We are indebted to the federal and state agencies, landowners, and leaseholders who own and control land in WGEW for their cooperation and patience. Because of the hard work and creativity of the SWRC technical staff in Tucson and Tombstone, research at WGEW has been both fun and successful. The insights of *Water Resources Research* special section Editors Chris Duffy, George Hornberger, and Scott Tyler and the suggestions of numerous anonymous reviewers greatly improved the presentation of data and research results.

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