Distribution and Application of Research Watershed Data

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Abstract

Research watersheds administered by the Agricultural Research Service (ARS) have collected valuable and unique hydrological data for more than 35 years. This paper describes the effort of one watershed to distribute that data to the public. A few examples of potential applications related to characterization of stream flow, sediment discharge and stream temperature are provided.

Keywords: hydrology, database, sediment, stream temperature

Introduction

The USDA-ARS currently maintains 13 research watersheds across the United States. ARS watersheds are distinct from other research watersheds in that land management on the watersheds is representative of regional agriculture and the hydrology therefore reflects management impacts. Although each watershed location is unique and conducts research specific to the local environment, they have in common intensive monitoring of hydrologic variables over many (in most cases >35 years) years.

The research watersheds may be thought of as outdoor laboratories for conducting hydrologic research. One product of these watersheds that has potential scientific and management applications is the database that results from long term, intensive monitoring. In many cases ARS watersheds are the only source of small order watershed data in the region.

One of the challenges confronting the watersheds is the dispersal of "clean", comprehensive data sets. By clean, we mean data that has been scrutinized for errors and, in some cases, made temporally complete, usually using correlation procedures. This step is tedious, time consuming and requires considerable expertise in both the instrumentation and local hydrology. Given the volume of data collected each hour and shifting personnel, data can easily be acquired much faster than it is processed. The result has been that, while ad hoc clean data sets are available upon request, each dataset requires a special effort and is rarely comprehensive. In addition, the true scope of potential data is rarely appreciated outside the research unit.

Currently there is an effort in the ARS to address this problem. In this paper we describe the approach taken by the Northwest Watershed Research Center, located at Boise, Idaho, which manages the Reynolds Creek Experimental Watershed (RCEW). We published a series of data reports describing the watershed database and made that data available electronically. In this paper we briefly describe those data reports. More information is available in the cited references. We then describe some examples of how experimental watershed data may be of value in addressing management concerns.

Reynolds Creek Experimental Watershed

The Northwest Watershed Research Center and RCEW were established in 1960 to develop fundamental information on runoff and erosion in a region where much of the available streamflow is derived from snowmelt, rain on snow and rain on frozen soil in rangelands. The 234 km^2 watershed is in the Owyhee Mountains 80 km southwest of Boise, Idaho, and is representative of snow-dominated high-relief, mixed-vegetation rangeland watersheds of the interior Pacific Northwest and northern Great Basin. Elevation ranges from 1098 m to 2254 m msl. Annual precipitation ranges from less than 250 mm at lower elevations to over 1000 mm at higher elevations, where 75% of annual precipitation is snow. Rangeland plant communities are dominated by sagebrush, bitterbrush, encroaching juniper, and perennial and annual grasses and forbs. Douglas fir and aspen stands are found in high-elevation snow accumulation areas. Land

