USDA

United States Department of Agriculture

Natural Resources Conservation Service

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NRCS

A Measure of Snow

A Report Based on Case Studies of

The Snow Survey and Water Supply Forecasting Program

Helping People Help the Land

www.wcc.nrcs.usda.gov

Photo courtesy of Paul Smidansky

Snow Measurements and Water Supply Forecasting

Dr. James E. Church

SNOTEL stations automatically collect data. Other sites require NRCS conservation professionals to access the site and manually collect the data.

Snow depth and snow water content data have been collected and disseminated throughout the Western United States for over 100 years. Early snow survey and water supply data were gathered through the efforts of university scientists, beginning with the work of Dr. James E. Church. In 1935, the Soil Conservation Service (SCS), now the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), established a formal cooperative Snow Survey and Water Supply Forecasting (SS-WSF) Program. The Agency was charged with responsibility for "conducting snow survey and water supply forecasts and the forecasting of irrigation water supplies." The new Program would also develop consistent methods for measuring snow and reliable models for accurate water supply forecasting.

Administered by NRCS, the SS-WSF Program has grown into a network of more than 1,200 manually-measured snow courses and over 750 automated Snowpack Telemetry (SNOTEL) weather stations in 13 Western States, including Alaska. (See map on page 4.) The SS-WSF Program provides manual snow course data collected by NRCS conservation professionals, automated SNOTEL data, and modeled water supply/streamflow volume data as well as issues streamflow forecasts for over 740 locations in the West. The data and the related reports and forecasts, are made available—in near real time for the automated SNOTEL sites—to private industry; to Federal, State, and local government entities; and to private citizens through an extensive Internet delivery system and other distribution channels.

With 50-80 percent of the water supply in the West arriving in the form of snow, data on the snow pack provides critical information to decisionmakers and water managers throughout the West. The basic data become even more valuable when used in concert with partner organizations to provide water supply forecasting tailored to meet end-user needs. According to researchers from multiple U.S. and international agencies, research centers, and academia, changes in the world's climate have resulted in a loss of predictability in weather, precipitation, and water transport and accumulation patterns. It is anticipated that the value the SS-WSF Program provides to society will increase over time as climate variability increases.

Recently, a study was done to analyze who uses SS-WSF data, how the data are used, and the value of the data. Users of the data were interviewed and specific events and activities were analyzed. This publication is based on that study.

Summer maintenance on a SNOTEL site.

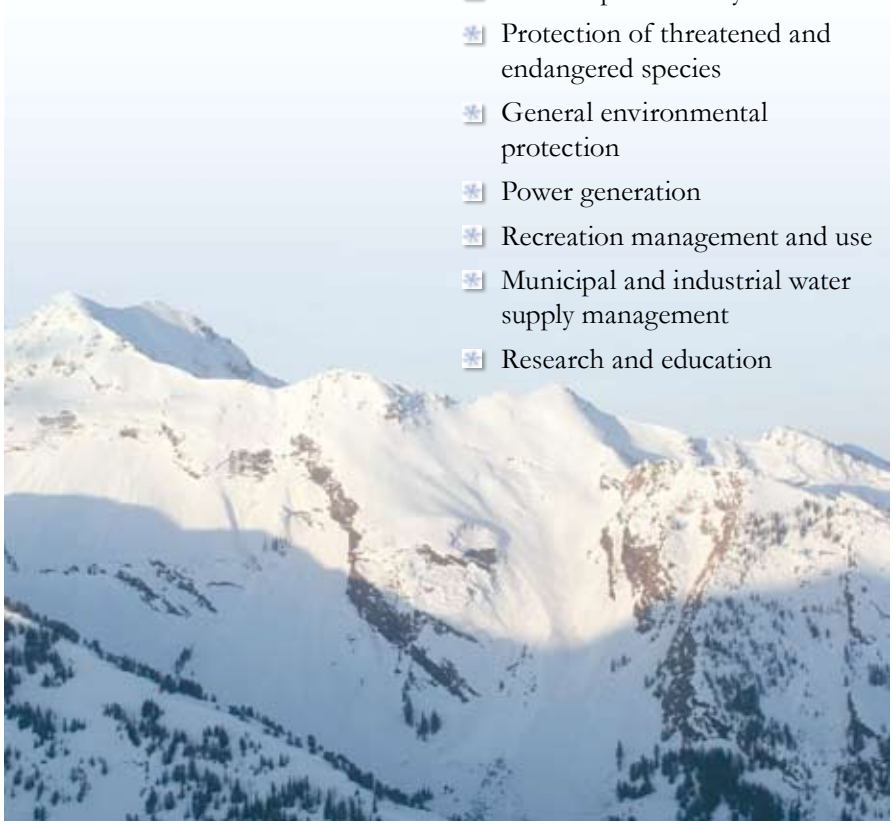
[1] Mille, P. C. D., et. al.. "Stationarity is Dead: Whither Water Management?," Science. Volume 319, February 2008, pp. 573-4.

