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A Review of the Forest Service Remote Automated Weather Station (RAWS) Network

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Abstract

The RAWS network and RAWS data-use systems are closely reviewed and summarized in this report. RAWS is an active program created by the many land-management agencies that share a common need for accurate and timely weather data from remote locations for vital operational and program decisions specific to wildland and prescribed fires. A RAWS measures basic observable weather parameters such as temperature, relative humidity, wind speed, wind direction, and precipitation as well as "fuel stick" temperature. Data from almost 1,900 stations deployed across the conterminous United States, Alaska, and Hawaii are now routinely used to calculate and forecast daily fire danger indices, components, and adjective ratings. Fire business applications include the National Fire Danger Rating System (NFDRS), fire behavior, and fire use. Findings point to the fact that although the RAWS program works and provides needed weather data in support of fire operations, there are inefficiencies and significant problem areas that require leadership attention at the National level.

Keywords: weather data, fire business, fire use, National Fire Danger Rating System, NFDRS, fire danger, RAWS, forest fire, wildland fire, weather observations, prescribed burns

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Contents

Introduction

All fire managers and fire weather forecasters rely on weather data from Remote Automated Weather Stations (RAWS). Incident meteorologists (IMET) forecasters from the National Weather Service and predictive service meteorologists from Geographic Area Coordination Centers (GACC) (see Glossary for terms and acronyms) extol the critical importance of the RAWS network for their daily work. In response to a RAWS-use survey, a Nevada IMET writes, "Having the weather data is critical to making forecasts for the future. Without data, we have no idea if we are making reasonable forecasts." A respondent from New Mexico asks, "If you don't have the ground-truth data, how can you make an intelligent decision?" An IMET from Missouri writes, "This is our only source for 10-hour fuel moisture determinations which are a key component in our Fire Weather Watch and Red Flag Warning decisions."

GACC meteorologists use RAWS data on a daily basis to calculate localized fire danger indices, components, and intermediate fire-related products. Comments from GACC meteorologists in the Rocky Mountain Area Coordination Center (RMACC), the Southwest Area Coordination Center, and the Eastern Great Basin Coordination Center range from, "Without high-quality fire weather data, how can we generate quality products to support fire business?" to "If I don't get operational support for the RAWS network in this Region, I'll do it myself…." In some geographic areas, such as places where maintenance of RAWS stations is a low priority and data quality has not been acceptable, GACC meteorologists have recently become directly involved in RAWS operations.

Given the severe fire seasons in recent years, it has become clear that we need to ensure that the overall effectiveness of the Forest Service RAWS network continues. Thus, there is a need to revisit the RAWS system to ensure high-quality, useful fire weather data. This report examines the extent to which RAWS affects fire management at all levels and explores opportunities for improvement.

We were selected to generate this report because we had no prior working knowledge of RAWS or of its integrated fire business role. This lack of working experience with RAWS allowed us to function as unbiased reviewers. It has been a challenge to understand the intricacies of RAWS, the interagency nature of the network, and to separate RAWS facts from myths. But Forest Service (FS) and Bureau of Land Management (BLM) personnel directly involved with RAWS and fire business have been extremely helpful and patient during the preparation of this report.

We were specifically asked to focus on the FS's RAWS network because the FS manages its RAWS differently than other agencies. Given that RAWS is an interagency program, it was impossible to completely segregate FS RAWS. Rather than restricting the final report to FS RAWS, we decided to make it inclusive of all RAWS-related parts. In order to give the reader as complete a picture as possible, we also decided to include many loose ends that have RAWS implications. Hence, we hope this review document will serve not only a useful role in understanding and improving FS RAWS, but also as an interagency RAWS reference.

What Is RAWS?

Many Federal, State, and other wildland resource management agencies share a common need for accurate and timely weather data to make vital operational and program decisions related to all aspects of wildland and prescribed fires. In the mid-1970s, the Forest Service (FS) and Bureau of Land Management (BLM) began research, development, and deployment of a RAWS utilizing a satellite data transmission system, the Geostationary Operational Environmental Satellite (GOES). RAWS has been developed using input from many operational users. The RAWS network has evolved into a valuable interagency resource providing essential weather data from remote locations nationwide for critical fire business support and decisionmaking.

The RAWS network as a whole is a weather station mesonet, which is defined as a collection of surface observing stations that cover a region in sufficient detail both in space and time to be able to monitor and nowcast the progression of mesoscale weather features (structure of fronts, outflow boundaries from mesoscale convective complexes, terrain circulations, and so forth). As of 2002 there were almost 1,900 stations deployed across the conterminous United States, Alaska, and Hawaii (fig. 1). The wildfire management agencies participating in the network include FS; BLM; Bureau of Indian Affairs (BIA); Federal Emergency Management Agency (FEMA); National Park Service (NPS); U.S. Fish and Wildlife Service (FWS), and state agencies. Personnel in the U.S. Department of Defense (DOD) and Department of Energy (DOE) also utilize RAWS for their own purposes.

A RAWS measures basic observable weather parameters: temperature, relative humidity, wind speed, wind direction, and precipitation in addition to fuel stick temperature. Increasingly, the capacity to measure barometric pressure and solar radiation has been added to many stations, particularly those meeting the new National Fire Danger Rating System (NFDRS) standards.

Data from the stations are now routinely used to calculate and forecast daily fire danger indices, components, and adjective ratings. Fire business applications such as NFDRS, fire behavior, and fire use constitute the primary uses of RAWS data. Often these data are also requested for uses other than fire weather support. Sensors and instrumentation other than the standard meteorological RAWS set have been added to provide weather data for nonfire applications such as air quality monitoring, climatology, ecological modeling, and environmental impact assessments.

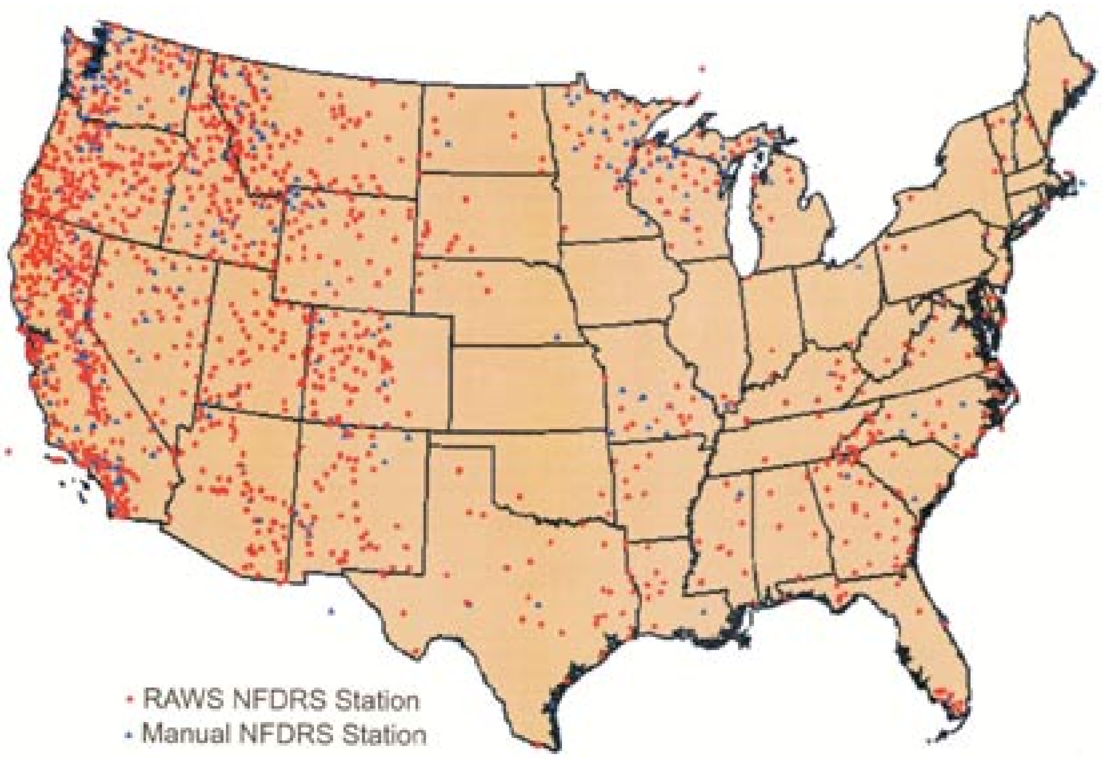

Figure 1. RAWS locations as of December 2001; adapted from the Wildland Fire Assessment System (WFAS-MAPS).

Is the RAWS Network Working?

Even though RAWS is an interagency operation implementing different management approaches, we found that the current network, although pieces outdated and inefficient, is functioning and slowly improving based on current data base maintenance, physical station maintenance standards, and data used regularly and appropriately to calculate fire danger. The RAWS network is constantly changing. Hardware and software are being repaired and upgraded on an as-needed basis, and operational standards and protocols are being improved. New NFDRS weather station standards have been published (NWCG – National Fire Danger Rating System, Weather Station Standards 2003), and short- and long-term strategic plans drafted. Also since the Internet has made it easy to access and retrieve RAWS data, databases are being upgraded to Internet-based applications and data access is being simplified.

Nevertheless, the RAWS network is not currently as efficient as it could be. Quality assurance of data, data streams, and station maintenance vary with location and ownership. Also, management and position responsibilities are not always clearly defined. This is not a criticism of those who support and operate the RAWS system nor of their dedication to maintaining the network, but a recognition that the RAWS network needs more attention, management, and support than it currently receives. There is an important distinction to be made between the RAWS data as measured and the many uses of RAWS data when assessing the RAWS program.

Finally, we have discovered some systematic errors in historical RAWS data records that may have serious operational impacts on current fire use decisions.

Report Organization

In this report, we summarize different aspects of RAWS function and performance, and we provide findings about its performance. We hope this review will serve as a valuable source of RAWS information and a users guide for searching and retrieving RAWS data. There are many aspects of RAWS that are not fully documented; hence, many references are personal communications and draft documents are not easily obtained.

The report is organized into 10 sections: Introduction, Background of the RAWS Network; Data Stream and Products; Operations, Protocols and Oranization; Use of RAWS Data in Fire-Related Applications; Data Retrieval; RAWS Projects under Development; Studies and Surveys; Additional Uses of RAWS Data, and Management Implications. We also include a Reference section, a Glossary of Terms and Acronyms; and Appendices. To make the report easier to comprehend and to use, we have relegated a fair amount of technical information and details to the appendices. For example, appendix A provides a list of RAWS-related Web sites and of entities affiliated or related to RAWS (see appendix A).

Background of the RAWS Network

This section relates the history of the RAWS network; the research, development, and testing involved; and the deployment of hardware and software. The latter has been a continuous process as the network has grown in size, requiring upgraded software and new databases to handle the enormous amount of data being collected.

A Brief History

Prior to station automation, weather data for fire danger rating calculations and general fire weather support were collected manually. The stations were usually located near an FS ranger station or BLM fire base. Typically, an operator would visit each weather station once per day during the fire season (Warren and Vance 1981; K. Shelley, personal communication 2001). It usually took 10 minutes to obtain the manual readings, which consisted of the following steps (Finklin and Fischer 1990; K. Shelley, NWCG – Fire Danger Working Team, Gaining a Basic Understanding of the National Fire Danger Rating System, January 2002):

1. Record the start wind-run count of the wind odometer.
2. Determine inches of last 24-hour rainfall with a ruler.
3. Record the dry and wet-bulb temperatures using a sling psychrometer.
4. Record the max/min air temperature for the past 24-hour and reset the instrument.
5. Record max/min relative humidity using hydrothermograph; check current relative humidity against wet-bulb temperature.
6. Observe wind direction for 1 minute and record it.
7. Observe and record the current state of the weather (SOW).
8. Record end wind-run odometer reading and time lapse from step 1 (typically approximately 10 minutes) and calculate and record the average wind speed (count per unit time).
9. After departing from the site, determine past 24-hr rain duration and lightning occurrence by asking local people.
10. Call the local agency supervisor's office to relay complete observation record for subsequent calculation of fire danger indices and components using look-up tables and nomograms, slide-rule, or hand-held calculator if available.

The historical procedure is an important aspect of the present-day RAWS program because ***current automated sampling protocols still reflect data collection limitations inherent in the manual observations***. Modern electronic methods exist that make it possible to extract additional and useful information from existing RAWS (for example, more frequent sampling, longer averaging periods, measurement statistics, and so forth). These are not currently employed, however, due to data transmission, manipulation, and storage limitations as well as an underlying 'if-it-works-don't-change-it' philosophy among users.

In 1975, the FS began investigating the use of an automatic data collection system utilizing the GOES to transmit fire weather data from remote locations (table 1). The GOES-based RAWS system was chosen to avoid the disadvantages of radio- or telephone-linked stations. Such limitations included the need for a line of sight to a base station for radio transmission or proximity to telephone lines for a telephone transmission. BLM soon became involved in a cooperative project with the FS to develop, evaluate, and deploy GOES-based RAWS (Warren and Vance 1981). In 1978, FS and BLM engineers developed the specifications for the final RAWS-GOES platform. These were based on experience gained during the development phase and on requirements set by the RAWS Steering Committee and the NFDRS Implementation Team. Except for hardware and data-logger software upgrades, the basic station configuration has not changed since then.

RAWS Classification Schemes

During the late 1970s many other Federal and State land management agencies began deploying RAWS in support of fire operations including the BIA, FWS, NPS, and California Department of Forestry (CDF). With the increasing numbers of RAWS deployed by various agencies and States, the need to distinguish between station types and to define station function became apparent (for example, NFDRS versus non-NFDRS; GOES versus non-GOES). Even today many stations are not GOES-capable. The proliferation of RAWS also generated the need to automate data collection, centralize databases, and calculate fire business related products, such as indices and components, that use RAWS data. The FS Pacific Northwest Region, followed by other FS regions and the BLM, informally adopted the weather station

Table 1: General Timeline of RAWS and Database Development.

Year	Occurrence
Late 1920s to present	Manual weather stations
1970	National Fire Danger research group formed; research initiated that generated the 1972 version of NFDRS
1975	RAWS/GOES planning and development initiated AFFIRMS launched on a time-share computer, also hosted NFDRS
1977 – late 1970s	Final RAWS specifications established 10 stations purchased and deployed – evaluated for 5 months 1978 version of NFDRS implemented
Early 1980s	First RAWS manual GTR-IMT-116; Other state and federal land management agencies began deploying RAWS
Late 1980s	1988 version of NFDRS released and implemented ASCADS version 1 released/implemented
1990	WIMS development initiated, designed to replace AFFIRMS 1990 Weather Station Handbook published
1993	AFFIRMS replaced by WIMS (Weather Information Management system) WIMS is new host for 1978 and 1988 NFDRS
Mid-1990s	WFAS development initiated WIMS development continues along with NIFMID/KCFast, etc.
1997	WFAS development initiated WIMS development continues along with NIFMID/KCFast, and so forth
1998	Experimental fire potential map added to WFAS WIMS/WEB development continues
2000	Fire Family Plus V 2.0 released NWCG-NFDRS (RAWS) Weather Station Manual released
2001	WIMS/WEB implemented along with NIFMID/KCFast/SIT/209/PocketCard, and so forth Still host of NFDRS 1978 and 1988 Present-day GACC Meteorologists take initiative to inventory and correct individual (cross agency) problems (siting, quality control, and so forth)
2002	Fire Family Plus V 3.0 released ASCADS re-engineering specifications established, to be implemented
2003	ASCADS patch implemented Update of NWCG-NFDRS (RAWS) Weather Station Manual released

classification standards, which were formally implemented in the late 1980s (B. Adams, personal communication 2002).

These weather station classification standards continue to be used by BLM's initial data handling system: the Automatic Sorting, Conversion, and Distribution System (ASCADS). The FS, however, has adopted a number code system for different types and classes of stations. Other land management agencies at the State and Federal level use both classification systems because all must use BLM's ASCADS and the FS's Weather Information Management System (WIMS) to process and manage RAWS data.

The National Wildfire Coordinating Group (NWCG)—an interagency group established to coordinate efforts of the participating agencies—has recently published new station classes and minimum standards.

For a description of these classification schemes, see Operations, Protocols, and Organization section.

RAWS Information Management Systems

With the increased number of weather stations being fielded came the necessity to automate and streamline data handling. At the same time that RAWS data-loggers, sensors, transmitters, and other hardware were being integrated, tested, and deployed, databases and software were also developed to manage the new influx of data. The automation of data collection allowed for the deployment of more RAWS and greatly enhanced the ability to collect weather information from areas that were difficult or impossible to visit on a daily basis. This led to the progressive development and upgrading of RAWS information management systems. In this section, we will take a look at the development of these systems.

National Fire Danger Rating System (NFDRS)

The National Fire Danger Rating System (NFDRS) is a computer model that calculates fire danger rating indices and components. It is used for fire business decisionmaking and as a management decision tool (see also appendix B). The manual version of the NFDRS was released in 1972, the first computerized version in 1975. New versions of NFDRS were released in 1978 and 1988. The 1988 version was in answer to concerns for better model response to drought and precipitation in the Southeast United States. As a decision support tool, NFDRS assumes that accurate 13:00 hour weather observations have been input to the system. It then uses these to generate fire danger indices and components. When this assumption was tested, it was found to be problematic. These findings are presented later in this report (see Management Implications section).

Administrative and Forest Fire Information Retrieval and Management System (AFFIRMS)

The Administrative and Forest Fire Information Retrieval and Management System (AFFIRMS) was a prototype information management system that initially hosted the 1975 computerized version of NFDRS. It was developed in response to the need to automate the manual version of NFDRS that had been released in 1972. Designed to be interactive and user-friendly, AFFIRMS was available nationally on a time-share computer system via commercial telephone lines. It allowed simultaneous entry of fire weather observations from numerous remote terminals at fire dispatch centers across the network. The data were then displayed along with the fire danger indices and components for specific RAWS sites. It continued to host the NFDRS models until 1993 when it was replaced by the NIFMID Weather Information Management System (WIMS).

National Interagency Fire Management Integrated Database (NIFMID)

The National Interagency Fire Management Integrated Database (NIFMID) is an ORACLE relational database that contains historic fire weather and fire occurrence information (see NIFMID flow chart in appendix C-1). It serves as a database warehouse for archiving fire business/management information, including RAWS weather observations. WIMS, which is part of NIFMID, is a weather information database (see WIMS webb application menu hiarchy, appendix C-2). It produces the daily and forecast fire danger indices and components using the NFDRS model(s) and archives all hourly RAWS observations for 18 months. Another NIFMID module, the Kansas City Fire Access Software (KCFast) database, stores all 13:00 hour observations for the entire period of record (see also KCFast flow chart in appendix D). In addition to the 13:00 hour observations, KCFast also contains all the hourly observations for 18 months as well as fire occurrence information – statistics by region, forest, and so forth. Other modules in NIFMID include firefighter pocket cards (see example in appendix E) and report generators and forms (for example, the national fire situation report, incident situation reports, and aircraft use). We describe NIFMID, WIMS, and KCFast in more detail in the Data Retrieval section.

Automatic Sorting, Conversion, and Distribution System (ASCADS)

In the late 1980s the Remote Sensing Fire Weather Support Unit (RSFWSU) at the National Interagency Fire Center (NIFC), also known as the Boise Depot, was instrumental in developing the Automatic Sorting, Conversion, and Distribution System (ASCADS). It has remained relatively unchanged to date but upgrades have been identified (see long-term upgrades to ASCADS section). ASCADS was originally designed as the single data handling entity to perform all RAWS functions including ingesting data, re-formatting, checking for quality assurance, and sorting raw data received through GOES. It also merged all data streams for distribution to various users, and provided both a short-term database (30 days) of RAWS data and long-term database of RAWS metadata. The original primary user was the RSFWSU, with only limited use by others. As the system evolved, an increasing number of clients began accessing the database for both weather and metadata. ASCADS is now the central short-term data cache and distribution point for all of the GOES RAWS. From ASCADS, weather data are sent to WIMS, the Western Regional Climate Center (WRCC), the National Weather Service (NWS) in Boise, and to the BLM/NIFC Wildland Fire Management Information System (WFMI) (USDI/BLM/RSFWS 2002). We describe ASCADS in more detail in the Data Retrieval section and see ASCADS flow chart in appendix F.

Wildland Fire Assessment System (WFAS)

The Wildland Fire Assessment System (WFAS) is not a RAWS database; it queries WIMS each afternoon to retrieve NFDRS products and to generate maps of selected fire weather parameters that are archived. WFAS was developed by the Fire Behavior Unit, Fire Sciences Laboratory, Rocky Mountain Research Station in Missoula, MT, as an Internet-based tool for fire business managers (see appendix G). Initially available in 1994 through the Fire Science Laboratory, WFAS was transferred to NIFC in 1999. WFAS is currently supported by NIFC, the USDA FS F&AM, and the National Information Systems Team (NIST). A WFAS Web site was redesigned in 2002 to provide easier access to current and archived products. We describe WFAS in more detail in the Data Retrieval section.

Western Region Climate Center (WRCC)

The Western Region Climate Center (WRCC) has taken on the responsibility of archiving and quality assuring RAWS hourly data. The WRCC database is the only systemwide archive of long-term hourly data for all active and inactive RAWS. The WRCC database also maintains a Station Metadata Summary for each RAWS. The historical record is documented for each station and has been quality assured for consistency. We describe WRCC in more detail in the Data Retrieval section (see also appendix H).

Multiagency Resource

The RAWS network has evolved over the past 24 years into a multiagency resource that serves the common need for remote area weather data in support of fire operations and the NFDRS. Today the most immediately useful RAWS data stream is distributed through ASCADS to NIFMID and WFAS. The RAWS network directly serves the interagency fire community by providing weather data through ASCADS to the NWS, NIFMID, WRCC, and indirectly to WFAS. NIFMID and WFAS provide the backbone weather support for the nation's fire business decisionmaking. RAWS also provides for immediate field operational weather needs at some stations through direct dial-up and/or station alert features.

NFDRS 2000 Standards

As part of the ongoing upgrade of RAWS, the National Wildfire Coordinating Group (NWCG)—an interagency group established to coordinate programs of the participating wildfire management agencies—published the NFDRS 2000 Weather Station Standards (NWCG 2000). It is intended to supplement (and update) parts of The Weather Station Handbook: An Interagency Guide for Wildland Managers (Finklin and Fischer 1990). The aim of the publication is to standardize procedures across agencies for the entire network. Contents include discussions of a station's operational period; site selection and station frame criteria; annual maintenance and repair; sensor suite and data stream transmission requirements; and a new station classification system. The NFDRS update recognizes that hardware upgrades are ongoing. The sensor suite will stay the same, although new methods are being developed to calculate fuel moisture and state-of-the-weather (SOW). Also under investigation is a hands-off method to validate and flag the 13:00 hour observation. The new operations protocols are briefly described below and in greater detail in appendix I.

Data Stream and Products

Summary of Data Flow

This section summarizes how RAWS data flows through various databases. The NWCG Information Resource Management Working Team (IRMWT) and the NWCG Data Administration Working Group (DAWG) are two entities working to standardize data handling. Their mission is to ensure the smooth exchange of data by providing a standardized format for entering metadata and weather data.

The flow of data from modern RAWS as currently required by NWCG is shown in figure 2. From the DCP-transmitter, RAWS data are transmitted to a GOES satellite (East or West satellite depending on location). RAWS data are then retransmitted to the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite, Data,

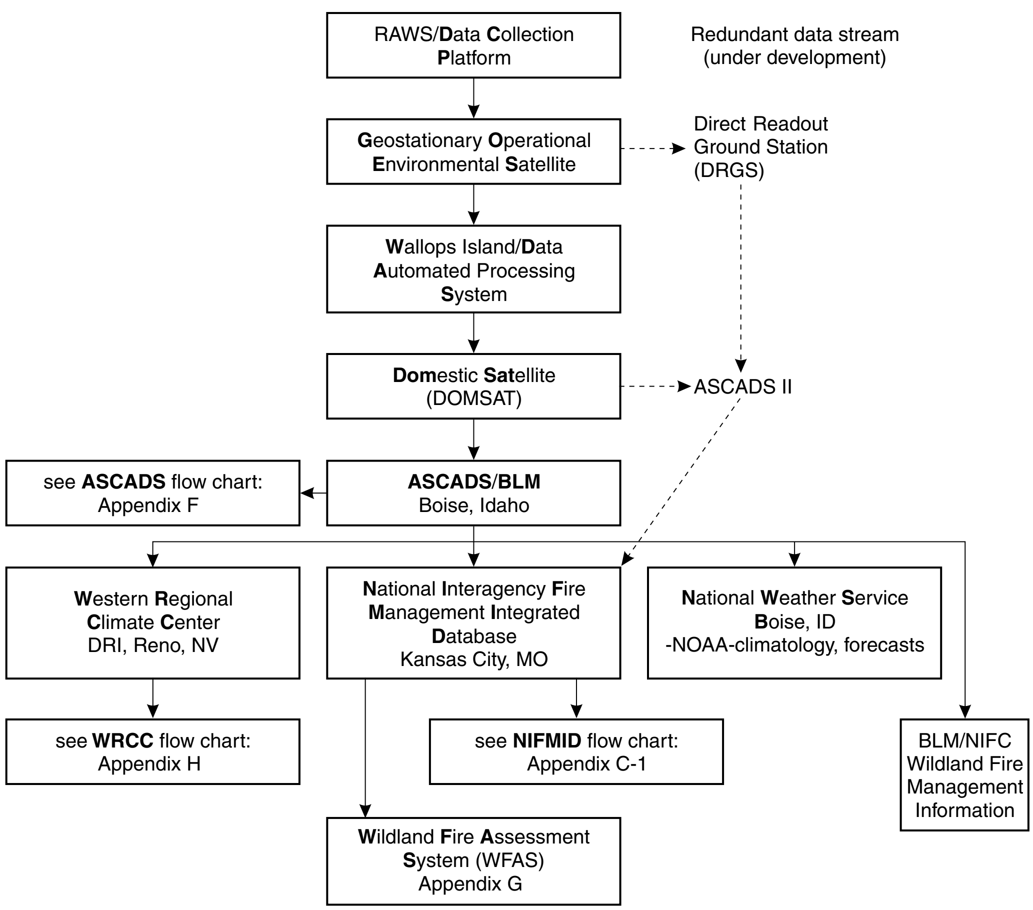

Figure 2. RAWS Data Stream.

and Information Service (NESDIS) center on Wallops Island, VA. From there, the data are again retransmitted via the Domestic Satellite (DOMSAT) to Boise, ID, to be ingested and processed by the BLM database, ASCADS, which is part of RSFWSU (also known as the Boise Depot). ASCADS is also used for metadata storage, maintenance documentation, and short-term data storage. From ASCADS, data are forwarded to the FS database, WIMS; to the WRCC; to the Boise NWS; and to the BLM/NIFC Wildland Fire Management Information System (WFMI).

WIMS receives additional RAWS data from stations (called dial-ups) that can only be accessed via telephone. A stand-alone multimodem computer (the HUB) located in Kansas City/NITC queries the dial-ups for data retrieval on a regular schedule (every 3, 6, 9, or 24 hours, depending on local needs). This system should be phased out of service by 2005 as part of the RAWS and WIMS upgrade programs.

The NFDRS fire danger indices and components are the fire-related primary products for which RAWS data are used; fire behavior and fire use are two others. All RAWS weather data are combined with their respective site information and NFDRS parameters that are contained within the station catalog file such as: climate class, slope class, fuel model, humidity code, and so forth. These are then processed through NFDRS algorithms daily to generate fire danger rating indices, components, adjective fire danger ratings, and fuel moisture (Cohen and Deeming, 1985; see also appendix B). Fire danger rating predictions are also made for the next day.

NWS uses RAWS data to prepare fire weather forecasts for regions and zones throughout the United States.

WFAS queries WIMS once a day to retrieve and then map NFDRS products for the entire United States. WFAS products include: indices and components, greenness, drought, weather forecasts (processed from NWS forecasts), adjective fire danger, atmospheric stability (Haines index), and lightning ignition efficiency (see appendix G). The Haines Index and lightning ignition efficiency are not NFDRS products.

The Western Regional Climate Center (WRCC) has recently introduced a RAWS monitoring Internet Web site (WRCC RAWS) that provides short- and long-term data summaries, current conditions, wind roses, site metadata, and so forth for most stations (see below and also appendix H).

The BLM/NIFC Wildland Fire Management Information System (WFMI) also provides RAWS data summaries, but this system is accessed primarily by local dispatch centers when using SIGs for their immediate area of operations. Greater detail about data access is provided in the Data Retrieval section.

Findings

Dial-up RAWS data are not processed through ASCADS. NWCG requirements are not currently satisfied per se; rather they are goals to live into.

Operations, Protocols, and Organization

This section summarizes station standards including RAWS site selection, sensor suite, data management, QA/QC, and personnel positions and duties. In pertinent sections, we describe both the standard protocol and the new NFDRS 2000 sampling protocol, maintenance program, and classification schemes. In this section, we also tabulate the number of RAWS stations by agency and type according to the ASCADS, FS, and NFDRS 2000 schemes. Also described are administrative organization and funding. (See also appendix I.)

Installation and Deployment

Once a site has been selected that meets all criteria, the RAWS can be deployed; involved personnel should receive formal training or help from those already trained. Station metadata parameters must be determined, recorded, and entered into both ASCADS and WIMS; these include slope; aspect; lat/long; elevation; sensor serial numbers; owner agency and unit; fuel model(s); current year green-up and freeze dates; and NFDRS indices and components, and their breakpoints.

An NFDRS 2000 RAWS should be located on level ground in a large open area with low vegetation cover. It should be sited away from dust and moisture sources and distant from obstructions such as buildings and trees. It should be oriented in such a way as to receive full sunlight for the greatest number of hours per day during the fire season. If positioned on a slope, a south or southwest aspect is required.

Sensor Equipment

The basic RAWS sensor suite includes a rain gauge; anemometer; wind vane; air temperature and relative humidity sensor; fuel stick to measure fuel temperature; and an instrument to monitor the battery voltage of the data logger or data collection platform (DCP). Optional sensors include a barometer; a fuel moisture sensor that may be combined with the fuel temperature stick; and a pyranometer to monitor global solar radiation. Dial-up stations require a modem and a cellular telephone. Most RAWS are either Vaisala/Handar or Forest Technology Systems (FTS) platforms; however, NPS uses Campbell Scientific Inc. systems as do some States.

The station must be synchronized with coordinated universal time. A GPS unit or a WWV synchronization clock is required for RAWS transmissions even though time records themselves are not part of the data stream. Currently as the older model DCPs (FTS 11 and Handar 540 series) are replaced by new models (FTS 12 and Handar 555 series), the WWV clocks are being replaced by GPS units. The older FTS 11 model had neither GPS units nor WWV synchronization clocks; owner/operators had to adjust the clocks in these DCP's by synchronizing them with computer clocks when the station was queried.

Cost is not the only consideration when choosing RAWS equipment: sensors and frames must be able to function and survive in remote locations, often under extreme weather conditions. Conformity to a common station standard provides ease of maintenance and calibration and lowers system costs in the long term.

Sampling Protocols

Standard Sampling Protocols

The measurements in standard reporting order are:

1. Rain gauge/precipitation (PPT) – tipping bucket, continuous cumulative 0.01 inch increments; some may be heated to melt snow. Mounted at 1 to 6 feet depending on tower model.

2. Wind speed (WS) – mph, 10 min mean prior to data transmission. Mounted at 20 feet.

3. Wind direction (WD) – degrees, 10 min mean prior to data transmission. Mounted at 20 feet.

4. Air temperature (AT) – ^{o}F, instantaneous value at time of data transmission. Mounted at 4 to 8 feet.

5. Fuel temperature (FT - optional) - ^{o}F instantaneous value at time of data transmission. Mounted at 10 to 12 inches above a prepared ground surface.

6. Relative humidity (RH) – percent, 10 min mean prior to data transmission. Mounted at 4 to 8 feet.
7. Battery voltage (BV) – volts, instantaneous value at time of data transmission. Inside the DCP box.
8. Barometric pressure (BP - optional) – inches of Hg, instantaneous value at time of data transmission. Mounted at 4 to 8 feet. This sensor is optional.
9. Direction of peak gust (item 10) during hour prior to transmission – degrees.
10. Peak wind speed (gust) – max mph during previous hour prior to data transmission.
11. Fuel moisture (FM - optional) – grams H_2O in a 100 g pine dowel, instantaneous value at time of transmission. Mounted adjacent to the fuel stick. This sensor is optional.
12. Solar radiation (SR) – watts/m^2, instantaneous value at time of data transmission. Mounted at 5 to 8 feet above the ground on south side of platform.

Although this sampling protocol is followed by most RAWS at the current time (spring 2003), the newer Vaisala/Handar 555 and FTS 12s follow a slightly different protocol. (See DCP Transmission Protocols below for details.) We have been informed that some stations transmit hourly averages of weather data. However, neither the RSFWSU nor the Fire and Aviation Management Applications Helpdesk (F&AM Helpdesk) could provide further information.

NFDRS 2000 Sampling Protocol

The new NFDRS update, NWCG NFDRS Weather Station Standards, PMS 426-3, 2000, proposes the following standard order for meteorological data transmission:

1. rainfall
2. 10-minute-average wind speed
3. 10-minute-average wind direction
4. air temperature (instantaneous)
5. 10-minute-average relative humidity
6. battery voltage
7. solar radiation (instantaneous)

Important parameters beyond the above basic seven are to be output in the following order:

8. barometric pressure
9. direction of peak wind gust
10. speed of peak gust
11. fuel temperature
12. fuel moisture

Solar radiation (SR) data will soon be used to calculate SOW and fuel moisture—two important inputs to the NFDRS model. Parameters such as max/min humidity, max/min air temperature, and fuel moisture are extracted from the 24, hourly transmissions prior to the 13:00 observation.

The NRDRS 2000 standards require and re-emphasize that the RAWS wind speed and direction sensors are to be mounted at a height of 20 feet. Due to NRDRS 2000 standards and also to new OSHA requirements, the height of wind sensor placement for some FS RAWS has been lowered. In the Studies and Surveys section, we discuss the effect of these height changes on RAWS data.

Recent Updates to NFDRS 2000 Standards

Three updates were recently made (March 2003) to the NFDRS 2000 Standards (NWCG publication PMS 426-3). The Station siting criteria regarding proximity to reflective surfaces was reworded for clarification. Also reworded was the wind direction sampling criteria: from a 10-minute average from 600 samples to 10-minute vector average from 600 samples. Another update, perhaps the most significant of the three, involved a change in the solar radiation sampling procedure: from an instantaneous, single measurement prior to transmission to a calculated 60-minute average using 60 once/min. samples prior to transmission. The instantaneous solar radiation data were randomly erroneous due to spurious reflections impacting the sensor. If a reflective cloud happened to be passing at the time of SR measurement, it can lead to unrealistically high radiation readings. (An analysis of this effect is presented in the Studies and Surveys section). This change will require reprogramming the data collection platform and will be implemented during 2003 as station owners and operators conduct annual site maintenance (K. Shelley, personal communication 2003; NWCG – NFDRS Weather Station Standards, 2003)

Findings on Solar Radiation Data

Questions have been raised as to whether the current SR sampling protocol (instantaneous or hour average) and sensor placement (4 to 8 feet) will provide inaccurate data (the authors, G. McCurdy of WRCC, and T. Brown of CEFA, personal communications, 2002). We find that sensor placement is not optimal for SR measurements, at least on Handar tripod frames because the sensor is currently mounted on the top cross beam adjacent to the white or light gray rain gauge. Reflections from the rain gauge may also affect SR readings. Hence, it may be preferable to raise the solar sensor to the same height as the top rim of the rain gauge or, alternatively, place it at the top of the mast. (The advisability of the latter placement would depend on mast strength.)

Positions and Responsibilities (RAWS, WIMS, and NFDRS)

RAWS, WIMS, and NFDRS responsibilities are defined and assigned to personnel in fire operating plans. (See appendix J. See also the Fire Danger Operating Plan—Arizona Strip field office, July, 1999, NFDRS Operating Plan Shasta, USFS Trinity Ranger Unit, April 1999; these latter can also be found in the 2002 intermediate-level NFDRS course reference materials.)

NFDRS 2000 Standards

The positions, responsibilities, and duties that appear in the NFDRS 2000 Standards (NWCG 2000) handbook are summarized as follows:

1. Station owner/program manager: is responsible for site selection and deployment of new stations, maintenance of new and old stations, QA/QC of data, WIMS duties, and response to ASCADS watchdog alerts. (See appendix K.)
2. Local dispatch centers: have a variety of responsibilities that may vary from center to center. For example, at the Fort Collins CO/Northern Front Range/Arapahoe-Roosevelt NF Dispatch Center, these duties include determining daily fire fighting resource availability; generating incident reports as required; entering required RAWS data into WIMS; posting NFDRS indices and components, and so forth (see appendix L). The Fort Collins Center has been given the responsibility of operating, managing, and maintaining seven RAWS in their immediate area (appendix J).
3. Field support and first responder: Annual maintenance, emergency repairs within 3 days of a breakdown occurrence, maintenance of ASCADS documentation, and so forth. Note that there is some overlap with station owner/manager and dispatch center duties. (The

USFS RAWS Web site is an extremely good source of RAWS information; see appendix A for Internet address. Links to procedures, FAQ's, example forms, and tech notes can be found on the USFS RAWS Web site; see Field Guide, RAWS 101, and Tech Notes items on the Web site.)

4. Agency regional coordinator: has agency RAWS oversight within a regional area (see appendix M for detailed regional coordinator responsibilities).
5. Agency coordinator: For the USFS, currently an individual and an assistant whose duties include oversight and coordination, such as responding to phone and e-mail queries; ensuring NWCG standards are adhered to; serving on various RAWS-associated working groups and teams (fire danger, fire weather, satellite transmission, and so forth); assigning and coordinating station transmission channels and transmission times; and organizing and training personnel in the deployment and operation of a RAWS. The Agency Coordinator manages the RAWS Web site, which received 6,680 unique hits in 2002, almost half of these in May and June alone. Operationally the FS RAWS Coordinator also functions as a USFS RAWS Helpdesk. (Note that the USFS RAWS help desk is separate and distinct from the F&AM help desk.) During FY02, the USFS RAWS Coordinator:
   - Responded to roughly 2,000 e-mail queries.
   - Responded to 2,000 telephone queries.
   - Performed work-related travel: 77 days for fire-related working groups and teams, and professional groups.
   - Conducted RAWS training/teaching for field operators.
6. Depot technician: is responsible for testing, maintenance, and calibration of sensors at the RSFWSU.
7. Depot manager: performs administrative oversight of RSFWSU operations, RAWS station contracts, and RSFWSU personnel.

Findings

RAWS or WIMS-related administration and operational responsibilities are seldom explicitly stated in an individual's position description. The informal and vague language in these position descriptions contains phrases such as weather-related duties or additional duties or collateral duties. Often personnel directly involved in RAWS-related operations interpret lack of specific duties in these position descriptions as an indication of lack of interest in the RAWS program by upper management. Thus, parts of the network are managed and function well while others that are not as well-managed function poorly. The result is a lack of or questionable quality in critically needed fire weather data (personal observations; D. Clements, F. Hesselbarth, T. Mathewson, and M. Nelson, personal communication 2002).

Local Quality Control and Assurance (QA/QC)

The local owner/operator or a dispatch center person is typically responsible for initial QA/QC of RAWS data (see above). Depending on the type of service contract, the local operator might also perform the annual sensor exchange and emergency repairs. Responsibilities include care and maintenance of the ASCADS and WIMS metadata files, and WIMS daily editing for NFDRS runs (e.g., the 13:00 hour data record is flagged from an R to an O). The local operator reviews recent data, especially the 13:00 LST observation, to verify reasonableness. Using WIMS/WEB, local personnel are also required to manually add the SOW and the lightning activity level (LAL) values to the 13:00 record. Note: the 13:00 RAWS observation should be the transmitted RAWS data recorded closest in time to 13:00.

The SOW is manually entered as a code number describing the weather at the time of observation. The index or code ranges from 0 (clear) to 9 (thunderstorms in progress). This is a critical input to the NFDRS model because many of the model products are based on the current observed SOW. For example, steady rain or snow will zero out NFDRS indices and components. Currently (spring 2003) the SOW input is based upon a number of sources: Web-cameras, local RH and precipitation (if any), or direct field observations. In the future SOW will be calculated from SR, RH, and precipitation and entered in WIMS automatically.

The LAL is a measurement of cloud-to-ground lightning activity observed within a 30-mile radius of the RAWS observation point. The NFDRS requires two inputs for LAL: the first covers the period from when the previous day's 13:00 observation was taken until midnight, and the second covers the period from midnight until the current day's 13:00 observation time. The scale ranges from 1 (no thunderstorms or cumulus clouds) to 6 (dry lightning occurrence). A 5 indicates frequent and intense lightning, thunderstorms, and moderate to heavy rain. These data are obtained from the BLM/NIFC Wildland Fire Management Information System (WFMI) in the form of maps generated for a given area. Based on this mapped data, an estimate of the LAL is manually recorded.

During the NFDRS course held in Lakewood, CO, in April 2003, students were advised NOT to enter LAL or human-caused risk into WIMS. No documentation was provided and none has been found by the authors of this report (M. Nelson, personal communication, May 2003. S. Peterson, course instructor, April 2003).

Operating Period

The optimal RAWS operating period for NFDRS requirements is year-round. The minimum is for the fire season with a 30-day initialization and equilibration period before the season begins – except for portable fire RAWS, which are usually deployed on a per incident basis. The local or regional Fire Management Officer or the GACC meteorologist decides upon the start and end of the fire season, which can vary from year to year. Some areas have a split season (for example, spring and autumn). Those using data from a station not owned by the user typically inform the station owner of their intended use of the data.