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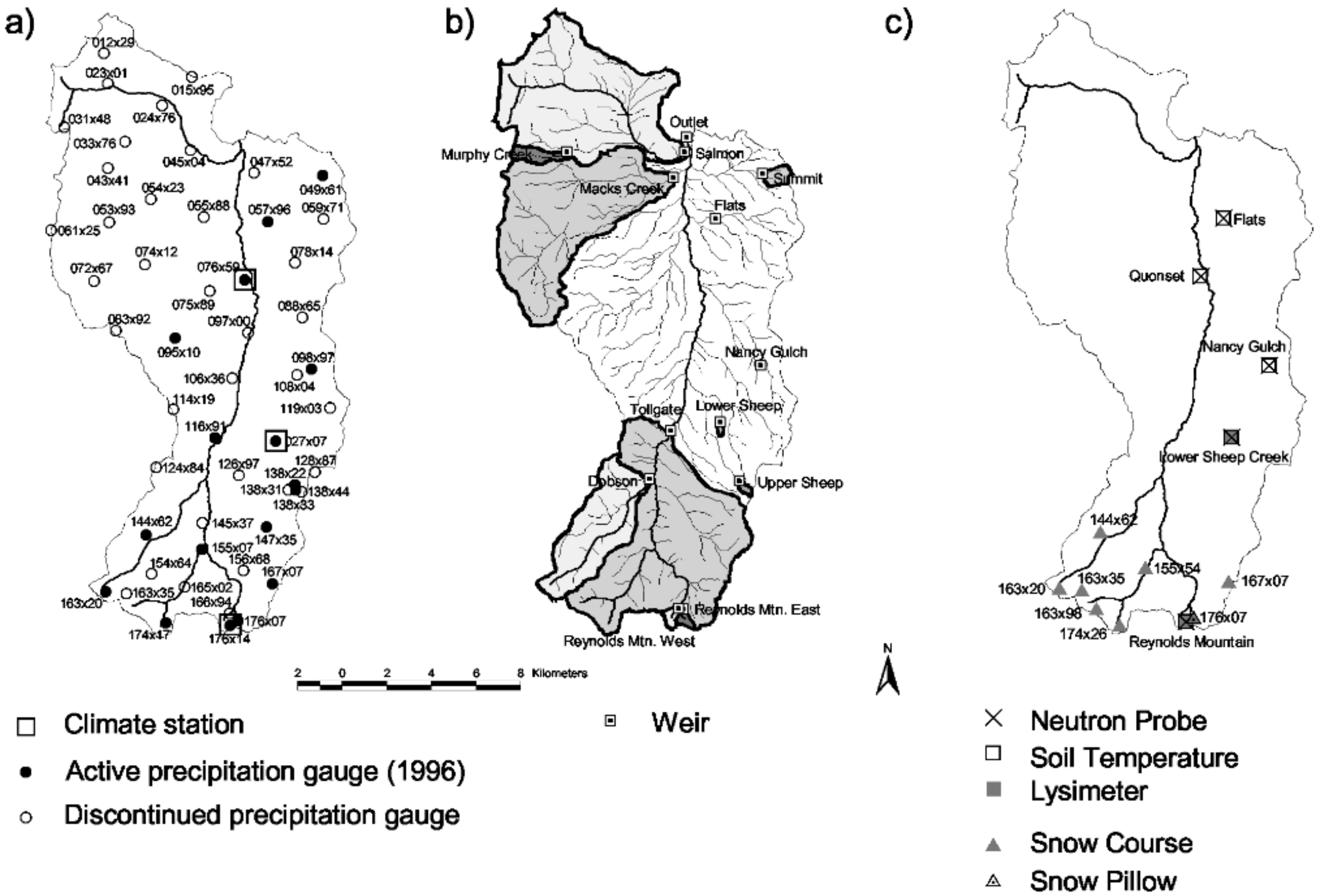

Figure 1. Location of primary instrumentation presented in the data reports.

ownership is 23% private and 77% public. All public lands are under grazing allotment. Hay production and grazing are primary uses of private lands. Wildlife (including a wild horse herd) and year-around recreation are increasingly important resource uses. All research is conducted within the context of a landscape managed under practices common to western resource management agencies and private producers.

Data reports

Instrumentation at the watershed is constantly changing. The published data reports represent the network and data collected between 1961 and 1996 (Slaughter et al. 2001). As of 1996, the RCEW network included 18 dual-gauge precipitation sites, three comprehensive climate stations, seven snow courses and nine stream gauging stations (Figure 1). Data are linked to a relational data base and archive in Boise via real-time radio telemetry with automated data quality checking protocols.

The methodology for gathering data has gone though a vast change since the establishment of the RCEW. Data recording has evolved from spring-driven chart recorders, which were reduced and digitized by hand, to the design and construction of custom data loggers and telemetry systems, to the current use of standard commercial data loggers, instrumentation and telemetry. This has significantly reduced the time and cost of maintaining the database and allowed us to take full advantage of the technological advances in electronics during the last decade.

There are eight published data reports that describe the data collected. Data are presented, along with tables showing the period of record, number of measurement sites, methods used, and examples of how each data set has been used in publications over the years. These are summarized, excepting the geographic database, which is in a different format, in Table 1.

Table 1. Summary of data presented in the data reports.