The Value of Reliable Information

Reliable information helps reduce uncertainty in making critical environmental, agricultural, industrial, and municipal management decisions based on annual and multi-year water supplies and streamflows within specific watersheds and sub-basins in the Western U.S. These decisions may be long-term, strategic-planning decisions; logistical, tactical, and operations planning decisions; short-term planning decisions; or immediate, reactive decisions.

Some of the critical decisions that require reliable water supply information are:

- Reservoir management
- Irrigation water management
- Cropping decisions
- Production estimation (Commodity futures markets)
- Risk management related to agriculture
- Planning and scheduling of water-related business and/or government activities
- Flood damage prevention
- Drought risk reduction
- Climate change risk assessments for long-term water availability
- Emergency response and emergency preparedness
- General public safety
- Protection of threatened and endangered species
- General environmental protection
- Power generation
- Recreation management and use
- Municipal and industrial water supply management
- Research and education



Measuring snow samples provides data used in water forecasting.

NRCS works with the National Weather Service and the media to provide winter snowpack and spring runoff information to the public.

Some individuals and organizations obtain and use the SS-WSF data directly, whereas others benefit from the data indirectly through modeling or other forecasting methods. Regardless, the value of timely, accurate information about snow pack and future water supplies is critical to many management decisions.

The reputation of NRCS is also a key factor in the reliability of the data and the information. According to one SS-WSF Program data user, a television weather reporter who was interviewed for the study, the expertise of Agency SS-WSF personnel is key to his ability to trust the information and to know that the data he is presenting to the public are accurate and relevant.

The National Weather Service (NWS) operates River Forecast Centers (RFCs) covering all of the U.S. In the mountain regions, the RFCs produce predictions, flood prediction, and other hydrologic and weather-related data products for the Western regions of the U.S. and part of lower British Columbia. They depend on NRCS SS-WSF Program data for the snowpack and water supply components of their data analysis and forecasting systems.

The river forecasts, along with NWS flood warnings, help save lives and give communities time to take appropriate actions to lessen flood damage. SNOTEL data are used to validate and adjust the amount of snow and snowmelt simulated in a hydrologic model which produces more accurate forecasts. These daily river forecasts are also used during non-flood periods for recreational purposes (rafting, kayaking, fishing, etc.).

Snow Survey and Water Supply Forecasting Program Area

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Case Studies

Case studies were conducted with a variety of users to assess the value of the data and the value of the Program in decisionmaking. Over 100 identified users of the information were interviewed as part of the study.

Although this study does not provide a comprehensive economic value of the SS-WSF Program, the users identified in this study provide clear evidence of the substantial value of the Program in both monetary and non-monetary benefits.

"You will know the value of water when the well goes dry."

- Benjamin Franklin

Production Agriculture

Despite the variety of agricultural operations in the Western U.S., a common denominator is some degree of dependence on a diverted or stored water supply. Although there is a large amount of dry (non-irrigated) cropland within the region, water is the essential resource in producing the agricultural products and irrigation is an essential agricultural production practice.

The Census of Agriculture reported that in 2003, there were over 52 million acres of irrigated land in the U.S. producing approximately $50 billion in agricultural output. Half of the water applied to those acres came from surface sources and 60 percent of the farms are in states benefiting from SS-WSF Program data.

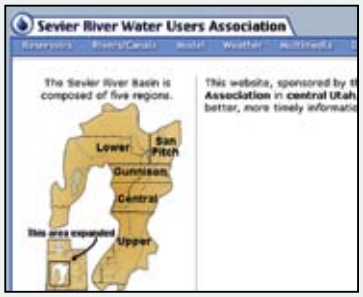
SS-WSF Program information influences production decisions on millions of acres of surface-water dependent, irrigated agricultural lands. Knowing how much water they will receive based on the total water supply and the relative seniority of their water rights enables producers to make cropping decisions that optimize their outcome in given water supply conditions.

Based on water supply information, producers could change the crops they grow.

Alfalfa is widely grown in the West for feeding livestock. Irrigated fields often allow multiple cuttings.