Maintenance and Calibration

At least once per year the RAWS sensors must be replaced by newly calibrated, refurbished, or repaired units. The replaced sensors are then processed at the RSFWSU (see below). The RSFWSU performs all meteorological sensor calibrations and necessary repairs either at the Boise Depot or, occasionally, in situ. The RSFWSU provides two, soon to be three, service contract options: full ride, depot, and NFDRS 2000 certification.

Service Contracts

Under the full ride contract, personnel from the RSFWSU visit each site once a year to perform the required maintenance, relieving local owners/operators of the duty (apart from emergency repairs). Under the depot contract, the local operator receives replacement sensors from RSFWSU, visits the RAWS, replaces sensors with replacement units, and performs any other station repairs. The local operator returns the replaced sensors to the RSFWSU for recalibration.

In the near future, the NIFC depot will begin to provide a third contract option: NFDRS 2000 certification. This certification will support those stations that are NFDRS 2000 compatible (NWCG 2000). RAWS designated as NFDRS 2000 data providers must be formally certified by RSFWSU technicians with the new NFDRS 2000 certification service option. Under the NFDRS 2000 certification contract, depot technicians will make site visits once per year and perform documented calibration/certification for the site. When the NFDRS 2000 certification is implemented, the RSFWSU will also continue to support the full-ride and depot service contracts. A full-ride service contract costs $2,500 per year (soon to increase to $2,625 per year); the depot contract is $650 per year (soon to increase to $675 per year); and the new NFDRS certification will cost $1,875 per year.

Staffing Needs

Given that almost 1,900 RAWS are deployed across the United States, completing the calibration and repair work is an enormous task. During FY 2001, the RSFWSU processed 221 nonmeteorological sensors/instruments and 7,880 meteorological sensors, 8,101 total, an average of about 22 per day. (P. Sielaff RSFWSU, personal communication 2002). The average for the past 10 years is 35 pieces/day, with a maximum of 11,000+ pieces of equipment processed in 1 year (P. Sielaff RSFWSU, personal communication 2002). The nonmeteorological instruments included modems, WWV clocks, display units, GPS units, and battery packs. The busiest months of the year are October through March, the nonfire season, when field operators are returning equipment to the depot. RSFWSU staffed 20 people for sensor and equipment maintenance as of July 2002. Eight were employed in-house at the depot itself. Twelve worked in field deployments servicing stations under the full ride contract. In addition to regular duties, depot staff also conducted research and development on sensors and weather station systems.

Findings

At present, it takes roughly 5 days for local and NIFC staff to respond to equipment failures. If more than 3 days of data are lost, NFDRS model applications must be reinitialized and stabilized. Hence, NFDRS modelers recommend that failure be repaired within 3 days. Realistically, due to personnel shortages and other assigned duties, response time will continue to be greater than 3 days.

Administrative Organization

Various land management agencies have different funding arrangements for their RAWS. The BLM has a centralized approach. Its Washington headquarters provides all funding from start-up to continuing operations; all stations are on the full ride contract. The NPS provides centralized financial support, but individual Parks must conduct yearly maintenance. The BIA has contracted directly with the BLM RSFWSU to provide for full ride maintenance for nearly all its stations. Although each of the FWS regions has its own agreement with the BLM, the arrangements are similar to those of the NPS. Individual States (usually State forest services) must work with the BLM via the USFS for start-up and ongoing operations. Some States deal directly with private sector vendors.

Management of the FS RAWS network flows from the Fire and Aviation Management (F&AM) Washington DC Office to the Fire (Applied) Operations/Boise, ID, to the Office of the FS RAWS Coordinator (currently located in Orifino, ID) and finally to Regional Coordinators. For example, in FS Region 2 (Rocky Mountain) the network is owned and maintained primarily at the Regional Office level, whereas in Region 3 (Southwest) ownership, management, and maintenance are divided between individual Forests and the Region (D. Clement, Region 1, and R. Shindelar, Region 3, personal communication2001). The management approach taken in FS Region 3 changed dramatically with the establishment of the Southwest GACC Predictive Services Center in 2001. Since the addition of GACC meteorologists, quality assurance and control and station maintenance have improved significantly (personal observation; K. Shelley, personal communication 2002).

In many cases, the Regional Coordinator will delegate further to the Forest or Dispatch Center level. For example, as indicated previously, in the FS Region 2, personnel in the Arapahoe/Roosevelt NF manage the RAWS in the Arapahoe/Roosevelt National Forest. When NF staff is not delegated to maintain stations, the Regional Coordinator has to do it. FS F&AM supports a user's help desk for WIMS/KCFast users in Boise, ID. This office is staffed during normal working hours.

FS Funding

Funding for Station Purchase, Repair, and Upgrades

Within the FS, each Forest or Region must provide justification and initial local funding to purchase a station with its own operating budget. Once a site is purchased and implemented, funds for yearly maintenance are then drawn from a separate RAWS fund established at the F&AM Washington Office—not from the budgets of individual Forests or Regions. The local and regional area fund support is based upon Annual Operating Plans submitted by FS Regions to the FS RAWS Coordinator. An example from Region 9 – Eastern is given in appendix N; note that the plan only includes maintenance costs for depot or full ride contracts. Contractual arrangements with the RSFWSU are made directly by the FS F&AM WO. Any additional costs associated with RAWS operations—salary, travel, vehicle use, WIMS-related duties, and so forth—are borne by the individual Forest or Region. All FS RAWS, except for 10 in the Umatilla and Malheur National Forests in the Pacific Northwest Region, are maintained through a depot contract.

A typical new RAWS costs about $12,500 to purchase. The Forest Service alone has approximately $10 million invested in RAWS stations based on the RAWS count. This estimate includes portable RAWS.

We estimate RAWS operating costs to be approximately $1,350 per station per year, which includes the depot contract cost, travel, salary, vehicle use, and so forth. (L. Holsapple, R. Powell, D. Clement, personal communication 2002). Using the depot contract as $650 per year, and the $1,350, we estimate that the yearly costs to operate FS network at approximately $1,068,450 to $1,121,100. (The authors base these estimates on interviews with RAWS personnel and access to RAWS databases.)

Once a RAWS station is purchased and part of a RFSFWSU program, there are no additional acquisition costs. There is no formal provision for station life-cycle funding; currently, this is part of the overall RAWS upgrade program (D. Clement, K. Shelley, personal communication 2002). For example, if a sensor or data-logger fails at some point, it is replaced by a functioning unit, and repairs are paid out of the depot or full ride service contract. Also, as new equipment becomes available, requests to upgrade are made through the annual regional maintenance/operating plan. Sometimes these requests are granted and sometimes not. If the request is approved, the old equipment is returned to the RSFWSU and the new equipment installed at the given station. The latter is paid for out of the maintenance contract. However, if a Region wants to upgrade a DCP, the Region must fund the new DCP. Sometimes old equipment is cannibalized. Sometimes the RSFWSU uses old equipment as full replacements for stations using older hardware. Except for testing a few sonic anemometers, there has been little change in meteorological sensor models over the years. The wind speed and direction instruments used on the portable fire RAWS, however, are single combination speed and direction units.

Funding for WIMS

WIMS is funded by the FS from the top. Traditionally, the FS Washington Office of Watershed and Air pays for maintaining and running NIFMID. (Note that F&AM pays for RAWS maintenance under the depot contract.) The WIMS reengineering effort is a multiyear project that includes development of WIMS/WEB and the upgrade. For FY 2002, $227,000 was originally budgeted for NIFMID operations, but the actual amount grew to $461,000. Discussions are still under way as to where the difference is to come from. In FY2001 $250,000 was budgeted; in FY2002 the figure grew to $350,000 for WIMS hardware and software re-engineering. (These figures were provided by Michael Barrowcliff and Jeff Barnes, National Systems Team, WO F&AM, 2002.) These funds have been provided by F&AM. Due to budget reductions in 2002, software upgrades were on hold. However, some hardware upgrades were continuing as of spring 2002. (See also WIMS Upgrades in the RAWS Projects Under Development section.)

Current Station Classification and Numbers of RAWS

As of summer 2002 the number of RAWS stations had grown to almost 1900. They are located throughout the conterminous United States, Alaska, and Hawaii, most are concentrated in the Western States (see fig. 1). In the late 1970s when RAWS were first deployed, the BLM and FS informally adopted weather station classification standards (Finklin and Fischer 1990); they were formally implemented in the late 1980s (B. Adams, personal communication 2002). These weather station classification standards continue to be used by ASCADS, the BLM's initial data handling system. The FS later adopted a number code system for different station classes, which is now to be replaced again by a new NFDRS 2000 classification (NWCG 2000).

Other State and Federal land management agencies use both classification systems because both ASCADS and WIMS are used to process and manage RAWS data. In addition to the FS, BLM, NPS, and BIA, the ASCADS database also hosts RAWS from agencies such as DOD, DOE, FWS, CDF, various State Departments of Natural Resources, and State and private forests.

ASCADS Classification Scheme

ASCADS uses five classes for stations (a description of Classes I through IV can also be found in Finklin and Fischer 1990):

- Class I: Permanent RAWS that operate year-round and receive the highest maintenance priority. Instrument suite includes tipping bucket rain gauge, anemometer, wind vane, air temperature/relative humidity sensor, fuel temperature sensor, barometer, and fuel moisture sensor. Depending on management needs, additional sensors can be added (for example, soil temperature and moisture probes, stream water gauge level, or air pollution monitoring instruments).
- Class II: Semipermanent RAWS that operate only during the fire season. Depending on immediate fire conditions these have either primary or secondary maintenance priority. The sensor suite is the same as for Class I stations.
- Class III: Portable RAWS used for controlled burn studies, prescribed burns, or special projects as needed. They are only deployed on a temporary basis. After use, they are returned to program owners. The BLM Class III units are cached at RSFWSU or redeployed to another site or project. All Class III units have secondary maintenance priority. The sensor complement is the same as for Class I.
- Class IV: These weather stations are essentially the same as Class III units but use radio communications to transmit data via either a voice synthesizer or RS232 port. They are used for the same purposes as Class III and can carry the same sensor suite.
- Class IX: This classification is reserved for stations deployed on military installations and at DOE facilities. It is hardly used because the stations in this classification are so few in number. The 15 Class IX USFS stations are all portables, perhaps deployed to Department of Defense (DOD) and Department of Energy (DOE) sites on loan for special projects or circumstances.

Table 2 tabulates the total number of stations counted under the ASCADS classification system.

Current Forest Service Classification Scheme

Table 3 gives the FS-coded count by agency and class as of May 2002. We extracted the information from raw data provided by the F&AM Applications Helpdesk.

The following agency and station types were coded according to the current FS classification system:

Table 2: Number of RAWS stations per ASCADS count,[1] April, 2002.

Agency/Class	I Permanent	II Semi-Permanent	III Portable	IV Radio Communications	IX Portable	Total
USFS	73	611	52	85	15	836
BLM	64	246	34	41		385
NPS	12	109	6	5		132
BIA	3	44	34	5		86
States[2]	3	181	4	20		208
Other[3]	2	138	4	7	40	191
Total	157	1329	134	163	55	1838

[1] Raw data was obtained from ASCADS; see report for Current Station Classification Systems.
[2] States: CDF+DNR+S&PF.
[3] Other: other federal agencies such as DOD, DOE, FWS, and others

Table 3: Number of RAWS stations per FS count,[1] April, 2002.

Agency	MnF[2]	MF[3]	SnF[4]	SF[5]	Total	Historic
USFS (1)	20	201	65	496	782	265
BLM (2)	3	25	43	270	341	102
NPS (3)	2	85	8	85	180	56
BIA (4)	0	17	2	27	46	1
States (5)	8	231	8	101	348	148
Other[6] (6+7+8)	29	74	16	60	179	39
Total	62	633	142	1039	1876	611

[1] Raw data obtained from F&AM Helpdesk.
[2] MnF: manual,non-NFDRS
[3] MF: manual, NFDRS
[4] SnF: satellite, non-NFDRS
[5] SF: satellite, NFDRS
[6] Other: other fed and city, county, and district

Agency Number	**Agency**
1	USDA FS
2	USDI BLM
3	USDI NPS
4	USDI BIA
5	State
6	City, county, district
7	Private or commercial
8	Other Federal
9	Unknown

For the purpose of tabulating the data in table 3, we combined agency codes 6, 7, and 8 (above) and included them in the Other category.

Station types or classes are coded as follows:

Code number	**Type/class**
1	Manual, non-NFDRS (manual person must visit site)
2	Manual, NFDRS (note that NFDS here indicates the old NDRS standard and not the new NFDRS 2000 standard)
3	RAWS, satellite, non-NFDRS
4	RAWS, satellite, NFDRS
5	RAWS, nonsatellite, non-NFDRS (nonsatellite: dial-up, and so forth)
6	RAWS, nonsatellite, NFDRS

7	Historic, nonactive
8	Dummy (temporary or test bed stations)
9	Unknown

For the count in table 3, we combined non-NFDRS station types 1 and 5 (above). We also combined NFDRS station Types 2 and 6 (above).

We excluded from the count in table 3 the 34 stations that were grouped into the Type 8 category above; these came from a cross-section of agencies, including Other. Although information for Type 9 stations was obtainable, we did not include these stations in table 3. This lowered the historical nonactive count by more than 1,100. Apparently, these Type 9 stations had been deployed for one to four fire seasons from the late 1960s through the 1990s. No agency currently claims ownership of such Type 9 stations. Hence, the Historic column in table 3 refers to stations that are no longer active but claimed by individual agencies. Their archived data are also still available through KCFast.

The total number of stations in table 2 for the ASCADS count is slightly less than the count provided by WIMS/F&AM Helpdesk in table 3—1,876 versus 1,838 (tables 2 and 3 respectively). Comparing the number of stations listed in the two databases by type or class proved somewhat difficult due to the different classification schemes and agency information. However, the results are presented in table 4; the highlighted pairs indicate similar counts for similar classes from the two databases. From table 4 it is evident that an exact determination of RAWS stations is not precisely known.

New NFDRS 2000 Classification Scheme

New station classes and minimum standards for NFDRS 2000 are as follows:

- NFDRS – Year-round Stations:
  - Operate 12 months to support wildland fire season
  - Are equipped with minimum NFDRS sensor suite (see above)
  - Meet minimum QA requirements
  - Deliver hourly readings to WIMS via GOES (24/7) and ASCADS
  - Provide the only data for NFDRS calculations processed regularly in WIMS
  - Use a heated or weighing rain gauge as necessary
- NFDRS – Seasonal Stations:
  - Operate to support fire season (but can operate 12 months)
  - Are equipped with minimum NFDRS sensor suite (see above)
  - Meet minimum QA requirements

Table 4: Comparison of RAWS station counts from F&AM Helpdesk (WIMS) and ASCADS, April, 2002.

Agency	ASCADS 1+2	WIMS SF+MF	ASCADS 3+4	WIMS MnF+SnF
USFS	684	697	137	85
BLM	310	295	75	46
NPS	121	170	11	10
BIA	47	44	39	2
States	184	332	24	16
Other	140	134	11	45
Totals:				
ASCADS	1838			
F&AM	1876			

- Deliver hourly readings to WIMS via GOES (24/7) and ASCADS
- Provide data for NFDRS calculations that are processed regularly in WIMS (during fire season operational period)

• Other:

- Includes all other stations that provide accurate weather data but do not meet NFDRS standards, hence are not used for NFDRS calculations.

• Manual Stations:

- Manual stations (telephone telemetry via the HUB or queried directly by local operators) are still used and provide basic 13:00 hour NFDRS inputs to WIMS during operational seasons: transmits one observation per day. Many of these are being upgraded.

Findings on Conformance with NFDRS 2000 Standards

Although the NFDRS 2000 standards above are being implemented across the network, we found that a station's current classification as an NFDRS station is based on the old standard and may not fully conform to the NFDRS 2000 standards. We also found that there is no official authority or entity to track or enforce compliance with the NFDRS 2000 standards, nor is there a deadline for the transition from NFDRS station to NFDRS 2000 station to be completed.

Use of RAWS Data in Fire-Related Applications

Brown and others (2001) identified four primary uses for RAWS data: NFDRS, fire behavior, fire use, and other. The first three categories are the primary justification for the RAWS network. Other refers to RAWS data use by agencies, businesses, universities, and miscellaneous groups for assessments other than fire. For example, the RAWS data set is one of many that are used for initialization and verification of mesoscale weather models used to generate higher resolution fire weather predictions (FCAMMS). (See Additional Uses of RAWS Data below.)

NFDRS Use

NFDRS use includes calculation of daily fire danger indices components and ratings: RAWS weather data provide the primary daily input used to parameterize the NFDRS model to generate daily fire danger ratings, indices, and components. Other NFDRS inputs include fuel model and types, slope and aspect, latitude, and average annual precipitation. NFDRS also includes intermediate products such as live and dead fuel moistures and lightning and human-caused occurrence indices (LOI and HCOI respectively, see Glossary). These two indices are considered indicators of ignition possibility and are independent of fire danger indices and components. appendix B provides an overview of the NFDRS model.

Fire Behavior

Fire behavior includes assessing real events and/or modeling fire spread and intensities for planning purposes (for example, for an initial attack or additional fire fighter deployments). BehavePlus and FARSITE (Fire Area Simulator) are the current fire behavior and fire spread models used by the FS. BehavePlus is used to predict incident wildland or prescribed fire behavior for fire management purposes. It uses site-specific input data, including weather, to predict fire behavior for a point in time and space. FARSITE is a model used to simulate the spread and behavior of fire in space and time for heterogeneous terrain, fuels, and weather. It is run on a PC but requires the support of ArcView, a Geographic Information System (GIS) application. FireFamily Plus (FF+) is a PC-based application that integrates historical fire occurrence with climatological and current RAWS data for calculating fire danger indices and components, fire business troubleshooting, analysis, gaming, or training. It can uniquely provide historical, seasonal, and current perspectives of fire danger that are either site-specific or weather-zone specific.

Fire Use

Fire use refers to management practices such as prescribed burning. Short- and long-term fire business planning (for example, managing preparedness levels) entails additional fire use applications supported with RAWS data products. For short-term planning, RAWS data is used for: determining staffing levels; duty hours; fire behavior modeling; fire danger rating (daily and short-term forecasts); tactical planning during a fire; prescribed burn go/no-go decisions; prepositioning of fire fighting/containment resources; and weather information to incident commanders and fire crews. There are also many management decisions based on RAWS data and NFDRS output: dispatch contingency plans for wildfires at different fire danger levels, fire danger preparedness levels, forest closure criteria, seasonal trend analyses, and as input for the National Fire Management Analysis System (NFMAS).

For longer-term planning, RAWS data provide for: severity funding requests; budget preparation; fire resource needs; planning for fire prevention and presuppression; restoration of forest and range lands; understanding seasonal droughts; modeling; seasonal fire danger analysis; and long-term climate analysis.

Data Retrieval

RAWS data can be accessed through WRCC and through WIMS/KCFast. RAWS data are also available via the NWS, ASCADS, WFMI, WFAST, and through the map-intensive Web site operated by the USGS Geospatial Multi-Agency Coordination Group (GeoMAC). Some RAWS data gateways archive data and others only store it for short periods. For example, ASCADS archives data for only 30 days. GeoMAC and the NWS provide the most recent 48 hours of data for easy retrieval.

Except for ASCADS, the above data gateways are accessible online; ASCADS access is via a terminal emulator. Appendix A provides Web addresses along with brief descriptions of each gateway. Additional details can also be found in appendix O.

Automatic Sorting, Conversion, and Distribution System (ASCADS)

ASCADS is the single entry point for all satellite-transmitted RAWS data. After ASCADS ingests RAWS data from the DomSat Receive System (DRS), it sorts and re-formats it into a relational database. ASCADS then distributes the processed data to the BLM/NIFC/WFMI; the NIFMID/KCFast; the NIFMID/WIMS; the NWS in Boise, ID; and the WRCC. In addition to hourly weather observations, ASCADS provides extensive metadata information for every station, including platform descriptions; location descriptions; site visit descriptions; maintenance history; and sensor complement and type. ASCADS stores the metadata permanently in addition to the weather data for 30 days. It also allows for text notation of station changes.

Access

ASCADS is menu-driven and gives dial-in users the ability to view and print reports of the most current RAWS site information, including site-specific watchdog alerts, recent weather data, and station metadata. Access to ASCADS is via a terminal emulator package such as Powerterm, Webterm, or Netterm; the password and username required for access can be obtained from the agency-specific RAWS coordinator. To facilitate display, associated data have been grouped into several screens. In appendix F, we provide a diagram of the data flow and menu choices (user interface) adapted from the ASCADS Field Users Guide Version 2.1 (2002).

Watchdog Function

The ASCADS watchdog is an important function within the database. It advises the owner/operator of invalid data (for example, data values that are out of range, missing, or not changing) and flags transmission errors or failures. The owner/operator must log onto ASCADS to obtain the most current advisories and data flags, which are limited to the last 2 days. The actual numbers defining the watchdog criteria vary from station to station; from region to region; and seasonally for any given station. For some sensors and data elements, such as wind speed and air temperature, the upper and lower limits are entered in ASCADS as part of the station's meta data. For others, such as rain gauge and solar radiation, there are no entries. There appears to be no watchdog master list short of examining the meta-data for all stations one at a time. In appendix P, we provide a list of alerts, data flags, and criteria for the basic RAWS 12 data set (personal communication, K. McGillivary). This list was provided by the BLM/NIFC/Applications Software Group, which is the group that maintains and programs ASCADS (P. Sielaff, RSFWSU/BLM/NIFC, personal communication, 2002).

Upgrades

Beginning in April 2003, ASCADS will be undergoing its first upgrade. The initial five upgrades are described in RAWS Projects Under Development section. There have also been extensive discussions leading to the draft of new ASCADS Business Rules for the two main user groups: weather data users and support/maintenance personnel. These rules, ASCADS Business Rules (Straub 2002), primarily concern formalizing procedures for maintaining RAWS metadata files and notifying users of any changes to these files.

Findings

ASCADS Helpdesk. The RSFWSU and the BLM/NIFC/National Systems Development group, in effect, act as the ASCADS Helpdesk but only during normal working hours. For example, no one was available to provide assistance during the weekend of June 8-9, 2002, when ASCADS crashed. It points to the need for a formal ASCADS help desk operational 24 hours per day, at least during fire season.

ASCADS Watchdog Criteria. We were unable to locate actual ASCADS watchdog criteria (minimum/maximum thresholds, maximum time limit without a change, and so forth) short of examining each station from within ASCADS. Even then, some data elements had no criteria entered while others did. The ASCADS Programming/Development Team was able to provide a list of qualitative information, and these are given in appendix P. Are the quantitative criteria hard coded for each station, taking into account different locations and changing seasons? Or are they entered by regional and/or local RAWS personnel as part of a station's metadata? We have been unable to determine this.

Western Regional Climate Center (WRCC)

WRCC is one of six regional climate centers in the United States. It is administered by NOAA's National Climate Data Center and NESDIS. The mission of WRCC is to archive and distribute climate data and information, facilitate, and improve use of such information for decisionmaking, conduct applied research related to climate, and improve coordination of climate-related activities from the local to the national level. The WRCC receives formatted

RAWS data from ASCADS, retabulates and reformats the data, and archives them. The center is a major long-term data archive for all RAWS in the United States, storing all 24 hourly observations per day, including the 13:00-hour observation used for NFDRS calculations.

Data Management

ASCADS sends meteorological data for all active RAWS to WRCC though a dedicated Internet line. The data, sent every 15 minutes, are automatically assimilated, reformatted, and saved in the WRCC database using their special in-house format. If the RAWS metadata has changed, WRCC receives a metadata file from ASCADS within 15 minutes of the update. This file is cross-referenced against the WRCC metafile of that station, and the WRCC file is updated. WRCC keeps the original NESDIS ID and NWS ID received from ASCADS for all RAWS, but it archives data based on its own WRCC ID system. The metadata file of each station archived at WRCC also contains the information contained in the metadata file provided by ASCADS.

The WRCC database maintains a Station Metadata Summary for each RAWS that contains information about all NESDIS IDs used at different times in the history of a particular station. This information is cross-referenced with another table, which tracks the history of individual NESDIS IDs with respect to their different locations over time and the duration of their operation. The fact that stations and transmitters are mixed has lead to the wrong data being aligned with the wrong location. Finally, the WRCC conducts ongoing QA/QC of incoming RAWS weather data; these criteria are listed in Brown and others (2002).

Archival Function

The WRCC database is the only systemwide archive of long-term hourly data from RAWS. It contains complete data records for all active and inactive RAWS. In some instances, these records go back more than 20 years. Other data archives such as ASCADS, WIMS/KCFast, and the University of Utah maintain only partial records. WIMS/KCFast keeps hourly records for up to 18 months while also supporting the long-term archive of manually adjusted 13:00 hour observations for each station. The University of Utah maintains an hourly RAWS database for the past 5 years only.

A unique aspect of the WRCC RAWS data archive, as compared to other RAWS databases, is that the historical record is documented for each station and thoroughly examined and quality assured for consistency. This is important because the RAWS NESDIS ID used by ASCADS and other information systems to track individual stations actually identifies specific satellite equipment rather than station locations. The six-digit NWS ID identifies station location but may also change through time. Circumstance may require the station to receive a new NESDIS ID despite the fact that its physical location remains the same. This creates discontinuity and confusion in the data record associated with a particular NESDIS ID. The research group at WRCC has spent an enormous amount of effort to recover the history of each NESDIS ID and restore the actual data records of all individual RAWS to ensure that all meteorological data archived for a particular RAWS have actually been measured at the location of that station. This type of work has not been conducted by other information systems except perhaps the one recently developed at the University of Utah.

Access

There are two ways to retrieve RAWS data from the WRCC: through special arrangements with WRCC or through the new WRCC Web site called the RAWS USA Climate Archive. This site allows the user to select a RAWS from either a list or a clickable map. Further options include: different graphing choices, tabulated data, and date ranges (see appendix A for the Web address). The site is similar to the BLM/NIFC WFMI site (see below). Development of this Web site began in 1999 and has been an ongoing project in collaboration with RSFWSU, which has provided limited funding as part of its long-term strategic plan. Some portions of the site are still under construction. (See a diagram of data flow, search options, and criteria in appendix H.) The existence of this Web site is not widely known and information about it has been mainly through word of mouth.

Clearly, the best method for obtaining data from multiple sites and/or extended date ranges is to contact the WRCC directly and request data files. The Web site provides information such as telephone numbers and other products. (See appendix A for the Web site address.)

Findings

A number of questions have been raised concerning the WRCC and ASCADS:

1. Should personnel be assigned to WRCC to manage RAWS metadata function as human watchdogs? There are considerable gaps in the ASCADS metadata base, but the planned integration of ASCADS and WIMS metadata would make this a moot point. If they are not integrated, then we find that, given the size and complexity of the database and the long learning curve on understanding the metadata issues, such a position would have to be permanently based at the Climate Center.
2. Should the WRCC play a more significant role in how ASCADS will function and how it will look in the short- and long-term future? The WRCC has already passed on recommendations addressing this subject to RSFWSU and the BLM/NIFC/National Systems Development Unit.
3. Should the WRCC take over some functions of ASCADS such as data ingestion and distribution? The WRCC seems disinclined to take on this role (G. McCurdy and K. Redmond, personal communication 2002). But the WRCC is willing to develop a wider range of fire weather-related products such as data analysis, QA/QC analyses, and spatial and network analyses. Such work has been recommended in studies carried out by Marsha (2002a, b), Brown and Hall (1997), Brown and others (2001), Brown and Hall (2001), and Brown and others (2002).
4. Current WRCC QA/QC of RAWS data remains at WRCC. There is no mechanism to update other databases (i.e., WIMS, ASCADS, etc.) with WRCC corrected data.

National Interagency Fire Management Integrated Database (NIFMID: WIMS/KCFast)

The National Interagency Fire Management Integrated Database (NIFMID) is an ORACLE application that contains historic fire weather and fire occurrence information. It serves as a database warehouse for archiving fire business/management information, including RAWS weather observations. All modules contained within NIFMID are accessible via the F&AM Web site (see appendix A for the Web address). A diagrammatic description of NIFMID and its modules is provided in appendix C-1. Accessing the NIFMID/WIMS/(KCFast database allows member users to retrieve historical weather, fire occurrence, and station catalog data. (For more details, see appendix A in the Fire Family Plus Users Guide V2.0 (RMRS 2000). Other modules in NIFMID include report generators and forms (for example, the national fire situation report, incident situation reports, and aircraft use), and firefighter pocket cards (see example of pocket cards in appendix E).

WIMS

The Weather Information Management System (WIMS) is also included within NFMID. WIMS is a weather information database that has hosted the NFDRS model(s) since 1993 (see appendix B and Current Status, Operations, and Protocols for more details on NFDRS and its relation to WIMS). WIMS produces the daily and forecasted fire danger indices and components using the NFDRS model(s). The main difference between WIMS and KCFast is that WIMS allows edits or new inputs to be made to these data or metadata sets; for more detail, see the WIMS/WEB Application User Guide, June 2001; appendix A of the Fire Family Plus Users Guide V2.0 (RMRS 2000).

Up to September 2001 WIMS was accessed via a terminal emulator, in the same way that users access ASCADS today (see above). The WIMS system uses two servers – an IBM mainframe and an IBM RISC6000/AIX; the IBM mainframe hosts the ORACLE database and the AIX machine hosts the Web/application server. Both WIMS and NIFMID are physically located at the USDA National Information Technology Center (NITC) in Kansas City, MO. Access is 24 hours a day, 7 days a week.

In June 2001, an Internet-based and interactive version of WIMS, the WIMS/WEB, was released (for the user interface with a hierarchy of menus and forms, see appendix C-2). The WIMS/WEB user interface and look are similar to that of WIMS. WIMS/WEB is a Web-based interactive package that allows the user to enter and manipulate data; retrieve weather information, fire weather forecasts, and smoke management forecasts; display NFDRS indices and components; and enter and retrieve point and trend forecasts and other NWS products.

Access to both WIMS and KCFast is initially the same; one can use the same user ID and password for both. To obtain a WIMS/KCFast user name and password, Forest Service personnel must contact their Regional Computer Security office to apply and to arrange for payment. At the time of this report (spring 2003), the fee is about $1.00 per day. With the move of the WIMS/NIFMID database to a dedicated server (see below: WIMS Upgrades) there will be no user fee.

KCFast

The NIFMID Kansas City Fire Access Software (KCFast) database stores RAWS data in two formats: The 1972 format that contains all the recorded 13:00 hour observations for the entire period of record, and the 1998 format that retains all the hourly observations for 18 months, including fire occurrence information (accessed via a different link within KCFast) and statistics by Region, Forest, and so forth. KCFast does not allow edits or new inputs to be made to these data or metadata sets. (See appendix Q for KCFast Data File Formats.)

Other Modules

Other modules that require weather information are Interagency Situation Report (SIT) (appendix R); the Incident Report Form 209 (appendix S); and Pocket Cards (appendix E). The SIT and Form 209 include general weather data during an incident, and pocket cards include graphs of NFDRS output as well as fire occurrence over time. The Aviation Management Information System (AMIS) and the Federal Excess Property Management System (FEPMIS) are also part of NIFMID, but neither requires weather data.

National Weather Service (NWS)

The National Weather Service provides a short-term RAWS data archive for the last 48 hours. The Boise Fire Weather/National Fire Page provides links to RAWS observations, data summaries, model output statistics, RAWS location information, current conditions, WFAS, satellite imagery, and various fire indices. (See appendix A for the Web address for the Boise Fire Weather/National Fire Page.)

BLM/NIFC Wildland Fire Management Information (WFMI)

The WFMI is a Web-based fire weather database managed by the BLM in Boise, ID. It replaced the BLM’s Initial Attack Management System (IAMS) in the late 1990s. WFMI receives fire weather data from ASCADS hourly. The user can request access to weather data summaries in a tabular or graphical format. Summaries of the standard RAWS observations can be accessed for periods from the most recent to the last 90 days. Also available are clickable maps for RAWS data access, station locations (latitude/longitude), and site descriptions.

The site descriptions consist of general information about the individual site: name, owner, point of contact, location, slope, aspect, vegetation, cover class, elevation, climate zone, ID numbers, sensor calibration or replacement dates, and so forth.

Also available at this site is information about local lightning activity (mapped strikes); fire reporting (restricted to BLM users); aviation (military training routes, FAA Airports, agency airbases; Very High Frequency Omnidirectional Radio Range (VOR) locations; and Dispatch Mission Planning and contacts for Aviation Wildland Firefighting resources; firefighter pocket cards (the same site linked from the F&AM Web application[s] page), and fire planning (for example, developing prevention and fuels management programs).

Wildland Fire Assessment System (WFAS)

WFAS is not an application to retrieve RAWS data but a Web-based interface to display NFDRS products. It generates and displays daily maps of selected fire weather parameters and fire danger indices and components. It also maps daily and forecast adjective fire danger ratings. WFAS queries WIMS every afternoon to generate these maps from current weather observations and NFDRS products. Each afternoon IMET forecasters from the NWS view these products and issue trend forecasts for fire weather zones. WIMS processes these forecasts into next-day index and component predictions. (See appendix G for details.)

The WFAS Observed (and Forecast) Fire Potential Index (FPI) maps are relatively new products; they are experimental as of August 2002. These maps use satellite-derived greenness indices, an NFDRS fuel model map (both at 1 km resolution), and an interpolated 10-hour time-lag fuel map as drivers to weight the relative influence of live and dead vegetation on fire potential. The 10-hour fuel moistures are calculated from weather station data and interpolated to 1 km resolutions. The FPI ranges from 0 (low) to 100 (high). The FPI appears to be strongly correlated with fire occurrence and can describe fire danger potential from a regional scale to a few square kilometers (Burgan and others 1998).

Geospatial Multi-Agency Coordination Group (GeoMAC)

The GeoMAC Web site was developed by USGS and implemented in 2001 in response to the 2000 fire season. During the 2000 fire season, 122,827 fires burned an estimated 8,422,237 acres along with hundreds of structures and valuable natural resources (North Central Research Station 2001). Over 25,000 firefighters, 900 fire engines, 200 helicopters, and all available air tankers were deployed. Long-term weather forecasts indicated that the hot, dry conditions throughout the Western United States would continue until fall weather brought enough rain to extinguish the large fires. Across the West, geographic fire coordination centers set priorities for deployment of firefighting resources based on human safety, protection of property, and natural resources. Determining these priorities required more information than provided by the existing standard printed maps and situation reports, fire managers decided that a visual representation of the active fires would give managers a better idea of where to focus resources. So they requested an application that would provide real-time geo-spatial information on the status, location, and proximity of wildfires to life, property, and infrastructure—hence, the GeoMAC.

GeoMAC is a map-intensive Web site. One of many options allows agency users and the public to access the last 24 hours of transmitted RAWS weather data via NWS links. If a particular station transmits only once per day, the 13:00 (LST) observation is provided. The RAWS sites can be displayed on a clickable map and are hyperlinked to the NWS database in Boise, ID. GeoMAC displays various information layers such as a situation report of active fires; fire perimeters; RAWS weather data; major cities, roads, lakes, and streams; and so forth. For detecting active fires, it can display thermal satellite images. (Appendix T provides a flow chart of GeoMAC choices, maps, and active layers).

Findings

As in the case of the WRCC Web site, no official release information concerning GeoMAC use and standards was received by FS Dispatch Centers (at least not by Fort Collins Dispatch). There appears to be no mechanism for informing local Dispatch Centers about new ways (and systems under development) to access RAWS data.

RAWS Projects Under Development

A number of projects are currently under development. Primarily, they pertain to new ways of accessing and displaying RAWS data via a Web-based interface. Both BLM and FS plan to reengineer and upgrade their RAWS databases (ASCADS and WIMS respectively). The RSFWSU plans to deploy a Direct Readout Ground Station (DRGS) at the National Interagency Fire Center (NIFC) in Boise, ID, as a backup to the GOES-DOMSAT system (field test phase as of October 2003). Data sampling will be increased from once per hour to every 30 minutes and eventually to once every 15 minutes. A new portable fire RAWS is under development.

As covered previously, the Western Regional Climate Center (WRCC) is in the process of developing a new Web-based RAWS data monitoring application called WRCC RAWS USA. A similar site has been developed as a collaborative project between the RMACC, the Eastern Great Basin GACC, and the University of Utah. Also being established are mesoscale weather forecasting centers (FCAMMS). Such a center has been in operation in the Pacific Northwest for some years and new centers are being established in the Rocky Mountain Region, California and Eastern Great Basin, the North Central Great Plains, and in the Southeast.

NFDRS 2000 Standards

As we have already discussed, the NFDRS 2000 standards are intended to standardize RAWS procedures across agencies for the entire network. As part of the NFDRS 2000 update, ongoing hardware upgrades are continuing. Although the sensor suite will stay essentially the same, new methods are being developed to calculate fuel moisture and SOW. The new operations protocols are briefly described in Operations, Protocols, and Organization section above and in detail in appendix I.

The RSFWSU Strategic Plan in Support of NFDRS 2000 Standards

In January 2002, a RSFWSU Strategic Plan was drafted by the BLM in cooperation with a number of other land management partners (FS, FWS, NPS, and BIA). Several issues were addressed and recommendations made relative to improvements in hardware and software technology and maintenance, in support of the NFDRS 2000 update. The Strategic Plan was further refined for the short term by the RSFWSU and the Systems Development Unit at the end of June 2002.

The proposed long-term upgrades call for an ASCADS with new hardware, software, and a mapping module, redundant data entry pathways (from DOMSAT as well as directly from GOES), shared databases with WIMS, and improved database capabilities (in other words, site photographs, metadata, and online accessibility). The secondary data transmission path would be via a Direct Readout Ground Station (DRGS; item 5 below). The DRGS would be able to mimic the GOES Data Collection System at Wallops Island by monitoring the GOES directly from NIFC/Boise.

Long-Term Upgrades to ASCADS

A meeting of the RSFWSU and ASCADS Systems Development team in Boise, ID, was held on June 27, 2002, in Boise, ID (meeting notes and P. Sielaff, personal communication 2002). Five 'must-have' upgrades or patches were identified to be implemented as soon as possible:

1. Increase number of transmissions to four per hour (15-minute transmission capability) with 5-second transmission windows (we note that this implies a transmission baud rate greater than the current 100 baud).
2. Increase the number of ASCADS data elements to 64 user-defined elements with the ability to display and distribute these additional elements for some stations. Standardization issues were not addressed.
3. Include a NFDRS (YES/NO) field in station metadata to advertise NFDRS 2000 compatibility.
4. Reconfigure ASCADS with a Web-based interface.
5. Interface ASCADS with a DRGS.

These RSFWSU Strategic Plan upgrades have now been agreed upon to essentially define the initial upgraded ASCADS configuration. Release is scheduled for April 2003 followed by a field testing prior to fire season.

In addition to the above critical modifications, RSFWSU identified a number of other requirements to be included in ASCADS in the future; among these were:

- Increased Watchdog capabilities
  - Alerts to be e-mailed to more than one user
  - Notification to multiple users if an NFDRS station goes offline or a sensor fails
- Mapping capability
  - User-generated maps showing RAWS by State, Region, and so forth
  - Increased report capabilities for users
- Property management reports
- Better functionality with user Annual Operating Plans
- Monthly maintenance calendar (another option off the main menu)
- Maintenance and/or improvement in ASCADS response speed with improvements in hardware and software
- Redefinition of the Station Classification database field to document new NFDRS 2000 standards
- Daily e-mails to notify identified users if annual calibration has not been performed for NFDRS 2000 stations
- Data shutdown option for NFDRS 2000 stations if annual calibration has not been completed
- Shutdown authority to RSFWSU for any RAWS coming through ASCADS
- Easier access into ASCADS in the Unit and/or Agency database fields (users with multiple jurisdiction currently have to trick the system)
- Implementation of an upgraded user-friendly interface.

As of mid-April 2003 the ASCADS database was moved to a new and faster server; in addition users must now use the SecureNetTerm terminal emulator. USDA Forest Service users must also obtain a new ASCADS profile (username and password) prior to setting up SecureNetTerm and connecting to ASCADS. Only one of the priority patch items (see above) is being implemented as of June 2003, and that is the DRGS, which has been installed but is still undergoing testing (B. Adams, personal communication June 2003).

Increase in Transmission Frequencies and Rates

Under the NFDRS 2000 standards, fire danger indices and components (BI, IC, ERC, and SC; see Glossary and appendix B for definitions) will be generated four times a day rather than only once. Some RAWS stations are being reprogrammed to transmit at 300 baud every 15 or 30 minutes. With the introduction of faster data transmission rates and frequency, RAWS data could be used to drive fire behavior models (for example, BehavePlus 1.0). New equipment upgrades are helping to make such applications possible, but the RSFWSU Strategic Plan notes that not all stations in the network would require this kind of sophistication.

RSFWSU had planned to test four transmissions per hour (that is, once every 15 minutes) at 300 baud during the 2002 fire season in cooperation with fire behavior analysts. However, preliminary work indicated that Wallops Island and WIMS could not handle the amount of data being sent. In addition, Wallops Island was experiencing problems in demodulating the 300 baud rate signal. The result was that stations transmitting at 300 baud missed transmissions frequently, with no regular pattern. This problem persists as of early spring 2003. As a result, several RAWS already transmitting at 300 baud were reassigned to 100 baud rate channels at the beginning of the 2002 fire season (K.Shelley, C. Maxwell, personal communication 2002). As of mid-May 2003 NOAA/NESDIS engineers believe they have resolved these problems with the 300 baud transmission rate. Limited testing has been conducted by the RSFWSU subsequent to the repairs at Wallops Island and vast improvement has been noted (B. Adams, personal communication June 2003; see also the FS RAWS Web site link to *RAWS News*). The authors have also observed a significant decrease in the number of missed transmissions from the Fernberg, MN super-RAWS station (on 300 baud since winter 2001-2002).