Data Report	Parameter Measured	Number of stations Maximum	Number of stations 1996	Years of Record	Sampling Interval
Precipitation	shielded precipitation	53	17	1962-1996	breakpoint
	unshielded precipitation				
	calculated precipitation				
Snow	snow course SWE	8	8	1961-1996	biweekly
	snow pillow	1	1		15 min
Daily Climate	T_{max} and T_{min}	3	3	1964-1996	daily
	pan evaporation	3	3	1974-1996	15 min
Continuous climate	humidity				
	solar radiation				
	wind speed, direction				
	barometric pressure				
Soil Lysimeter	lysimeter water	4	0	1976-1991	hourly
Neutron Probe	soil water content	18	14	1970-1996	biweekly
Soil Temperature	soil temperature	5	5	1981-1996	15 min
Discharge, Sediment	suspended sediment	3	3	1965-1996	event based
	stream discharge	13	8	1963-1996	breakpoint, 15 min

In the geographic data report (Seyfried et al. 2001a) both spatially continuous and spatially discrete site location data are presented for all parameters described in the reports. The spatially continuous data are georeferenced to a 30 m digital elevation model (DEM) UTM projection derived from U.S. Geological Survey contours. In addition to basic topographic data from the DEM, this report includes watershed boundaries, stream channel locations, geology, soils, vegetation, land ownership, and road network data. These are available as 14 separate layers.

The precipitation report (Hanson 2001) contains data from 53 sites (Figure 1a). The period of record varies from as little as 6-8 years for a few sites to 35 years for 15 of the sites. Included with the precipitation data are measurements of shielded and unshielded precipitation and the computed wind-corrected value.

In the snow data report (Marks et al. 2001), 35 years of biweekly data from eight snow courses and 14 years of hourly snow water equivalent data from a snow pillow operated in the upper portion of the watershed are presented. Locations of the snow measurement sites are shown in Figure 1c. The snow course data include average snow water equivalent and snow depth taken along each snow course.

Climate data (other than precipitation) from three sites (Figure 1c) is presented by Hanson et al. (2001). It consists of 35 years of climate data from three sites, including daily values of maximum and minimum air temperature and pan evaporation. Since 1981, a number of climatic variables have been measured hourly (Table 1).

Basic soil water content and temperature data are presented in the lysimeter (Seyfried et al. 2001b), neutron probe (Seyfried et al. 2001d) and soil temperature (Seyfried et al. 2001c) data reports. Neutron probe data at several sites (Figure 1c) has been collected for over 25 years and consists of multiple depths. The lysimeters functioned for about 12 years and were used to check the neutron probe calibration. The soil temperature data, to a depth of 180 cm, has been functional since 1981 at 5 sites (Figure 1c).

Pierson et al. (2001) present hourly and breakpoint streamflow data from 13 weirs (Figure 1b). Nine weirs are currently in operation, with periods of record ranging from 23 to 35 years. Suspended sediment data were collected by manual sampling and several different automated samplers on an event basis.

Data availability

Data presented in each of these reports are available from the anonymous ftp site: ftp.nwrc.ars.usda.gov in the directory “databases/rcew” maintained by the USDA Agricultural Research Service, Northwest Watershed Research Center in Boise, Idaho. Each type of data presented is stored in an appropriately named subdirectory as ASCII files that have been compressed using a standard “zip” compression utility. Each file has an ASCII header providing brief information on file contents, location (Easting and Northing, UTM zone 11), both the GPS elevation and the DEM elevation, time format, period of record, column contents and units, missing data key, contact, citation and disclaimer information. In addition, a subdirectory contains a viewable version of a more detailed description of each data set, including additional photographs, data analysis, and graphical data presentation, that is stored in PDF format as intro.pdf geog.pdf, precip.pdf, climate.pdf, snow.pdf, soil_micro.pdf, and flow_sed.pdf. An ASCII README file in each directory gives a detailed description of the file formats and contents.

Example Applications

The existence of the basic data and scientific infrastructure facilitates research into many topics. Some examples of current research at the RCEW include, effects of fire on hydrologic response and cattle grazing: subgrid variability of remote sensing pixels, and effects of wind redistribution and canopy variation on snow melt and stream flow dynamics. The data are also informative for a number of management related parameters.