Case Study – Sevier River Basin, Utah, Alfalfa Growers

From the mid-1990s until the water year of 2005-06, the Intermountain West experienced drought conditions that ranged from mild to severe, depending on the specific location. During this drought, the local water commissioner operated the reservoir and diversion system based on a drought-response management plan using SNOTEL data. At the same time, alfalfa growers within the Sevier River watershed based their production decisions in part on the information provided by the SS-WSF Program and the SNOTEL system. Taking the water supply information into account, many producers adjusted their cropping operations to compensate for the dry conditions and counteract the water shortage they faced. By using the water they did receive to grow "horse" hay for out-of-state markets, they were able to sell at a market price that was significantly higher than that of standard local "cattle" hay, and avoided suffering economic losses during the drought. The average annual market-based benefit to these producers was approximately $15.57 million with a total benefit of approximately $109 million.



Graphic Source: Sevier River Water Users Association Website

Case Study – Twin Falls, Idaho, Agricultural Producers

In southern Idaho, producers in the Salmon Falls and Twin Falls irrigation tracts rely on SNOTEL data and stream forecast information as input in making decisions about what, when, and how much to plant. Irrigation district managers within this region use SS-WSF Program data and forecasts early in the season to inform their water users on the percentage of their full irrigation allotment they should expect to receive in the upcoming growing season. These irrigation allotment predictions are based on SS-WSF data that show (1) the probability of varying levels of water supply given existing snowpack, soil moisture, and water content; and (2) historic probabilities for additional snowpack and water content accumulations. These reports are crucial to producers who use them to make cropping and operation decisions well in advance of the growing season. Based on modeling of the typical cropping patterns in the area for a 160-acre farm, the value of the USDA NRCS SS-WSF Program data to producers in this region is estimated as ranging from $27 per acre in a normal year to $111 in a water short year. Based on irrigated acres in those areas, the total value to producers is estimated to be as much as $21.8 million in a water short year.

Gates allow producers to control irrigation water to their fields.

Some irrigation systems flood the fields.

SS-WSF Program information is critical both for crop inputs and water availability at major brewery plants.

Photo courtesy of Anheuser-Busch, Inc.

Case Study – Anheuser-Busch Agricultural Contracting

Anheuser-Busch depends on SS-WSF Program data as a primary input in contracting supplies of barley in Idaho, hops in Washington, and grain from many States and Canada. According to Anheuser-Busch, approximately 70 percent of farmers' acres of production are under contract rather than purchased on the end-of-season spot market. Reliable information enables Anheuser-Busch to make decisions on input, production, and supply far ahead of time. Their decisions are sometimes made as far as 1.5 years in advance which provides stability, predictability, and higher profitability to their operations.

Recreation

Tourism is one of the largest industries in the Western States. Many categories of tourism and recreation are, in one way or another, dependent on or affected by either snowpack levels, water supply volumes, or both. Commercial and private users of SS-WSF Program data include recreation associations, hunters, fishermen, boaters, skiers, snowmobilers, campers, tourists, and others whose recreational activities or travel plans might be affected by snow depths or streamflows. The users' interests in SS-WSF Program data fall into two main categories that are not necessarily mutually exclusive: safety and the quality of a planned recreational experience.

Recreationalists use SNOTEL data on snowpack levels at ski areas and runoff levels on streams for rafting or fishing.

Case Study – River Rafting Outfitters

An outfitter operating a river rafting business in the Intermountain West reported that SNOTEL data had indicated that river conditions would render their traditional rafting equipment inoperable in the 2002 season—ultimately the worst season on record for rafting in the area. Based largely on the Program information, the firm purchased $50,000 worth of smaller craft that would be operable in the environmental conditions predicted by the data.

Without the advantage of streamflow projections prior to the beginning of the rafting season, the low water levels would have resulted in a year with little to no revenue. Instead, the decision to purchase the smaller craft resulted in a $600,000 revenue year. In an interview with the outfitter, they stated that without the SS-WSF Program information, they would have had "a zero dollar year" in revenue for the 2002 river-running season.

Another outfitter reported a similar outcome during the 2002 low-water year. The value of Program data for that outfitter was estimated at $3.5 million in avoided losses.

Photo courtesy of Dennis Loreth

Photo courtesy of Dennis Loreth

Flood Management

The SS-WSF Program helps government and communities make informed reservoir management decisions to reduce potential flooding. NRCS scientists and engineers use the data in forecasting models to predict the timing and volume of peak flows. The use of that information can minimize flood damage on critical river segments. According to one government employee, without the availability and reliability of that information, they could make a decision to release or hold water that could "potentially be a disaster."

Case Study – Oakley, Idaho

During the winter of 1983-84, record amounts of snow accumulated in the hills above Oakley Reservoir. In January 1984, SCS issued a SS-WSF Program bulletin stating that snowpack amounts in southern Idaho were as much as 300 percent of normal in places. Lower Goose Creek Reservoir, also known as Oakley Reservoir, above the town of Oakley, Idaho, had filled only once since its construction. Over decades, the natural outlet channel had filled in with farms, homes, businesses, and other infrastructure. It became apparent that due to the high snowpack, the reservoir was going to spill, threatening widespread and devastating damage in the community.