IWOS Development

Development of the Incident Weather Observing System (IWOS) is under way; it will replace the aging portable Fire RAWS (FRWS). The new system will also be a portable RAWS with the same sensor suite. In addition to the hourly observations transmitted via GOES, IWOS will be accessible via a hand-held radio to obtain current information. If critical thresholds are exceeded, it will also be able to provide alerts using a voice synthesizer and a radio.

WIMS Upgrades

Upgrades to WIMS will automate several processes that are now manual. When the WIMS upgrade is complete, the following manually entered observations will be automated: SOW, LAL, and the daily 13:00 hour (LST) observation (this latter required manually changing the R designation to an O). As of spring 2003, software upgrades have been put on hold due to budget constraints. Some hardware upgrades are still planned: specifically the WIMS/NIFMID database will be moved from the System D mainframe to an IBM AIX server at NITC. (J. Barnes, NST, personal communications 2003, FAMWEB Technote 2003-01, May 2003).

New Web Sites/Data Access/RAWS Products

The Rocky Mountain Area GACC (RMACC) contracted with the U.S. Geological Survey Mapping Center/Geospatial Multi-Agency Coordination Group (GeoMAC) to develop a Web site (titled Rocky Mountain Area Red Flag, see appendix A for address). The Web site described previously in the Data Retrieval section displays fire weather watches and red flag warnings at near real time for fire danger zones within the region. Fire weather watches are issued when red flag warning criteria are expected within 12 to 48 hours. The NWS issues red flag warnings to alert fire managers when specific weather conditions, combined with dry fuels, could lead to dangerous fires. Criteria may be dry lightning storms, high atmospheric instability coupled with low fuel moistures, low humidity, or winds above a threshold speed. These warnings help managers plan resource allocation and appropriate fire containment activities. The Web site also provides map layers with links to fire fuels, RAWS weather, situation reports, geographical features, cities, roads, and political boundaries. Some pages within this site are still under development.

The RMACC is also collaborating with the Eastern Great Basin GACC and the University of Utah Cooperative Institute for Regional Prediction (CIRP) to develop a Web site to display near real time RAWS data and weather information collected by other networks. Included are trends, low- and high-resolution maps, satellite images, station data summaries and metadata, tabular weather data, and meteograms. Development criteria include: a field-accessible information-access platform, an easily understood format, quick download, and a minimum number of links to retrieve desired information. Although still under development, some products are available: maps; some mesoscale model (MM5) products; and weather data and summaries for the RMACC, Great Basin, the Southwest, California and other Forest Service Regions. (The Web address is given in appendix A under University of Utah—Cooperative Institute for Regional Prediction.)

Geographic Area Coordination Centers (GACCs)

Geographic Area Coordination Centers (GACCs) as they are organized today have been in operation since spring 2001. Modern GACCs were established to provide support for fighting large fires at regional levels when National Forest or county dispatch centers need additional support. Following the 2000 fire season, the need for daily and short-term forecast fire danger assessments was recognized. Previously, assessments had been made on an as-needed basis, but often were out-of-date by the time they were completed. These fire danger assessments take the form of fire business products (daily and forecast): fire intelligence; fire weather; fire safety and prevention information; and fire danger rating indices and components; and fire safety. Detailed roles and responsibilities have been described in a strategy document prepared by the National Multi-Agency Coordinating Group (NMAC: NMAC Predictive Services Task Group and Charter 2002; R. Ochoa, personal communication 2002) at the National Interagency Coordinating Center (NICC), in Boise, ID.

The National Fire Plan provides funding for personnel, logistics, and physical plant to create these fire danger assessments on a day-to-day basis, especially during the fire season (R. Ochoa, personal communication 2002). Two full-time predictive service meteorologists support each GACC. If the GACCs cannot meet requests because they are supporting multiple incidents, or when GACCs are competing for resources, requests for equipment and supplies are referred to NICC.

Studies and Surveys

We present an overview of previous RAWS use studies. Then we summarize the responses to a RAWS-use survey and present the results of a survey of commercially available meteorological sensors with specifications. The latter was specifically requested to document the currently available, off-the-shelf, state-of-the-art meteorological sensors (for example, the sonic anemometer model currently being tested by RSFWSU). We next describe a prototype RAWS (super-RAWS) deployed in northern Minnesota and provide a comparison between RAWS fire-data specific protocols and more traditional hourly averaged data. We also investigate some other issues: a comparison of WRCC and KCFast data sets; the effects of changes in tower height and placement; the reporting of the 13:00 hour observation time; and DCP transmission protocols.

Previous RAWS Use Studies

RAWS data have been used in climatology studies (Brown and Hall 1997), fire-danger ratings, fire behavior analyses, and for quality control and assurance of the data itself. The use of RAWS data in regional spatial assessments has often been hampered by inadequate RAWS data quality. In attempts to correct this problem, GACC meteorologists have focused on analyzing individual RAWS data series within their regions. Several recent studies (Brown and others 2001; Marsha 2001a,b) have explored statistical approaches to analyze RAWS data in order to develop a methodology for optimizing intraregional RAWS deployments, to help define fire weather zones, and to identify priority stations within those zones. Brown and others (2002) conducted a quality control study on historical RAWS data from 242 sites in California. The goal was to examine data records and to flag or remove records deemed questionable, unacceptable, or implausible. The resulting clean data files are now used for fire danger rating analyses and climatological studies.

Marsha Study: Identification of Priority Stations Within Zones

Marsha (2001a,b) defined an objective method to design a more efficient RAWS network, in terms of number and siting, to meet the weather needs of wildland fire managers in the Pacific Northwest. The analysis consisted of two parts: (1) a wind rating was employed for each RAWS in the States of Washington and Oregon; and (2) cross-correlation matrices were computed for daily minimum relative humidity (RH) of each RAWS within the sub-areas.

Wind Rating. The wind rating was designed to identify and assess those RAWS that are wind sensitive (in other words, show good response to elevated wind speeds and have good variability). These criteria were evaluated by examining the distribution of the RAWS hourly wind speeds. Archived historical data were used to construct a climatological distribution of the peak wind speed for every 4-hour time period over several years. From the latter the median and 90th percentile peak wind speeds were determined. The spread statistic was then defined as the following:

$$\frac{u_{90} - \overline{u_m}}{\overline{u_m}}$$

where u_{90} = 90th percentile peak WS and u_m = the median peak WS. Marsha's wind sensitivity rating used the following criteria:

1. 90th percentile peak wind speed >= 4.47 m/s (10 mph) during a 4-hour time period, and
2. the spread statistic for the same time period >= 0.50

The assigned ratings were:

0 - if the above criteria were not met for any of the six 4-hour time periods of the day

1 - if the above criteria were met for at least one 4-hour time period of the day

2 - if the above criteria were met for at least one daytime and one nighttime 4-hour time period

RAWS with zero were considered inadequate, 1 adequate, and 2 good.

Relative Humidity Matrices. Part two of Marsha's study was a cross-correlation analysis of minimum daily afternoon RH for each RAWS within a zone, resulting in correlation matrices for all RAWS. It defined a nonrepresentative RAWS as a station with the highest number of correlations at or above a given threshold (in this study, an 'r' coefficient value of 0.90 was chosen based on the geographic area being examined). Such stations were removed from the matrix as were the other sites that correlated with it at or above the threshold r value. A high r value was taken as an indicator of a redundant or nonprimary weather station. Those stations that were most similar in terms of RH were removed from the matrix. The process was repeated until a sub-set of key RAWS remained that were uniquely different from one another. If a draw occurred between sites, priority was given to the site or sites with a wind sensitivity rating of 1 or 2.

Due to local concerns over losing a site, no station was physically removed from the PacNW network, the non-representative RAWS were simply labeled as secondary stations.

Findings

The Marsha study was designed to provide a specific result for a specific area. It may not be a useful approach for other regions: NFDRS products from the selected study stations will no doubt reflect the selection criteria.

Brown Study: Optimization of Intraregional RAWS Deployments

Brown and others (2001) used two approaches in an analysis of the Great Basin (primarily Nevada) RAWS network. The first was similar to that taken by Marsha (2001a, b), correlating July monthly mean air temperatures, relative humidity (RH), and wind speed (WS) for six RAWS over periods of at least 9 years. This analysis was designed to examine how station separation related to climate characteristics. Results indicated that stations as close as 11 km (about 7 miles) demonstrated low correlations for wind speed, while stations as far apart as 30 km (about 19 miles) had high correlation for temperature. Thus, use of single parameter correlation statistics alone in determining a site's importance or redundancy could be misleading.

Geostatistical Approach. The Brown study applied a more formal geostatistical approach than was commonly used in the analysis of meteorological networks (Gandin 1970) to establish the maximum distance between stations based upon a single climate variable. Variogram plots (a graph of the variance of paired observations as a function of distance) were calculated for July monthly mean air temperatures for the 116 RAWS in the region. The study then used the results to fit a mathematical model which, in turn, was used to generate a uniform field of estimated temperature. Brown and others (2001) found that the optimum distance for station spacing (and highest spatial correlation) was about 43 km (roughly 27 miles). The actual correlation (r) was only 0.45, interpreted as quite low.

Study Results. The authors suggested that elevation variation across the region caused significant climate differences; they attributed the low correlation values to these elevation differences. In a subsequent analysis, temperature data grouped into three elevation ranges greatly improved the results and also indicated that the maximum distance between stations should be no more than about 80 km (50 miles).

Other Studies

Meteorologists from the RMACC (T. Mathewson and R. Mann) and the SWACC (C. Maxwell and R. Wooley) have recently conducted informal, unpublished, applied studies similar to those of Marsha (2001a,b) in efforts to define weather zones and to study NFDRS indices and component variations within their respective GACC regions.

Survey of RAWS Users

At the suggestion of the FS WO Research Staff (D. Cleaves), we constructed a user survey with questions targeting RAWS data use, type of data, importance of data, and sampling protocols. More than 100 surveys were sent to users through various means, including mail, e-mail, and personal delivery. A total of 44 responses were received, evenly divided between the NWS Weather Forecast Offices and Federal and State land management agencies. We tabulated responses and summarized the answers to those that were open-ended. Specific questions and a summary with greater detail are provided in appendix U.

Multiple Uses

Most respondents reported multiple uses for RAWS data. The prevalent uses for RAWS data are weather prediction and forecasting followed by incident management and monitoring weather for prescribed fires. Almost 90 percent of respondents used hourly and daily (specifically, the 13:00 hour observation) RAWS data. The real-time and event specific categories accounted for the remainder.

Nearly all data parameters plus NFDRS outputs are used by land management personnel. NWS forecasters use all the meteorological data. However, less than half use NFDRS products. Fuel temperature was the datum least frequently used by all respondents. NWS forecasters use RAWS data almost exclusively for specific locations or for weather climate zones, while nearly all land management agency personnel use the data set for a specific region or GACC area.

The majority of land management agency respondents use RAWS data for fire business applications – to calculate NFDRS indices, components, and adjective ratings; and to determine staffing levels, incident management, and longer term preparedness. Respondents from the NWS use RAWS data primarily for producing fire weather forecasts, determining red flag warning and fire weather watches, public weather forecasts, point/spot forecasts for specific incidents, and severe weather warnings.

Assessment of Current RAWS Network

All respondents considered RAWS critical for supporting their decisionmaking process; staffing; ensuring fire fighter safety; for calculating NFDRS indices and components; making both area and spot fire weather forecasts; and for real-time weather monitoring during prescribed burns and wildfires. All meteorological data were rated of high importance by all respondents, but NWS/WFO personnel tended to rate NFDRS products lower compared to the personnel from land management agencies.

No respondent indicated station overlap in his or her area (agency region or weather forecast zone). Coverage was deemed pretty good or adequate in the Western United States except for eastern Colorado, east of the Mississippi River, and some areas in the FS Southern Region.

Almost all respondents indicated a desire for a change in the traditional RAWS sampling protocol: more frequent sampling and data transmission; NFDRS product calculation/output more than once per day; and ready access to the larger data set. Three respondents suggested leaving the system alone, making no changes at all.

Four respondents indicated an explicit inclusion of RAWS duties and/or responsibilities in their respective position descriptions (PDs) and one included PD specifics: see appendix K for a sample PD of RAWS related duties. (See also Findings on Personnel Issues in the Management Implications section on the need to explicitly describe RAWS-related duties in individual FS PDs.)

Survey of Commercially Available Meteorological Sensors

We were asked by our WO sponsor to conduct a meteorological sensor/instrument survey as part of our review. The purpose of these results is to give planners, managers, and operators associated with RAWS a thorough list of available off-the-shelf sensors for potential future use with fire weather stations. Although current operational features of the RAWS system demand uniformity of instrumentation across the network, it makes sense to keep abreast of new sensor technologies. The survey includes sensor specifications that are sometimes overlooked when choosing manufacturers.

Air Resource Specialists, Inc. was funded to gather and compile technical information from known meteorological equipment vendors and prepare a comprehensive tabular summary of sensors associated with RAWS operations:

- Wind speed
- Wind direction
- Ambient air temperature
- Relative humidity
- Precipitation
- Barometric pressure
- Solar radiation
- Fuel moisture
- Fuel temperature
- Soil moisture
- Soil temperature

Appendix V with attached CD provides a detailed list of currently available, off-the-shelf sensors, their technical specifications, manufacturers, current price, and a narrative for each sensor type. This information was compiled between January and April 2002. Each section in the appendix V CD is preceded by a narrative describing each factor or specification within the survey. The manufacturer and model number for each sensor group are highlighted in a separate color. Since there are more parameters than will fit on one 8 ½ by 11 inch page, successive pages give the additional parameters for each group of sensors. Color changes denote when new groups of instruments are listed.

Experimental Prototype Super-RAWS

Description

The USDA FS WO Air Resource Management Program and the FS WO National Weather Program, with support from FS RMRS scientists, have funded a prototype enhanced RAWS station. This super-RAWS is equipped with the standard suite of sensors as well as additional sensors and alternative sensors not used on standard RAWS and not limited to fire-related parameters. Super-RAWS was deployed within the Superior National Forest at the Fernberg tower site, 20 miles east of Ely, MN. Operational since September 2001, the super-RAWS transmits data as per NFDRS standards using a Campbell Scientific data-logger and GOES transmitter.

An assessment of future weather data needs of Federal land management agencies and the expanding list of uses and applications of RAWS weather data led to the deployment of the super-RAWS. These include: leaf wetness; soil temperature and moisture; air and soil vertical temperature difference (delta temperature); vector wind speed; moisture content of decomposing surface litter (duff); and associated statistics (see appendix W for the complete data list). Super-RAWS data may support climatological studies, pollution dispersion modeling, and modeling of ecosystem carbon exchange and water vapor flux (Zeller and Nikolov 2000). The latter ecosystem modeling may also provide a new approach for the analyses of future fire potential since the amount of water within the ecosystem is accounted for.

Comparison of RAWS and Super-RAWS Data Sets

The Fernberg super-RAWS data set provided an opportunity to: (1) compare traditional RAWS protocol 10-minute and instantaneous data with hourly average data routinely used in other meteorological and environmental assessments, and (2) evaluate new sensor technologies such as sonic anemometry for wind speed and wind direction versus the standard cup-vane wind sensors used at most RAWS.

According to the standard RAWS protocol, wind speed, wind direction, and relative humidity are provided as 10-minute averages, while temperature and solar radiation are instantaneous measurements obtained just prior to transmission. The super-RAWS was programmed to provide both RAWS protocol and averaged hourly data. Thus, the super-RAWS collects the standard RAWS 10-minute averages and instantaneous measurement as subsets of the hourly averaged super-RAWS data. Two different protocols were programmed to simultaneously record and report data allowing the same instruments to be used to record both standard RAWS and super-RAWS outputs.

Super-RAWS obviously increased the number of data elements measured and transmitted. Because ASCADS can only handle a maximum of 12 data records, the standard RAWS component of super-RAWS was limited to 12. These standard RAWS parameters were previously listed in the Sampling Protocols subsection. The super-RAWS measures and transmits 48 data elements. The remaining data elements available on the super-RAWS are: weather data for each hour (for example, averaged 00:01 to 01:00 data are recorded as 01:00) in terms of means and statistical measures (for example, standard deviations and maximum values). The mean hourly wind speed and direction were recorded at the RAWS protocol 20 feet (6 m) as well as at 50 feet (15 m) above ground level; ambient temperature was measured at heights of 9 to 10 feet (3 m) and 50 feet (15 m).

Method of Comparison of RAWS and Super-RAWS Data Sets

We analyzed data that were obtained using standard and super-RAWS protocols during the period March 21 through June 17, 2002. In a statistical comparison of the time series of RAWS 10-minute and instantaneous values versus the super-RAWS hourly averages data, we calculated and studied the coefficient of determination (R^2), slope (S – a nondimensional variable in this case), and intercept (I – where the regression plot intercepts the y-axis) of the regression line, and a frequency distribution (histogram) of the residuals. We chose the hourly means as the independent variable against which standard RAWS data were compared. The comparison included: wind speed, wind direction, solar radiation, ambient temperature, and relative humidity. We also evaluated discrepancies in hourly measurements between the sonic anemometer and cup/vane sensors by plotting cup/vane data versus sonic for both wind speed and wind direction.

Results of Comparison of RAWS and Super-RAWS Data Sets

All data described in this section are provided in appendix X. The analysis indicates that solar radiation, wind speed, and wind direction, as measured using standard RAWS protocols, demonstrate larger deviations from hourly values than do temperature and relative humidity.

Solar Radiation. Given the high temporal variability of solar radiation, we conclude that instantaneous solar measurements do not adequately represent average hourly conditions. In about 30 percent of all cases, instantaneous solar radiation values deviated from true hourly means by more than 50 W m^{-2} (fig. X-1). Updates to the solar radiation sampling procedure should significantly reduce these differences (see Recent Updates to NFDRS 2000 Standards subsection). In fact, new NWCG weather station standards (NWCG – National Fire Danger Rating System, Weather Station Standards. 2003) call for the use of an hourly average of solar radiation (from 60 samples). This change will begin to be implemented in 2003 as data-loggers are reprogrammed.

Truncation of Wind Speed Data. As shown in figure X-2, deviations of reported wind speed from the true values can be substantial. We found that the RAWS 10-minute wind speed data are truncated to a whole integer with .0 added back by the data-logger/program (for example, 6.9 becomes 6.0). This presents a systematic bias in the values reported for WS that is reflected in the low slope of the regression between hourly averages and 10-minute means (fig. X-2). Because of the high variability of wind speed within any hour in addition to the artificial truncation of 10-minute data, values reported by RAWS can underestimate the actual mean hourly wind speed by at least 1 mph and often by as much as 3 mph. This happened about 80 percent of the time.

Wind Direction Measurements. Measurements of wind direction (WD) showed a lesser bias than those for wind speed. Yet, in about 15 percent of cases, the 10-minute average WD departed from the hourly WD by more than 20 degrees (fig. X-3). Occasionally the RAWS WD was reported as opposite (180°) the hourly WD average. Wind direction data obtained from the vane and the sonic were similar (fig. X-4). In most cases, discrepancies in the sonic WD were within ± 20 degrees (see fig. X-4, lower panel).

Temperature and Relative Humidity Measurements. RAWS standard measurements of temperature and relative humidity were relatively close to hourly averages of these elements (see fig. X-5 and X-6). Relative humidity data showed somewhat larger deviations compared to temperature (fig. X-6). However, the accuracy of RH sensors is typically ±5 percent.

Differences Between Wind Speed Measured by Cup Versus by Sonic Anemometer. The super-RAWS was equipped with colocated cup and a sonic anemometers. A comparison of the two hourly wind speeds revealed that the cup anemometer tended to record larger values, especially at higher wind speeds (fig. X-7). This is most likely due to the well-known cup-response phenomenon: turbulence causes cups to over-spin. Also, the cup anemometers have start/stop thresholds at lower wind speeds (for example, the cup will not start spinning below a threshold WS). But the sonic anemometer does not have this threshold limitation. In the case of the super-RAWS, the minimum cup WS was programmed to be 0.5 mph. So if the WS was zero, the data logger would record and report 0.5 mph while the sonic anemometer, with no starting threshold, would report 0 mph. Hence, the frequency distribution (of cup – sonic) is shifted slightly to the right . (See fig. X-7, lower panel.)

Findings of Comparison of RAWS and Super-RAWS Data Sets

There are discrepancies in the standard RAWS protocols and in comparing RAWS data with 1-hour averages. Since fire danger is evaluated daily, perhaps further study is needed to address the impact of using the current RAWS sampling protocols.

Comparison of WRCC and KCFast Data Sets

Description of WRCC and KCFast Data Sets

We have made direct comparisons between four RAWS congruent data-sets from WRCC and from KCFast in an effort to evaluate database integrity. These comparisons quantify differences over the years when the data overlapped. We have also used the FF+ application to calculate fire danger indices and components (historical means and daily minimums and maximums) over the course of a fire season for these data sets. A summary is given below and additional details are given in appendix Y.

As previously discussed, WIMS/KCFast is a major long-term archive of RAWS observations. To review, the database supports two formats. The 1998 format retains all hourly data but stores it for only 18 months. The 1972 data format contains only 13:00-hour RAWS observations, and it stores the data for the entire period of record. The WIMS/KCFast archive based on the 1972 format is currently the information source used to compute NFDRS indices and components used in fire business support.

The 1998 KCFast file format provides a time tag for individual data records, which contains year, month, day, and observation time. However, the 1972 format does not provide an observation time since it is implicitly assumed that each daily observation refers to the 13:00, and only 13:00.

Due to the great operational significance of the KCFast RAWS dataset, the quality of archived 13:00-hour observations is important. Since operators manually flag these observations in the WIMS data base (along with entering SOW and LAL), the possibility exists for human errors such as using the wrong observation time for the 13:00 hour; accidentally changing numerical values of meteorological elements; entering incorrect SOW and/or LAL;

and so forth. Human errors were assessed by comparing KCFast historical records of 13:00-hour RAWS observations with the WRCC long-term archive of quality-controlled 13:00-hour RAWS observations. (See the section on the WRCC in this report.) We also evaluated differences in meteorological observations between KCFast and WRCC databases in terms of their impact on computed NFDRS indices and components.

In an attempt to quantify the likely magnitude of such human errors and their impact on computed NFDRS indices and components, we analyzed the historical record of several RAWS (specifically, Doyle, CA; Cheeseman, CO; Lake George, CO; and Redfeather, CO). We selected the Colorado stations to represent mainly FS-operated RAWS in Colorado with data record lengths of at least 10 years. The selection of the Doyle, CA site was random.

Method of Comparison of WRCC and KCFast Data Sets

We obtained meteorological data in the 1972 format for each of the four RAWS sites from the official KCFast Web site. The WRCC provided standard hourly data for the same RAWS from their database. The WRCC files were processed to extract 13:00-hour observations for each evaluated element and site. KCFast records were processed to extract archived values for the four elements being compared: ambient temperature, relative humidity, wind speed, and precipitation.

Using the time tags provided by the two databases, we aligned the 13:00-hour daily observations extracted from the WRCC database with corresponding records from the KCFast archive for each RAWS. Arithmetic differences were computed between KCFast and WRCC in the data records of each meteorological element for each of the four RAWS sites. The daily differences in recorded 13:00 hour values were plotted against time for the entire period of data archive overlap between KCFast and WRCC.

We also evaluated differences between the two data records in terms of correlation coefficient, slope, and intercept of the regression between the two time series for each element. Results were plotted using SigmaPlot 2001. We assumed that the WRCC data record was the correct one because it has been thoroughly examined by the WRCC staff; WRCC QA/QC criteria can be found in Brown and others 2002. Where the KCFast 13:00-hour observations differed from corresponding WRCC data, we interpreted this difference as an error caused by human factors.

Using FF+ as previously discussed, we evaluated the impact of KCFast data errors on NFDRS indices and components. FF+ as currently used by most fire managers in the United States is designed to ingest meteorological data in the KCFast 1972 format. It also requires a KCFast Station Catalog file for input. For each RAWS, we ran FF+ twice using (1) an original KCFast data file and (2) the WRCC 13:00-hour values. The comparison of FF+ runs only differed in the values of the main four meteorological elements: temperature, RH, WS, and precipitation. The rest of the support data were identical. We studied the behavior of four NFDRS indices and components: Spread Component (SC); Energy Released Component (ERC); Burning Index (BI); and Ignition Component (IC). Each index and component was represented by seasonal time series of its mean and maximum values, respectively. As with the meteorological data comparison, NFDRS indices computed from WRCC data were assumed to be the control against which the KCFast-based indices were compared.

Results of Comparison of WRCC and KCFast Data Sets

The comparisons above revealed significant differences between KCFast and WRCC data archives for all RAWS sites studied. Figure Y-1 in appendix Y shows the temporal dynamics between the 13:00-hour weather observations in WRCC and those in KCFast for the Cheeseman station in Colorado (NWS ID: 053102) over a period of about 15 years. (Figure Y-2 presents scatter plots and correlation statistics of the two time series. All figures and table Y-1 can be found in appendix Y.) As evident from the graphs, data in the KCFast record can deviate from WRCC values by as much as 54 ^{o}F for temperature, 68 percent for relative humidity, and 23 mph for wind speed. The pattern of differences and their magnitude appear to be random.

After carefully examining numerous days with nonzero differences and comparing KCFast 13:00 values with the complete hourly record from WRCC, we discovered that many data points entered in the KCFast archive as 13:00-hour observations actually came from other hours during the same day and, in some cases, even from early morning hours of the next day! In several instances, we found that not all values of meteorological elements originated from the same hour (in other words, temperature and humidity data were taken from the 11:00-hour while wind speed came from the 12:00-hour). This occurred over several days at the Doyle station during the early 1990s. We found that meteorological data entered into WIMS/KCFast as 13:00-hour observations, were often taken from hours ranging from 10:00 to 17:00. The pattern of discrepancies in meteorological data described for Cheeseman is similar to that found for all other three RAWS. It appears that station operators have systematically either made random errors by incorrectly flagging the 13:00-hour observations or chose to change the data to better represent the conditions as they saw it.

Discrepancies in meteorological records between the KCFast and WRCC databases had a sizable impact on computed NFDRS indices and components. Figure Y-3 shows deviations of mean values of the Spread Component (SC) for Doyle, CA. Errors in the KCFast data archive caused the mean SC to be overestimated for this site by 10 to 40 percent over most of the fire season. The SC maximum daily values showed much larger deviations (for example, 20 to 100 percent) compared to WRCC results (fig. Y-4). As indicated by the correlation statistics, the maximum SC values based on the KCFast record are poorly related to those derived from WRCC data. In this case, deviations tend to be positively biased. In other words, the KCFast data seem to consistently cause an overestimation of SC values for Doyle. Figure Y-5 shows errors in the calculation of the BI for the same site. Other indices and components computed for Doyle showed a similar error pattern. Table Y-1 provides coefficients of determination (R^2) and regression slopes (S) for indices and components computed comparing the KCFast and WRCC datasets for all four RAWS.

Figure Y-1 reveals another interesting pattern, which seems to be more or less present at the other three RAWS as well: after 1997, the KCFast record appears to match WRCC data considerably better than in previous years. Data discrepancies for all elements, while still occurring, are significantly less frequent after 1997. We suspect that this improvement was the result of a coordinated effort by the FS, BLM, and other land management agencies to improve the quality of RAWS observations as well as the accuracy of fire weather and business applications. We think this was achieved mainly through training and impressing upon personnel the critical importance of RAWS data in calculating fire danger ratings. This was especially the case after the South Canyon (Colorado) fire in 1994 where 14 firefighters lost their lives. There were also vast improvements in hardware and software during the 1990s: in 1993 WIMS was implemented and training became available. In the mid-1990s, an increasing number of stations were being upgraded with new DCPs, with an increase in transmission frequency from once every 3 hours to one per hour, with transmissions close to the top of the hour for priority stations, and with the conversion of dial-up stations to GOES platforms. And finally, concerted efforts were made at the local FS level to properly maintain the stations. This also entailed new training efforts that continue to this day (K. Shelley and R. Gripp personal communication 2002). Nevertheless, the potential for human error in the current manual data-entering requirement is still a weak link for RAWS data going to WIMS.

Findings

This analysis indicates that the errors in the KCFast data archive tend to produce biased estimates of the mean and maximum values for most NFDRS indices and components. Maximum values are more adversely affected than means. An important implication is that biases in long-term means and maximums could create a false impression about the actual fire danger at a site. For example, in the case of Doyle, an overestimation of historical values of BI and SC over a significant portion of the fire season could lead to an incorrect conclusion that fire danger was not exceptional in year 2002 at this site. On the other hand, NFDRS indices computed for Cheesman using the KCFast dataset tend to be underestimated (as indicated by the regression slopes in table Y-1). In addition, indices for Cheesman such as BI, SC, and IC show a significant dispersion around the values derived from the WRCC record. An important implication then is that biases in long-term means and maximums could create a false impression about the actual fire danger at a site and affect real-time decisions about staffing and resource allocation during actual firefighting.

These discrepancies must be addressed immediately since the KCFast data set is an active part of current fire business.

Effect of Changes in Tower Height and Sensor Placement

Description of Changes in Sensor Mounting Heights

RAWS data users must be aware that changing sensor mounting heights (NWCG 2000) will affect the data being collected. For example, wind speed (WS) decreases logarithmically as height decreases while relative humidity (RH) increases as the height decreases or the ground is approached. RH, which is a function of evaporating soil moisture and transpiring vegetation (Oke 1978), also has diurnal fluctuations related to temperature changes. If WS or RH sensor height is changed, or if sensors are moved, NFDRS indices and components will be affected. Wind speed, slope, and fine fuel moisture (sensitive to current RH and temperature) are direct inputs for the spread component (SC) calculation, which in turn, along with ERC, is used in calculating the ignition component (IC) and burn index (BI). Wind speed does not enter into the calculation of the ERC but 100- and 1000-hour fuel moistures do, which over the long term (days to weeks) respond to day length, max/min temperature, RH, and precipitation (see NWCG 2000; Cohen and Deeming 1985).

According to the NFDRS 2000 standards (NWCG 2000), the RAWS wind speed and direction sensors should be mounted at a height of 20 feet and the RH sensors at 4 to 8 feet (NWCG Weather Station Standards 2000). The international meteorological surface observation standard for wind measurement height is 10m (32.8 feet.). In FS Region 6 (Pacific Northwest), FS once used 10m Rohn25 towers as RAWS and, hence, meteorological wind sensors on these RAWS were often above 20 feet. Since these towers are no longer OSHA compliant, they have been phased out of service over the past 4 to 5 years and replaced with either Vaisala/Handar or FTS RAWS frames. In most cases, the replacement has caused sensors to be placed approximately 13 feet lower.

At this lower height, we would expect the measured wind speeds to be noticeably less than the recorded climatology for the location. If this were the case, it would present a continuity problem in using such data for FF+ and other fire danger calculations. To get a rough estimate of the effect of height change, we decided to examine an actual example of a change from a 10-meter tower to a 20-foot tower at Redfeather, CO. In August 2002, the 20-foot replacement tower was installed at Redfeather west of the 10-m tower, which, due to location, resulted in an actual 20.8 foot difference in aboveground WS sensor height. (The base of the 10 m tower was sited on a large boulder 8 feet above base of the new 20-foot tower: 32.8+8=40.8.) We caution the reader that the following example is an oversimplification since the example does not take into account variable atmospheric stability conditions. Use of these methods should be preceded by consultation with a trained meteorologist.

Method of Calculating Effect of Changes in Sensor Mounting Height

Calculating wind speed differences as a function of height are typically performed using either the power-law method or the logarithmic profile method. The power law is used for full boundary layer applications, while the logarithmic profile is usually recommended for applications close to the ground. Both are shown below:

Power law:

$$\frac{U_{20}}{U_{40.8}} = \left(\frac{z_{20}}{z_{40.8}}\right)^m$$

where U is wind speed; z is measurement height; and m is the power law exponent. Although m is dependent on the site and meteorological conditions, the value m≈0.1 is used for smooth surfaces and m≈0.4 for rougher surfaces;

Logarithmic profile:

$$U_{20} = \frac{u_*}{k}\ln\left(\frac{z_{20}}{z_{40.8}}\right) + U_{40.8}$$

where u_* is the site and meteorology dependent friction velocity; and k = 0.4 is the so-called von Karman constant.

We first plotted actual Redfeather mean wind speeds for each hour of the day: August 21 through September 24, 2001 and August 21 through September 24, 2002—pre- and post-tower height change (see fig. 3). Then using the power law approach with m=0.9 during nighttime hours and m=0.45 during daylight, and with a 20.8 foot reduction in anemometer height we adjusted the year 2001 data set, and then we did the same using the logarithmic profile method with u = 1.3 (night and day) and k = 0.4. We also calculated and plotted the 2001:2002 ratio for each hour of the day. The results from both adjustment methods reflect the actual 2002 data. The 2001:2002 ratio of actual data show a diurnal multiplier, equal to about 2 for the nighttime and 1.5 for the daytime.

Figure 4 shows the percent difference in the BI and SC for the Redfeather, CO, RAWS for the 1970 through 2001 fire seasons using adjusted and unadjusted winds from the KCFast database. The adjusted wind speeds were calculated using the logarithmic profile equation with a u* = 1.3, k = 0.4, and a height decrease of 20.8 feet. Mean and maximum SC and BI for the fire seasons 1970 through 2001 were then calculated (FF+) using the actual and adjusted data sets.

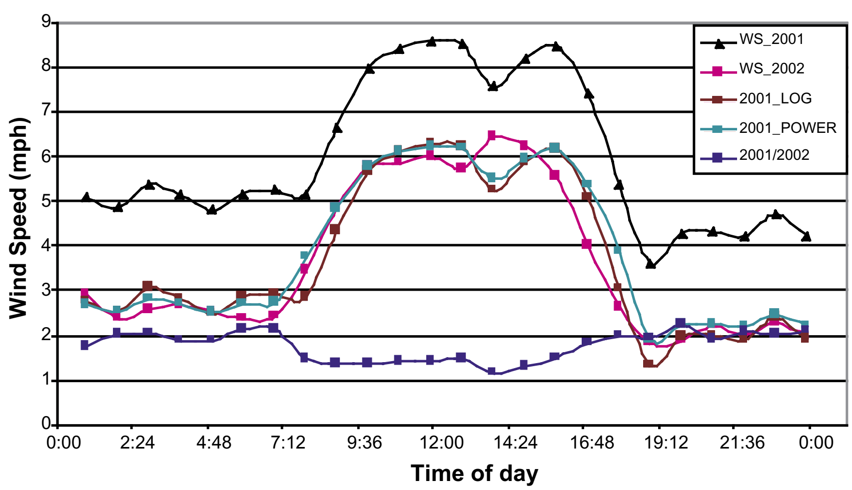

Figure 3: Mean wind speeds for each hour of the day between August 21 and September 24 in 2001 and in 2002.

The SC and BI were chosen because they are influenced directly by wind speed (compared to ERC). Given that wind speed decreases with height, these differences will always be greater than zero. For SC throughout the fire season, percent decrease ranged from 14 to 20 percent for daily means, and differences in the maximum values varied from 5 to 20 percent . For BI, decreases in daily means ranged from 8 to 11 percent, and differences in the maximum values ranged from 4 to 10 percent. The reduction in wind speeds also lowered the 90th and 97th percentile SC and BI values.

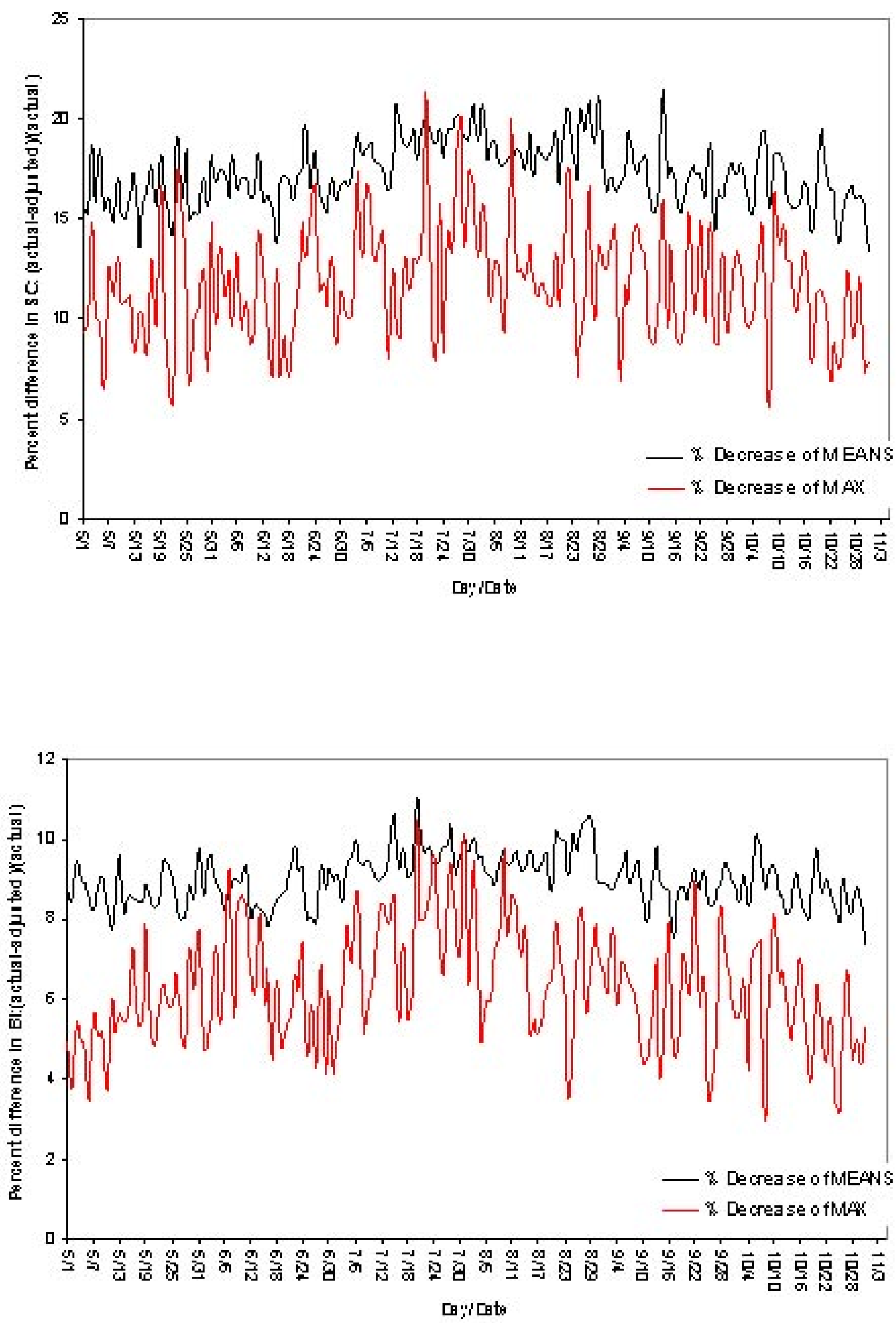

Figure 4: Percent decrease in daily mean spread component (SC) and burning index (BI), 1970-2001 at Redfeather CO RAWS.

Findings from Calculation of Effect of Changes in Sensor Mounting Height

If the wind speed and direction sensors are lowered, actual fire danger could be underestimated when compared to the unadjusted historical record. This could have far-reaching consequences for fire business decision support and ultimately resource allocation. Further discussion of this topic is beyond the purpose of this review, except to alert fire managers that using unadjusted climatology for sites where the height of sensors has been changed may result in incorrect management decisions. It will take many years of new measurements to affect the unadjusted climatology.

Issues Around GOES Transmit Times and 13:00 Hour Observation Time

Because all GOES RAWS transmit times cannot occur exactly at the top of the hour, for example, 13:00 LST, priority stations are usually assigned transmit times as close as possible to the top of the 13:00 hour. But the difference in transmission times raises the question about how the 13:00 hour observation (or any hour for that matter) is defined. Although there is no formal rule, the general RAWS rule is that any data record transmitted between 12:30 and 13:30 is defined as the 13:00 hour observation (in other words, the 12:30 to 12:59 time is moved up and the 13:01 to 13:30 time is moved back). These times are all Local Standard Time (LST). However, it takes anywhere from 10 to 15 minutes for an observation to reach WIMS, so if the transmit time is 13:25 the observation will not be seen or available for human editing until at least about 13:40. So, does the Dispatch Center or Regional Coordination Center use the 12:25 as seen at 12:40 or the 13:25 observation for their 13:00 hour values? The decision becomes a judgment call but is usually made through consultation and discussions between personnel of the Dispatch Center, GACC, and the NWS fire weather forecasters. The decision criteria are based on what each center needs in terms of fire weather data. This uncertainty is reflected in the results shown in the WRCC versus KCFast data comparison previously presented (also appendix Y).

Complicating matters, different RAWS databases record observation time in different ways. ASCADS archives the actual transmit time, in minutes and seconds after the hour in Greenwich Mean Time (GMT). The NWS reports the observation time rounded to the nearest hour (as described above). WIMS reports observation times numbered from 0 to 23 for the 'R' observations (LST hours) with the implicit understanding that the actual time is that which is given plus the number of minutes to the transmission time after the hour which is reported. This format is followed in the DOBS (or Display Observations) interface option within WIMS. The DRAWS (Display RAWS observations) gives the actual transmission time stamp. The WRCC reports both GMT and LST depending on the sub-database that is being accessed (old or new interface respectively) or the time stamp chosen by the user – LST or GMT.