Characterization of stream flow

Basic stream flow data for smaller order streams is often lacking but management of watersheds may require some characterization of the stream flow regime. Questions arise such as: Were samples collected during a “typical” year? What are high or low stream discharge levels? How does flow vary downstream? Data collected from a research watershed are site-specific but can provide considerable insight into these and other questions within the region, especially considering the general lack of such data and the fact that many years of data collection are required to establish a valid statistical relationship.

In Figure 2, average monthly stream discharge from three sites along Reynolds Creek (Figure 1) are shown. Although the overall seasonality of flow is similar for all three locations, the relative distribution changes considerably downstream as the source areas become more variable. Discharge increases downstream, although the change from Tollgate to the Outlet is small considering that the Tollgate drainage area is only about a quarter that of the Outlet.

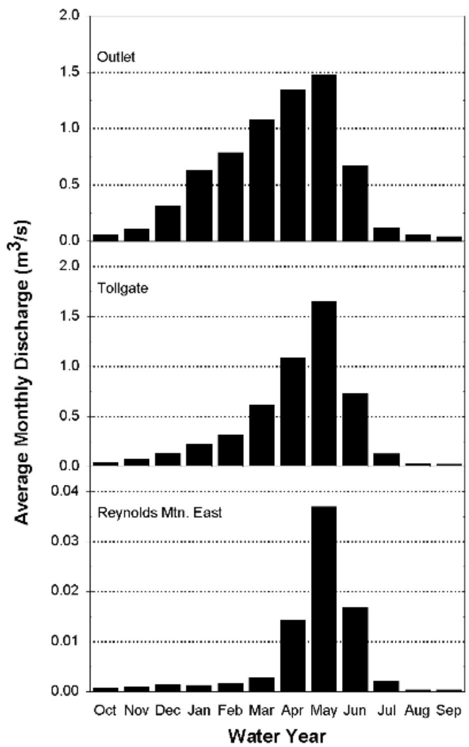

Figure 2. Average monthly stream discharge from three locations on Reynolds Creek.

Sediment discharge

Sediment discharge is of great concern in many watersheds, but numerous questions surround the issue of sampling. Although sediment concentration is generally related to stream discharge level, it is also strongly dependent on whether stream discharge is increasing or decreasing, the nature of the event causing discharge and the nature of the source area for discharge. Figure 3 shows suspended sediment concentrations at three locations along Reynolds Creek (Figure 1). Note that concentrations were much higher for a given level of discharge when stream flow was increasing than when it was decreasing. There was very little suspended sediment at Reynolds Mountain East when flow was generated by snowmelt, but increased dramatically during a rainfall event. Some of the highest sediment