In an unprecedented effort, the U.S. Army Corps of Engineers, the National Guard, SCS, canal companies, State and local government entities, local civic groups, businesses, religious organizations, and individuals worked together to design and build a canal to safely channel water to the Snake River. The project succeeded in preventing any serious damage to the land or the community. An SCS estimate put the value of damage protection for farmland alone at $60 million—$112 million in 2005 dollars—an amount that does not include potential damage to buildings and infrastructure within Oakley and other downstream communities.

Case Study – Utah 2005 Flood Preparation

During the runoff season of 2005, many streams set record high flows. In spite of these high flow levels, flood damages were very limited in magnitude. Local and State officials credited that low level of flood damage to the advanced warnings supplied by NRCS SS-WSF Program reports and presentations.

Benefits are observed by contrasting the experience of 2005 which made extensive use of SS-WSF Program information, to the two flood years of 1983 and 1984 when the snow water content of the spring snowpack was similar. In 1983-84, total damages in the State of Utah reached over $660 million in 1983-84 dollars (approximately $1.35 billion in 2005 dollars). The flood damage prevention value of SS-WSF data in Utah in 2005 was estimated as equal to half of the 1983-84 losses, or $626 million in 2005 dollars. Although some of this amount is potentially offset by infrastructure improvements made in response to the 1983-84 floods, it does not take into account the significant amount of urban and suburban development that occurred between 1984 and 2005.

On Coal Creek, a stream which flows through the town of Cedar City, the total runoff in 2005 was estimated at approximately 75,300 acre-feet of water compared to the historic average of approximately 21,000 acre-feet. In spite of the extremely high volume of water that passed through the community, flood damages were minimal due to advance preparations that were taken based on SS-WSF Program data and information. The City estimated the value of the homes protected at approximately $15 million which does not include the value of businesses, public facilities, schools, and infrastructure.

Municipal and Power

Power, utility, and water companies use the SS-WSF data in their long-range planning decisions. They can also use the data in forward contracting for purchasing and selling power in the wholesale market.

Case Study--Denver Water Board

Denver Water Board uses SNOTEL real-time snowpack and water supply forecast information as input for their reservoir management decisions. If decisions were based only on the historic water supply averages, they could lose as much as $5.5 million annually in potential revenue due to suboptimal transfers of water between the various storage reservoirs within their collection and distribution system.

Photo courtesy of Bureau of Reclamation.

Case Study--Idaho Power

Idaho Power uses NRCS SS-WSF Program data in their decisionmaking for reservoir and cloud seeding operations. Modeling their management decisions without access to SS-WSF Program data, Idaho Power determined they would expect a reasonable error factor of about 5 percent in reservoir operations decisions. This would result in as much as $18 million in lost annual revenue.

The Bonneville Dam on the Columbia River provides power for many communities. Changes in water levels or releases of water must be managed to protect critical salmon habitat on the Columbia and its tributaries.

Conclusion

In summary, analyzing the value of the SS-WSF Program—even with the limited number of case studies examined--shows that the Program is definitely providing net economic benefits to the U.S. economy and to society as a whole. Should climate variability increase—as is expected by many of those interviewed for the study, and as current climate research strongly suggests—the value of the data generated by the NRCS SS-WSF Program will increase accordingly.

Interviews conducted with decision-makers who use the data revealed:

- An absolute reliance on the near real-time data collected by the SNOTEL network for routine, critical, natural resource management and flood forecast decisions for the public good or profit (agricultural, power generation, or recreational decisions for economic gain);
- An unbiased water supply volume forecast plays a critical role in planning and executing water management decisions ranging from an individual farmer's decisions to basin-wide, multiple-use decisions;
- The need for reliable, real-time, Internet-based access to data and water supply products; and that
- Customers place a high value on the integrity of the NRCS SS-WSF Program data.

The Snow Survey and Water Supply Forecasting Program provides a unique, reliable data and information source that is critical to managing limited water supplies in a manner that can achieve economic, social, and natural resource goals in the Western U.S.

Acknowledgement

The information in this Summary is based on an analysis of the USDA NRCS National Water and Climate Center, Snow Survey and Water Supply Forecasting Program. The study was completed by Julie Suhr Nelson, economist, NRCS Utah, and other conservation professionals who assisted in providing information.

The USDA NRCS National Water and Climate Center is located in Portland, Oregon. For more information on the Center or the Snow Survey and Water Supply Forecasting Program, go to the website at http://www.wcc.nrcs.usda.gov/, or contact Michael Strobel, Director, 503-414-3055.

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