DCP Transmission Protocols (Vaisala/Handar 540 and 555, FTS 12s, and Campbell Scientific 23X)

Most RAWS DCPs are either Handar or FTS models, but some DCPs are Campbell Scientific, Inc. models. Each model uses slightly different data collection and transmission protocols.

Vaisala/Handar Models

The Vaisala/Handar 540 begins collecting data for transmission 10 minutes before the transmit time. Averages are calculated immediately prior to transmission, instantaneous parameters are recorded, and the DCP transmits to the GOES.

Although the Vaisala/Handar 555 is the newest state-of-the-art DCP, it is less efficient than the 540 model in calculating even a small number of averages. Theoretically these calculations should take only 30 seconds (by the 555), but 2 minutes was programmed to ensure enough time (B. Adams, personal communication 2002). Thus, the Vaisala/Handar 555 begins collecting data 12 minutes prior to transmission and ends data collection at 2 minutes prior to transmission. Instantaneous values are recorded, averages calculated, and values are formatted/truncated. Precipitation, a cumulative value reported in 0.01 inch increments, is transmitted in a xx.xx format. Wind speed and direction averages are transmitted as three characters each (as xxx). For example, if WS is recorded as 7.9 mph, it is truncated to 7 mph, two zeroes are added and it is transmitted as 007. All other elements are reformatted in a similar way (NWCG Weather Station Standards, 2000). At the assigned transmission time, the data are sent to GOES and retransmitted to Wallops Island/Data Collection System (DCS) Automated Processing System (DAPS), thence to ASCADS via DOMSAT.

FTS Models

The FTS 12s follow a similar procedure: their DCP begins collecting and calculating a 5-second running average on the required parameters 12 minutes before transmission. At minus 2 minutes, values are truncated, and instantaneous parameters and averages are moved to the transmitter and, at the assigned time, sent to GOES.

The FTS 11 follows a different procedure: At 12 minutes prior to transmission, data collection begins for WS and WD. RH for both FTS models is an instantaneous reading, contrary to NFDRS 2000 protocols. For WD, the FTS 11 assigns integer values depending on the wind quadrant; a 5-second running average (for 10 minutes) is calculated and the last 5-second average is transmitted. The FTS 12 calculates a running 5-second vector average (for 10 minutes) in degrees; similarly to the model 11, the last average is transmitted. For WS, both the model 11 and 12 measure a wind count per minute for 10 minutes; in effect, the amount of wind passing a given point—similar to the old wind odometers. Counts per minute data are collected and converted to actual WS; a once-per-minute running average is calculated. The final 10-minute average WS is transmitted. At minus 2 minutes, values are truncated and instantaneous parameters and averages are moved to the transmitter and transmitted to GOES.

The older model FTS 11s are all dial-ups. They are contacted via telephone by the NITC-HUB computer on a schedule that is set by the station owner/operator. The actual schedule depends on the season, local needs, and whether data in addition to the 13:00-hour observation is needed.

Campbell Scientific Models

Campbell Scientific data-loggers also truncate data: values are formatted prior to transfer to the GOES transmitter. When the Campbell Scientific data-logger program is executed, each data element is formatted to conform to RAWS/BLM standards so that the first 12 elements of the data stream can be ingested by ASCADS. Each data point is configured with a fixed number of characters. Decimal points are treated as characters. (The exact first 12 formatting is given in appendix W, far right column—elements 1-12.) The data are then copied to the transmitter and subsequently transmitted.

Findings Regarding DCP Transmission Protocols

Data Truncation. When we compared data retrieved from the super-RAWS via telephone modem with raw data ingested by ASCADS, we found that the Campbell's data-logger program/algorithm for the transmitted RAWS was truncating data elements. This was confirmed by Campbell engineers/programmers (D. Brown, personal communication 2002). This issue may not seem important because we are discussing an underestimation of WS by 1 mph or less. However, when one considers that RAWS data are primarily used for NFDRS, fire business decision support, and for fire severity funding requests, one recognizes that accuracy and precision become more and more important as lives, property, and funding are at stake. We investigated the difference between the satellite-transmitted and telephone-transmitted super-RAWS data and concluded that the probability for a wind speed being, say, 7.0 versus 7.1 versus 7.2 and so on up to 7.9 was exactly the same (see fig. X-2c). Hence, a recorded RAWS wind speed of 7.0 is more precisely stated as 7.45±0.45. This is true for all RAWS data: past, present, and future unless corrected.

DAPS does not reformat the data it receives from GOES. Prior to retransmission through DOMSAT to ASCADS, DAPS adds the NESDIS ID, year, day, and a GMT stamp to the top of the data stream. ASCADS performs minimal formatting of RAWS data, removing the front-end zeroes on data and adding a decimal point and a zero (.0). So, the 007 described above for WS will appear as 7.0 in the WSM column of the view converted OBS data option (see ASCADS flow chart in appendix F, bottom left). If the user chooses raw OBS data, he/she will see the most current transmission in exactly the same format that DAPS used when it retransmitted the data stream.

Handar, FTS, and Campbell DCPs (data-logger plus transmitter) truncate data elements except for precipitation and battery voltage (which is truncated to one decimal place). Data truncation could have consequences in calculating fire danger indices and components over the long term; in addition, information is lost. *We find that the issue of truncated versus un-truncated data will affect indices and components.*

DCP Data Sampling. We find that Handar and Campbell DCPs use different sampling protocols to calculate measured averages.

Additional Uses of RAWS Data

Beyond fire-related applications discussed earlier, RAWS data are used in support of climatological analyses, air quality monitoring, ecological process modeling, and weather data mapping. In this section, we summarize RAWS support for indirect fire and nonfire business applications.

Brown and others (2001) developed the following list of uses for historical and climatological RAWS data:

- support for court cases
- forecasts of fire severity based on historical information
- prescribed burn planning
- fire severity funding requests
- development of fire management plans
- monitoring soil erosion
- environmental restoration and risk assessment
- budget analysis
- forest health assessment
- ground water, watershed, and hydrologic assessments
- impact studies on wild life
- soils studies
- climatological studies
- ecosystem model parameterization
- weather forecast model initialization and verification
- interpolation of meteorological parameters to locations where no weather stations exist

This review discusses these other uses of RAWS data:

- air quality modeling and monitoring in the atmospheric boundary layer including air pollutant trajectory studies
- aerosol (airborne particulate matter) and trace gas flux measurements
- physical, regional, and seasonal climatological analyses
- environmental aerodynamics
- ecosystem process modeling
- weather research;
- mesoscale weather forecasting support

Air Quality Monitoring

In addition to helping define weather and forecast zones and performing basic weather network analyses, RAWS has been used to support air quality monitoring in the Southwest and elsewhere.

An outcome of the New Clean Air Act, the Western Regional Air Partnership (WRAP) is a collaborative air quality related effort of Tribal, State, and various Federal governmental agencies organized to implement the recommendations of the Grand Canyon Visibility Transport Commission (GCVTC) and to develop technical and policy tools needed by Western States and Tribes to comply with the Environmental Protection Agency (EPA) regional haze regulations. A network of committees, forums, and stakeholders representing a wide range of interests manage the activities of the WRAP. Public involvement is an integral part of the Partnership. For example, WRAP supported an effort to monitor particulate matter (PM_{10}, particulates less than 10 microns in size) and ozone (O_3) concentration several years ago. The instruments used to monitor these parameters were integrated with a standard portable fire RAWS platform using the Handar DCP and the standard suite of meteorological sensors. The sampling protocol was not standard RAWS since wind speed and direction followed EPA's hour average protocol. PM_{10} (ug/m^3), ozone concentration (parts per billion: ppb), solar radiation, and all other meteorological elements were also hour averages. A running 24-hour average for PM_{10} was also calculated (Peter Lahm, personal communication 2002). Unfortunately, no formal records were kept. Although transmission is limited to 12 data records, this application illustrates a potential flexibility within the existing RAWS-ASCADS-WIMS systems that is not commonly used.

Measurement of Aerosols (Airborne Particulate Matter)

For smoke and visibility monitoring programs and for fire manager smoke management programs, air resource and fire managers have indicated that the ideal situation would be to have remote access (via satellite and/or Internet accessible database) to both weather and particulate matter data from the same location and at the same time. In 1998 and 1999 the FS Technology and Development Program (in Missoula, MT) and the WO Air Resource Management Program, field- and laboratory-tested five instruments that measure airborne particulate matter (Trent and others 2000). The key items evaluated were accuracy in measuring smoke concentrations, comparison of results from two identical instruments, reliability, portability, power needs, data collection, and cost. Based on these criteria, the Air Resource Management Program chose and purchased a number of MIE DataRams. The DataRam is small, human-portable, and affordable. It is able to measure $PM_{2.5}$ or PM_{10}, upon deployment and immediately transmit data via a commercial satellite (Orbcomm). It is sufficiently accurate for the smoke and particulate monitoring needs for wildfire and prescribed burns. A unique capability of this system is that data are sent and posted to a publicly available Web site (address given in appendix A), so data can be viewed in near real-time.

During summer 2002, a number of these instruments were deployed on two large Colorado wildfires: Hayman and Missionary Ridge. Both deployments were successful (R. Fisher, personal communication 2002). One drawback is the need to acquire simultaneous meteorological data; hence, it must be colocated with a weather station. To solve this need, however, DataRAM tests were conducted in FS Region 3 (in 2002) that connected the DataRAM with a FTS portable RAWS weather station. Forest Technology Systems developed the interface that converts analog output from the DataRAM for digital input to the weather station and subsequent transmission with meteorological data via GOES. The tests were successful and the data can be ingested by ASCADS (K. Shelley and C. Maxwell, personal communications 2002; authors' personal observations 2002).

Climatological Analyses

Typical climatological analyses using RAWS data include wind roses that provide information about wind direction and speed. Conditional wind roses can be generated to assist in planning fire operations by combining wind rose data with other data such as RH and temperature. For example, figure 5 shows that RH data for the Redfeather Lakes, CO, RAWS from July 2000 to July 2001 are almost linear with respect to rank probability. However, the amount of actual water vapor mass, perhaps a useful measure of dryness, during the same period is distributed logarithmically (fig. 6). By combining the wind and water mass data, conditional wind roses (fig. 7 and 8) were prepared for the Redfeather RAWS site for the same time period: July 2000 to July 2001. Note that wind velocities and directions during periods of dry weather (greater than 2 g H_2O m^{-3}) are higher and more westerly compared to wet conditions (less than 5 g H_2O m^{-3}) when velocities were lower and wind directions more southeasterly.

In addition to studies covered previously in the Studies and Surveys section, quality control analyses of RAWS data along with regional and seasonal climatologies have been published for the Nevada RAWS network and year 2000 fire season (Brown and Hall 1997 and 2001, respectively). All these types of climatological use of RAWS data can help plan fire operations.

Studies of Environmental Aerodynamics

Weather data are being used to help solve wind engineering or environmental aerodynamics problems, including house siting and orientation, mitigating existing problems, locating industrial emission stacks, assessing biohazards and radioactive exhausts, and determining wind loads on high- and low-rise buildings and bridges. Texas Tech University, Colorado State University, many Engineering Departments, and private consulting companies are actively involved in this type of research and using RAWS data.

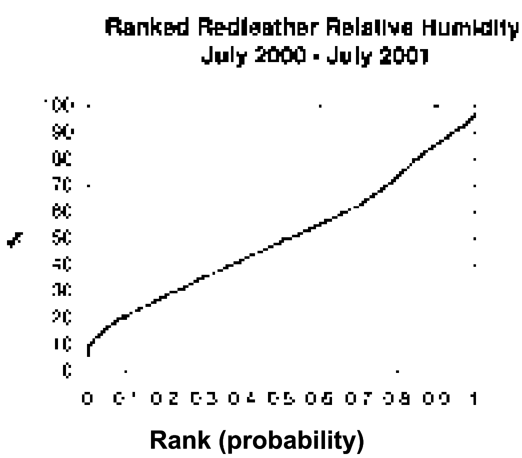

Figure 5: Percent relative humidity (RH – y axis) vs rank probability at the Redfeather RAWS July 2000 – July 2001.

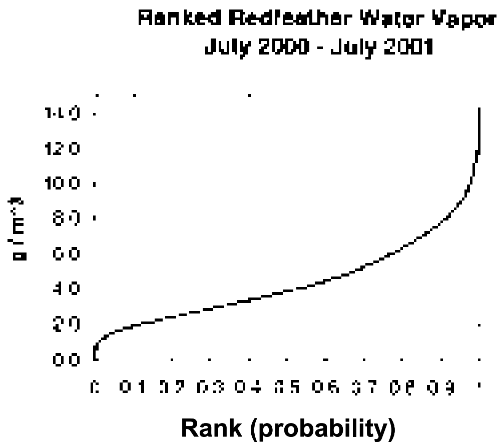

Figure 6: Water mass (g m^{-3}) vs rank probability at the Redfeather RAWS July 2000 – July 2001.

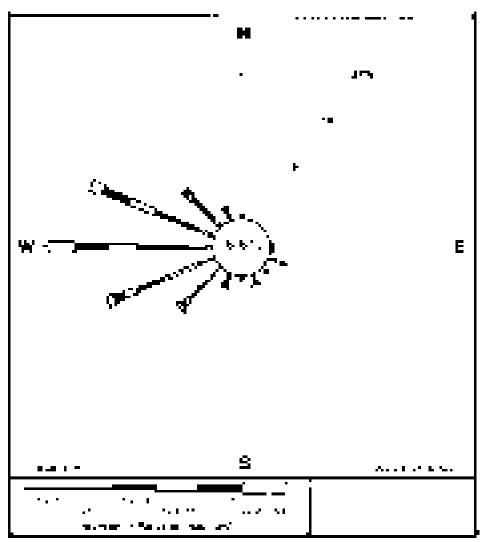

Figure 7: Conditional wind-rose (for water mass < 2 g m^{-3}) for the Redfeather RAWS July 1, 2000 – July 31, 2001.

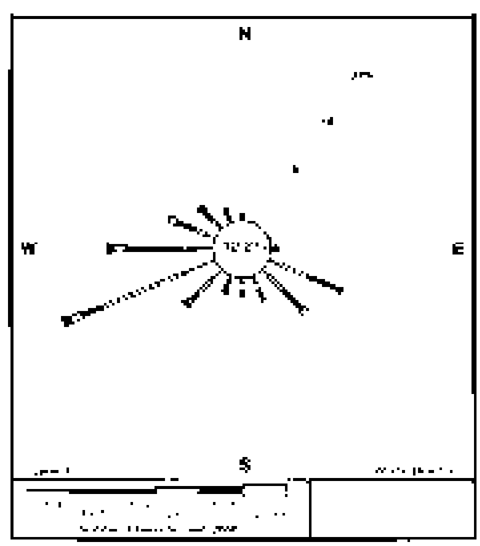

Figure 8: Conditional wind-rose (for water mass < 5 g m^{-3}) for the Redfeather RAWS July 1, 2000 – July 31, 2001.

Ecosystem Process Modeling

Modeling of ecosystem processes (cycling of nitrogen, carbon, phosphorous, and sulfur) requires environmental data. In the case of the Century model (Parton and others 1987), two of the most important parameters are soil temperature and moisture. These data can be collected by adding additional sensors to a RAWS platform as was done for super-RAWS. Forest stand and individual tree growth models also require weather data input: JABOWA (Botkin and others 1972; Botkin 1993); TREGRO (Weinstein and Beloin 1990); and FORFLUX (Zeller and Nikolov 2000).

Figure 9 shows modeled and measured ecosystem CO_2 flux (μ mole^{-2} s^{-1}) versus day of year at Toolik Lake, Alaska, 1996 using Long Term Ecological Site (LTER) network weather data that is similar to the super-RAWS data.

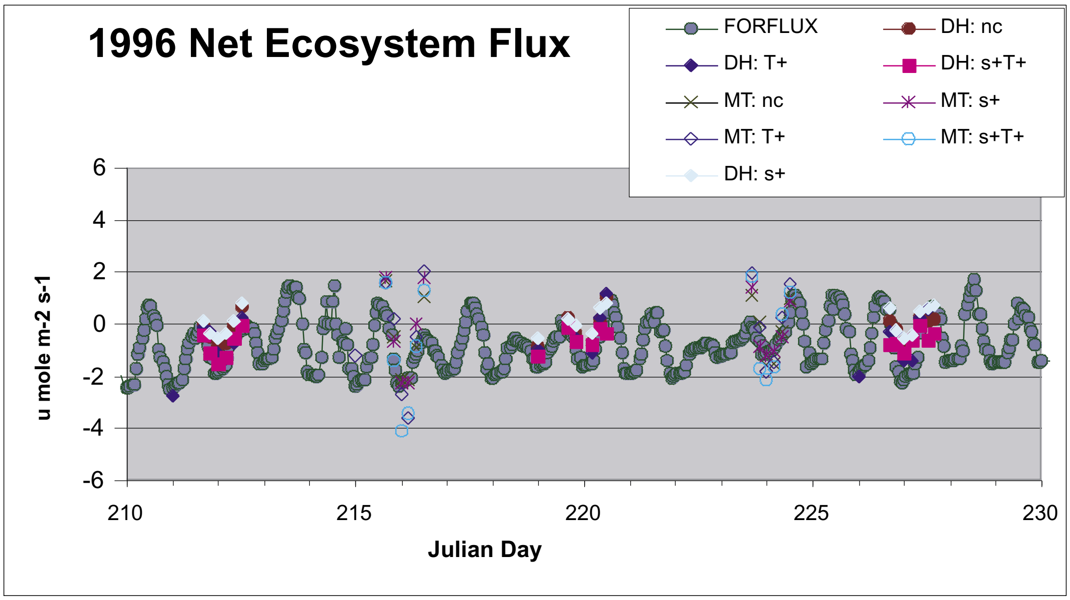

Figure 9: Modeled ecosystem CO_2 flux (μ mole^{-2} s^{-1}) vs. day of year at Toolik Lake, Alaska 1996. This site is part of the Long Term Ecological Site (LTER) network (DH: dry health; MT: moist tundra; ST: enhanced snow; T+: enhanced temperature).

Weather Research

WFAS, discussed above, is an ongoing research/operation project. Supported by the USDA FS F&AM, it uses RAWS data to generate maps of selected fire weather and to provide the NFDRS fire danger indices and components on a daily basis (see also appendix G).

Mesoscale Weather Forecasting Support

The Northwest Regional Modeling Consortium, which is part of the Fire Consortia for Advance Modeling of Meteorology and Smoke (FCAMMS), is a group of local, State, and Federal agencies and cooperating private companies formed during the 1990s in the Pacific Northwest. Its purpose is to provide funding and continuing support for a regional weather prediction system by combining resources and personnel. The system is based on the Penn State/National Center for Atmospheric Research (NCAR) mesoscale atmospheric model (MM5). The consortium produces 60-hour forecasts twice a day at 4-, 12-, and 36-km resolution. This is one of the highest resolution weather forecasting programs in the United States. The RAWS data set is one of many used to initialize model runs and to verify forecast results. Future FCAMMS products will include air quality and smoke modeling, a ventilation potential (winds forecasting), and fire danger forecasts driven by local weather data (RAWS data among them).

The Eastern Area Modeling Consortium (EAMC) is a multiagency group founded in 2001 to support the National Fire Plan (NFP) by using mesoscale models (MM5) to:

- Make accurate and useful fire weather forecasts and develop improved fire weather indices at national and regional scales.
- Link forecast information with fuel loadings and fire potential.
- Develop improved model predictions of smoke transport and diffusion.

EAMC is also composed of researchers, and fire, air-quality, and natural resource managers at the Federal, State, and local levels.

Three other consortia have been established in other parts of the United States to encompass regions roughly corresponding to those of the USFS: the Rocky Mountain Center, the Southeastern United States, and California and Nevada. All five consortia have essentially the same objectives and work together to achieve these goals under the FS program: FCAMMS.

MesoWest is another cooperative modeling MM5 project between researchers at the University of Utah, forecasters at the Salt Lake City NWS office, the NWS Western Region Headquarters, and personnel of participating agencies, universities, and commercial firms. The goals of this project are to provide access to current weather observations in the Western States, and provide regional weather forecasts using MM5. The NWS, among others, helps support this project.

MesoWest relies upon weather observing networks that are managed by Federal, State, and local agencies and private firms. The Federal networks include RAWS, Snowpack Telemetry (SNOTEL), Automated Surface Observing System (ASOS), and Automated Weather Observing System (AWOS) among others (see Glossary for brief identification information). Temperature, relative humidity, wind speed and direction, precipitation, and other parameters are available through MesoWest from several hundred locations. MesoWest surface observations are used in high-resolution spatial and temporal analyses centered on Utah.

The data archive is operated by the NWS to monitor weather conditions around the region. Researchers also use MesoWest extensively to study severe weather events such as winter snowstorms and damaging winds. MesoWest is available to the educational community as well.

The Advanced Regional Prediction System Data Analysis System (ADAS) at the University of Oklahoma is another mesonet similar to MesoWest that has been configured to perform three-dimensional and surface-based analyses over regions with complex terrain. ADAS relies on archived MesoWest observations as an important source of local data to modify an initial background data field provided by NCEP RUC2 analyses (see Glossary for brief identification information of NWS's NCEP and RUC2).

Management Implications

Current Issues

As of spring 2003, the status of FS-operated RAWS was 'adequate' to 'improving' to 'hard to pin down'. As the GACC meteorologists in FS Regions 3 and 9 have taken over some coordination, maintenance, and data processing, they have vastly improved network operations, and continue to make improvements (C. Maxwell, K. Shelley, and S. Marien, personal communication 2002; authors' personal observation, 2001 and 2002). During FY2002 a number of priority NFDRS RAWS stations that had been poorly maintained were moved, replaced, or refurbished (e.g., Penasco in Region 3, and Camp 4 and Douglas Ingram in Region 6; C. Maxwell, R. Shindelar, and K. Shelley, personal communications 2002). Operations in other FS Regions also continue to improve with ongoing network hardware upgrades. Maintenance on stations is occurring on a more or less regular basis and an increasing number of FS personnel are being trained on station hardware and software, WIMS, and NFDRS (authors' personal observations).

ASCADS and WIMS metadata and weather data file maintenance is random with need for improvement (T. Mathewson, C. Maxwell, R. Shindelar, M. Nelson, and R. Powell, personal communications, 2002):

- RAWS site visits not always reported or, in some areas, not made at all.
- Incorrect fuel model, climate class, or location are used for NFDRS calculations at some stations.
- Stations remain coded as frozen well into spring.
- ASCADS metadata not maintained routinely by users.
- WIMS not maintained by all users (for example, 13:00 hour observation is not flagged; SOW not entered; LAL not entered).

In informal interviews, FS personnel involved in the RAWS program primarily at the dispatch center level described ASCADS and WIMS as difficult to use (especially ASCADS). They also claimed that ASCADS and WIMS failed to provide products in a timely fashion and that personnel have not received adequate training as to their use and retrieval of products (R.Powell, F. Hesselbarth, M. Nelson, C. French, personal communication 2002). Some of these problems may be resolved when planned training on WIMS and NFDRS takes place (courses are offered on a yearly basis and in different FS Regions) and, as discussed in the Projects Under Development section, the reengineering of ASCADS and WIMS is completed.

The WRCC, NIFMID/WIMS, NIFMID/KCFast, NWS, and the BLM/NIFC databases all rely on an antiquated system, ASCADS, for data. ASCADS has, in effect, become a well-known choke point for the RAWS data stream. The proposed ASCADS upgrades will, we hope, solve these problems. Some database erroneous-data problems are not being addressed.

We have found discrepancies in the station locations—and even station existence—listed in different RAWS databases such as ASCADS and Fire and Aviation Management (F&AM) Helpdesk (T. Mathewson, R. Mann, personal communication 2002).

Most RAWS, as a mesonet function, lack the capability to record year-round precipitation. Cost and power considerations preclude equipping all RAWS with all-weather precipitation gauges, but selected site upgrades to provide this important piece of information would improve the system.

Findings

In this section we list a number of findings. The order in which these findings are presented does not indicate priority. Given the fluidity of the RAWS system, some findings may already be in the correction implementation process. Before any new studies are contemplated and/or proposed, individuals should read through this study for orientation, then contact and coordinate with agency and regional RAWS coordinators/personnel. A contact list is given in appendix Z.

Personnel

1. **Additional Personnel and Enlarged Work Area at RSFWSU.** Given the current and increasing number of RAWS stations and given the new NFDRS 2000 certification requirements, the RSFWSU workload will increase. The RSFWSU processes and maintains

thousands of RAWS meteorological sensors and other station-related equipment every year (see table 5; a total of 8,101 during FY2001). This is a staggering workload for eight in-house technicians and 12 field personnel. Given the critical importance of the RAWS data, current manning and existing space limitations at the RSFWSU (authors' personal observations and communication with Boise Depot staff), there is a potential negative impact on the overall RAWS data quality.

2. **Additional USFS RAWS Coordination Office and Regional Office Personnel.** The USFS RAWS Coordination Office has a heavy work schedule as indicated by the figures and description of duties in the Operations, Protocols, and Organization section above. Duties were scaled back in June 2002 (K. Shelley, personal communication 2002), and in the future, regional coordinators will take over teaching the RAWS maintenance training courses. This may necessitate the transfer of existing personnel or the addition of trained regional personnel to help in the management and administration of the network. For example, utilize the part-time Web master who maintains and supports the official FS RAWS Web site at the coordinator level to help in responding to queries made through the Web site, and so forth.

3. **Updated Position Descriptions to Include RAWS-Associated Duties in Position Description of All Personnel Involved in RAWS-Related Activities.** FS RAWS are currently managed as an extra duty in most cases. At all levels of involvement, detailed descriptions of RAWS maintenance, administration and other responsibilities should be included and explicitly stated in individual Position Descriptions (PD). This would provide the incentive and accountability as well as management support and interest for the RAWS program and the need for high-quality weather data. Examples of PD phrasing are provided in appendices K and M.

4. **Ongoing Followup of RAWS Training.** Continuing efforts must be made to impress upon personnel tasked with WIMS daily duties how critically important the RAWS network, data collected, and fire danger indices and components are. This is currently stressed in training courses (WIMS, fire behavior, NFDRS, and others; advanced courses are also offered for the last two), but ongoing followup is needed. Training courses might be made mandatory for personnel tasked with WIMS daily duties.

Table 5: RSFWSU RAWS sensor maintenance report for FY 2001 - (P. Sielaff/RSFWSU 2002)

	WS	WD	RH/AT	SR	FM/FT, FT, SM/ST, TB	Non-Met Sensor Hardware	TOTALS
Region 1	46	39	51	25	74	177	412
Region 2	37	37	56	1	35	149	315
Region 3	20	19	36	10	48	91	224
Region 4	51	52	51	19	91	198	462
Region 5	102	101	137	33	160	538	1071
Region 6	84	74	110	16	141	225	650
Region 8/9	97	95	128	2	191	182	695
Region 10	0	0	0	0	0	0	0
BLM FIELD	194	184	399	188	367	280	1612
CSEPP	134	134	82	0	7	173	530
NPS	72	72	75	11	132	247	609
OTHER	124	124	134	26	159	621	1188
FWS	44	40	37	7	67	138	333
TOTALS	1005	971	1296	338	1472	3019	8101

Region 1-10: All FS Regions; BLM FIELD: BLM RAWS and others on full ride contract; CSEPP: Chemical Stockpile Emergency Preparedness Program; OTHER: BIA, States, City, County, District, Private, or Commercial

Sensors: WS: anemometer; WD: wind vane; RH/AT: relative humidity/air temperature; SR: Solar Radiation

FM/FT: fuel moisture/fuel temperature; FT: fuel temperature; SM/ST: soil moisture/soil temperature; TB tipping bucket

Non-Met Sensor Hardware: data collection platform; antenna; solar panel; cable for sensors; telephone modem; battery pack; clock, keypad display; GPS

5. **Standardization of FS RAWS Duties at Regional and Local Dispatch Level.** RAWS duties are not standardized across the FS, which result in nonstandard maintenance and operational procedures, which is not an optimum management strategy for such a critically important weather station network.
6. **Increase in ASCADS Support During Fire Season.** To avoid interruption of the RAWS data flow, ASCADS support during fire season should ideally be increased to 24 hours per day, 7 days per week. The RSFWSU and the BLM/NIFC/National Systems Development group in effect act as the ASCADS Helpdesk but only during traditional working hours. For example, no one was available to provide help when, over the weekend of June 8 and 9, 2002, ASCADS crashed. A formal ASCADS help desk could have immediately fixed that situation.

Upgrades to Stations

1. **Additional RAWS Sensors and parameters.** The ability to add non-NFRDS user-specified sensors to the basic RAWS sensor suite would provide useful flexibility. This would provide for additional site-specific support for fire weather forecasters, meteorologists, climatologists, nonfire researchers such as ecological modelers, and regional modeling consortia. For example, monitoring soil temperature and moisture could help in improving the calculation of the KBDI. Depending on the number and type of sensor, the cost/benefit ratio need not be prohibitively high (see the appendix V CD for sensor costs). Along these lines, to support weather data use and research activities by the interagency fire community (forecasting, NFDRS, fire behavior models, fire severity requests, and so forth), the establishment of a number of expanded RAWS similar to the experimental super-RAWS site in Fernberg, Minnesota discussed earlier may be useful. They could provide for weather data use by nonfire groups, including university research groups, mesoscale modeling groups, aviation, severe weather forecasting, business applications, climatological analyses, air quality monitoring, and others. The number of data parameters that ASCADS can ingest should be increased and made adjustable depending on the need and uses of the station owner/operators. The latter is part of the ASCADS patch currently (spring/summer 2003) being implemented.
2. **Faster Paced Upgrades.** The ongoing RAWS upgrade program addresses many RAWS problems. However, the pace might be quickened to replace existing 1980s technology. An example of aging stations still in service was found in the Washington-Jefferson NF, Virginia: all stations visited were Forest Technology Systems FTS11 models; all are well maintained and data are currently being retrieved via telephone (at the local and national levels). These stations will become obsolete and non-NFDRS 2000 compliant within 2 to 3 years. Unfortunately the Washington-Jefferson NF does not have the funds to upgrade to a GOES capable system at the present time.
3. **New Emerging Sensor Technologies.** There are a vast number of manufacturers of meteorological equipment and sensors in addition to those used at present by the RAWS. Our sensor survey (appendix V and attached CDROM) was included to give planners, managers, and operators associated with RAWS a thorough listing of available sensors for use in gathering fire weather data. Although standardization makes for ease of maintenance, it makes sense to keep abreast of new sensor technologies. The question must be asked: Could some of these other manufacturers provide less expensive, more reliable equipment without sacrificing data quality?
4. **Solar Radiation (SR) Data Collection Protocol and Sensor Placement.** The instantaneous SR measurement problem is being corrected; however, sensor placement is still not optimal for SR measurements, at least on Handar (lunar lander) frames. At present, the instrument is mounted on the top cross beam adjacent to the rain gauge (painted white or light

gray). Reflection from the rain gauge could affect SR readings, so we recommend that the sensor be raised to at least to the same height as the top rim of the rain gauge. An alternative placement is at the top of the mast if it can support the SR sensor weight.

5. **More Frequent and On-Demand Outputs.** Increase station transmission frequency to two and possibly four times per hour as weather affecting fires can and often does changes at these temporal scales. This increase in transmission frequency is currently being planned for. Fire danger indices and components also change rapidly – in less than 24 hours – in response to rapidly changing weather as well as diurnally. We recommend that these outputs be calculated hourly or possibly on demand during the fire season and especially during an incident or prescribed burn.
6. **Verification of Conformity of Station to New NFDRS Standards.** We note that there does not appear to be a specific plan to switch from the old to new NFDRS RAWS standards.

Upgrades to Product and Data Retrieval Systems

1. **Continued Development of WFAS.** The Wildland Fire Assessment System (WFAS) generates valuable products that are used and understood by both meteorologists and nonmeteorologists from dispatch centers to regional coordination centers (see above and appendix G). For these reasons, the continued development of WFAS and its products is in order.
2. **Support for ASCADS Re-engineering.** ASCADS is at the beginning of a reengineering process. Five priority upgrades will hopefully be implemented within 1 year; additional items will be added in stages (discussed above in the RSFWSU Strategic Plan in spport of NFDRS 2000 standards). It is critical to include in this plan both Quality Assurance and Quality Control of RAWS data. One suggestion is to produce a master list of watchdog criteria which would be used to determine numerical limits of metadata in ASCADS and to correct metadata discrepancies between ASCADS and WIMS. The watchdog criteria exist (appendix P), but the authors were unable to locate the actual numerical values short of logging on each individual station through ASCADS.
3. **Support of GACCs and Predictive Service Participartion in RAWS.** Regional Geographic Area Coordination Center (GACC) Predictive Services have been in active operation for almost 2 years. In addition to the services and products discussed above, new and unique products are being generated. GACC meteorologists have taken personal interest in the RAWS within their own areas and in some cases have taken over QA/QC of data, maintenance and other site activities. It may be reasonable to establish a permanent mechanism for these GACC meteorologists to assume RAWS responsibilities.
4. **Correct Data Discrepancies.** It should be a priority to plan for correction of errors in the existing WIMS/KCfast 13:00 observation climatology; correction of the RAWS data-truncation problem; automation of the daily 13:00 hour RAWS human interface to ensure data accuracy; and combine ASCADS and WIMS station classification schemes, including auditing station inventories to track the number of RAWS stations in the system.
5. **Combination of ASCADS and WIMS functions in One Application/Database:** It is obvious that the functionality of ASCADS and WIMS overlap and that that overlap is the cause of some problems in the integrity of the RAWS data itself. The combination of these databases and information management systems into one application is considered in the RSFWSU Strategic Plan. It would also most likely provide a cost saving.

Other

1. **Periodic Reviews.** Periodic reviews of regional FS RAWS programs would result in greater uniformity and accountability at dispatch and regional levels and provide a check for proper maintenance and operating procedures. In turn, it would ensure that high-quality data reaches ASCADS and WIMS.

2. **Exploration of Outsourcing of Limited RAWS Functions.** Forest Service RAWS operating costs are roughly $1,350 per year per station, and about $1.1 million per year for the entire FS network. Could the private sector manage and maintain the RAWS network (functioning as an outsource) at the field level more efficiently? Could these functions be outsourced? Basic RAWS data collection and delivery and field maintenance might be outsourced while retaining the functionality of the data processing for value-added fire use products. **If such changes were ever made, we strongly recommend that data handling, access, and retrieval functions remain within the land management agencies: specifically within the operational fire interagency management government community. It would be a costly and a significant mistake to allow privatization of the data and its use because data is needed by users regardless of ability to pay.**
3. **QA/QC of All RAWS Metadata.** All RAWS metadata and data must be critically and objectively examined – a QA/QC process. This has been done for all RAWS in California (Brown and others 2002) and is beginning in FS Regions 2 and 3 (T. Mathewson and C Maxwell, personnal communication 2002) but not for the entire network. Such a study is overdue.
4. **Unification of RAWS under One Management Authority.** It is clear after reading this report that it is difficult to thoroughly grasp the RAWS program and describe the exact direction it is moving. Several entities are working on several upgrades, some coordinated, some not. Perhaps a single interagency authority to operate RAWS is in order.

Conclusion

The RAWS monitoring network is a national asset and is functioning, even with the inefficiencies of being a multiagency network with many user and owner choices for individual station's operation. At the FS level, station and data quality vary with management of the network within each region. The BLM funds and operates its RAWS stations from the national level, top down, under a single quality assurance (QA) authority, while in the FS each Region determines its own management approach.

Individual stations meeting NFDRS standards provide data in support of fire weather forecasting and for calculating fire danger rating indices – the primary mission of the network. The entire network is in perpetual transition as hardware and software are upgraded and data transmission is streamlined. Apart from the standard maintenance and upgrade schedule for RAWS stations, there are other factors driving this process. An increasing number of institutions other than those directly involved with fire weather (both public and private) are requesting and using RAWS data for fire and nonfire uses and applications. Even more important, the Federal interagency fire community is demanding more frequent and higher quality weather data for more precise and timely calculation of fire danger indices and components.

Streamlining, upgrading, and maintaining the network are priorities for those directly involved in RAWS management and fire business decisionmaking (K. Shelley, P. Sielaff, and R. Gripp, personal communication 2001). Also, suggestions have been discussed and recommendations are being made to improve quality control and quality assurance (QA/QC) of data and metadata for NFDRS calculations. The new NFDRS 2000 protocol is designed to ensure that each NFDRS station and its sensors receive regularly scheduled maintenance and calibration. The NFDRS 2000 (NWCG 2000) establishes strict standards and procedures for NFDRS stations that are necessary to maintain a high level of QA/QC. Changes in the RAWS data transmission pathway are also under consideration: a DRGS has been installed at NIFC so that GOES can transmit data directly to Boise for ingestion by ASCADS. RAWS administration, maintenance, and first response personnel in a given FS Region provide critically important support and are directly involved in data QA/QC.

Finally, separating RAWS monitoring from the overall RAWS function, there are errors in existing official RAWS databases that are accessed daily to provide managers with indicies used for fire resource deployment decisions—some of these errors are potentially life threatening.

This review has hopefully integrated the general knowledge base of RAWS information, and provided an understanding of the network. A consideration of its findings will improve RAWS efficiency and performance.

Glossary of Terms and Acronyms

209: Specific fire incident report form; accessed through NIFMID; must be filed daily during an incident.

ACC: Area Coordination Center; for example RMACC is the Rocky Mountain Area Coordination Center in Lakewood, CO. The Southwest ACC is in Albuquerque, NM.

ADAS: Advanced Regional Prediction System Data Analysis System.

Adjective fire danger rating: An application of NFDRS indices and components based upon the primary station fuel model and staffing index (such as ERC or BI). Used primarily for public information releases, and fire and resource management decision making.

AFFIRMS: Administrative and Forest Fire Information Retrieval and Management System; proto-weather information management system replaced by WIMS in 1993.

AMIS: Aviation Management Information System; generates aviation use reports for FS regions; accessed through NIFMID.

ARF: Arapahoe-Roosevelt National Forest.

ARS: Air Resource Specialists, Inc.; environmental/atmospheric consulting company based in Fort Collins, CO.

AFFIRMS: Administrative and Forest Fire Information Retrieval and Management System; a computerized proto-weather information management system; no longer in use.

ASCADS: Automated Sorting Conversion and Distribution System, BLM-administered (interagency) database/ system used as a primary method of retrieving data from the GOES (see below) satellite and forwarding to BLM Web server, WIMS, the NWS, and the WRCC. (ASCADS ingests the retrieved RAWS data from DOMSAT and sorts it into a relational database that is menu driven but DOS-based.) It is used for metadata storage, maintenance documentation, and produces watchdog alerts. ASCADS is a single source for all RAWS data such as maintenance history, sensor suite, location, route, and raw weather data; but it is not a long-term storage archive. It is essentially a pump converting data derived from GOES/Wallops Island/DOMSAT to formats accessible to other systems.

ASOS: Automated Surface Observing System; sponsored by the NWS, DoD, and the FAA.

ASTM: American Society for Testing and Materials.

AT: Air temperature; measured in degrees Fahrenheit .

AWIPS: Advanced Interactive Processing System; a NWS application used for interactive processing, display of hydrometeorological data, and the rapid disseminations of warnings and forecasts in a highly reliable manner.

AWOS: Automated Weather Observing System; primarily located at airports; maintained by the FAA or State, local or private organizations.

AWS: Automatic Weather Station, non-GOES telemetered station.

BEHAVE: A fire behavior model; it is a Windows application used to predict wildfire behavior for fire management purposes and uses a minimum amount of site-specific input data to predict fire behavior for a single point in time and space. The current version is BEHAVEPlus 1.0.

BIA: Bureau of Indian Affairs.

BI: Burn index; see appendix B.

BLM: Bureau of Land Management; part of the USDI (see below).

BP: Barometric pressure.

CDF: California Department of Forestry.

CEFA: Climate, Ecosystem, and Fire Applications; a research group that is part of the DRI Division of Atmospheric Sciences, Reno, NV, that is concentrating on fire weather applications. Has carried out numerous climatological and QA/QC studies using RAWS data.

CIFFC: Canadian Interagency Forest Fire Centre.

CIRP: Cooperative Institute for Regional Prediction; is developing a Web site for the display of recent RAWS data at hourly, daily, and weekly times scales. A collaborative project between the RMACC and Eastern Great Basin CC.

Components: Calculated (by the NFDRS model) values related to fire danger, for example, spread, energy release, and ignition components.

COTS: Commercial off-the-shelf, referring to a package of software or program or hardware available for purchase and use from a commercial vendor.

CSEPP: Chemical Stockpile Emergency Preparedness Program; deals with chemical and weapons emergencies.

DAWG: Data Administration Working Group.

DAPS: Data Collection System (DCS) Automated Processing System; all simply known as DAPS.

DCP: Data Collection Platform; data-logger of the RAWS.

Delta temperature: Vertical difference in temperature, in air used for atmospheric stability, in soil used for heat transport direction and intensity.

Dimensionality: Dimensionality may be viewed as an attempt within the logical mind to resolve the hierarchy of energy into discrete bands, or ranges of experience, so that they may be referenced separately. The reality is that there is no separation. There are no clear boundaries between one vibrational experience and another. There is only a gradation, a phasing of varying states experience. These altered states of awareness are known as dreams. Though deceptively simple in appearance, this premise of “oneness” has proven difficult to resolve within the rational mind. The ancient texts however have offered this very concept, through many different languages, for thousands of years. (Braden 1977)

DOBS: Display observation.

DoD: Department of Defense.

DOE: Department of Energy.

DOMSAT: Domestic satellite transmits RAWS data from Wallops GOES ground station to ASCADS.

DRI: Desert Research Institute is a part of the University and Community College System of Nevada. DRI pursues a full-time program of basic and applied environmental research on a local, national, and international scale. Areas include water resources and air quality, global climate change and the physics of the earth's atmosphere.