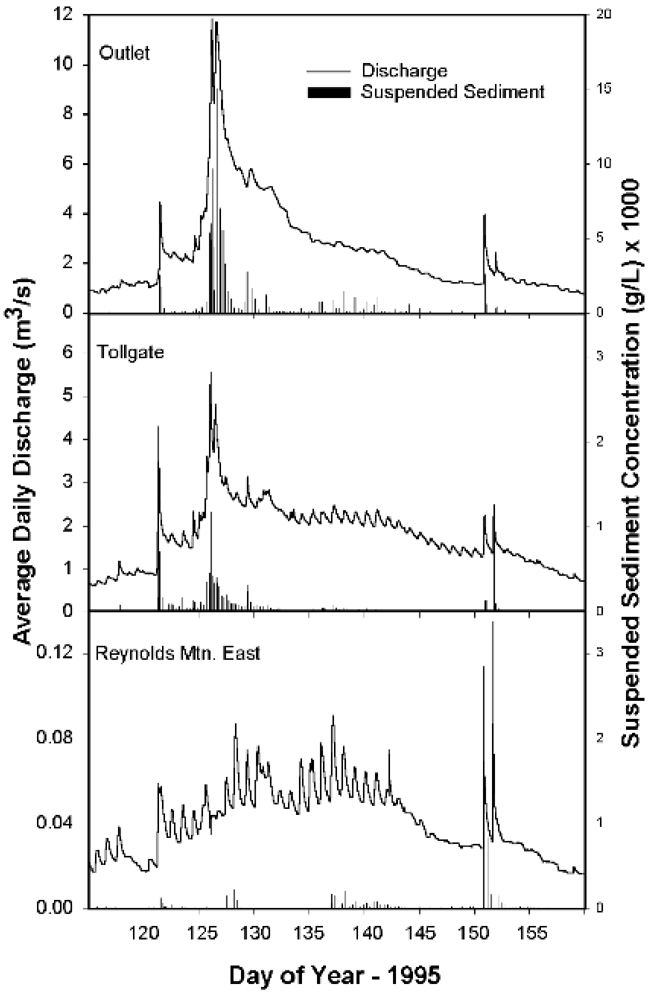

Figure 3. Average daily discharge rate and associated suspended sediment concentration for Outlet, Tollgate, and the Reynolds Mountain East watershed during spring flow in 1995.

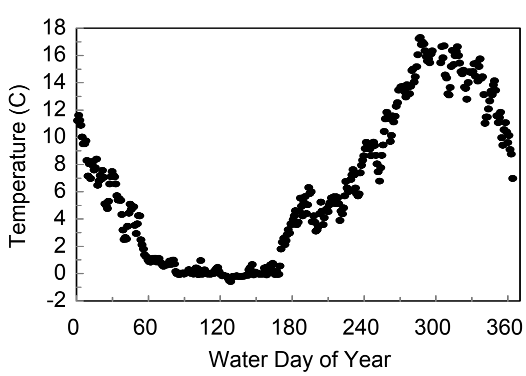

Figure 4. Noon-time well-mixed stream temperature at the Dobson Creek weir for one year.

concentrations we observe result from conditions in which the lower elevation, sparsely vegetated areas of the watershed contribute to stream flow.

Stream temperature

As needs change, so does the nature of data collected at the watersheds. Stream temperature was not collected at the RCEW prior to 1997 and therefore not included in the data reports. However, as stream temperature has become an issue of increasing interest, a stream temperature monitoring program has begun. The data presented here were collected at the weir throat and represent a mixed water condition. Although this may not be the most critical temperature for fish survival, it does represent an index of how temperatures vary with time and space within a watershed.

As with sediment concentration, there are several issues related to sampling of stream temperature. Again, stream temperature is related to discharge level, but also exhibits pronounced seasonal and diurnal variations. These factors should be taken into consideration when characterizing stream temperature.

In Figure 4 we show the variation in stream temperature at noon each day for one year taken at the Dobson Creek weir. During the winter, temperatures are close to freezing as the weir is often covered with snow and/or ice. Temperatures are most variable during the spring, when discharge may be derived from either snowmelt or rainfall. Another period of high temperature variably is in late summer, when temperatures are near maximum.

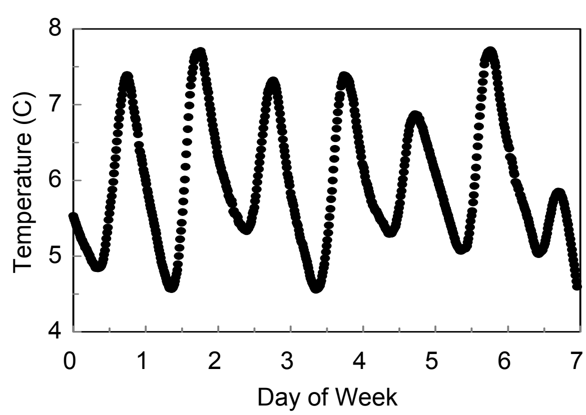

Figure 5. Stream temperature measured at the Dobson Creek were at 15 minute intervals from May 1-7, 2002.

Another concern is the amount of diurnal temperature fluctuation. Stream temperature, measured on 15 minute intervals from 1 May to 7 May, 2002 at the same site are shown in Figure 5. Stream temperatures at the weir ranged 2 to 3 °C during the day. Although the signal is considerably damped relative to air temperature, it is clear that air temperature variations are reflected in the stream temperature. Maximum temperatures during this week occurred between 5 and 6 PM. Temperatures at noon were much closer to the minimum than the maximum.

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