EOS: Earth Observing System; a long-term NASA project and the center piece of NASAs Earth Science Enterprise.

EPA: Environmental Protection Agency (USA).

ERC: Energy release component; see appendix B.

FAA: Federal Aviation Administration.

F&AM: Fire and Aviation Management, Forest Service, Washington Office responsible for national RAWS systems.

F&AM Applications Helpdesk: Fire and Aviation Management Applications Helpdesk; real time help via telephone with WIMS, KCFast, SIT, 209, Pocket Cards, AMIS, and FEPMIS (1-800-253-5559 or 1-208-387-5290).

FAQ: Frequently asked question.

FARSITE: Fire Area Simulator 2.0; spatially referenced fire behavior model.

FCAMMS: Fire consortia for advance modeling of meteorology and smoke, mesoscale weather forecasting centers.

FDWT: Fire Danger Working Team; part of the NWCG (see below).

FEMA: Federal Emergency Management Agency.

FEPMIS: Federal Excess Property Management System; accessed through NIFMID.

FF+ or FFP: Fire Family Plus; a desktop computer application used widely for fire weather and occurrence analysis (see appendix B for more details).

Fire danger indices: e.g. Burn Index (BI), NFDRS, 100-hr fuel, etc.

Fire season: Generally, May 1 through October 31, but it depends on the area.

Fire use: Prescribed burns and wildfires that are allowed to burn to achieve management goals.

FM: Fuel moisture as percent of oven dry weight.

FPI: Fire Potential Index; experimental, uses satellite derived greenness, a NFDRS fuel model map, and calculated 10-hour fuel moisture to determine potential fire danger, scale ranges from 0 percent (low) to 100 percent (high).

FRWS: Fire RAWS; portable weather stations deployed during an incident or prescribed burn.

FS: Forest Service.

FSL: Forecast System Laboratory conducts applied meteorological research and development to improve and create short-term warning and weather forecast systems, models, and observing technology.

FT: Fuel temperature measured in degrees Fahrenheit.

FTP: File Transfer Protocol, process used to transfer files between different types of systems (such as internet, pc to pc, servers, and so forth).

FTS: Forest Technology Systems, Ltd. is a Canadian company that sells fully operational RAWS stations. Handar, a subsidiary of Vasaila, Inc. and Campbell Scientific Inc. and FTS are the current three major suppliers of RAWS stations.

Fuel model: A simulated fuel complex for which all fuel and site descriptors (such as type of fuels, slope, aspect, climate class, and so forth) required by the NFDRS model have been supplied.

FWS: Fish and Wildlife Service.

FWWT: Fire Weather Working Team.

Frozen: Opposite of green-up, frozen and green-up dates are specific to each RAWS, each fire season.

GACC: Geographic Area Coordination Center; regional level fire business coordination center.

GeoMAC: Geospatial Multi-Agency Coordination Group.

GMT: Greenwich Mean Time or Universal Time Coordinate (UTC).

GOES: Geostationary Operational Environmental Satellite, the satellite used for data relay from NFDRS weather stations to ASCADS.

GPS: Geo-Positioning System.

Green-up: The beginning of a new cycle of plant growth used within the NFDRS model.

Haines Index: Also called the Lower Atmosphere Stability Index (LASI); calculated from the difference in temperature of two atmospheric levels and dew-point depression (see Haines 1988).

HOIC: Human caused occurance index.

HUB: Multimodem PC housed at NITC calling telephone telemetered weather stations, delivering the data to WIMS.

IIAA: Interagency Initial Attack Assessment.

IAMS: Initial Attack Management System; no longer in use, replaced by the BLM/NIFC Wildland Fire Management Information system in the late 1990s.

IC: Ignition component; see appendix B.

IMET: Incident Meteorologist; a NWS meteorologist issuing fire weather forecasts from Weather Forecast Offices. The term IMET has also been used for GACC meteorologists when they work in the field on fires.

Incident Report: A brief report on a wildland fire containing information resources available, local weather, size of burned area, expected containment date, and so forth. This form is either e-mailed or faxed to a local Forest or Regional (GACC) dispatch center.

IRMWT: Information Resource Management Working Team, chartered to identify policy-level information issues that affect, or are likely to affect, interagency fire management activities and to provide advice to NWDG members on how to address those issues through information and communication systems.

ISO 9000: International Organization for Standardization.

IWOS: Incident Weather Observing System; new portable fire RAWS under development.

JABOWA: Forest stand growth model; named after the original developers.

KBDI: Keetch-Byram Drought Index; a measure of cumulative moisture deficit in deep duff and organic soils; used as an input in the 1988 NFDRS model.

KCFast: Kansas City Fire Access Software; long term RAWS data archive; part of NIFMID.

LAL: Lightning activity level; a numerical rating ranging from 1 to 6 that represents observed or forecast strike frequency and characteristics of cloud-to-ground (CG) lightning for a fire zone.

LOI: Lightning Occurrence Index; a numerical rating of the potential for lightning caused fires.

LST: Local Standard Time.

MCOI: Man Caused Occurrence Index; a numerical rating of the potential for human caused fires.

Metadata: information about information; usually nonnumeric. For example as this relates to RAWS the station catalog is a metadata file containing general information about the station/site (station ID, site description, State and county codes, lat/long, station type and name, station owner, conversion codes, access control, site physical description, and so forth) and NFDRS parameters (fuel model(s), live fuel type, climate class, annual precipitation, lat/long, and so forth).

METAR: Meteorological Aviation Routine Weather Report.

Meteograms: A time graph of several meteorological elements on a single plot such as AT, dew point, and RH).

MIE: Company that manufactures instrumentation (called DATA RAWS) for smoke particulate monitoring.

MODIS: Moderate Resolution Imaging Spectroradiometer; high-resolution satellite images.

MOS: Model Output Statistics.

NAGFDR: National Advisory Group Fire Danger Rating; recently renamed the Fire Danger Working Team.

NASF: National Association of State Foresters.

Natural Resource Project-EOS Training Center, University of Montana, Missoula MT: Offers training and workshops for natural resource managers in the use of advanced satellite and model applications available for evaluating difficult landscape-level measurements – fire business decisionmaking. Collaborates with the USDA Forest Service, Rocky Mountain Research Station (RMRS) - Fire Sciences Laboratory/WFAS development group (among others) in the development of Surface Moisture Index (SMI) maps and smoke/visibility and wildland fire detection/monitoring programs; the last two involve the use of satellite imagery.

NCAR: National Center for Atmospheric Research.

NCEP: National Centers for Environmental Prediction.

NDVI: Normalized Difference Vegetation Index.

NESDIS: National Environmental Satellite Data Information Service; provides access to global environmental data from satellites and other sources. Formed in 1980 by combining the National Environmental Satellite Service (NESS) and the Environmental Data Service (EDS) two line offices of NOAA, NESDIS acquires and manages the United States operational environmental satellites, provides data and information services, and conducts related research.

NFDRS: National Fire Danger Rating System; a computer model that calculates fire danger rating indices and components, used for fire business decisionmaking and as a management decision tool. The NFDRS set of computer programs and algorithms allows land management agencies to estimate the current day's and the following day's fire danger at multiple scales and areas. NFDRS characterizes fire danger by evaluating the approximate upper limit of fire behavior in a fire danger rating area during a 24-hour period. Calculations of fire behavior are based on fuels, topography and weather: the fire triangle. NFDRS output gives relative ratings of the potential growth and behavior of any wildfire. Fire danger ratings are guides for initiating presuppression activities and selecting the appropriate level of initial response to a reported wildfire rather than detailed real time site-specific information. NFDRS computations are based on once daily, mid-afternoon observations (2 p.m. LST) from the Fire Weather Network comprising some 1,500 weather stations throughout the conterminous United States and Alaska. These observations are sent to WIMS where they are processed by NFDRS programs. Many of the stations are seasonal and do not report during the nonfire season.

NF: National Forest.

NFMAS: National Fire Management Analysis System; a strategic fire management and budget planning tool based upon a cost-benefit analysis of firefighting activities to support fire program budget requests. NFMAS was later adopted by other non-FS wildland fire-management agencies. NFMAS-based analyses affect the composition, structure, and budgets of fire-management organizations.

NICC: National Interagency Coordination Center; based in Boise, ID.

NIFC: National Interagency Fire Center.

NIFMID: National Interagency Fire Management Integrated Database, database/warehouse for archiving fire business/management information; includes RAWS weather observations.

NIST: DOC, National Institute for Standards and Technology, Boulder, CO.

NITC: National Information Technology Center, located in Kansas City, MO; the NIFMID/WIMS/KCFast host.

NMAC: National Multi Agency Coordinating Group; part of NICC (see above).

NOAA: National Oceanographic and Atmospheric Administration, Department of Commerce.

NPS: National Park Service, Department of Interior.

NST: National System Team, Information Systems Team for F&AM fire applications.

NWS: National Weather Service, each afternoon NWS Fire Weather Forecasters from the National Weather Service also analyze these local observations and issue forecasts for fire weather forecast zones.

NRC: Nuclear Regulatory Certification.

NWCG: National Wildfire Coordinating Group, an interagency group established to coordinate programs of the participating wildfire management agencies. Interagency fire weather and fire danger working teams within this group make recommendations for network and individual station life-cycle management, network standards, better planning, and technology transfer.

O: The 13:00 hour observation, which is the observation used in the fire danger model.

ORACLE: A commercial computer database system.

OSHA: Occupational Safety and Health Administration.

PacNW: Pacific Northwest; common acronym for this FS Region.

PCHA: Personal Computer Historical Analysis.

PC: Personal computer.

PD: Position Description; an FS document detailing job duties and responsibilities.

Pocket Card: The Fire Danger Pocket Card is a method of communicating information on fire danger to firefighters. The objective is to lead to greater awareness of fire danger and increased firefighter safety. The Pocket Card provides a description of seasonal changes in fire danger in a local area using graphics and short text. It is used by both local and out-of-area firefighters.

Predictive Service Meteorologist: A new breed of meteorologist who work for Federal land management agencies in GACCs. They provide "predictive" services for fire business purposes as opposed to forecast services provided by NWS. The distinction is a matter of semantics and forecast authority.

PSD: EPA Prevention of Significant Deterioration monitoring.

R: All non-13:00 hour observations; they are not used in the NFDRS model; commonly called the RAWS observations.

RAWS: Remote Automatic Weather Station, fire weather station network.

Red flag warning: Initiated when weather conditions are such that fire danger is high.

Remote Sensing Unit:

RH: Relative humidity; measured in percentage

Rocky Mountain Area Fire and Aviation Management Web site: This Web site for the Northern Rockies Coordination Center provides links to fire intelligence, fire weather, fire danger, training, incident management, fire aviation, other GACC's, and so forth.

RMACC: Rocky Mountain Area Coordination Center, Lakewood, CO.

RMRS: Rocky Mountain Research Station, USDA Forest Service.

RSFWSU: Remote Sensing Fire Weather Support Unit (also known as the Boise Depot); operated by the BLM as an interagency weather station repair and maintenance facility located in Boise, ID.

RUC2: Rapid Update Cycle version 2; a numerical weather forecast model.

S-491: Basic intermediate level National Fire Danger Rating System course; taught at various times in different parts of the country at Regional training centers, such as Redding, CA, Missoula, MT, and other places.

SC: Spread component; see appendix B.

SIG: Special interest group, as used in grouping one or more RAWS data sets for fire applications in WIMS and FF+.

SIT: Interagency Situation Report: report form typically filled out at the dispatch center level forwarding to regional level; accessed through NIFMID.

SNOTEL: SNOwpack TELemetry; sponsored by the Natural Resources Conservation Service (NRCS); collects and transmits snowpack and related climatic data.

SOP: Standard operating procedure.

SOW: State of the weather; scale of 1 to 9: clear to thunder storms. A SOW of 5,6,7 will zero out all NFDRS indices and components.

SR: Solar radiation; usually measured in watts/m^2.

SWACC: Southwest Area Coordination Center, Albuquerque, NM.

TREGRO: A tree physiology simulation model that predicts the growth and patterns of carbon allocation expected for an isolated tree exposed to various levels of ozone, nutrient stress, and water availability.

Tx: Abbreviation for transmission.

USDA: United States Department of Agriculture.

USDAFS: United States Department of Agriculture Forest Service.

USDAFS RAWS Web site: Official RAWS Web site provides an introduction to RAWS and an overview of the network, including history, description, rationale for it's establishment, news, technical information, FAQ's, contacts, and many links.

USDI: United States Department of the Interior.

USGS: United States Geological Survey.

VOR: Very High Frequency Omnidirectional Radio Range.

Watchdog: Automated alert process in ASCADS for assessing weather station performance.

WD: Wind direction.

WFAS: Wildland Fire Assessment System; Web-based interface providing weather and NFDRS products, primarily maps. WFAS-MAPS generates national maps of selected fire weather and fire danger components (ignition, energy release, and spread components) of the NFDRS. To generate these maps, WFAS queries WIMS each afternoon for the daily weather observations.

WFMI: Wildland Fire Management Information; a BLM managed fire weather database it replaced the BLM Initial Attack Management System (IAMS) in the late 1990s.

WFO: Weather Forecast Office; part of the National Weather Service (NWS).

WIMS: Weather Information Management System; weather information database; also the host for the NFDRS model. WIMS archives (short term) and manages all RAWS data (GOES and non-GOES). The 13:00-hour data points are permanently archived, but the 24 hourly points are kept for 1 year. WIMS, which was implemented in 1993, was developed as a cooperative venture between the Forest Service Weather Program and Fire & Aviation Management (F&AM) staffs. WIMS also provides station metadata, fire history, and other information,and is accessible via the Internet (user name and password protected).

WO: Washington Office of the USDA Forest Service.

WRAP: Western Regional Air Partnership is a collaborative air quality related effort of tribal, state, and various Federal governmental agencies organized to implement the recommendations of the Grand Canyon Visibility Transport Commission (GCVTC) and to develop technical and policy tools needed by Western States and Tribes to comply with the Environmental Protection Agency (EPA) regional haze regulations.

WRCC: Western Regional Climate Center is one of six regional climate centers in the United States, is administered by NOAA and specifically by the National Climate Data Center and NESDIS. The mission of the WRCC is to archive and distribute climate data and information; promote better use of this information in decisionmaking, conduct applied research related to climate; and improve coordination of climate-related activities ranging from local to national scales.

WS: Wind speed.

WWV: Call sign for worldwide universal time radio transmission; used for clock synchronization on RAWS.

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Appendix A. Lists of RAWS-Related Entities and Web Sites

1. Related Entities

Institution, Dept., Database, etc.	Agency Affiliation	Relation to RAWS/Comments
Arapaho Roosevelt NF Interagency Wildfire Dispatch	USDAFS	Arapaho Roosevelt NF dispatch center – fire information for ARNF; provides links to other wildland fire sites. Operates RAWS in ARNF.
Automated Sorting, Conversion, and Distribution System (ASCADS)	BLM	Receives RAWS data from DOMSAT and stores data for 30 days. Re-distributes fire weather data to WIMS, WRCC, BLM/NIFC databases.
Boise Fire Weather	NOAA	NOAA/NWS fire weather web site for southern ID. Links to recent RAWS data.
Climate, Ecosystem, and Fire Applications (CEFA)	DRI/Univ. Nevada	A research division of the DRI concentrating on fire weather applications. Has carried out numerous climatological and QA/QC studies using RAWS data.
CA Wildfire Coord. Group	Interagency	Southern CA Fire Operations web site; displays RAWS data for S.CA.
Fire Application User Guides	USDAFS	Internet web page listing fire related software and their user guides – both can be downloaded.
Fire & Aviation Management Washington Office	USDAFS	FS section working to advance technologies in fire business management and suppression, maintains and improves mobilization and tracking systems. Provides funding for the RAWS network and RAWS databases.
Forecast Systems Laboratory (FSL)	NOAA	FSL conducts applied meteorological research and development to improve and create short-term warning and weather forecast systems, and models. Uses the RAWS data set among others.
Geospatial Multi-Agency Coordination Group	USGS/ GEOMAC	Map-intensive web site, provides recent RAWS data, mapped locations across the United States.
Geostationary Operational Environmental Satellite (GOES)	NASA	GOES home page; satellite initially used for global weather monitoring now also used for data transmission relay for RAWS.
Interagency Geographic Area Coordination Center's	Interagency GACC	A web site with links to regional GACC sites. GACC Predictive Services use RAWS data for fire weather guidance.
Kansas City Fire Access Software (KCFast)	Interagency	Long-term RAWS data archive (13:00 hr obs.) and mid-term (18 month) archive of all obs. See text and Appendix D.
MesoWest	University of Utah	Meso-scale forecasting (MM5) group based at the Univ. Utah; see text for brief description. Uses RAWS data set among others.
MM5 Smoke and Fire Weather Resources	Univ. of Washington	Smoke and fire weather information/resources, MM5 forecast output etc. Part of the Northwest Regional Modeling Consortium based at the University of Washington, Seattle. See FCAMMS.

Institution, Dept., Database, etc.	Agency Affiliation	Relation to RAWS/Comments
MODIS – Moderate Resolution Imaging Spectroradiometer	NASA	High-resolution satellite images; instruments deployed on the EOS Terra and Aqua satellites. Can detect thermal sources such as fires. Not RAWS-related as such but used for fire support.
MODIS Rapid Response Web Fire Maps	University of Maryland	Satellite imagery of active fires in the continental United States; taken with the – Moderate Resolution Imaging Spectroradiometer.
National Fire Danger Rating System (NFDRS)	NWS/Inter-agency	A NOAA web site providing a very good summary of the NFDRS which uses RAWS data.
National Fire Plan Web Site	Interagency	Overview, links to other sites, firefighting, rehab., fuels reduction, community assistance. Link to NFP maps by the GeoMAC group.
National Fire Weather /National Weather Service	NOAA/NWS	A NWS Forecast Office, Boise ID. Links RAWS data access from the NWS by state.
National Interagency Fire Center (NIFC)	Interagency	The nation's support center for wildland firefighting; coordinates and supports wildland fire and disaster operations.
National Interagency Fire Center (NIFC)/ BLM Weather	Interagency	BLM fire weather data archive at NIFC – most recent 12/24 hour. Hosted by BLM. RAWS data access for local/dispatch center users. Password protected.
National Interagency Coordination Center (NICC)	Interagency	National interagency Coordination Center; national center for coordination and support of wildland fire fighting.
National Wildfire Coordinating Group (NWCG)	Interagency	An operational group designed to coordinate programs of the participating wildfire management agencies. Sets standards for RAWS stations and procedures.
National RAWS Data Server/NWS, Boise	NWS	NWS list of RAWS stations by state with access to recent data.
Natural Resource Project-EOS Training Center	University of Montana	Links to fire and climatological applications; maps of surface moisture stress, temperature, precipitation, etc.
NFDRS Forecasting for forecasters	NOAA	Instructions for NWS fire weather forecasters on using RAWS data for NFDRS modeling.
Northwest Coordination Center (NWCC)	Interagency	Pacific Northwest Region GACC. Uses RAWS data for fire business guidance.
Numerical Weather Data	UCAR	Central web site providing links to meso-scale weather modeling groups. All use RAWS data to help parameterize forecasting models, but not exclusively.
NWS/Portland Fire Weather Program	NOAA/NWS	Web site for Portland OR area forecasts, clickable maps, fire weather etc. NOAA/NWS local office. Access to RAWS and METAR data.
RAWS/AWS USFS Fire Application Support	USDAFS	Internet links to configure PC's for ASCADS and links to technical notes for RAWS/AWS and the HUB.
RAWS Contact List	Interagency	USFS, NPS, BLM and FWS regional coordinator's telephone and email contact list.
RAWS Model output statistics (MOS)	NWS	Guidance for making forecasts using RAWS data. A statistical approach.

Institution, Dept., Database, etc.	Agency Affiliation	Relation to RAWS/Comments
RAWS Temperature/ Humidity Forecast Guidance	BLM	A statistical assessment/interpretation of the max and min temperature and humidity for some key RAWS in the PacNW based on regression equations.
RAWS: Remote Automated Weather Stations	USDAFS	Official USFS RAWS site, many links. An excellent web site to begin learning about the RAWS network.
Remote Sensing Fire RAWS (RSFWSU)	BLM	Location in Boise ID (at NIFC) where all maintenance and calibration of Weather Support Unit equipment is carried out.
Rocky Mountain Area Fire and Aviation Management	USDAFS	Site provides internet links to fire weather, red flag warnings, NWS websites, RAWS data access, and more for the Rocky Mtn. Region.
Scripps Institution of Oceanography/ Experimental Climate Prediction Center (ECPC)	Univ. CA San Diego	Developing fire management products from the ECPC regional spectral model (RSM) and performing verification analysis of RSM fire forecast products. Both in collaboration with CEFA.
University of Utah-Cooperative Institute for Regional Prediction	University of Utah	Access to RAWS fire weather data, data summaries, model (MM5) products, and maps. Parts still under development.
USFS Fire Applications Support-SIT User Guide	USDAFS	User guide for SIT – how to and what to input for the first step in creating the National (fire) Situation Report. Done from the Dispatch Center level. The form requires some general weather data input.
USFS National Home page	USDAFS	Internet home page for the USDA Forest Service.
USFS/PacSW/Riverside Fire Laboratory	USDAFS	USFS laboratory conducting research in fire weather forecasting, fire behavior, and fire management.
USFS Southwest Region-Wildland Fire Operations	USDAFS	USFS Southwest Region (R3) internet home page for fire operations: fire weather and intelligence, incident management, and predictive services. Access to regional RAWS data.
USFS/RMRS/Missoula Fire Science Laboratory	USDAFS	The Fire Sciences Lab (FiSL), an arm of the Rocky Mountain Research Station located in Missoula, MT, is home to the Fire Behavior Project, Fire Chemistry Project, and the Fire Effects Project.
US/Satellite radar java GIF animation	Plymouth St. College	GOES infrared satellite imagery of thermal sources from Plymouth State College weather center.
Ventilation Climate Information System (VCIS)	USDAFS/ PNWRS	Mapped and graphed data of wind speed, mixing height, and ventilation index. Collaborative effort between USDAFS and PacNW Research Station. Funded by USDOI-USDA-Joint Fire Science Program.
Watershed, Fish, Widlife, Air, Rare Plants, and Soil	USDAFS	FS section studying and managing watersheds, riparian systems, wildlife, air quality, and so forth. Provides funding for NIFMID maintenance and operations, for this report, and Super-RAWS, Fernberg, MN.
Weather Information Management System (WIMS)/F&AM Web Apps.	USDAFS/ Interagency	Internet site/page providing access to NIFMID and on to WIMS, KCFast, PocketCards, and other non-fire related databases. NIFMID= National Interagency Fire Management Integrated Database.

Institution, Dept., Database, etc.	Agency Affiliation	Relation to RAWS/Comments
Western Regional Climate Center (WRCC)	DRI/Univ. Nevada	A division within the DRI; serves as a complete RAWS data archive for all hourly obs. and period of record.
Western Regional Climate Center (WRCC)_RAWS_USA	DRI/Univ. Nevada	Welcome page for access to RAWS maps, locations, data summaries, lister, and so forth. Out of Service.
Western Regional Climate Center (WRCC) RAWS and METAR images and data	DRI/Univ. Nevada	RAWS data/access: maps, tables, time series, wind roses, some metadata, etc.
Wildland Fire Assessment System (WFAS)	USDAFS	Provides maps of NFDRS components and indices, FWx forecasts, Haines, KBDI, Palmer etc. See Appendix G.
Wildland Fire Assessment System (WFAS) – Quick Links	USDAFS	A web site with links to WFAS maps and experimental products: fire weather, danger ratings, drought, greenness, KBDI, indices and components, and RAWS weather data (current days and predicted).
Wildland Fire Training	USDAFS	Interagency list of various fire training courses.

2. List of Selected RAWS-Related Web Sites

Web Site	Agency	Address/Comments/Reference
Arapaho Roosevelt NF Interagency Wildfire Dispatch	USDAFS	http://www.fs.fed.us/arnf/fire/fire.html **Arapaho Roosevelt NF dispatch center – fire information for ARNF; provides links to other wildland fire sites.**
Automated Sorting, Conversion, and Distribution System (ASCADS)	BLM	http://www.fs.fed.us/raws/book/primer/ascadsfieldguide.htm ASCADS tips: http://www.fs.fed.us/raws/book/primer/ascads/tips.shtml **These are links to a ASCADS user guide and to a file of helpful hints. RAWS database; access is via a terminal emulator and is password protected. See Appendix P and body of text for more details**
Boise Fire Weather	NOAA	http://www.boi.noaa.gov/fwx.htm **NOAA fire weather Internet site; based in Boise, ID.**
Canada Fire Research Network (Canadian Forest Service)	Canadian Service Forest	http://www.nofc.forestry.ca/fire/frn/English/frames.htm **Provides information about the Canadian version of NFDRS.**
Canadian Centre Interagency Forest Fire (CIFFC)	Canadian Forest Service	http://www.ciffc.ca/ **Canadian version of NICC; members include federal, provincial, and territorial forest fire managers.**
Climate, Ecosystem, and Fire Applications (CEFA)	DRI/Univ. Nevada	http://www.dri.edu/Programs/CEFA/ **A research division of the DRI concentrating on fire weather applications.**
CA Wildfire Coord. Group	Interagency	http://www.fs.fed.us/r5/fire/south/fwx/raws.shtml **Riverside/South Ops interagency fire forecast and warning unit.**

Web Site	Agency	Address/Comments/Reference (section)
DataRAM page	USDAFS	http://www.satguard.com/usdafs/ **Access to airborne particulate matter/smoke/visibility data from deployed DataRAMS at: wildfires, Rx burns, and so forth. Near real time.**
Desert Research Institute (DRI)	University of Nevada	http://www.dri.edu/ **DRI internet home page.**
Fire Application User Guides	USDAFS	http://www.fs.fed.us/fire/planning/nist/distribu.htm **Internet page listing software and their user guides – both can be downloaded.**
Forecast Systems Laboratory (FSL)	NOAA	http://laps.fsl.noaa.gov/usfs/usfs_home.html **Fire weather forecasts/guidance using the MM5/Local Analysis Prediction System (LAPS) mesoscale model for most of USFS Region 2.**
Forecast Systems Laboratory (FSL)	NOAA	http://www.fsl.noaa.gov/ **FSL conducts applied meteorological research and development to improve and create short-term warning and weather forecast systems, models, and observing technology.**
Geospatial Multi-Agency Coordination Group	USGS/ GEOMAC	http://geomac.usgs.gov/ **Map-intensive site, provides RAWS data, mapped locations across the United States. Public access does not require password.**
Geostationary Operational Environmental Satellite (GOES)	NASA	http://rsd.gsfc.nasa.gov/goes/ **GOES home page; satellite initially used for global weather monitoring now also used for data transmission relay for RAWS.**
Interagency Geographic Area Coordination Center's	Interagency GACC	http://www.fs.fed.us/fire/fire_new/links/links_regional.html **Internet links to regional GACC sites.**
Kansas City Fire Access Software (KCFast)	Interagency	http://famweb.nwcg.gov/ **Long term RAWS and fire data archive; password protected, see text and Appendix D for details.**
MesoWest	University of Utah	http://meteor.met.utah.edu/mesowest/ **Mesonet and forecasting (MM5) group based at the Univ. Utah.**
Mesoscale Modeling Consortia: FCAMMS	Interagency/ Northwest	http://www.atmos.washington.edu/~cliff/consortium.html **All have been established to provide accurate, timely, and useful fire weather forecasts, link forecast information with fuel loadings and fire potential, and develop improved model predictions of smoke transport and diffusion.**
	Interagency/ California and Nevada	http://www.cefa.dri.edu/Operational_Products/operational_index.htm **CEFA products.**
	Interagency/ Rocky Mountains	**Rocky Mountain Center** http://www.fs.fed.us/rmc
	Interagency/ Eastern	http://www.ncrs.fs.fed.us/eamc/
	Interagency/ Southern	http://shrmc.ggy.uga.edu/

Web Site	Agency	Address/Comments/Reference (section)
MM5 Smoke and Fire Weather Resources	University of Washington	http://www.atmos.washington.edu/gcg/smokeandfire/ **Smoke and fire weather information/resources, MM5 forecast output, and so forth.**
MODIS – Moderate Resolution Imaging Spectroradiometer	NASA	http://modis.gsfc.nasa.gov/ **High-resolution satellite images; instrument deployed on the EOS Terra and Aqua satellites. Can detect thermal sources such as fires.**
MODIS Rapid Response Web Fire Maps	University of Maryland	http://firemaps.geog.umd.edu/Cont_US_HTML/viewer.htm **Satellite imagery of active fires in the continental United States; taken with the Moderate Resolution Imaging Spectroradiometer.**
National Fire Danger Rating System (NFDRS)	NWS/ Interagency	http://www.seawfo.noaa.gov/fire/olm/nfdrs.htm **NOAA site providing a very good summary of the NFDRS.**
National Fire Weather/National Weather Service	NOAA/ NWS	NWS:http://www.wrh.noaa.gov/Boise/index.htm RAWS data access: http://raws.boi.noaa.gov/rawsobs.html **NWS Forecast Office, Boise, ID. RAWS data access from the NWS by state.**
National Climatic Data Center (NCDC)	NOAA	http://lwf.ncdc.noaa.gov/oa/ncdc.html **National weather data archive, links to NOAA, NESDIS.**
National Fire Plan Web Site	Interagency	http://www.fireplan.gov/index.cfm **Overview, links to other sites, firefighting, rehab., hazardous fuel reduction, community assistance. Link to NFP maps by the GeoMAC group.**
National Interagency Fire Center (NIFC)	Interagency	http://www.nifc.gov/ **The nation's support center for wildland firefighting; coordinates and supports wildland fire and disaster operations.**
National Interagency (NIFC)/BLM Weather	Interagency	http://www.nifc.blm.gov/nsdu/weather/index.html **BLM fire weather data archive at NIFC – most recent 12/24 hour. Hosted by Fire Center BLM. RAWS data access for local/dispatch center users. Password protected.**
National Interagency Coordination Center (NICC)	Interagency	http://www.nifc.gov/nifctour/nicc.html **National interagency Coordination Center; national center for coordination and support of wildland fire fighting.**
National Wildfire Coordinating Group (NWCG)	Interagency	http://www.nwcg.gov/ **An operational group designed to coordinate programs of the participating wildfire management agencies. Provides links to publications and other fire sites.**
National RAWS Data Server/ NWS, Boise	NWS	http://www.boi.noaa.gov/FIREWX/Raws/TABLES/rawsText.htm **NWS list of RAWS stations by state with access to recent data.**
Natural Resource Project-EOS Training Center	University of Montana	http://eostc.umt.edu/forestry/default.asp **Links to fire and climatological applications; maps of surface moisture stress, temperature, precipitation, and so forth.**
NFDRS Forecasting for forecasters	NOAA	http://www.wrh.noaa.gov/portland/nfdrs.htm **Web page on NFDRS 'how to' for forecasters.**

Web Site	Agency	Address/Comments/Reference (section)
NOAA Fire Weather site	NOAA	http://www.spc.noaa.gov/fire/ **NOAA Storm Prediction Center: fire weather forecasts.**
Northwest Coordination Center (NWCC)	Interagency	http://www.or.blm.gov/nwcc **Northwest region GACC.**
Numerical Weather Data	UCAR	http://www.rap.ucar.edu/weather/model/ **Central web site providing links to meso-scale weather modeling pages (see also Interagency Modeling Consortia).**
NWS/Portland Fire Weather Program	NOAA/ NWS	http://nimbo.wrh.noaa.gov/portland/fwx.htm **Portland, OR, area forecasts, clickable maps, fire weather, and so forth. NOAA/NWS local office.**
Public Broadcasting System	PBS/NOVA	http://www.pbs.org/wgbh/nova/fire **PBS/NOVA web site of a television program about wildland fire broadcast on May 7, 2002.**
RAWS/AWS USFS Fire Application Support	USDAFS	http://www.fs.fed.us/land/fire/planning/nist/raws_aws.htm **Internet links to configure PCs for ASCADS and links to technical notes for RAWS/AWS and the HUB.**
RAWS Contact List	Interagency	http://www.fs.fed.us/raws/contacts.shtml **USFS, NPS, BLM and FWS regional coordinator's telephone and e-mail contact list.**
RAWS: Remote Automated Weather Stations	USDAFS	http://www.fs.fed.us/raws/ **Official USFS RAWS site, many links.**
RAWS data summaries (12 and 24 hour obs)_NWS	NWS	http://raws.boi.noaa.gov/rawssum.html **NWS RAWS data summaries by state.**
RAWS Fact Sheet	BLM	http://www.fire.blm.gov/FactSheets/raws.htm **RAWS FAQS.**
RAWS location information	NWS	http://raws.boi.noaa.gov/rawsidx.html **List of all RAWS sites (NWS)by state, lat/long, elev., and abbreviated** list of sensor suite.
RAWS Model output statistics (MOS)	NWS	http://www.wrh.noaa.gov/Saltlake/projects/ifp/data/RAWSMOS/rmoslist.html **RAWS/MOS fire weather forecasts and guidance for making such forecasts.**
RAWS Temperature /Humidity Forecast Guidance	BLM	http://www.or.blm.gov/nwcc/nwcc-reports/rawsguide/product.htm **A statistical assessment/interpretation of the max and min temperature and humidity for some key RAWS in the PacNW based on regression equations.**
Real-time Observation Monitor and Analysis Network (ROMAN)	University of Utah/ MesoWest	http://www.met.utah.edu/roman/ **Access to RAWS fire weather data, data summaries, links to model (MM5) products, maps, GACCs, NWS, and AWOS.**
Regional (USFS) websites	USDAFS	Northern Rocky Mountain (R1): http://www.fs.fed.us/r1/ **Regional (USFS) websites – links to regional information.**

Web Site	Agency	Address/Comments/Reference (section)
	USDAFS	Rocky Mountain Area (R2): http://www.fs.fed.us/r2/
	USDAFS	Southwestern (R3): http://www.fs.fed.us/r3/
	USDAFS	Intermountain (R4): http://www.fs.fed.us/r4/
	USDAFS	Pacific Southwest (R5): http://www.fs.fed.us/r5/
	USDAFS	Pacific Northwest (R6): http://www.fs.fed.us/r6/
	USDAFS	Southern (R8): http://www.fs.fed.us/r8/
	USDAFS	Eastern (R9): http://www.fs.fed.us/r9/
	USDAFS	Alaska (R10): http://www.fs.fed.us/r10/
Remote Sensing Fire Weather Support Unit (RSFWSU)	BLM	http://www.nifc.gov/nifctour/remsens.html **RSFWSU web tour plus information about the Boise Depot.**
Rocky Mountain Area Fire and Aviation Management	USDAFS	http://www.fs.fed.us/r2/fire/rmacc.html **Site provides Internet links to fire weather, red flag warnings, NWS websites, RAWS data access, and more for the Rocky Mtn. Region.**
Rocky Mountain Area Red Flag	USDAFS/ USGS	http://rockys28.cr.usgs.gov/fweather_dev/viewer.htm **Mapped information of red flag warnings, fire weather watches as well as links to information on fire fuels, RAWS weather, situation reports, geographical features, cities, roads, and political boundaries.**
Scripps Institution of Oceanography/ Experimental Climate Prediction Center (ECPC)	Univ. CA San Diego	http://ecpc.ucsd.edu/ **Developing fire management products from the ECPC regional spectral model (RSM) and performing verification analysis of RSM fire forecast products. Both in collaboration with CEFA.**
University of Utah – Dept. of Meteorology	University of Utah	http://www.met.utah.edu/ **University of Utah – Dept. of Meteorology internet home page.**
US/Satellite radar java GIF animation	Plymouth St. College	http://vortex.plymouth.edu/psc_satrad_an.html **GOES IR satellite imagery from Plymouth State College weather center.**
USFS Fire Applications Support-SIT User Guide	USDAFS	http://www.fs.fed.us/land/fire/planning/nist/sit_ug/situserguide2001_a.pdf **User guide for SIT – how to and what to input for the first step in creating the National (Fire) Situation Report.**
USFS National Home page	USDAFS	http://www.fs.fed.us/ **Home page for the USDA Forest Service.**
USFS/RMRS/ Missoula Fire Science Laboratory	USDAFS	http://www.firelab.org/ **The Fire Sciences Lab (FiSL), an arm of the Rocky Mountain Research Station located in Missoula, MT, is home to the Fire Behavior Project, Fire Chemistry Project, and the Fire Effects Project.**
USFS/PacSW/ Riverside Fire Laboratory	USDAFS	http://www.rfl.psw.fs.fed.us/index.html **USFS laboratory conducting research in fire weather forecasting, fire behavior, and fire management.**
USFS Southwest Region-Wildland Fire Operations	USDAFS	http://www.fs.fed.us/r3/fire/ **USFS Southwest Region (R3) Internet home page for fire operations: weather, intelligence, and management.**

Web Site	Agency	Address/Comments/Reference (section)
Ventilation Climate Information System (VCIS)	USDAFS/ PNWRS	http://www.fs.fed.us/pnw/fera/vent **Mapped and graphed data of wind speed, mixing height, and ventilation index. Collaborative effort between USDAFS and PacNW Research Station.**
Weather Information Management System (WIMS)/F&AM Web Apps.	USDAFS Interagency	http://www.fs.fed.us/fire/planning/nist/wims.htm http://famweb.nwcg.gov/ **Internet site/page providing access to WIMS/KCFast/SIT/209/Pocket Cards/AMIS/FEPMIS. Password protected, interactive.**
Western Regional Climate Center (WRCC) + multiple links	DRI/Univ. Nevada	http://www.wrcc.dri.edu/index.html **A division within the DRI; serves as a RAWS data archive as well as weather data from other networks. Provides many other weather-related products.**
Western Regional Climate Center (WRCC)_ RAWS_USA	DRI/Univ. Nevada	http://www.wrcc.dri.edu/wraws/ **Welcome page for access to RAWS maps, locations, data summaries, and so forth. Inactive.**
Western Regional Climate Center (WRCC) RAWS and METAR images and data	DRI/Univ. Nevada	http://www.wrcc.dri.edu/raws/raws2.html **RAWS weather data access: maps, tables, ime series, wind roses, etc..**
Wildland Fire – Assessment System (WFAS) Home Page	USDAFS	http://www.fs.fed.us/land/wfas/ **Provides maps of NFDRS components and indices, FWx forecasts, Haines, KBDI, Palmer etc.**
Wildland Fire – Assessment System (WFAS) Quick Links	USDAFS	http://wfas.net/cgi-bin/nav.cgi?pages=wfas&mode=6&fullpageview **Links to WFAS maps and experimental products: fire weather, danger ratings, drought, greenness, KBDI, and indices and components.**
Wildland Fire Training	USDAFS	http://www.fs.fed.us/fire/fire_new/training/fire_training.html **Interagency list of various fire training courses.**
WRCC RAWS Climatology Products	DRI/Univ. Nevada	http://wrcc.sage.dri.edu/fire/RAWS.html **Access to Nevada RAWS climatology: single images, animations for the period 1985-1995.**

Appendix B. NFDRS Structure and Operations

Prior to the late 1960s, a number of fire danger rating systems were used by different land management agencies and in different parts of the United States; there was no consistency. The National Fire Danger Rating System (NFDRS) was developed to address this problem; it was released for use in 1972. The design resulted in a model that is scientifically based, adaptable by local fire managers, applicable anywhere in the United States, and fairly inexpensive to operate. The model was upgraded in 1978 and again in 1988; the basic structure of the present day NFDRS is given below in Figure B-1.

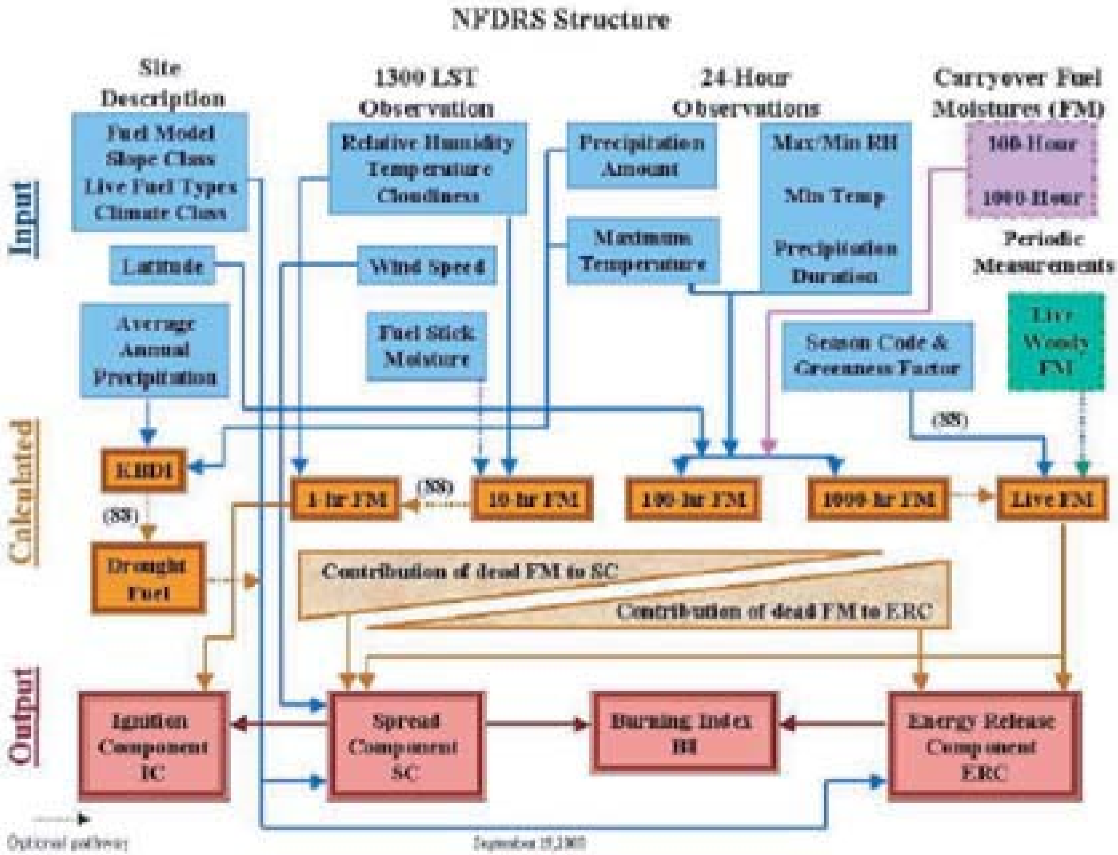


Figure B-1: Basic structure of the National Fire Danger Rating System (from: NWCG – Fire Danger Working Team. January 2002. Gaining a Basic Understanding of the National Fire Danger Rating System: A Self-Study Course. Sponsored by: USDA, USDI, NASF).

Fire danger is commonly described as: The resultant descriptor of the combination of both constant and variable factors which affect the initiation, spread, and difficulty of control of wildfires on an area. Factors such as fuels, weather, topography, and risk are integrated to evaluate the daily fire potential in an area. The NDDRS combines the effects of current and expected conditions of certain fire danger attributes into one or more adjective or numeric indices that reflect an area's protection needs. The rating for an area provides the manager a tool to evaluate and make day-to-day (and even 2-3 days in advance) fire business decisions such as staffing levels, pre-positioning or re-distribution of resources, and severity requests (emergency funding). Danger ratings reflect the general conditions for very large areas – tens of thousands of acres – affecting an initiating fire and can be calculated for both current and predicted conditions. The interpretation and application of NFDRS products is based upon four underlying assumptions:

- It relates to the potential of an initiating fire that spreads without extreme behavior, through continuous fuels on a uniform slope,
- Fire activity is addressed from the standpoint of containment not putting out a fire,
- Danger ratings are relative and are linearly related,
- Ratings reflect near worst-case circumstances in exposed locations and during the warmest and driest part of the day.

The NFDRS is comprised of three major parts:

- The parameters, constants, and formulae used to calculate fire-spread, rates of combustion, and ignition temperatures,
- Site descriptors (meta data) for the rating area – fuel model(s), slope class, grass type (annual vs. perennial), climate class, annual rainfall, etc.
- Data used to calculate daily ratings take two forms: weather observations and the parameters used to control the actual calculations with the NFDRS model.

Changes in the weather can affect the daily danger ratings significantly. Quality control is thus extremely important - of the data itself and at every step of the data stream, as well as of the instruments used to collect it. The other parameters are user-defined and may change during the course of a fire season; they include state of herbaceous vegetation, shrub type, staffing index thresholds, fuel moisture, season codes and greenness, and KBDI.

Today there are three processors generating daily fire danger indices and components all using the same computer code: WIMS, Fire Family Plus, and Fire Weather Plus. WIMS is a system that helps users manage weather data/information. It is also the host for the NFDRS and many federal and state fire and resource management agencies use WIMS to generate their fire danger ratings. Hourly data from RAWS across the United States are sent to WIMS and archived (but only for a maximum of two years) in the NIFMID for future reference and/or analysis. Station meta-data is also stored in WIMS. The advantage of a central management system and processor such as WIMS/NFDRS is that data are stored automatically and available to all users. Anyone can directly access station records, data, and outputs from any station in the RAWS network. The NFDRS model itself has been described in great detail by Cohen and Deeming (1985).

Fire Family Plus is a recently released desk-top PC Windows application operating against a MS Access database; version 3.1 was released in summer 2003. The package is a suite of modules with which the user can generate summaries of fire weather, danger ratings, and fire occurrence for one or more RAWS in a given area or adjacent areas from data extracted from NIFMID. This allows the user to analyze fire danger as it affects fire business, generating fire danger and climatology trends, fire business decision thresholds, fire fighter pocket cards, and weather and NFDRS product troubleshooting.

Fire Weather Plus is a PC-based application originally developed by Forest Technology Systems (FTS) to support fire danger calculations for RAWS (and other remote stations) marketed by the company. The developers have recently added modules enabling the user to interface with other (non-FTS) weather stations. Because the core of the package is the same code as that used by WIMS/NFDRS and Fire Family Plus, the same input parameters would result in the same output as WIMS/NFDRS or FF+.

NFDRS Outputs/Products

Interrmediate

These are the modeled moistures for the different classes of live and dead fuels, which are in turn used to calculate the final NFDRS indices and components. Live fuel moisture (FM) is calculated for herbaceous and woody vegetation; parameters for both types tend to start low at the beginning of a fire season, reach a peak mid-season, and decline as the vegetation senesces. Climate class will affect values as will vegetation type within each broader class, thus, annuals will dry at a faster rate than will perennials.

- Dead fuel moisture is calculated based upon precipitation and relative humidity. Fuel moistures are determined for each of the four time-lag fuel classes: 1 hr, 10 hr, 100 hr, and 1000 hr; the 10 hr FM is also measured directly. The time-lag of a fuel class is proportional to its diameter and is loosely defined as the time it takes a fuel particle to lose (or gain) 2/3 of the difference between the current level of moisture within the fuel and the equilibrium moisture content.
- The X-1000 hr FM is not a dead FM, but rather a fuel moisture recovery value and is used to calculate the live herbaceous FM over the course of the fire season.

Indices and Components

The ignition component (IC) is the probability that a firebrand introduced into a fine fuel complex will cause a fire requiring containment action. The ignition component can range from 0 when conditions are cool and damp, to 100 on days when the weather is dry and windy. Because such a fire must have the potential to spread, the spread component is one of the drivers used in the calculation of the IC; the other is 1 hr FM which in turn is driven by hourly and daily weather (AT/RH, SOW, and indirectly WS). As a result the IC can change rapidly, as frequently as hour to hour.

The burn index (BI) is a number relating fire behavior to the amount of effort needed to contain a single fire in a particular fuel type within a rating area, and is directly driven by the spread component (SC) and the energy release component (ERC).

The SC is the forward rate of spread at the head of the fire in feet per minute. The SC value is derived from a mathematical model that integrates the effects of wind and slope with fuel bed and fuel particle properties to calculate the forward rate of spread. The SC is different for each fuel model.

The ERC is defined as the potential available energy per square foot of flaming fire at the head of a fire, and is given in units of BTUs per square foot. Like the SC, the ERC is unique for each fuel model. The rate of combustion is almost totally dependent on the same fuel properties as are considered in the SC calculation. However, the main difference in the calculation of the two components is that the FM of finer fuels determines SC whereas ERC calculations require moisture inputs of the entire fuel complex, live and dead. Because WS does not enter the calculation of the ERC, day-to-day variation is not large.

The fire load index (FLI) is a rating of the maximum effort required to contain all probable fires in a given danger rating area during a given period of time. Because the FLI is a composite of the IC, SC, and ERC plus human and lightning caused risk inputs, it is highly variable from one administrative unit to another. This index provides no information as to the potential fire danger as the other indices and components do, and so is seldom used in fire business decision making.

The Keetch-Byram drought index (KBDI) is not a product of the NFDRS, but is a standalone index used to gauge the effects of drought on fire potential. The actual value of the index is an estimate of the amount of precipitation (in 0.01 inches) needed to saturate soil so a value of 0 is complete saturation of the soil. The index only deals with the top 8 inches of the soil profile, so a KBDI value of 800 (the maximum) means 8.00 inches of precipitation would be needed to bring the soil back to saturation. The Keetch-Byram Drought Index's relationship to fire danger is that as the index value increases, the vegetation is subjected to increased moisture stress and begins to dry and live fuel is added to the dead fuel load in a given area. The KBDI can be used in combination with other 1978 NFDRS products to help in decision making, KBDI is a requisite input if using the 1988 NFDRS model.

Applications of NFDRS Products

Geographic Area Coordination Centers (GACCs) assess their readiness levels on a daily basis based upon forecast fire activity. Actions can include pre-positioning of resources, recalling off duty personnel, ordering additional equipment, or pre-planning dispatch and response actions. These contingencies are all part of fire business and can be very expensive, so high-quality fire danger information (NFDRS product) is critical which in turn requires high-quality data used for model input. The last includes site descriptions (fuel models and fuel types, climate class, slope, aspect, mean ann. rainfall etc.) and hourly and 13:00 hr weather data (RAWS).

For fire management pre-planning, individual GACC's or fire danger zones must decide which index or component reflects the unit's response needs. Comparison of past fire sizes with corresponding SC, IC, ERC, or BI can help in making this decision. Examining the meaning of each can help in deciding what resource is best suited in containing a fire. For example: how well does an individual component or index correlate to ultimate fire size? Fire Family Plus and NFDRS can provide these answers. Plans for initial and continued response to an incident can be made based on these types of analyses.

The NFDRS model also calculates fire danger adjective ratings; these are primarily for public use and range from low to extreme. The ratings are driven by weather, the primary fuel model specified for the area, the slope, aspect, climate class, and grass type, and the fire danger index or component associated with the fire zone.

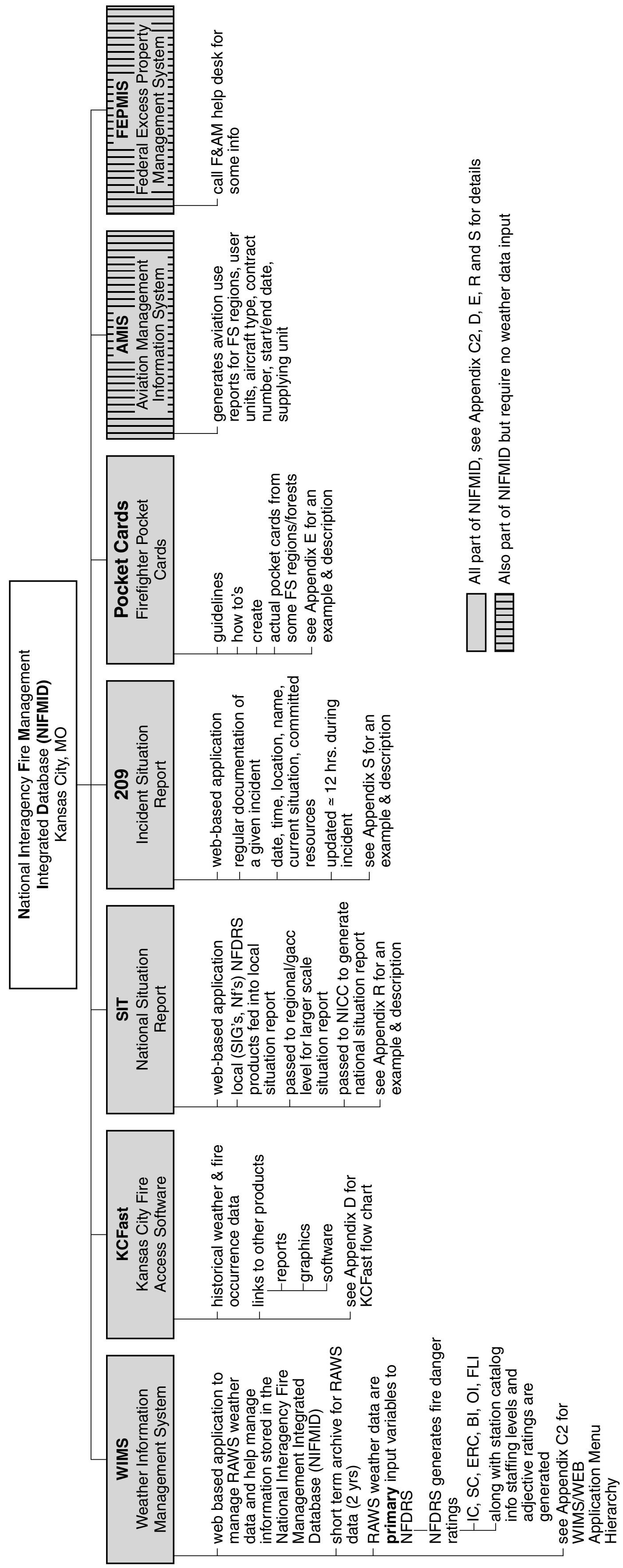
The USFS and other land management agencies have a process whereby local units (national forests or ranger districts) can request additional funding to augment their basic fire suppression budget. Criteria for such severity requests require supporting data showing that current conditions are significantly worse than originally forecast (and so planned for). One method is to compare current NFDRS indices or components with historic worst case and 'normal' data for the same dates. The ERC and 1000-hr fuel moisture are often used for these types of comparisons and Fire Family Plus is an excellent tool for analyses at this spatial scale.

NFDRS products are also used in the creation of firefighter pocket cards; the cards contain information relative to current conditions, seasonal trends, and comparisons with historic patterns. In addition the cards contain information about NFDRS indices and components for the local area, thresholds of extreme fire behavior, and local fire danger interpretations. The cards can be created through the National Fire and Aviation Management Web Applications web site or by using Fire Family Plus, see Appendix E for an example.

Finally, NFDRS ouput is used to calculate daily industrial (logging) fire precaution level (IFPL), to guide public use restrictions, and to help in wildland fire suppression go-no go decisions.

Appendix C-1. NIFMID Flow Chart

Appendix C1: National Interagency Fire Management Integrated Database (NIFMID): Umbrella Structure for WIMS/KCFast/SIT/209/Pocket Cards/AMIS/FEPMIS



Appendix C-2. WIMS/WEB Application Menu Hierarchy

This appendix shows the WIMS/WEB application hierarchy of menus and forms (adapted from WIMS User Guide, June 2001). Top level menu choices are in blue, second tier are shown in red, third tier in black, and fourth tier in green. The WIMS Web Application User Guide provides significantly greater detail than this appendix; it is also available for download from the Internet USDA Forest Service Fire Application Support, User Guides (http://www.fs.fed.us/fire/planning/nist/distribu.htm). Acronyms are defined in the Glossary. Page numbers of major headings in the User Guide are also given where applicable.

DATA – Data entry and manipulation
- OBS – Observations (p. 84)
  - NOBS – To display the create observation form i.e. enter a new observation for a station or a station within a special interest group (SIG) for all fields – station ID, time, type, SOW, AT, RH, WS, WD, etc.
  - EOBS – Edit observations; user can edit previous observations or correct invalid archived data
  - DOBS – Display observations – allows user to display observations from a RAWS
  - DRAWS – Display RAWS – allows user to display RAWS observations from a single station or from all stations within a SIG
  - HOBS – Help for user on the OBS menu choice
- FCST – (p.100) Forecasts – allows user to display, create, and edit weather forecasts. The NWS does in fact provide these narrative forecasts which are stored in WIMS in a shared file directory
  - DFCST – Display forecasts
    - DPFCST – Display point forecasts; display a site specific weather forecast for a station or SIG for a specific day and time
    - DTFCST – Display trend forecasts; displays forcasted weather information for a station or SIG over a given time period
  - DNFCST – Display narrative forecasts
    - SPOT – Spot
    - SMOKE - Smoke
  - NFCST – New forecasts; enter new forecasts – for NWS-user authorized only
    - NPFCST – Enter new point forecasts
    - NTFCST – Enter new trend forecasts
  - EFCST – Edit forecasts; with the two options directly below allows user to:
    - EPFCST – Edit point forecast for a station or SIG
    - ETFCST – Edit trend forecast for a station or SIG
- STA – Station information (p.43); before weather observations can be entered for a given station associated information (meta data) must be entered and stored in WIMS
  - MSTA – maintain station; allows user to create a new manual or RAWS station, edit an existing station, list existing stations, edit NFDRS parameters
    - NSTA – New station; enter meta data for a new station (becomes part of the station catalog) – station ID, site description, state and county codes, lat/long, station type and name, station owner, conversion codes, access control etc. general station information
    - ESTA – Edit station; display or edit station catalog information or add or delete sensors of a RAWS station. This also includes editing NFDRS parameters
    - LSTA – List station; list station numbers (NESDIS ID) of a specific owner, list all station numbers of a specific agency, list all station numbers of a specific owner for a given observation time
    - ENFDR – Display/edit default NFDRS parameters; after creating a new station and saving the information WIMS displays the Create Default/Edit NFDRS Parameters form; the user must enter additional meta data for use by the NFDRS model in order for fire danger indices and components to be calculated (see Appendix 8 for more NFDRS details)
  - MSIG – Maintain special interest groups (SIG's); stations in different locations, regions, or

administrative boundaries can be grouped together to form a special interest group this also applies to stations within an area, region, or admin. unit. A station within one SIG can also be a member of one or more other SIGs. Each station within a SIG is weighted reflecting its relative importance within the group; the sum of weights for the group must equal one. Fire danger indices and components can be calculated for the group as a whole.

NSIG – New SIGs; create a new special interest group – enter the station number of each station to be included in the group

ESIG – Edit SIGs; the user can add or delete station numbers of a SIG

DSIG – Delete SIGs; the user can delete an entire SIG or SIGs if no longer needed or used

LSIG – List SIGs; allows user to list SIGs owned by the user or another user

EAVG – Display/edit NFDRS weight assignments; mentioned above and allows the user to assign weights to individual stations within a SIG to calculate weighted average values for NFDRS indices and components. The weights are a reflection of the importance of a station relative to the others within the group. Criteria for assigning weights include such factors as the area a station represents, historic fire occurrence, public use patterns, importance to local managers

MACL – Maintain access list; a list of those who are allowed access to enter or edit weather station data for an individual station or SIG

NACL – New access control list; create a new access control list for specific WIMS users

EACL – Edit access control lists; add, delete, and change access designations

DACL – Delete access control list; delete a list that is no longer needed

LACL – List access control list; allows a user to identify access lists that the user or another WIMS user owns

HMACL – Help MACL; help with access lists

HSTA – Help with station information (STA)

DNFDR – Display National Fire Danger Rating (p.124); display NFDRS information

DIDX – Display index format; allows user to display key fire weather variables for regular and special observations and forecasts; variables include fuel model, fuel moisture content, wind speed, wind direction, IC, ERC, SC, BI, FLI, staffing leveladjective fire danger rating, KBDI etc.

DIDM – Display moisture index form; allows the user to track and compare key NFDRS carry over values for a list of observations including the x1000 live fuel moisture. Calculated vs. measured woody fuel moisture can be compared. Live fuel moisture recovery value for the 1, 10, 100, 1000, and x1000 hour fuels can be compared on a daily basis.

DMGR – Display manager format; allows the user to display a number of different fire weather elements/parameters as well as NFDRS indices and components

DSHR – Display short format; displays station information such as fuel model/slope class/grass type/climate class, total precipitation (ppt.), hours of ppt., adjective fire danger, staffing level

DAVG – Display weighted averages for a SIG; combines NFDRS indices and components from individual weighted) stations within a SIG into a single index or component

DABR – Display abbreviated format; user can display a shortened version of the Index form (DIDX above) for regular and special observations; key fields include IC, SC, ERC, BI, etc.

PLST – (p.37) Data capture from OBS/FCST/NFDR; capture and save data in a simple text format for stations or SIGs; the user can specify type and number of observations, number of NFDRS observations, number of forecasts, and number of NFDRS forecasts

UTIL – Utilities (p.138); the user can custom tailor a WIMS profile, send and receive e-mail, and access different WIMS files from Private and Shared File directories

PROFILE – Profile setup and edit; fields include name, agency, WIMS menu to display, financial accounting information, telephone numbers, etc.

LUSER – WIMS user list (logon ID's and names); provides a listing of WIMS logon IDs and WIMS user names and telephone numbers

NWSPROD - National Weather Service products (p.119)

FWFCST – Fire weather forecasts; fire weather forecasts are issued twice daily by the NWS fire weather forecast office and contain: discussion of weather activity for an area and an overall forecast for each zone. These forecasts remain in WIMS for three days. This option displays a list of available forecasts.

REDFLAG – Red Flag Warnings; these warnings outline specific areas where the forecasted fire weather conditions indicate imminent fire danger i.e. high temperature, low humidity, and/or high wind speed. Criteria can vary depending on local conditions. Similar to fire weather forecasts this option displays a file directory/listing of red flag warnings for the current day and the previos three days

SPOT – Spot forecasts; these are issued by the NWS as requested by the user for a specific location and time; they include forecast location information, a discussion of weather activity, and an overall forecast, forecasted temperature, and forecasted humidity. All spot forecasts currently available are listed.

SMOKE – Smoke management forecasts; these are issued by state meteorologists and display wind and airflow forecast information for prescribed burn purposes

ONARR – Various other narratives; these include all other available forecast information in narrative format such as marine forecasts

FMWS – Fire management web sites: internet hyperlinks to a number of fire weather and RAWS related web sites

NIFC – National Interagency Fire Center
FAMAH – F&AM Fire Application Helpdesk
WFAS – Wildland Fire Assessment System
FWX – Boise Fire Weather Page
WRCC – Western Rgional Climate Center
NWS – National Weather Service, main page
USFSFTP – U.S.Forest Service ftp site
RAWS – Official USFS RAWS site

ADMIN – System administration; unavailable to the general user and not discussed in the WIMS User Guide

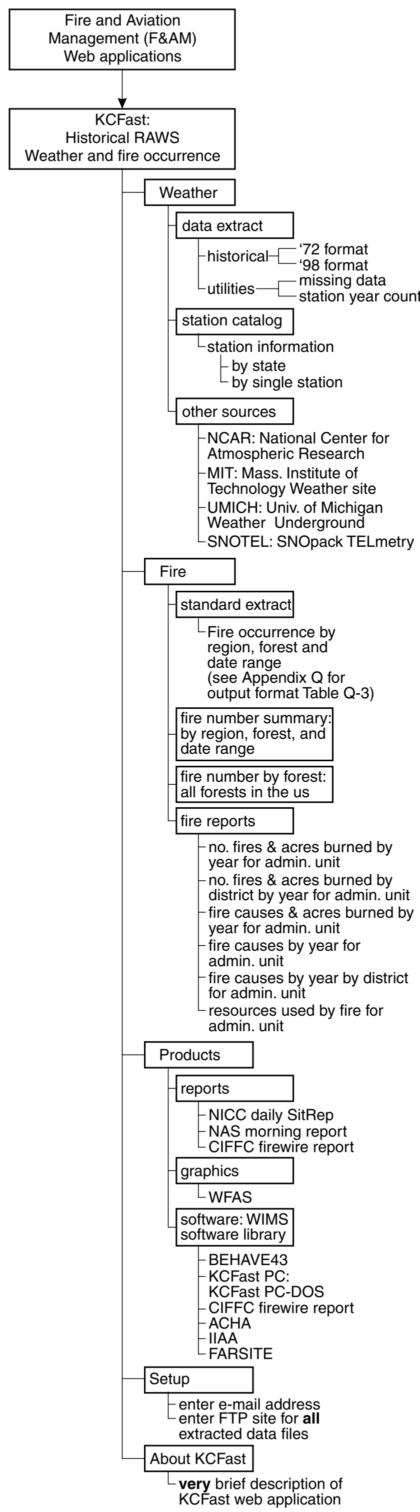
MSHARE -
SETUP – DBA maintenance menu
LOGS – NWS/RAWS log display
EOWN –
DSTA – Delete station information
HADMIN –

HWIMS – WIMS help; on-line help with WIMS

EXIT – Exit; exit/log-off from WIMS

Appendix D. KCFast Flow Chart

KCFast is a web-based, long-term RAWS data archive for weather, fire occurrence, fire numbers, and fire reports. The application also provides various products such as situation reports and Internet links to graphics and software. Weather data for the entire period of record can be retrieved in two different formats: The 1972 (only the 13:00 hour observations) or the 1998 (all hourly observations if they archived). All details are given below in the flow chart; for acronyms see the glossary.



Appendix E. Fire Danger Pocket Cards for Firefighters

The Fire Danger Pocket Card is a way to communicate information about fire danger to firefighters. (See example below.) The goal is to provide a greater awareness of fire danger and subsequently increased firefighter safety. The Pocket Card gives a description of seasonal changes in fire danger potential in a local area, which makes it useful to both local and out-of-area firefighters. It can be generated via NIFMID or FF+.

The Pocket Card has an important day-to-day pre-suppression use. When the morning and afternoon weather are read each day, the actual and predicted indices are announced. The firefighters can reference their card to establish their position in the range of possible values for danger rating. More importantly, the card provides a method for everyone involved with wildland and prescribed fire operations to communicate a common understanding of key index values provided by the NFDRS. Local fire management personnel can produce the cards using Fire Family Plus. Cards are data input choice dependent and should be developed locally with local fire management involvement to meet local fire management needs.

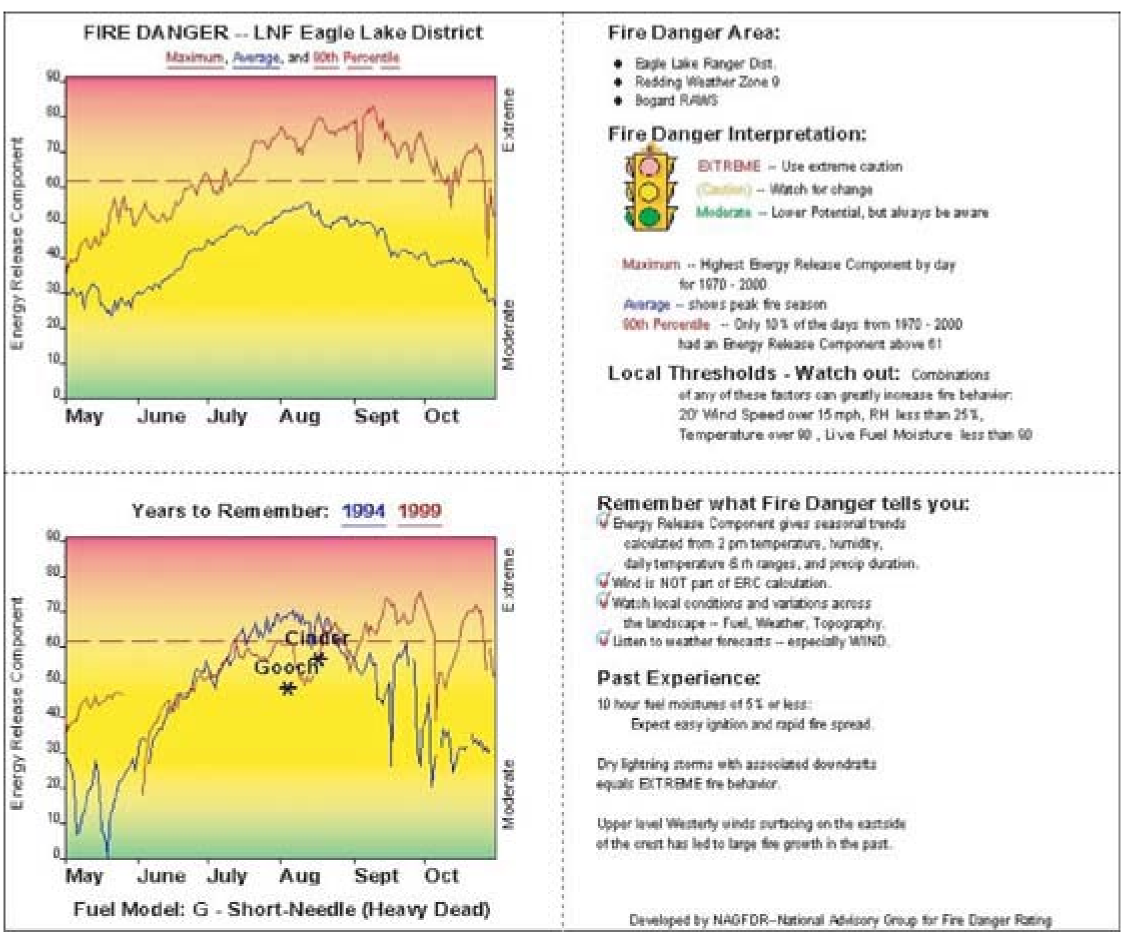
The F&AM web applications/Pocket Card site provides additional information, publications, real examples, and guidelines for creating a Pocket Card using Fire Family Plus.

North Zone

Lassen National Park

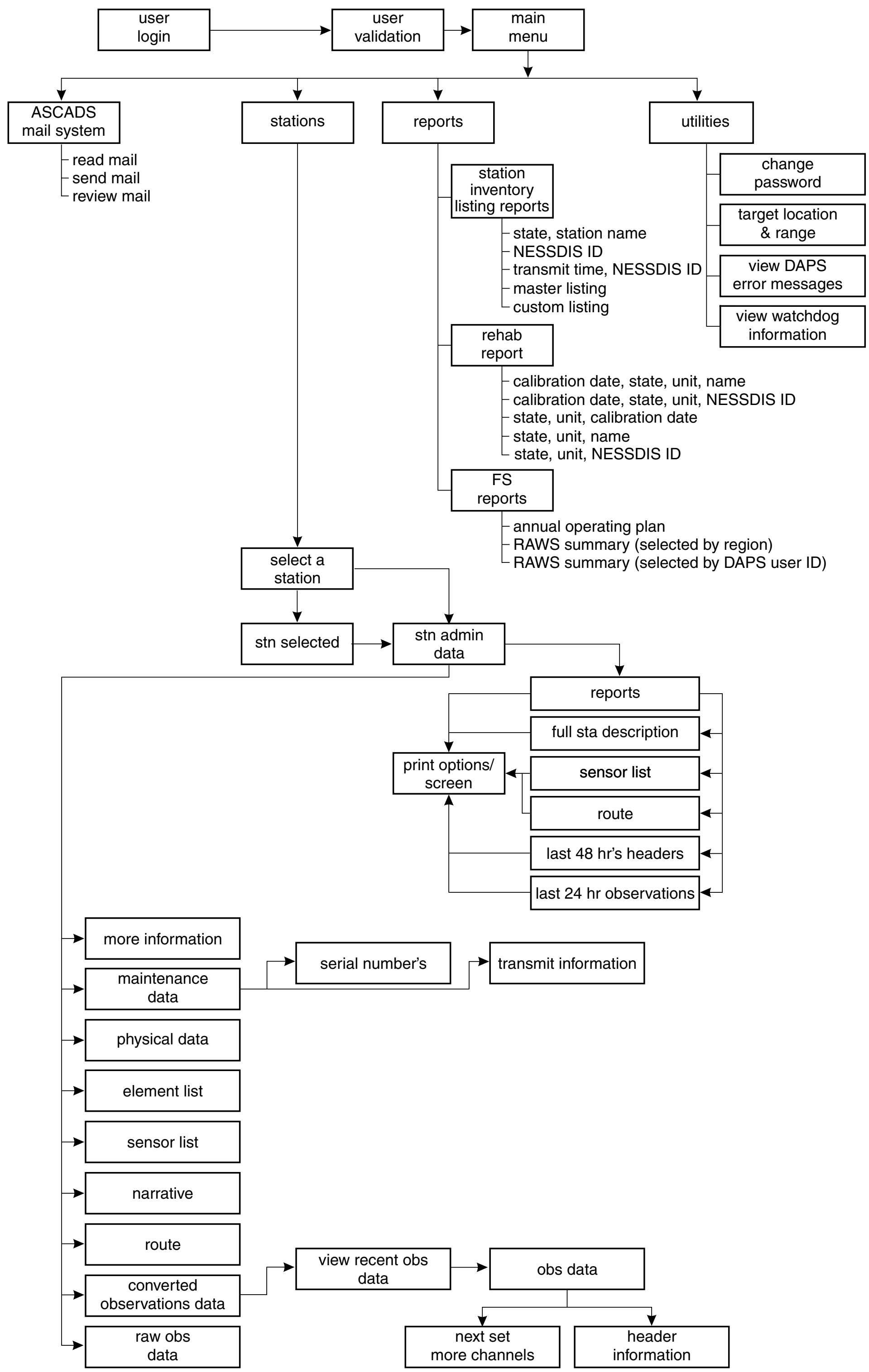
Eagle Lake District

Fuel Model G - ERC



Appendix F. ASCADS Flow Chart

The flow chart below describes the Automated Sorting, Conversion, and Distribution System (ASCADS), which is the main/central distribution point from which all other databases receive RAWS data. The flow charts show the main, report, and station menu hierarchies (adapted from ASCADS User Guide Version 2.1, BLM, Section Data Retrieval/ASCADS).



Appendix G. WFAS Background and Evolution

This Appendix supplements the information about WFAS that was provided in the text.

Background

The Wildland Fire Assessment System (WFAS) was developed initially as an Internet-accessible experimental tool for fire business managers by the USDAFS Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula MT. The current version provides a national view of weather and fire potential, including national fire danger and weather maps and satellite-derived greenness maps. As of Spring 2003 the USDAFS Washington Office of Fire and Aviation Management and the National Information Systems Team (NIST), Boise, ID support the program. The broad area component of the WFAS (see Appendix A for Internet address) is generating maps of selected fire weather parameters and fire danger indices and components of the NFDRS (see Appendix B). Adjective fire danger ratings (daily and forecast) are also mapped. WFAS queries WIMS each afternoon and generates maps from the daily 13:00 weather observations and NFDRS products. Each afternoon Fire Weather Forecasters from the National Weather Service also view these local observations and issue trend forecasts for fire weather forecast zones. WIMS processes these forecasts into next-day index forecasts.

On the maps RAWS data and NFDRS products are reported for clusters of 12 stations. Values between stations are estimated with an inverse distance-squared technique on a 10-km grid. This works fairly well in areas of relatively high station density, but has obvious shortcomings in other areas. Station location is based on the latitude/longitude cataloged by local station managers in WIMS. These maps are updated daily year round. They are prototype WFAS products and are subject to change.

Daily fire weather and next day forecast maps are based on the mid-afternoon (1 pm LST) observations from the RAWS network as reported to WIMS by 5 pm (MST). Mapped parameters include average wind speed, 24 hour total precipitation, air temperature, relative humidity, and dew point. (These forecast maps are generally issued only during the fire season, and many areas of the country will not have forecasted information. As a result, some large data gaps and resulting bizarre interpolations will result as compared to the day's observed maps). Forecast maps of NFDRS indices and components are based on the afternoon fire-weather zone trend forecasts issued by National Weather Service Fire Weather Forecasters. Intermediate NFDRS products such as dead and live fuel moisture are mapped. Dead fuel moisture products are a function of air temperature and humidity - and are critical in determining potential fire danger. Live fuel moisture or greenness maps are generated weekly and are based on comparisons with standard references, on the Normalized Difference Vegetation Index (NDVI), and on differences from historic NDVI data.

Finally, in addition to all the above, the Keetch-Byram drought index and lower atmosphere stability index (LASI or Haines) maps are generated. The former is a measure of soil moisture content and responds to air temperature, daily and annual precipitation. The Haines index is used to forecast the probability of generating large wildfires often associated with low humidity and unstable atmospheric conditions above canopy in upper air.

System Status and Update Information up to June 2002

June 2002: The WFAS site was redesigned to provide easier access to products. Archived data is accessible and organized by calendar date. Comparisons between years can be displayed. Animation of a sequence of images can be viewed.

-Apr-01: Year 2001 transition in greenness maps.

21-Sep-00: Lightning ignition efficiency extended to conterminous United States.

15-Mar-00: Map Archives Updated.

10-May-99: NIST assumes responsibility for support and maintenance.

29-Mar-99: Haines Index available again.

23-Mar-99: Haines Index temporarily unavailable.

26-Feb-99: Map Archives now include 1998 maps.

19-Jan-99: Name of lightning ignition potential map changed to lightning ignition efficiency. The content is the same as before.

23-Sep-98: Greenness Support Tools updated.

26-Jun-98: Experimental forecast experimental fire potential map added.

12-Jun-98: References to lightning location removed; link to the Oklahoma Mesonet Experiment updated; greenness map data archival extended from one week to four.

24-Nov-97: 1 Km Resolution NFDRS Fuel Map available.

18-Jul-97: A new look reflects the completion of converting WFAS-MAPS to the USDA, Forest Service's new computing platform using ARC/INFO instead of GRASS4.1. Some of the features include:

- Inclusion of Alaska Information
  - Daily fire weather maps (as reported through WIMS)
  - Morning 12Z Haines Index Maps
  - Greenness Maps
- On-line access to Map Archives
  - Weekly Greenness Maps, 1989-1996 (Lower 48 Only)
  - Daily WFAS Maps, 1996 (Lower 48, Fire Danger, KBDI, FM1000)
- A Experimental Products link for a new 1km Resolution Fire Potential Map.

18-Feb-97: Greenness Departure data unavailable from EROS in Winter.

15-Oct-96: Daily observations and forecasts (text format), sorted by state may be viewed

09-Sep-96: Greenness DATA and Support Tools Available via FTP.

Appendix H. RAWS Data Access via WRCC

Figure H-1 describes the old data access hierarchy with search criteria indicated. Figure H-2 describes a new web-accessible archive still under construction; stations can be chosen either from a list or a clickable map. Graphing options (some still under development) can then be chosen from the displayed list. (See also Data Retrieval section of text and Appendix O.)

Figure H1 - "Old" Data Access Hierarchy
(No longer in service)

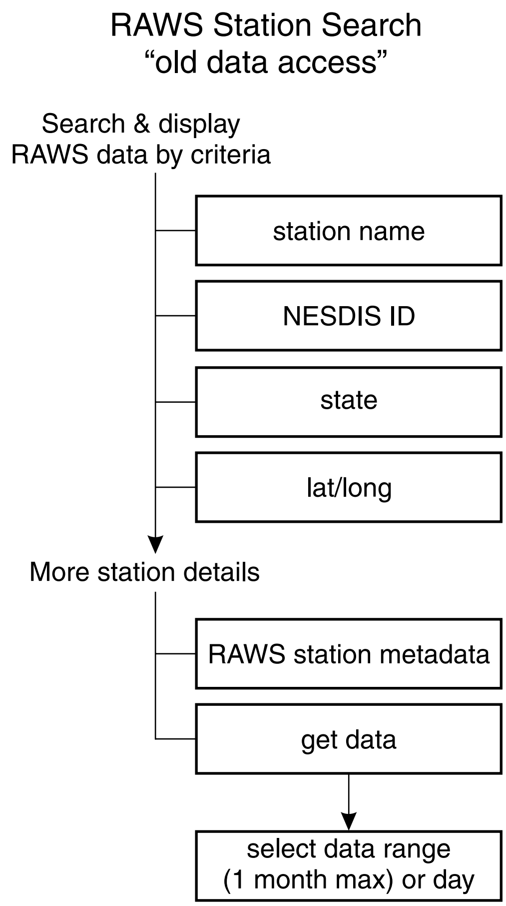
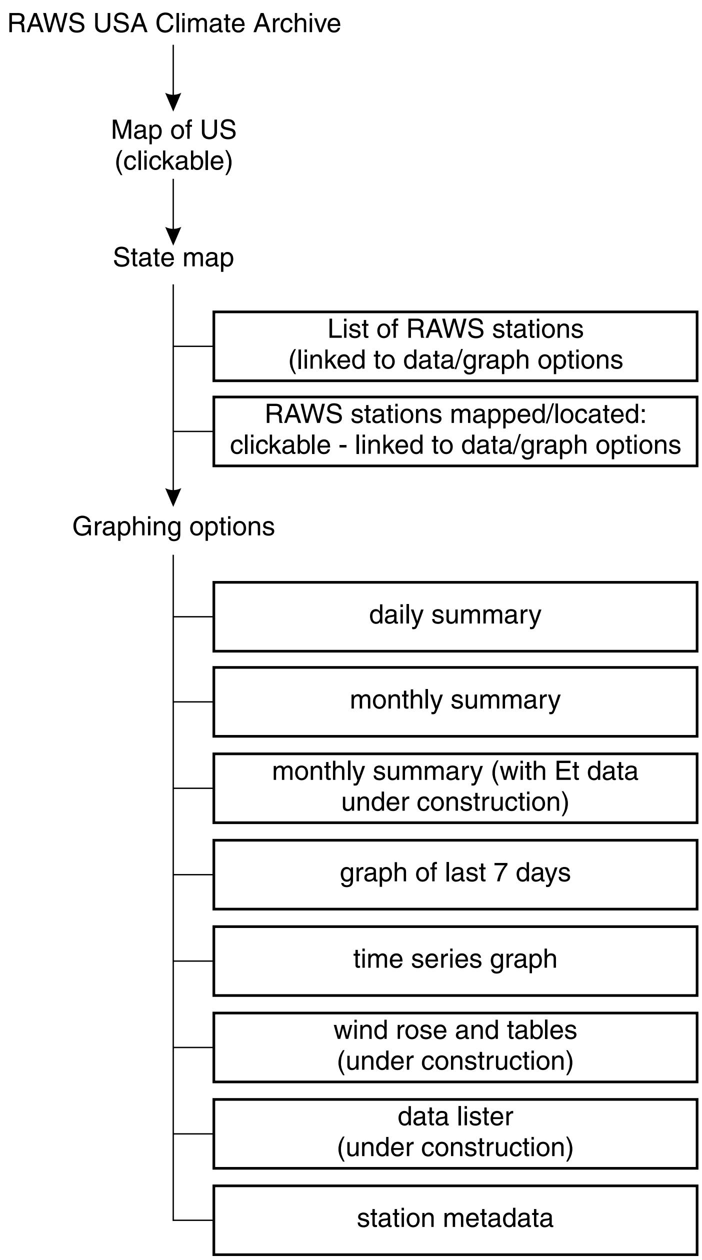


Figure H2 - New web-accessible RAWS USA Climate Archive (current, 2003, WRCC RAWS data portal)



Appendix I. RAWS Operations and Personnel Responsibilities

This Appendix gives an overview of RAWS operations and hardware, sensor and data requirements, and personnel duties and responsibilities. It provides details of information summarized in the text.

The optimal operating period for all RAWS used for the NFDRS is year-round. However, the minimum operational period is determined by the following criteria (NWCG-NFDRS, PMS 426-3):

1. A minimum 30-day start up and data collection period prior to the need for NFDRS indices is required for each seasonal weather station to properly calibrate the model.
2. Wildland fire season as designated by the local manager, Region, or Geographic Area Coordination Center but generally beginning in late spring and ending in early autumn.
3. Fluctuations in fire season length can occur from one year to the next. Use of the visual greenness images available through the Wildland Fire Assessment System (WFAS) is recommended to assist the local or regional fire manager in determining the beginning and end of the fire season.

Non-owner use. The following guidelines are recommended for any use of weather station data for NFDRS that is not owned by the user.

1. Notify the station owner/operator that you are using this station for NFDRS or other applications.
2. When a longer operating season is required by an adjacent unit, the non-owner should assist in the management of that station, including contributing to any additional costs for operation or maintenance.

Sensor and Data Requirements, Data Flow

The minimum sensor complement for a RAWS requires the following: hourly measurements of precipitation (cumulative), 10-minute average wind speed, direction, and RH, instantaneous air temperature and fuel temperature. The NFDRS upgrade requires hour average solar radiation. The National Fire Danger Working Team has recommended that fuel moisture data obtained from sensors being used at the present time not be used in NFDRS calculations; only observed data from manual fuel sticks are to be used. In the NFDRS upgrade, solar radiation sensors will provide input to the model in order to calculate fuel temperature and moisture values as well as 'state of the weather'.

Present-day fire weather observations as now required by the NWCG are sent from each RAWS via satellite transmitter to a GOES, then to Wallops Island/DAPS, to Domestic Satellite (DOMSAT), and finally to the BLM/Remote Sensing Fire Weather Support Unit (RSFWSU)/ ASCADS. From ASCADS data are distributed to the NIFMID (which includes WIMS and KCFast), the Western Regional Climate Center (WRCC), National Weather Service (NWS)/ Boise, and another database called BLM Wildland Fire Management Information - Support. Some RAWS data are sent to WIMS from the HUB. The HUB is a multi-modem PC computer installed next to the WIMS system in Kansas City. This computer calls telephone-telemetered stations on a pre-set schedule; data are automatically uploaded to WIMS. All RAWS data are combined with site fuel type and topographic parameters (the station catalog/meta-data) then processed through NFDRS algorithms to generate fire danger indices and components. Forecasts are also made for next day NFDRS products and dead fuel moisture, and non-NFDRS products such as: greenness, drought (KBDI), atmospheric stability (Haines index), and lightning ignition efficiency (see Wildland Fire Assessment System (WFAS) see Appendix A and G for web site address and more information about WFAS respectively).

Local Dispatch Center Data Management Responsibilities

At roughly 14:00 hr LST at local dispatch centers around the United States, the 13:00 hr RAWS observations for that area's stations are processed. This involves accessing the representative stations through WIMS within the given area/weather zone(s) which in turn are within fire danger rating zones. The data/observation flag 'R' (record) is changed to an 'O' (observation) for each station, this is done to 'alert' the NFDRS model to use only the "O" (daily 13:00 hr) for calculating intermediate and final fire products. The SOW and lightning activity is entered for the 'O' data.

The NFDRS model is then automatically run and products displayed for the primary fuel model for each station originally specified. There may be more than one RAWS within a fire danger rating zone; in such cases, composite products may be calculated. Results are then entered into SIT – the first step in creating the national situation report. The results are also posted at dispatch centers.

Site Selection

Site selection criteria and considerations are given in the National Fire Danger Rating System Weather Station Standards (NWCG 2000). Administratively, a fire weather forecaster, GACC meteorologist, or other interagency fire weather personnel should be involved in the process, as well as the National Weather Service (NWS), because a unique NWS identification (ID) number must be assigned to any new or re-located station. In addition, data transmission via GOES requires a separate National Environmental Satellite Data Information Systems (NESDIS) ID number obtained through the owner's agency NESDIS ID coordinator.

Equipment Selection

Equipment cost is not the only consideration in choosing sensors and tower frames to purchase: other criteria include life cycle costs, data transmission, maintenance and calibration, data storage and retrieval, the value of shared data, ease of installation and turn-around, and compatibility with equipment used in the RAWS network. Data needs beyond NFDRS may be factored into equipment selection as well as upgrading the DCP when required. A final question to be considered is: Can the data logger accept additional sensors beyond those required for NFDRS data needs? Part of this RAWS review and upgrade study includes a detailed list with specifications of most current weather sensors available in the United States. (See appendix V and CD-ROM)

Tower Specifications

Many NFDRS weather stations are located in remote and rugged locations, where they may be either permanent or semi-permanent. Some collect and transmit data year round, often under severe conditions. There are three common tower configurations used in the RAWS network: Rohn tower, Handar (lunar lander), and portable. All have several characteristics in common – ruggedness and the ability to survive in remote locations and extreme weather conditions.

If a tower is to be climbed, it must conform to the Occupational Safety and Health Administration (OSHA) regulations; non-climable towers must have pivoting masts so that the operator can service all sensors mounted on the mast while operator stays close to the ground.

General tower specifications

1. Able to survive 125 mph winds.
2. No vertical or horizontal movement after installation.

3. Able to withstand snow loads typical of high mountain locations in the western USA.
4. Able to support technical personnel on the tower while servicing sensors (applies to Rohn configuration).
5. Provide mounting surfaces and locations to meet NFDRS sensor requirements.

The OSHA requirements are new and have necessitated the replacement of several older, non-standard 33-foot (10-m) towers. This change has introduced a change in wind speed climatology that must be addressed (see main text for discussion: p39 Effects of Changes in Tower Height and Sensor Placement).

Installation/Deployment

Once a site that meets all criteria has been selected it can be prepared for installation of a RAWS. Personnel involved should have attended a RAWS maintenance class or be assisted by trained personnel.

The minimum meta-data needed for a RAWS as stored in ASCADS are: Slope, aspect, position, antenna angle and azimuth, elevation, latitude and longitude, and all serial numbers for sensors and data loggers. Additional information includes noting local magnetic declination when aligning the tower, GOES antenna, and wind vane. A hard copy of all this information should be kept by the station owner and updated (in ASCADS as well) when any changes are made.

Quality Assurance

Quality assurance/control (QA/QC) of weather data used for NFDRS calculations is the responsibility of the local station owner/manager, and should be monitored at all levels of data acquisition and storage. These responsibilities include field data acquisition, transmission, and data archive to NIFMID/WIMS/KCFast. The local operator is also responsible for ensuring that maintenance is performed, that all activities are documented in ASCADS, visually checking data on a daily basis to ensure that the information corresponds to actual conditions – that it makes sense. There is also an automated detection and notification system within ASCADS ‘watchdog’ that monitors data for gross errors and alerts local operators to out-of-range observations and performance problems such as non-functioning sensors. This function of ASCADS requires that the operator, owner, or personnel in a local dispatch center access ‘watchdog’ through ASCADS. Additionally, an Agency or Fire Weather Coordinator should periodically review RAWS operations at the local level.

Maintenance and Calibration

To ensure quality control and assurance of the collected weather data, regularly scheduled maintenance and calibration and quick response to sudden or unexpected system failures are required. Two maintenance contract options are currently available through the BLM: ‘depot maintenance’ and ‘full-ride’. The former requires that the owner/operator of a station be responsible for annual station maintenance and emergency repair. At least once a year sensors are removed, returned to the Boise, ID BLM Depot, and replaced with calibrated sensors. The full-ride contract requires that personnel from the BLM’s Remote Sensing/Fire Weather Support Unit (RSFWSU) respond to emergencies and perform annual station rehabilitation. Depot sensor calibration standards and priorities are given in NWCG: National Fire Danger Rating System Weather Station Standards (2000).

Not all RAWS will be NFDRS 2000 compatible, but for those that are fully documented maintenance/calibration will be required. The RSFWSU has proposed to introduce a third level of maintenance contract ‘NFDRS 2000 certification’; under this contract each RAWS providing data to the NFDRS 200 network will be visited once per year for documented calibration/certification by technicians from the NIFC depot.

Positions, Responsibilities, and Training Standards

Station owner/program manager: Responsible for site selection, station placement, maintenance; ensures QA/QC of data, that the data are sent to WIMS, and that correct NFDRS calculations are made. Also, ensures that personnel are available to respond to weather station failures.

Field support technician/first responder: Responsible for performing annual maintenance and responding to station system failures, maintaining up-to-date documentation in ASCADS. Required to attend systems training (i.e. FTS and/or Handar systems).

Depot technician: Responsible for bench maintenance and calibration of station sensors and subsequent testing. Provide support to field personnel and first responders as needed.

Agency/regional fire weather coordinator: Responsible for agency or regional oversight and coordination and QA/QC; ensures that station meta-data and documentation are current in both ASCADS and WIMS; ensures that training is available; assists with station operations and long term management planning.

Depot manager: is responsible for administration of depot and full-ride contracts.

Funding and financial support

Within the FS, each Region, Forest, or Ranger District must provide the initial justification and funding to obtain a station (frame, sensors, DCP etc. – $12,500). Funding for continued operation (full ride ($2,500), NFDRS certification (proposed at $1,800), or depot contract ($650)) is paid out of the owners overall operating budget at the Washington Office level; the regional or local FS owner never manages these RAWS operating funds. The BLM has taken a different approach: their Washington headquarters provides all funding from startup through continued operation.

Other land management agencies have different arrangements: The NPS provides centralized overall funding for their RAWS, but individual Parks deal with station maintenance (full ride, depot, or NFDRS certification contracts). The BIA has contracted directly with the BLM for full ride contracts for nearly all their RAWS. The FWS has a centralized funding arrangement for maintenance, but each Region has its own agreement with the BLM for maintenance. Individual States must work through the FS to make purchasing (stations) and maintenance arrangements with the BLM, and must make their own user agreement with NESDIS for data transmission. Some States have gone directly to private vendors to purchase and maintain a RAWS, bypassing the BLM depot altogether.

Operating costs for information and data processing and management are handled at a very informal level thereby avoiding inherent administrative costs. At the current time the FS does not pay the BLM directly for the use of ASCADS, nor does the BLM pay the FS for the use of WIMS; an informal ‘trade’ arrangement is in place. Also, part of the ASCADS operating budget comes out of the various depot contracts of each RAWS not part of the BLM network.

Appendix J. Sample of the Fort Collins, CO, RAWS Operating Plan

NORTHERN FRONT RANGE INTERAGENCY
WILDLAND FIRE COOPERATORS

WEATHER STATION MAINTENANCE
OPERATING PLAN

Last Revision: May 2003

WEATHER STATION NETWORK WEBSITE:
http://www.fs.fed.us/arnf/fire/gallery_wx.html

PREPARED BY: Mark S. Nelson
PROJECT MANAGER

Table of Contents

I. The purpose of this document is to outline procedures, identify responsible personnel and track fiscal responsibility for the installation, maintenance, and planning of the remote access fire weather stations used by the cooperating agencies of the northern front range of Colorado. The project manager is Mark Nelson (970) 498-1040.

II. The Northern Front Range Interagency Wildland Fire Cooperators (NFRWFC) maintain and use a network of Remote Access Weather Stations to provide National Fire Danger Ratings (NFDRS) and general weather and seasonal trend information. These stations are all electronic in nature and require various levels of Satellite, Solar power, Cell Phone and Data logger technology. Proper maintenance and care of the stations is critical for proper use and interpretation of National Fire Danger Ratings, Preparedness planning, fire planning, smoke management and Public and firefighter safety and numerous fire management activities. The network currently consists of seven remote access weather stations. Five are Handar Satellite telemetry units and the other two are Forest Technologies Systems incorporating telephone modems. The Handar stations are located at Redfeather Lakes, RMNP headquarters building in Estes Park, near Sugar Loaf fire station in Boulder County, Gilpin County near the Pickle Gulch Picnic Area, and Corral Creek at the Mount Evans Outdoor Lab. The FTS units are located in Redstone canyon behind Horsetooth Reservoir, and the Keewaneeche Visitor center at the west entrance of Rocky Mountain National Park. The stations at Kewaneeche is scheduled to be replaced by Handar 555 GPS, Radio Alert systems in 2003. Redfeather, Estes Park, Boulder, and Clear Creek stations were upgraded to 555 DCP's with GPS, and radio alert systemsin 2000/01. The Corral Creek station was installed in the spring of 2001.

III. All agencies have agreed that baseline NFDRS fire danger ratings and FireFamily Plus Seasonal Severity charts, and Pocket Cards will be generated by the Fort Collins Interagency Dispatch office and distributed by electronic means including e-mail, Fax machines, and the FTC website.

(http://www.fs.fed.us/arnf/fire/fire.html See Fire Danger Section). The Dispatch Center will maintain all software programs, WIMS access, and current knowledge of the NFDRS applications and weather station maintenance agreements. Center staff will have training in WIMS (Weather Information Management System). The project manger will have responsibility for WIMS station catalog maintenance, NFDRS (National Fire Danger Rating System), Fire Family Plus software, Fire Weather Plus software, FIRES, and NetTerm/ASCADS applications.

IV. All of the Remote access weather stations will be covered under the National Raws Maintenance agreement. The Arapaho-Roosevelt National Forests will maintain this agreement through the Regional offfice. As decided by the Northern Front Range Wildland Fire Cooperators Board of Directors, funding for these agreements will be provided by cooperating agencies. The current year agreements will be for the following:

Redfeather:	Arapaho-Roosevelt will finance $650.00	Station Owner: ARF
Larimer:	Poudre Fire Authority will finance $650.00	Station Owner: PFA
Estes Park:	Rocky Mountain National Park will finance $650.00	Station Owner: ARF
Boulder:	Arapaho-Roosevelt will finance $650.00	Station Owner: ARF
Gilpin:	Arapaho-Roosevelt will finance $650.00	Station Owner: ARF
Clear Creek:	Arapaho-Roosevelt will finance $650.00	Station Owner: ARF
Sulphur:	Arapaho-Roosevelt will finance $650.00	Station Owner: ARF

These funds will be collected as part of the annual funding agreement(s) for support of the Fort Collins Interagency Dispatch Center. The Project Manager will consolidate and coordinate the National Maintenance agreement. Maintenance agreement costs will be reviewed annually and adjustments to annual funding agreements will be reviewed by the NFRWFC Board of Directors.

V. The following is a generic outline of annual maintenance procedures:

1. The project manager will ensure that all stations are covered by the national contract each fiscal year.
2. The project manager will review, update and present this Operating Plan to the NFRWFC Board of Directors in the spring of each year.
3. The project manager will order replacement sensors for each of the stations. These sensors will be shipped to the responsible Maintenance technician listed in this Operating Plan.
4. The identified technician will change the sensors at the station. Inspect station for damage, identify needed repairs and check operation.
5. Complete the RAWS station maintenance documentation and send it to the Project manager.
6. Return the used Sensors within two weeks of receiving sensors.
7. Coordinate with the project manager on any additional needs, training, problems.
8. Any station programming changes will be coordinated by the Project manager.

VI. Station Maintenance Technicians

Project Manager: Mark Nelson

Redfeather	Handar	Arapaho-Roosevelt	Mark Nelson	498-1040
Larimer	FTS	Poudre Fire Authority	Phil Kessler	282-1301
Estes Park	Handar	Rocky Mountain National Park	Doug Watry	586-1237
Boulder	Handar	Arapaho-Roosevelt	Mark Nelson	498-1040
Gilpin	Handar	Arapaho-Roosevelt	Mark Nelson	498-1040
Clear Creek	Handar	Arapaho-Roosevelt	Mark Nelson	498-1040
Sulphur	FTS/Handar	Arapaho-Roosevelt	Doug Watry	568-1237
Gunsight	Handar	BLM	Craig Dsp	

VII. Short- and long-term issues to address with the current Remote access weather station network.

SHORT TERM ISSUES/PLANS:

Replace weather stations with the new generation of Handar RAWS station (GPS, Satellite, and Voice Alert Capabilities) at Sulphur and Larimer. All stations will need to meet national standards by 2005. These new stations will allow hourly transmission of weather data, meet future station requirements and allow for voice alert capabilities over a radio system when pre-determined variables are reached at the station site. Example: station will transmit alert when wind speed exceeds 12 mph and relative humidities are below 15%. The follow outlines short- and long-term implemetaion and maintenance goals.

1. Order and replace sensors for all weather stations under National contract in April/May.
2. Update seasonal FireFamily + (ERC/BI/1000-Hours) charts and Firefighter Pocket Cards and post on website as needed.
3. Review Fire Restriction and Closure Criteria annually.
4. Document all weather station changes in ASCADS.

LONG TERM GOALS AND PLANS:

1. Review of existing equipment and technology and evaluation on a yearly basis. Conversion of FTS stations to new satellite technology, standardization of station type should be evaluated and addressed for short- to long-term planning applications. Prepare for implementation of expected national weather station standards.
2. Software development and changes in fire weather data processing (Fire Wx Plus, WIMS, Firefamily +, NFDRS, FIRES, ASCADS, Handar Programming Software, etc... need to be maintained.
3. Development of RAWS maintenance capabilities, particularly of the Handar station(s), needs to be established and maintained.
4. Training for field personnel needs to be formalized to address understanding and implementation related to NFDRS, preparedness planning, pre-dispatch plans, Fire Restriction/ Closure Criteria, fire behavior, safety, etc...

Appendix K. Sample Position Description of RAWS-Related Duties at the Operational Level

Major Duties

Directs collection of weather data at stations on the forest. Maintains Forest RAWS (Remote Automatic Weather Stations) network, including field maintenance and programming. Trains others in station maintenance and repair. Receives and interprets weather forecasts; determines daily staffing plans for forest and districts. Provides daily fire weather data, and burning indices to ranger districts, cooperators and industry.

Factor 1, Knowledge Required by the Position

Working knowledge of RAWS including the ability to plan for the maintenance and repair to the assigned network of stations and train other technicians as necessary.

Factor 2, Physical Demands

The work sometimes requires above normal physical exertion when making site visits to the RAWS stations for set-up and maintenance, or functioning as the site manager. This includes some lifting of heavy objects.

Position Description as related to fire weather stations and fire weather program[2]

1. To manage the fire weather data collection network to ensure that accurate weather data is collected and processed.
2. Monitor the collect fire weather data from automated fire weather stations.
3. Monitor and approve calculated Fire Danger Indices.
4. Ensure the (organization's)= automated weather station sensors are properly maintained.
5. Provide quality control of fire weather observations generated from the weather stations i.e. checking for erroneous readings.
6. Properly maintain the (organization's)= weather station catalog information (green up, freeze dates, fuel models etc) in the national Weather Information Management System (WIMS).
7. Provide quality control for the fire danger maps produced daily for the Wildfire Information Center internet web site.
8. Monitor National Fire Danger Rating System (NFDRS) indices and Canadian Fire Danger Indices.
9. Investigate any indices that appear to be erroneous.
10. Alert supervisor/MIFC Coordinator when indices indicate potential problem.
11. Monitor long-term drought indicators and climatology and graph trends.

[2] D. Miedtke, MN Interagency Fire Center, 2002

Appendix L. Sample of Daily SOP from NF Dispatch Center

FTC Daily Routine

****NOTE** MOST of the websites listed below can also be accessed from our Fort Collins Interagency Dispatch Center home page http://www.fs.fed.us/arnf/fire/fire.html by going down through the various sites. You can do it either through that page or by checking for these sites in the Favorites. Use the direct address listed if the WO server goes down.**

08:00 -Take phone off forward, retrieve any voice mail messages
-Broadcast: Fort Collins Dispatch Center is in service at 08:00, KAC-249 using select group on radio select the following repeaters: Roosevelt: DIR, Arap-CCRD: SQW, Arap-SRD: SCW.
-Check DMS mail profiles (COFTC/COFTCMOB) and read/forward/print as necessary.

To take phone off forward:

Pick up phone using line 1348; get a dial tone. Press forward. Light next to 1348 will stop blinking.

To retrieve messages:

Dial 2650 on FS phone. Wait for message and hit #. Dial 1348. Enter password XXXX listen to instructions and hit 5 to play messages. After messages have played completely hit 9. At prompt, hit 9 again and this will delete messages and close you out of the system.

To broadcast on Simulcast:

Go to the SELECT GROUPS button and click on it, at the bottom of the screen there will appear a row of buttons. Select DAILY BRDCST 1 and reset the repeaters to Roosevelt: DIR, Arap-CCRD: SQW, Arap-SRD: SCW.

To check DMS mail profiles:

Double-click on DMS icon. Click on the DMS profile (and inbox) you want to look at (COFTC or COFTCMOB). When it asks for a password for each profile, it is the same as the user (type in coftc or coftcmob). Read inbox items and determine who needs to see them… your options: you deal with the item immediately, you print the item and distribute it, or you forward it to whomever needs to see it. Once the item is dealt with, delete it. If you do not know who should get it, don't be afraid to ask

09:00 -Confirm tactical and administrative aircraft and pilots availability/status with Tom Landon (xxx-xxx-xxxx), his designee, or Airtanker Base Manager.
-Status SEAT (T182) with Fred Winkler (xxx-xxxx) if it is positioned in FTC area.
-Update any resource (aircraft, overhead, crew, equipment) availability changes in ROSS.

To confirm aircraft and pilots:

MOST OF THE TIME TOM LANDON AND FRED WINKLER WILL CALL IN THE MORNING AND STATUS THE AIRCRAFT, IF THEY ARE UNAVAILABLE: IF Tom Landon is NOT shown to be committed to an incident, call Tom at his cell phone (xxx-xxx-xxxx). If Tom is shown as committed or unavailable, try Ivan Pupulidy (xxx-xxx-xxxx or xxx-xxx-xxxx) or Mark Michelsen (Jeffco Airtanker Base Mgr., xxx-xxx-xxxx). Ask what the status is of each aircraft and each pilot (ask for location, status, which plane they will fly, and ask if there is anything odd or in the works we should know about). Write this information on aviation white board. Usually, Fred Winkler will contact us by phone to tell us the SEAT's availability. Call helicopter manager for area helicopters.

09:15 -Confirm Pre-Dispatch cards are set at appropriate levels for yesterday's declared action class.
-Determine Preparedness Level.
-Retrieve, print, and post the National Situation Report, R-2 Sit. Report, and National Weather Service morning fire weather forecasts from the web sites.
-Retrieve, print, and post the 24-hour lightning map (Do NOT distribute).

To determine preparedness level:

Read preparedness level cards on sliding map board. Determine likely level and confirm with Mark Nelson or Mike Foley then ensure that the pre-dispatch cards are set to the corresponding preparedness level.

To get Sit. Report and fire weather forecasts:

Use the links from the FTC home page to get to the National Weather Service-fire weather forecasts area and print the forecasts for zones 212, 218, 215, and 216. Many times the forecasts for zones 212 and 218 are combined, as are the forecasts for zones 215 and 216. You can tell by looking at the header just before the long geographical descriptions of the zones. The sit reports are the first links under the Fire Intelligence header. Print and post all of these items to the clipboards in the hall.

To get to the lightning report, follow the link and enter Username: COFTC, Password: XXXXXX. THIS CHANGES MONTHLY. Print this on the color printer.

National Sit. Report: http://www.nifc.gov/news/sitreprt.pdf
Weather: http://www.crh.noaa.gov/den/fir2znft.html
RMACC Detailed Sit. Report: http://www.fs.fed.us/r2/fire/rmasit.htm
24-Hour Lightning Map: http://www.nifc.blm.gov/cgi/nsdu/Lightning.cgi/Page/ViewSelect?Submit=Continue

09:30 -If the preparedness level is 1 or 2 ensure participation in a weekly conference call on Monday. If the preparedness level is higher than 2 the conference call becomes daily.
-Adjust resource staffing/location on IA map based on the above information.

To adjust map:

Place magnets on Initial Attack map (on the sliding board) corresponding to engines, crews, etc. and their current locations.

10:00 -Broadcast abbreviated versions of weather reports on simulcast.
-Broadcast and post regional aviation resource status on High fire danger or above days.

You will have to broadcast the weather on Simulcast as done at 0800. First let folks know it's coming by broadcasting All stations, stand by for today's fire information report and forecast and then releasing the transmit button and waiting a few seconds. Broadcast just the weather discussion and the today part of the forecast. We do not broadcast 10K free winds. Try to listen to someone do this before you attempt it alone.

BETWEEN 11:00 – 13:00 Take a lunch break---I MEAN IT!!! You never know when the day will get so busy that you will not have a chance to stop for a breather, let alone a snack!

14:00 -Determine observed weather at WIMS stations from the web, phone calls, etc.

To determine observed weather at WIMS stations:

FROM NORTH TO SOUTH:
50505 – Red Feather (up by Red Feather Lakes)
50508 – Larimer (above Lory State Park/Horsetooth Reservoir) (13:00)
50507 – Estes Park/Utility (right by Estes Park)
50402 – Sulphur/Kawuneeche (west of Grand Lake, north of Granby) (13:00)
50604 – Boulder (just west of Boulder)
51901 – Pickle Gulch (just west of Golden Gate Canyon State Park)
51804 – Corral Creek (just east of the north end of Mt. Evans Wilderness)

You want to get the weather over the sites within 5 minutes of 2 PM. Report thunderstorms if they are obviously building and will happen soon, but not if they may happen sometime this evening or did happen and were done an hour ago.

-Compare weather to codes and determine appropriate code, using the attached codes to determine sky conditions.

14:15 -Enter weather observations into WIMS from all stations by 14:30 at the latest (EOBS).
-Retrieve weather observations, FTC weighted average, and actual fire danger rating (DOBS, DAVG, DIDX). Process and upload to the web site.

To enter and retrieve weather:

-Go to the WIMS page, which is linked off of the FTC home page under the header FTC Mobilizations Guides/Operating Plan then under CHAPTER 20: Administrative Procedures
-Click on the WIMS button.
-Enter the username and password. This changes, so ask one of the permanent party. As of 5JUNE03 it is: Username, XXXXXX, Password, XXXXXX.
-At the top of the page is a quick path option window. Type EOBS into this window.
-In next screen: Station ID should be blank, SIG should contain ftc2, Type should read R, the date should be today's, and the time should read 12
-Click the find button
-A list of weather stations should appear. If they do not, then it is possible you are trying to early. Wait and try again later.
-Use the mouse to change the R value in the OT column to O. This changes the data from raw data to an observation.
-In the W column, correlate the sky conditions that you collected at 1400 with the numbers of the weather stations and enter the approriate value.
-Click in the Save box.
-Once the data has been saved, it should appear in green. If it appears in a red box an error message will inform you why.
-Close the pop-up window and reset ftc2 to read ftc3, and the time to 13.
-Repeat all of the data entry and saving functions already performed, on these two stations.

-In the Fast Path window, enter DOBS (display observations)

-Leave Station ID blank, in SIG enter ftc, change Type to O, ensure the Date is correct, and leave the time blank.
-Click Find
-Click in the Print box
-A new window will open, go to the File menu then the Save As item and overwrite the file that appears. This is yesterday's data.

-In the Fast Path window, enter DAVG (daily average)
-SIG should read ftc, Type should be O, the date should be correct, and the Time should be blank.
-Click the Find box.
-Click in the Print box
-A new window will open, go to the File menu then the Save As item and overwrite the file that appears. This is yesterday's data.

-In the Fast Path window, enter DIDX (display indices)
-Leave Station ID blank, SIG should be ftc, Type should be O, the Date should be correct, and the Time block should be blank.
-Click the Find box.
-Click in the Print box.
-A new window will open, go to the File menu then the Save As item and overwrite the file that appears. This is yesterday's data.
-Now, YOU ARE DONE IN WIMS, and you can exit the page.
-Minimize your applications until you can see the desktop and click on the Upload DOBS, DAVG, DIDX icon. This will run a routine that posts the data to the web site. When the program pauses and asks you to press any botton, ensure that the window is active beforehand by clicking in it with the mouse.
-Check the web page under Fire Danger/Severity and Northern Front Range Fire Danger Ratings to ensure the right data is posted and it is current. This ensures you did the WIMS entry correctly.

IF you miss a day or two, you WILL have to enter observation data anyway…just make sure you do it in CHRONOLOGICAL order OR that Mark does a recalculation of the station data

15:30 -Print and post afternoon weather forecast.
-Access WIMS and retrieve forecasted fire danger ratings (DMGR).
-Update and post the Fire Management Forecast form.

To print/post afternoon weather:

Go to the same site as morning weather, http://www.crh.noaa.gov/den/fir2znft.html, and repeat the process.

To access WIMS and retrieve forecasted fire danger ratings:

-Enter WIMS program as at 2:15.
-In the Fast Path area enter DMGR (data manager)
-Leave Station ID blank, set SIG to ftc, set Type to F for forecasted, and enter the date in format DD-MMM-YY (05-JUN-03). Be sure and enter the FOLLOWING DAY'S DATE.
-Click the Find box.
-Click in the Print box.

-A new window will open, go to the File menu then the Save As item and overwrite the file that appears. This is yesterday's data.
-Close the WIMS window, and upload the data to the web site using the Upload DMGR icon. Check the web site to ensure that it has been updated.

To record and post the NFDRS (Fire Management Forecast):

Retrieve the clipboard that contains the Fire Management Forecast form, this is in the hallway in one of the bins. the top portion is filled out using the FTC Average data from the web page. The Haines Index is on the national weather service forecast. The bottom portion is filled out using Today's Actuals from the web page for the first data set. BE SURE TO USE THE TOP LINE FOR EACH STATION (the G fuel model). Use Tomorrow's forecast to fill in the data for the bottom data set.

THFM=1000 hour fuels
EC=Energy Release Component
SL=Action Class
R=Fire Danger Rating

16:00 -Broadcast the Fire Management Forecast and the afternoon fire weather forecast on simulcast.

To broadcast the afternoon weather and Fire Management Forecast:

Read only the today portion of the fire weather forecast. Read the Afternoon Fire Management Forecast by breaking it up into time efficient chunks with breaks in the flow. Read each station completely, todays values and forecast values, before proceeding to the following station. Finish by saying This concludes the fire management forecast at _________(time), KAC-249.

17:30 -Call CRC, PBC, RMMC and determine need for Tanker/Base coverage. Close out with Tanker Base/pilots.

To determine need for Tanker and Tanker Base coverage:

Call Craig (xxx-xxx-xxxx), Pueblo (xxx-xxx-xxxx), and RMACC (xxx-xxx-xxxx) dispatch centers. Ask if they'll need Airtanker or Tanker Base coverage past 1800. Check with Pueblo if they could use SEAT past 1800. Call tanker base to let them know what time they should be done based on your calls to the dispatch centers.

17:45 -Prepare and process the daily Fire Situation Report.
-Update, print, and post to the website the FTC Status Report.

To prepare and send Situation Report:

-Go to internet explorer to http://famweb.nwcg.gov/. THIS IS THE SAME PAGE YOU USED TO ACCESS WIMS, AND SHOULD BE BOOKMARKED.
-Click on the Sit Report button.
-Use the same password as WIMS to access the site.
-Use the tabs at the top of the screen and input the data required. At the end of each screen click on the Submit Data button. On the last screen, click on submit. When you are done, simply exit the window and the data will be saved.

To prepare and post the FTC Status Report:

-Open Microsoft Frontpage from the Start Menu
-Once the program is open, go to File and Open
-Open K:/eco/ftc web page/Morning_Report

-Edit the report and save it using the save command.
-Close Frontpage
-On the desktop, click on the Upload FTCSIT icon.
-Check the web page to ensure the FTC Status Report has posted.

18:00 -Broadcast: Fort Collins Dispatch is out of service at 18:00, KAC-249 on simulcast.
-Place the phone on forward to the on-call dispatcher's voicemail or pager.

To broadcast out-of-service:

Just like all the other group broadcasts.

To forward phone:

Pick up phone using line 1348; get a dial tone. Press forward. Dial in WHOLE pager number or WHOLE extension number (so for Mark's pager, dial 9-490-5291 or for his extension, 9-498-1040). Hang up the phone. Light next to 1348 should be blinking.

Confirm that all duties, obligations, AIRCRAFT, and resource orders are complete & close out with all initial attack resources.

MONDAY: -Conduct Weekly PL 1,2,3 (Daily at PL 4 & 5) Conference call. xxx-xxx-xxxx Pass code: xxxx# Conference Leader: Mark Nelson
-Distribute weekly availability request to COFTC-REDCARD mailing list
SUNDAY: -Print and post appropriate documents for hallway display. Seasonal Trend Chart updates.
AS NEEDED: RX Burn Reports

Appendix M. Regional RAWS Coordinator Responsibilities and Duty Guidelines[1]

The duties of Regional RAWS Coordinators vary throughout the different regions of the Forest Service. However, several responsibilities are common to all Regional positions. The level of involvement in the program varies based on the Regional needs and management direction. However, at a minimum, the individuals are expected to:

1. Assure that the Automated Sorting, Conversion and Distribution System (ASCADS) database is complete and current. This includes:
   - Requests for NESDIS ID's and transmit times are received from the field and forwarded to the National RAWS Coordinator. These include: new RAWS stations, moved stations, and upgrades from 3 hrly to 1 hrly and to high data rate.
   - Monitor network to make sure that the assigned transmit times meet the needs of the users. Coordinate with National RAWS Coordinator to obtain better times as necessary.
   - Manage the portable RAWS platforms used for project work to ensure maximum utilization.
   - Verify in their Region, that there is a platform data file (PDF) in ASCADS for each automatic weather station that the Forest Service owns (regardless of telemetry method).
   - Notify the National RAWS Coordinator when new stations are purchased, or old stations are taken down or moved.
   - Assure that maintenance information is tracked in the narrative portion of ASCADS for each station.
2. Through the ASCADS database, annually prepare a Regional Annual Operating Plan (AOP) for their automatic weather station network and verify the accuracy via email to the National RAWS Coordinator. This needs to be done by the reply due date established in annual letter requesting the AOP (usually August of each year). This information includes maintenance support needs requested through the BLM.
3. Facilitate information sharing throughout their Region on new technology, changes in procedures, overall network design and operation.
   - Represent Region at weather and RAWS meetings (FS and interagency)
   - Review and recommend additions, removal and placement of RAWS on NFS lands.
   - Call upon the National RAWS Coordinator, manufacturer's representatives, and/or the BLM REMS Depot for latest technology information.
   - Support the corporate data concept regarding weather data collected by providing guidance to local units on short and long term weather data storage.
4. Recognize maintenance deficiencies and take steps to correct problems. Those steps can include, but are not limited to:
   - Assure that RAWS Watchdog is monitored by local units.
   - Monitor RAWS Watchdog and notify forests when problems have not been responded to in a timely manner.
   - Monitor the quality of data coming out of the RAWS network thru WIMS. (Sometimes this is an indicator of sensor problems that are not picked up with the technical watchdog report.)
   - Schedule maintenance training at a Regional level. Assistance in this effort is usually available from the National RAWS Program.
   - Work one-on-one with the local units to train and assure proper maintenance methods are understood and followed.
   - Share training opportunity information that becomes available. This information will normally come from the National RAWS Program.
   - Contact the National RAWS Coordinator, manufacturer's representatives, or the BLM REMS Depot for support as necessary.

[1] (Kolleen Shelley, 1/22/1999). Some of these points could certainly be used in a position description. Referenced from Draft: Operations and Protocols/Positions and Responsibilities item 4.

Appendix N. Forest Service Region 9 RAWS Operating Plan for FY03[1]

REMOTE WEATHER ANNUAL OPERATING PLAN
USFS REGION 09
Report Date: 07/31/02 15:32 GMT

Unit: **ALLEGHENY NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
~~	ALLEGHENY	TEL-DATA	FTS	DEPOT	675.00

Total Maintenance Charge for ALLEGHENY NF : $ 675.00

Unit: **CHEQUAMEGON-NICOLET**

NESS ID	Name	TX Method	DCP	Maint.	Charge
3284818C	LAONA	SATELLITE	FTS	DEPOT	675.00
~~	GLIDDEN - FTS	TEL-DATA	FTS	DEPOT	675.00
~~	WASHBURN - FTS	TEL-DATA	FTS	DEPOT	675.00

Total Maintenance Charge for CHEQUAMEGON-NICOLET : $ 2025.00

Unit: **CHIPPEWA NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
~~	CASS LAKE	TEL-DATA	FTS	DEPOT	675.00
~~	CUTFOOT - FTS	TEL-DATA	FTS	DEPOT	675.00

Total Maintenance Charge for CHIPPEWA NF : $ 1350.00

Unit: **GRN MTN & FINGER LKS**

NESS ID	Name	TX Method	DCP	Maint.	Charge
32760078	SWEEZY	SATELLITE	FTS	DEPOT	675.00
~~	ELMORE	TEL-DATA	FTS	DEPOT	675.00
~~	ESSEX JUNCTION	TEL-DATA	FTS	DEPOT	675.00

Total Maintenance Charge for GRN MTN & FINGER LKS : $ 2025.00

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Unit: **HIAWATHA & OTTAWA NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
328355D0	BLUE LAKE	SATELLITE	FTS	DEPOT	675.00
3283604A	ELKHORN	SATELLITE	FTS	DEPOT	675.00
3283733C	RACO	SATELLITE	FTS	DEPOT	675.00
328346A6	WATERSMEET	SATELLITE	FTS	DEPOT	675.00

Total Maintenance Charge for HIAWATHA & OTTAWA NF : $ 2700.00

REMOTE WEATHER ANNUAL OPERATING PLAN

USFS REGION 09

Report Date: 07/31/02 15:32 GMT

Unit: **HOOSIER NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
3284D1F0	HARDIN RIDGE	SAT,TEL	FTS	DEPOT	675.00
328530F8	TIPSAW LAKE	SAT,TEL	FTS	DEPOT	675.00

Total Maintenance Charge for HOOSIER NF : $ 1350.00

Unit: **HURON-MANISTEE NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
32851614	BALDWIN	SAT,TEL	FTS	DEPOT	675.00
3285238E	MIO	SAT,TEL	FTS	DEPOT	675.00

Total Maintenance Charge for HURON-MANISTEE NF : $ 1350.00

Unit: **MARK TWAIN NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
32720542	AVA	SATELLITE	FTS	DEPOT	675.00
3233E796	CARR CREEK	SATELLITE	FTS	DEPOT	675.00
3271F2C8	DONIPHAN	SATELLITE	FTS	DEPOT	675.00
3271E1BE	SINKIN	SATELLITE	FTS	DEPOT	675.00

Total Maintenance Charge for MARK TWAIN NF : $ 2700.00

Unit: **MIDEWIN TALL GRASS**

NESS ID	Name	TX Method	DCP	Maint.	Charge
326F42B0	MIDEWIN TALL GRASS PRARIE	SATELLITE	FTS	DEPOT	675.00

Total Maintenance Charge for MIDEWIN TALL GRASS : $ 675.00

Unit: **MONONGAHELA NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
~~	DAVIS (BEARDEN) - FTS	TEL-DATA	FTS	DEPOT	675.00
~~	MARLINTON - FTS	TEL-DATA	FTS	DEPOT	675.00

	Total Maintenance Charge for MONONGAHELA NF :				**$ 1350.00**

Unit: **SHAWNEE NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
3282B4D8	DIXON SPRINGS	SAT,TEL	FTS	DEPOT	675.00
3282D13E	BEAN RIDGE	SATELLITE	FTS	DEPOT	675.00

	Total Maintenance Charge for SHAWNEE NF :				**$ 1350.00**

Unit: **SUPERIOR NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
32728356	SUPERIOR #1	RAD-VOICE	FTS	DEPOT	675.00
327273D2	SUPERIOR #2	RAD-VOICE	FTS	DEPOT	675.00
~~	SUPERIOR #3	RAD-VOICE	HANDAR	DEPOT	675.00
~~	SUPERIOR #4	RAD-VOICE	HANDAR	NONE	$.00
327F5658	FERNBERG	SATELLITE	OTHER	NONE	$.00
~~	ELY - FTS	TEL-DATA	FTS	DEPOT	675.00
~~	ISABELLA - FTS	TEL-DATA	FTS	DEPOT	675.00
~~	MEANDER FTS	TEL-DATA	FTS	DEPOT	675.00
~~	SEAGULL - FTS	TEL-DATA	FTS	DEPOT	675.00

	Total Maintenance Charge for SUPERIOR NF :				**$ 4725.00**

Unit: **WAYNE NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
~~	DEAN	TEL-DATA	FTS	DEPOT	675.00

	Total Maintenance Charge for WAYNE NF :				**$ 675.00**

Unit: **WHITE MOUNTAIN NF**

NESS ID	Name	TX Method	DCP	Maint.	Charge
32352246	GREAT GULF	SATELLITE	HANDAR	DEPOT	675.00
~~	LANCASTER	TEL-DATA	FTS	DEPOT	675.00
~~	WHITE MTN NF	TEL-DATA	FTS	DEPOT	675.00

	Total Maintenance Charge for WHITE MOUNTAIN NF :				**$ 2025.00**

Remote Weather Annual Operating Plan
FY 2003
Region 09

July 31, 2002

-- STATIONS --

Total HANDAR Stations:		3
Total FTS Stations:	+	35
Total CAMPBELL Stations:	+	1

Total Stations:		39

-- MAINTENANCE --

Stations on Full Maintenance:	0
HANDAR Stations on Depot Maintenance:	2
FTS Stations on Depot Maintenance:	35
Stations on Data Only Maintenance:	0
Stations on Warranty Maintenance:	0

Full Maintenance Charge:		$ 0.00
Depot Maintenance Charge (HANDAR):	+	$ 1350.00
Depot Maintenance Charge (FTS):	+	$ 23625.00
Data Only Maintenance Charge:	+	$ 0.00
Warranty Maintenance Charge:	+	$ 0.00

Total Maintenance Charge:		$ 24975.00

-- REGION SUMMARY --

Total Stations Cataloged:	39
TOTAL NETWORK FUNDING REQUIRED:	$ 24975.00

Appendix O. Data Retrieval

This Appendix provides more detail on the information summarized in the Data Retrieval section of the report. The following RAWS databases are major sources for recent and archived data as of spring 2003, but may change if Internet addresses change or if new sites are generated.

Western Regional Climate Center (WRCC)

There are two ways to retrieve RAWS data from the WRCC via the Internet or direct arrangements with WRCC. A new WRCC project/web site (http://www.wrcc.dri.edu/wraws/ RAWS USA Climate Archive) released in spring 2003, allows the user to select a RAWS from either a list or a clickable map. The user can then select from a list of different graphing options to retrieve data summaries, time series graphs, monthly or weekly summaries, and so forth. Data flow, search options and criteria are diagrammed in Appendix H-Z.

A third alternative is to contact the WRCC directly and request data files; for data from multiple sites and/or extended date ranges this is clearly the best method. Appendix A gives their web site address which in turn provides additional information such as telephone numbers, other products, etc.

National Interagency Fire Management Integrated Database (NIFMID)

Accessing NIFMID/KCFast allows member users to retrieve historical weather, fire occurrence, and station catalog data but does not allow changes to be made to these data and meta-data sets. (An excellent How-to… can be found in Appendix A of the Fire Family Plus Users Guide V2.0 (RMRS Fire Sciences Lab, Systems for Environmental Management, July 2000)).

Steps include:

1. Via internet – see Appendix A for web address and Appendix C-1 and D for more detail,
2. Login as usual (requires user ID and password) and follow instructions to retrieve data set; KCFast will send data file to a FTP site,
3. Go to the FTP site indicated,
4. Find and select the file that was requested,
5. Go up to the FILE menu, scroll down to 'Copy to folder', click on browse, select a destination folder, and click on OK. The raw data file will be copied into the selected folder.

Access to WIMS is initially the same as that for KCFast, and one can use the same user ID and password. WIMS/WEB is a web-based interactive package that allows the user to enter and edit data; retrieve weather data, fire weather forecasts, and smoke management forecasts, display NFDRS indices and components, enter and retrieve point and trend forecasts, and other NWS products.

WIMS/Web came on-line in mid 2001. It is a web-based interactive application ingesting, archiving (meso-term – 2 years), and managing RAWS weather data stored in other modules of the NIFMID. These other modules include KCFast (long-term archive for 13:00 hour weather and fire occurrence), report generators (for the national fire situation report, incident situation reports, and aircraft use), and firefighter pocket cards. The WIMS is also host for the NFDRS model producing daily and forecasted) fire danger indices and components. WIMS, KCFast, and the other modules contained within NIFMID are accessible via the internet – F&AM web applications (http://famweb.nwcg.gov/).

WIMS and KCFast usernames and passwords can only be obtained from FS Regional level computer security offices.

Geospatial Multi-Agency Coordination Group (GeoMAC)

GeoMAC is a map-intensive website that allows all users to access the last 24 hours of transmitted RAWS weather data, if that particular station transmits once per hour, otherwise the 13:00 (LDT) observations are given. Various map (information) layers are available such as thermal images (of active fires), situation report of active fires, available perimeters, RAWS weather, major cities, major roads, lakes, streams, and so forth. Multiple layers can be called up at any one time but only the top layer is active at a time.

Steps are:

1. Go to the Wildland fire access page (http://geomac.usgs.gov/),
2. Click on the Wildland fire maps button under 'Public Server', which takes the user to the GeoMAC overview map,
3. On the right hand side the user can choose map layers to display; each time different layers are chosen the map needs to be refreshed – the refresh button is at the bottom,
4. In the lower left hand corner are application buttons: locator, zoom, pan, hyperlink, etc.
5. If RAWS weather is the active layer then sites will be indicated on the map by small blue squares,
6. Click on the hyperlink button, then click on a mapped RAWS site, these are hyperlinked to a data archive housed by the NWS in Boise, ID.

The National Weather Service (NWS)

The National Weather Service is another RAWS data archive; the Boise Fire Weather/ National Fire Page (http://www.boi.noaa.gov/firewx.htm) provides links to RAWS observations, data summaries, model output statistics, RAWS location information, current conditions, the WFAS, satellite imagery, and various fire indices.

ASCADS

ASCADS takes selected RAWS data from the DomSat Receive System (DRS) and sorts and re-formats it into a relational database. ASCADS then passes the converted and formatted data to the BLM Web Server, the NIFMID/WIMS, the NWS, and WRCC. ASCADS is a single source for all RAWS information such as maintenance history, sensor complement, location, route, point of contact, and observation data. It was moved onto new server hardware spring 2003.

ASCADS is a user-friendly, menu driven interface that gives users the ability to view and print reports of the most current information associated with a RAWS. Extensive information is associated with every station. To ease viewing of station data, associated data have been grouped into several screens. Data flow and screen menu choices have been diagrammed in Appendix F (adapted from the ASCADS Field Users Guide Version 2.1 2002). Access to ASCADS is via a terminal emulation package such as Secure Netterm in the FS. All passwords, user names, and edit access must be obtained from RAWS agency coordinators.

Appendix P. ASCADS Watchdog Alerts and Data Flags

Complete list of the ASCADS Watchdog alerts and data flags (provided by K. McGillivary (Applications Software Group/BLM/NIFC) and P. Sielaff (RSFWSU/BLM/NIFC 2002). Note that many of the parameters are not actually used.

WATCHDOG EVENT DESCRIPTION 8/19/2002

DAPS ERROR	Parity Error Detected
DAPS ERROR	See Incidental Info for Detail
INCONSISTENCY	Fuel Temp Not Consistent With Air Temp
STATION	Offline
STATION	Station Description Changed
STATION	Transmissions Resumed
TRANSMISSION	Arrival Time is Drifting
TRANSMISSION	Bad Character Count
TRANSMISSION	Frequency
TRANSMISSION	Missing Entire Transmission
TRANSMISSION	Missing Header
TRANSMISSION	Missing Observation
TRANSMISSION	Modulation
TRANSMISSION	Power (Signal Strength)
TRANSMISSION	Wrong Character Count Received
AIR QUALITY	Change Too Large
AIR QUALITY	Format Error Detected
AIR QUALITY	Invalid Data
AIR QUALITY	Parity Error Detected
AIR QUALITY	Reading Missing
AIR QUALITY	Reading Too High
AIR QUALITY	Reading Too Low
AIR QUALITY	Reading Unchanged Too Long
AIR TEMPERATURE	Change Too Large
AIR TEMPERATURE	Format Error Detected
AIR TEMPERATURE	Invalid Data
AIR TEMPERATURE	Parity Error Detected
AIR TEMPERATURE	Reading Missing
AIR TEMPERATURE	Reading Too High
AIR TEMPERATURE	Reading Too Low
AIR TEMPERATURE	Reading Unchanged Too Long
BAROMETRIC PRESSURE	Change Too Large
BAROMETRIC PRESSURE	Format Error Detected
BAROMETRIC PRESSURE	Invalid Data
BAROMETRIC PRESSURE	Parity Error Detected
BAROMETRIC PRESSURE	Reading Missing
BAROMETRIC PRESSURE	Reading Too High
BAROMETRIC PRESSURE	Reading Too Low
BAROMETRIC PRESSURE	Reading Unchanged Too Long
BATTERY VOLTAGE	Change Too Large
BATTERY VOLTAGE	Format Error Detected
BATTERY VOLTAGE	Invalid Data
BATTERY VOLTAGE	Parity Error Detected
BATTERY VOLTAGE	Reading Missing
BATTERY VOLTAGE	Reading Too High
BATTERY VOLTAGE	Reading Too Low
BATTERY VOLTAGE	Reading Unchanged Too Long
CLOUD LAYER	Change Too Large
CLOUD LAYER	Format Error Detected
CLOUD LAYER	Invalid Data
CLOUD LAYER	Parity Error Detected
CLOUD LAYER	Reading Missing
CLOUD LAYER	Reading Too High

CLOUD LAYER	Reading Too Low
CLOUD LAYER	Reading Unchanged Too Long
DEW POINT	Change Too Large
DEW POINT	Format Error Detected
DEW POINT	Invalid Data
DEW POINT	Parity Error Detected
DEW POINT	Reading Missing
DEW POINT	Reading Too High
DEW POINT	Reading Too Low
DEW POINT	Reading Unchanged Too Long
FUEL MOISTURE	Change Too Large
FUEL MOISTURE	Format Error Detected
FUEL MOISTURE	Invalid Data
FUEL MOISTURE	Parity Error Detected
FUEL MOISTURE	Reading Missing
FUEL MOISTURE	Reading Too High
FUEL MOISTURE	Reading Too Low
FUEL MOISTURE	Reading Unchanged Too Long
FUEL TEMPERATURE	Change Too Large
FUEL TEMPERATURE	Format Error Detected
FUEL TEMPERATURE	Invalid Data
FUEL TEMPERATURE	Parity Error Detected
FUEL TEMPERATURE	Reading Missing
FUEL TEMPERATURE	Reading Too High
FUEL TEMPERATURE	Reading Too Low
FUEL TEMPERATURE	Reading Unchanged Too Long
GAMMA RADIATION	Change Too Large
GAMMA RADIATION	Format Error Detected
GAMMA RADIATION	Invalid Data
GAMMA RADIATION	Parity Error Detected
GAMMA RADIATION	Reading Missing
GAMMA RADIATION	Reading Too High
GAMMA RADIATION	Reading Too Low
GAMMA RADIATION	Reading Unchanged Too Long
RAIN GAGE	Change Too Large
RAIN GAGE	Format Error Detected
RAIN GAGE	Invalid Data
RAIN GAGE	Parity Error Detected
RAIN GAGE	Reading Missing
RAIN GAGE	Reading Too High
RAIN GAGE	Reading Too Low
RAIN GAGE	Reading Unchanged Too Long
RELATIVE HUMIDITY	Change Too Large
RELATIVE HUMIDITY	Format Error Detected
RELATIVE HUMIDITY	Invalid Data
RELATIVE HUMIDITY	Parity Error Detected
RELATIVE HUMIDITY	Reading Missing
RELATIVE HUMIDITY	Reading Too High
RELATIVE HUMIDITY	Reading Too Low
RELATIVE HUMIDITY	Reading Unchanged Too Long
SHAFT ENCODER	Change Too Large
SHAFT ENCODER	Format Error Detected
SHAFT ENCODER	Invalid Data
SHAFT ENCODER	Parity Error Detected
SHAFT ENCODER	Reading Missing
SHAFT ENCODER	Reading Too High
SHAFT ENCODER	Reading Too Low
SHAFT ENCODER	Reading Unchanged Too Long
SNOW DEPTH	Change Too Large
SNOW DEPTH	Format Error Detected
SNOW DEPTH	Invalid Data
SNOW DEPTH	Parity Error Detected
SNOW DEPTH	Reading Missing

SNOW DEPTH	Reading Too High
SNOW DEPTH	Reading Too Low
SNOW DEPTH	Reading Unchanged Too Long
SNOW PILLOW	Change Too Large
SNOW PILLOW	Format Error Detected
SNOW PILLOW	Invalid Data
SNOW PILLOW	Parity Error Detected
SNOW PILLOW	Reading Missing
SNOW PILLOW	Reading Too High
SNOW PILLOW	Reading Too Low
SNOW PILLOW	Reading Unchanged Too Long
SOIL MOISTURE	Change Too Large
SOIL MOISTURE	Format Error Detected
SOIL MOISTURE	Invalid Data
SOIL MOISTURE	Parity Error Detected
SOIL MOISTURE	Reading Missing
SOIL MOISTURE	Reading Too High
SOIL MOISTURE	Reading Too Low
SOIL MOISTURE	Reading Unchanged Too Long
SOIL TEMPERATURE	Change Too Large
SOIL TEMPERATURE	Format Error Detected
SOIL TEMPERATURE	Invalid Data
SOIL TEMPERATURE	Parity Error Detected
SOIL TEMPERATURE	Reading Missing
SOIL TEMPERATURE	Reading Too High
SOIL TEMPERATURE	Reading Too Low
SOIL TEMPERATURE	Reading Unchanged Too Long
SOLAR RADIATION	Change Too Large
SOLAR RADIATION	Format Error Detected
SOLAR RADIATION	Invalid Data
SOLAR RADIATION	Parity Error Detected
SOLAR RADIATION	Reading Missing
SOLAR RADIATION	Reading Too High
SOLAR RADIATION	Reading Too Low
SOLAR RADIATION	Reading Unchanged Too Long
VISIBILITY MILES	Change Too Large
VISIBILITY MILES	Format Error Detected
VISIBILITY MILES	Invalid Data
VISIBILITY MILES	Parity Error Detected
VISIBILITY MILES	Reading Missing
VISIBILITY MILES	Reading Too High
VISIBILITY MILES	Reading Too Low
VISIBILITY MILES	Reading Unchanged Too Long
VISIBILITY MTNCE	Change Too Large
VISIBILITY MTNCE	Format Error Detected
VISIBILITY MTNCE	Invalid Data
VISIBILITY MTNCE	Parity Error Detected
VISIBILITY MTNCE	Reading Missing
VISIBILITY MTNCE	Reading Too High
VISIBILITY MTNCE	Reading Too Low
VISIBILITY MTNCE	Reading Unchanged Too Long
WATER FLOW	Change Too Large
WATER FLOW	Format Error Detected
WATER FLOW	Invalid Data
WATER FLOW	Parity Error Detected
WATER FLOW	Reading Missing
WATER FLOW	Reading Too High
WATER FLOW	Reading Too Low
WATER FLOW	Reading Unchanged Too Long
WATER LEVEL	Change Too Large
WATER LEVEL	Format Error Detected
WATER LEVEL	Invalid Data
WATER LEVEL	Parity Error Detected

WATER LEVEL	Reading Missing
WATER LEVEL	Reading Too High
WATER LEVEL	Reading Too Low
WATER LEVEL	Reading Unchanged Too Long
WATER PRESSURE	Change Too Large
WATER PRESSURE	Format Error Detected
WATER PRESSURE	Invalid Data
WATER PRESSURE	Parity Error Detected
WATER PRESSURE	Reading Missing
WATER PRESSURE	Reading Too High
WATER PRESSURE	Reading Too Low
WATER PRESSURE	Reading Unchanged Too Long
WATER QUALITY	Change Too Large
WATER QUALITY	Format Error Detected
WATER QUALITY	Invalid Data
WATER QUALITY	Parity Error Detected
WATER QUALITY	Reading Missing
WATER QUALITY	Reading Too High
WATER QUALITY	Reading Too Low
WATER QUALITY	Reading Unchanged Too Long
WATER TEMPERATURE	Change Too Large
WATER TEMPERATURE	Format Error Detected
WATER TEMPERATURE	Invalid Data
WATER TEMPERATURE	Parity Error Detected
WATER TEMPERATURE	Reading Missing
WATER TEMPERATURE	Reading Too High
WATER TEMPERATURE	Reading Too Low
WATER TEMPERATURE	Reading Unchanged Too Long
WATER TURBIDITY	Change Too Large
WATER TURBIDITY	Format Error Detected
WATER TURBIDITY	Invalid Data
WATER TURBIDITY	Parity Error Detected
WATER TURBIDITY	Reading Missing
WATER TURBIDITY	Reading Too High
WATER TURBIDITY	Reading Too Low
WATER TURBIDITY	Reading Unchanged Too Long
WEIGH GAGE	Change Too Large
WEIGH GAGE	Format Error Detected
WEIGH GAGE	Invalid Data
WEIGH GAGE	Parity Error Detected
WEIGH GAGE	Reading Missing
WEIGH GAGE	Reading Too High
WEIGH GAGE	Reading Too Low
WEIGH GAGE	Reading Unchanged Too Long
WIND DIRECTION	Change Too Large
WIND DIRECTION	Format Error Detected
WIND DIRECTION	Invalid Data
WIND DIRECTION	Parity Error Detected
WIND DIRECTION	Reading Missing
WIND DIRECTION	Reading Too High
WIND DIRECTION	Reading Too Low
WIND DIRECTION	Reading Unchanged Too Long
WIND SPEED	Change Too Large
WIND SPEED	Format Error Detected
WIND SPEED	Invalid Data
WIND SPEED	Parity Error Detected
WIND SPEED	Reading Missing
WIND SPEED	Reading Too High
WIND SPEED	Reading Too Low
WIND SPEED	Reading Unchanged Too Long

Appendix Q. KCFast Data File Formats

Table Q-1 contains the 1972 Data File Format of RAWS 13:00-hour observations. Table Q-2 contains the 1998 Data File Format of all hourly observations. Table Q-3 contains the Standard Extract: Fire Occurrence Output Format.

Table Q-1: RAWS Weather Station 1972 Data Format (*.fwx).

Field	Field Name	Columns
1	STATION NUMBER	1-6
2	YEAR	7-8
3	MONTH	9-10
4	DAY	11-12
5	STATE OF WEATHER (CODE)	13
6	DRY BULB TEMPERATURE (°F)	14-16
7	RELATIVE HUMIDITY (%)	17-19
8	HERBACEOUS GREENNESS FACTOR	20-22
9	HERBACEOUS VEGETATION CONDITION	23-24
10	HUMAN-CAUSED RISK	25-27
11	WIND DIRECTION (8 POINT)	28
12	WIND SPEED (MPH)	29-31
13	WOODY VEGETATION CONDITION	32
14	10-HR FUEL MOISTURE (%)	33-35
15	WOODY GREENNESS FACTOR	36-38
16	MAXIMUM TEMPERATURE (°F)	39-41
17	MINIMUM TEMPERATURE (°F)	42-44
18	MAXIMUM RH (%)	45-47
19	MINIMUM RH (%)	48-50
20	SEASON CODE	51
21	PRECIPITATION DURATION (HRS)	52-53
22	PRECIPITATION AMOUNT (IN)	54-57
23	LIGHTNING ACTIVITY LEVEL	58-60
24	RELATIVE HUMIDITY VARIABLE (see note)	61
25	FORECAST FLAG	79
26	REGION NUMBER	80

Note: RH variable 1 = Wet bulb, 2 = RH%, 3 = dew point.

Table Q-2: RAWS Weather 1998 Data Format.

Item	Cols	Type	Description
1	01-03	3A	Record type (W98). All records begin with this record type identifier code.
2	04-09	6N	Station Number.
3	10-17	8N	Observation date (YYYYMMDD).
4	18-21	4N	Observation time (0000-2359).
5	22	1A	Observation type (O=NFDRS, R=RAWS other than at the standard NFDRS observation time, F=Forecast, X=Other).
6	23	1N	State of weather code
7	24-26	3N	Dry bulb temperature (degrees Fahrenheit or degrees Celsius based on Measurement Type code [col. 63]).
8	27-29	3N	Atmospheric moisture (wet bulb temperature, relative humidity (percent), or dewpoint temperature based on Moisture Type code [col. 62]).
9	30-32	3N	Wind direction azimuth measured from true north. 0 (zero) means no wind direction, 360 is north.
10	33-35	3N	Average windspeed over a 10-minute period (miles or kilometers per hour based on Measurement Type code).
11	36-37	2N	Measured 10-hour time lag fuel moisture.
12	38-40	3N	Maximum Temperature (degrees Fahrenheit or degrees Celsius based on Measurement Type code [col. 63]).
13	41-43	3N	Minimum Temperature (degrees Fahrenheit or degrees Celsius based on Measurement Type code [col. 63]).
14	44-46	3N	Maximum relative humidity (percent).
15	47-49	3N	Minimum relative humidity (percent).
16	50-51	2N	Precipitation duration (hours).
17	52-56	5N	Precipitation amount based on Measurement Type code [col. 63]. Blanks=no precipitation. U.S. measurement: inches with implied decimal nn.nnn format; trace shown as 00005. Metric measurement: measured in millimeters, no implied decimal; trace shown as 00001.
18	57	1A	Wet flag (Y/N).
19	58-59	2N	Herbaceous greenness factor (0-20).
20	60-61	2N	Shrub greenness factor (0-20).
21	62	1N	Moisture Type code (1=Wet bulb, 2=Relative Humidity, 3=Dewpoint).
22	63	1N	Measurement Type code: 1=U.S.,2=Metric. Affects temperature (^{o}F or ^{o}C), wind (miles or kilometers per hour), and precipitation (decimal inches or millimeters).
23	64	1N	Season code (1=Winter, 2=Spring, 3=Summer, 4=Fall).
24	65-68	4N	Solar radiation (watts per square meter).

Table Q-3: Standard Extract: Fire Occurrence Output Format.

Field	Field Name	Columns
1	REPORTING FS REGION	1-2
2	REPORTING FS UNIT	3-4
3	FIRE NUMBER	5-7
4	DISTRICT NUMBER	8-9
5	STATISTICAL CAUSE	10
6	GENERAL CAUSE	11
7	SPECIFIC CAUSE	12-13
8	CLASS OF PEOPLE	14
9	FIRE SIZE CLASS	15
10	TOTAL AREA BURNED	16-24
11	FS AREA BURNED	25-33
12	NON-FS, UNDER FS PROTECTION AREA BURNED	34-42
13	NON-FS AREA BURNED	43-51
14	VEGETATION COVER TYPE	52-53
15	NFMAS ASPECT	54
16	TOPOGRAPHY CODE	55
17	FMZ_CODE	56-59
18	BLANK	60
19	REPRESENTATIVE WEATHER STATION NUMBER	61-66
20	NFDRS FUEL MODEL	67
21	FIRE INTENSITY LEVEL	68
22	FIRE INTENSITY SOURCE	69-70
23	LATITUDE (DDMMSS)	71-76
24	LONGITUDE (DDDMMSS)	77-83
25	TOWNSHIP	84-88
26	RANGE	89-93
27	SECTION	94-95
28	SUB-SECTION	96-99
29	PRINCIPAL MERIDIAN	100-101
30	SLOPE PERCENT	102-104
31	ASPECT CLASS	105
32	ELEVATION (FEET)	106-110
33	STATE CODE	111-112
34	COUNTY CODE	113-115
35	PROTECTION AGENCY	116-118
36	OWNERSHIP AT ORIGIN	119
37	PRESCRIBED FIRE (Y/N)	120
38	ESCAPED FIRE (Y/N)	121
39	INITIAL SUPPRESSION STRATEGY	122

40	FFF COST, IN DOLLARS	123-131
41	FIRE IGNITION DATE (YYYYMMDD)	132-139
42	FIRE IGNITION TIME (HH24MI)	140-143
43	FIRE DISCOVERY DATE (YYYYMMDD)	144-151
44	FIRE DISCOVERY TIME (HH24MI)	152-155
45	FIRST ACTION DATE (YYYYMMDD)	156-163
46	FIRST ACTION TIME (HH24MI)	164-167
47	SECOND ACTION DATE (YYYYMMDD)	168-175
48	SECOND ACTION TIME (HH24MI)	176-179
49	DECLARED WILDFIRE DATE (YYYYMMDD)	180-187
50	DECLARED WILDFIRE TIME (HH24MI)	188-191
51	FIRE CONTAINED DATE (YYYYMMDD)	192-199
52	FIRE CONTAINED TIME (HH24MI)	200-203
53	FIRE CONTROLLED DATE (YYYYMMDD)	204-211
54	FIRE CONTROLLED TIME (HH24MI)	212-215
55	FIRE OUT DATE (YYYYMMDD)	216-223
56	FIRE OUT TIME (HH24MI)	224-227
57	FIRE NAME	228-247
58	FIRE ID (NIFMID ID#)	248-254
59	PCODE	255-259
60	WILDERNESS	260-262

Appendix R. SIT – Interagency Situation Report

The Interagency Situation Report (SIT) program is a web application; rather than information being mailed first to the GACC's then to NICC, the GACC's and NICC can go directly to the SIT web server and generate reports using the data that the local dispatch offices had entered. The last includes daily fire statistics, resource information, incident information, planned fires, and preparedness levels. During the fire season this information and situation reports are generated daily; during non-fire season the report is submitted irregularly depending on the level of incident activity. Examples are provided of input and output for the Fort Collins Dispatch Center as of September 12, 2003 (see below).

Dispatch Office Detailed Situation Report 10/8/2003

Ft Collins Dispatch Center

Wildfire Activity					New Human		New Lightning		Uncntrld	YTD Human		YTD Lightning	
		Unit ID	Fire Dngr	P L									
Unit Name	Agency				Fires	Acres	Fires	Acres	Fires	Fires	Acres	Fires	Acres
FTC COUNTIES	CNTY	CO-FTX			NR					6	8	15	148
				sum						6	8	15	148
Rocky Mountain Arsenal	FWS	CO-RMR			NR					0	0	0	0
				sum						0	0	0	0
ROCKY MOUNTAIN NATIONAL PARK	NPS	CO-RMP			NR					0	0	1	0
				sum						0	0	1	0
ARAPAHO-ROOSEVELT N.F./PAWNEE N.G.	USFS	CO-ARF			NR					12	1	38	33
				sum						12	1	38	33
				total						18	9	54	181

No report for fire danger levels.

Prescribed Fires daily Report									
Prescribed Fires						Wildland Fire Use (WFU)			
		New		Year to Date		New		Year to Date	
Unit	Agency	Fires	Acres	Fires	Acres	Fires	Acres	Fires	Acres
CO-FTX	CNTY	NR		1	10	NR		0	0
	sum			1	10			0	0
CO-RMR	FWS	NR		4	275	NR		0	0
	sum			4	275			0	0
CO-RMP	NPS	NR		4	64	NR		0	0
	sum			4	64			0	0
CO-ARF	USFS	NR		7	890	NR		0	0
	sum			7	890			0	0
	total			16	1,239			0	0

Remarks for office.

Large Fire Totals								
Acreage	Personnel	CRW1	CRW2	HEL1	HEL2	HEL3	ENGS	OVHD
0	0	0	0	0	0	0	0	0

Resource status (a = Available, c = Committed)																				
	AIRT		SEAT		LEAD		AAAC		SJAC		HEL1		HEL2		HEL3		CRW1		CRW2	
Unit	a	c	a	c	a	c	a	c	a	c	a	c	a	c	a	c	a	c	a	c
Totals																				

Total Committed Resources (Large Fire and IA/Extended Attack)						
CRW1	CRW2	HEL1	HEL2	HEL3	ENGS	OVHD
0	0	0	0	0	0	0

Who is on call?

Return to the Select Dispatch Office Menu

Report executed on: 08-Oct-2003 1438 mountain time

Appendix S. 209 Incident Report Form

The incident Status Summary Form 209 is used for reporting information on a regular basis about incidents of significance. The 209 form is now web based and can be accessed through NIFMID at local, geographic, and national levels. When possible, information is entered at the management level that is nearest to the incident or at the dispatch level and so on. Information inputs include: date, time, location, incident name, current situation and outlook, committed resources, size, percent contained, threat level, basic current weather data and forecast (when available), and major problems and concerns. An example form is provided below.

ICS-209 Form 10/10/03 3:08 PM

Incident Status Summary (ICS-209)

1: Date	2: Time	3: Initial | Update | Final	4: Incident Number	5: Incident Name
09/12/2003	**1800**	Update: **XX**	**WA-OWF-398**	**NEEDLE**

6: Incident Kind	7: Start Date Time	8: Cause	9: Incident Commander	10: IMT Type	11: State-Unit
Wildland Fire	**08/05/2003 2000**	**Lightning**	**Hart**	**1**	**WA-OWF**

12: County	13: Latitude and Longitude	14: Short Location Description (in reference to nearest town):
OKANOGAN	Lat: **48° 36´ 0"** Long: **120° 40´ 0"**	**12 MILES NW OF WINTHROP, WA. near the Town of Mazama**

Current Situation

15: Size/Area Involved	16: % Contained or MMA	17: Expected Containment	18: Line to Build	19: Costs to Date	20: Declared Controlled
21,250 ACRES	**60 Percent**	Date: Time:		**$3,227,297**	Date: Time:

21: Injuries this Reporting Period:	22: Injuries to Date:	23: Fatalities	24: Structure Information
1	**2**	**0**	

25: Threat to Human Life/Safety:	Type of Structure	# Threatened	# Damaged	# Destroyed
Evacuation(s) in progress ---- No evacuation(s) imminent -- **XX** Potential future threat -------- **XX** No likely threat ---------------	Residence	**100**		
	Commercial Property			
	Outbuilding/Other			

26: Communities/Critical Infrastructure Threatened (in 12, 24, 48 and 72 hour time frames):
12 hours:
24 hours:
48 hours:
72 hours:

27: Critical Resource Needs (kind & amount, in priority order):
1. **HCWM (3)**
2. **SEC 1 or 2 (6)**
3. **SPUL (1), COST (1), TIME(1)**

28: Major problems and concerns (control problems, social/political/economic concerns or impacts, etc.) Relate critical resources needs identified above to the Incident Action Plan.
STEEP RUGGED TERRAIN, FALLING SNAGS MAKE CONTROL EFFORTS DIFFICULT IN DIVISION A AND C. ACCESS VIA HELISPOTS ALSO OF CONCERN.

29: Resources threatened (kind(s) and value/significance):
COMMUNITY WATERSHEDS, VIEW SHED

30: Current Weather Conditions	31: Resource benefits/objectives (for prescribed/wildland fire use only):
Wind Speed: **8-12G20** mph Temperature: **65** Wind Direction: **WEST** Relative Humidity: **35**	

32: Fuels/Materials Involved: **10 Timber (litter and understory) heavy down and dead fuels**

file://localhost/Users/connie/Desktop/Connie's%20Work/PUBLICATIONS/GTRs/Zachariassen%20GTR/r_print_209_head.html Page 1 of 3

33: Today's observed fire behavior (leave blank for non-fire events): **FIRE IS CREEPING TO THE EAST TOWARD THE LOST RIVER DEVELOPMENT CARRIED BY THE LARGE FUELS. HIGH HUMIDITY IS LIMITING THE FINE FUELS TO BURN AGGRESSIVELY AND SPOTTING FROM THE OCCASIONAL TORCHING OF SMALL POKESTS OF TIMBER WITHIN THE PERIMETER.**
34: Significant events today (closures, evacuations, significant progress made, etc.): **DIRECT LINE CONSTRUCTION IN DIVISION C ALONG CALOWAY CREEK AND DIVISION A BETWEEN METHOW RIVER AND H-4.**
Outlook

35: Estimated Control Date and Time:	36: Projected Final Size: **115,000**	37: Estimated Final Cost: **$6,670,000**	38: Tomorrow's Forecasted Weather Wind Speed: **2-3** mph Temperature: **70** Wind Direction: **UP CANYON** Relative Humidity: **25%**

39: Actions planned for next operational period: **CONTINUE LINE CONSTRUCTION IN DIV. C. BEGIN LINE CONSTRUCTION IN DIV. D BETWEEN CALOWAY CREEK AND MC GEE CREEK. MOP UP AND LINE IMPROVEMENT CONTINUING IN DIV. A AND E.**
40: Projected incident movement/spread during next operational period: **SHOULD NOT BE ANY SIGNIFICANT MOVEMENT OF SPREAD DURING NEXT OPERATIONAL PERIOD HOWEVER ALL DIVISIONS ARE TO BE MORE CAUTIOUS DUE TO A WARMING AND DRYING TREND.**
41: For fire incidents, describe resistance to control in terms of:
1. Growth Potential - **Medium**
2. Difficulty of Terrain - **Extreme**
42: How likely is it that containment/control targets will be met, given the current resources and suppression/control strategy? **GOOD CHANCE CONTROL OBJECTIVES WILL BE MET WITH THE ADDITION OF FIVE TYPE 1 HAND CREWS OVER THE NEXT SEVERAL OPERATIONAL PERIODS.**
43: Projected demobilization start date:
44: Remarks: **ALL HIKING TRAILS IN THE VICINITY OF THE FIRE REMAIN CLOSED. HIGHWAY 20 IS BEING MONITORED TO KEEP TRAVELERS FROM STOPPING AND OBSERVING THE FIRE ACTIVITY AND CREATING PARKING HAZARDS BECAUSE OF THE INCREASED HELICOPTERS. THE NEEDLES INCIDENT IS BURNING APPROXIMATELY 12 MILES NORTHWEST OF WINTHROP IN VERY STEEP RUGGED TERRAIN WITH LITTLE TO NO ACCESS. THE ONE INJURY WAS SEVERE ANKLE SPRAIN. HARTS PASS ROAD WAS OPEN TODAY OF SNAGS AND DISCOVERED ONE OUTBUILDING AND CAMPGROUND WAS BURNED OVER AT HARTS PASS.**
45: Committed Resources

Agency	CRW1		CRW2		HEL1	HEL2	HEL3	ENGS		DOZR		WTDR	OVHD	Camp Crews	Total Personnel
	SR	ST	SR	ST	SR	SR	SR	SR	ST	SR	ST	SR	SR		
NPS													6		6
PRI			3		4	1	3	22		2		17	55		163
OTHR													12		12
CNTY													8		8
USFS	4		4										66		224
BIA													1		1
FWS													2		2
BLM	2		2										17		99
ST			2			1		10					50	2	125
Total	6	0	11	0	4	2	3	32	0	2	0	17	217	2	640

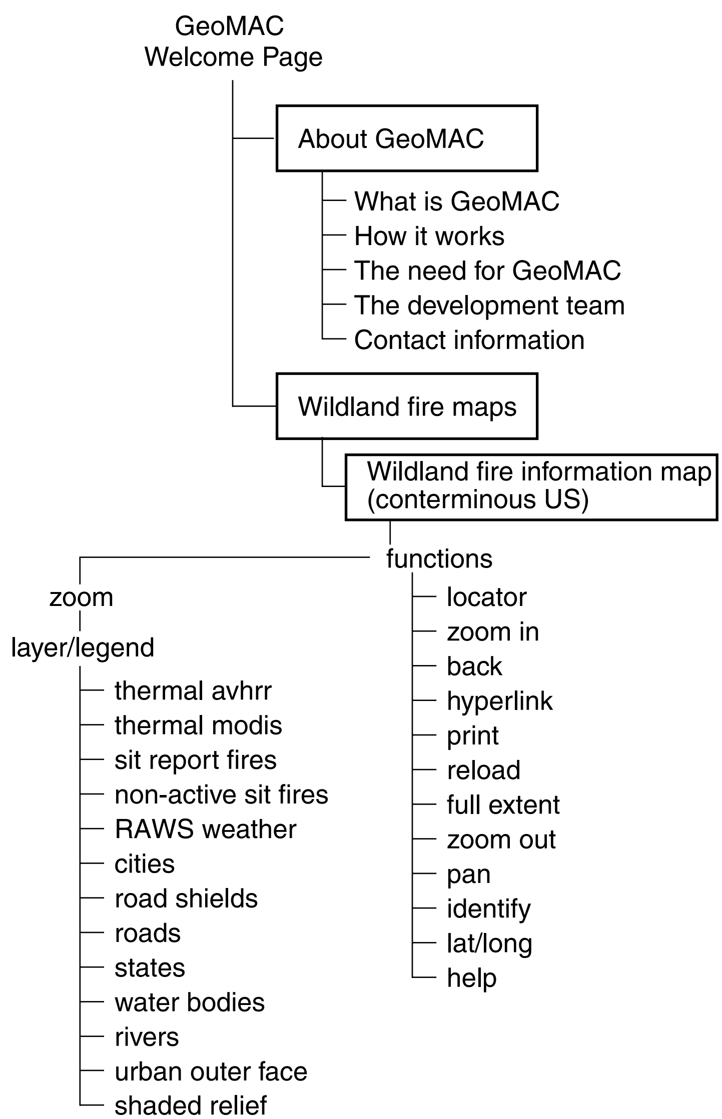
46: Cooperating and Assisting Agencies Not Listed Above:
OKANOGAN COUNTY SHERIFF'S OFFICE, WSP, OKANOGAN COUNTY FIRE DISTRICT #6

Approval Information

47: Prepared by:	48: Approved by:	49: Sent to: **NWCC** by: **JAM**
JAMES MUNROE, SITL (T)	**STEVE HART, IC**	Date: **09/12/2003** Time: **1830**

Appendix T. GeoMAC Site Hierarchy and Options

This web-based fire application was developed by the Geospatial Multi-Agency Coordination Group of the U.S. Geological Survey. A flow chart is presented below. Further details are given in the Data Retrieval section of the report and in Appendix O.



Appendix U. Summary of Responses to RAWS Survey

Survey questions were primarily concerned with data use, sampling protocols, importance of data, and data type elements. Responses were processed by simply tabulating results for fixed questions and parts of questions and then summarized. A total of 44 responses were received, evenly divided between NWS/WFO and federal and state land management users.

Survey question 1. What do you use RAWS for ?

incident management
fuels management
prescribed burning
research
hydrology
avalanche management
water quality or stream levels
air quality monitoring
resource management
public awareness/communication
weather prediction/forecasting
legal
other(?)

RAWS data were used for multiple purposes by all respondents. Of the above choices weather prediction/forecasting was the primary category accounting for 71% of use followed by incident management, prescribed burning (both roughly 40%), and fuels management. RAWS data were also used to support basic research, hydrology, public awareness/communication, resource management, and air quality monitoring by respondents. The category 'other' included general weather monitoring and summaries, and spot forecasts. Virtually all NWS respondents use RAWS data for weather prediction/forecasting; five do not use RAWS data at all nor are they involved in issuing fire weather forecasts.

Survey question 2. What type of weather data or NFDRS output do you use ?

fire danger rating indices/components (e.g. IC, BI, ERC, SC)
wind speed
wind direction
relative humidity
air temperature
rainfall/precipitation
fuel temperature
fuel moisture
peak wind gust
direction of peak wind gust
solar radiation
other (?)

NFDRS indices and components are used by 45% of NWS/WFO's, the remainder did not use any NFDRS output. Twenty percent of land management responses indicated no NFDRS output use; the remainder did use NFDRS indices and components. Wind speed and direction, relative humidity, air temperature, precipitation, and fuel moisture were elements used by about 83% of all respondents. Fuel temperature and direction of peak wind gust were used by only about one-third of respondents. The other category included max/min air temperature, max/min RH, and KBDI.

Survey question 3. What data frequency do you use ?

daily
hourly
instantaneous/real time
event specific
minute

Almost 88% of all respondents use hourly and daily (daily = the 13:00 hr observation) observations; the real time and event specific categories accounted for the remaining responses. Almost all respondents indicated using data at multiple frequencies.

Survey question 4. What spatial resolution (area) do you use the data for and what do you need ?

GACC
agency region
national forest area
weather/climate zone
a specific location

Ninety percent of NWS/WFO respondents use the RAWS data set for a specific location and/or weather/climate zone. Sixty-eight percent of land management responses indicated use of RAWS data for agency regions and national forest areas; 21% for GACC use, weather/ climate zone, or a specific location; 11% did not respond to this question. These results are not very surprising given the different mandates driving these agencies and their different areas of interest and concern.

Survey question 5. For what decision(s) or judgment(s) are the data used for (briefly describe in your own words).

The majority of land management agency respondents use the RAWS data set for fire business applications (calculating NFDRS indices and components), determining staffing levels, incident management, informing the public (adjective fire danger ratings). Respondents from the NWS also use RAWS data for fire weather forecasting, public weather forecasts, red flag and fire weather watches, severe weather warnings, point forecasts, and forecast verification. The difference in use by these two groups was split along agency lines

Survey question 6. What potential impact of the data use do you see on your decision/judgment ? and Why ? (please briefly describe).

Given the answers to this question it was interpreted by respondents either as: describe the impact upon decision making resulting from lack of RAWS data or as: describe the importance of the RAWS data for your primary use of the data set. With respect to the former, answers range from: I cannot live without RAWS data – too many critical decisions are based on historical and current weather conditions to If you don’t have ground-truth data how can you make an intelligent decision? The importance of RAWS data was critical for calculating NFDRS indices and components, area fire weather and spot/point forecasts, fire fighter safety, resource management, staffing, and monitoring weather during prescribed burns or an incident. This was true for both the NWS and land management agency personnel.

Survey question 7. Do you have any geographic areas or topographic settings where weather sampling/stations overlap or areas where there is not enough coverage ? If either or both, where ?

The answers to this question indicated an interpretation of: Is there any overlap of RAWS coverage in your area? Answers were almost all: no overlap in coverage, pretty good coverage, or adequate to there are gaps in my area/not enough coverage – we need more stations (authors quotation marks). The latter were mostly from areas in the mid-west continental United States, North-East, and East. One respondent indicated both conditions (FS Southern Region) and only two described overlapping station coverage; the last were two WFO areas located in North Carolina.

Survey question 8. Updating/upgrading RAWS data collection and NFDRS output protocols:

Background given as part of the question: Many users of RAWS data demand that they need a specific record like the 10-minute average wind speed or the instantaneous temperature, etc. as recorded only once per hour prior to transmission time. This has lead to disproportional competition for transmission times close to the top of the hour. Others have been asking for hourly averages or hourly maximums/minimums (of air temp. and/or relative humidity) as more representative of the actual weather. The current RAWS data output protocols are based on what was possible in the past when data could only be collected manually. With modern communication new data protocols are now possible – transmission more than once an hour and higher rates. It is true that our fire danger rating indices and components (IC, BI, ERC etc. – generated once per day for 13:00 LST) are currently based on the existing RAWS data collection protocols and any changes would require testing of the effects on these indices and possible minor adjustments. However the indices may be improved with such changes. Please provide your thoughts, support or disagreements on the subject of changing data collection and NFDRS output protocols to take advantage of modern capabilities. (Please feel free to use any additional space).

This is a loaded question and we thought it would elicit some strong response; it did not. Only three out of all the respondents (about 9%) emphatically advocated leaving the sampling protocol and overall procedures as is. All other responses indicated a desire for change: real time data access, NFDRS output more than once per day, higher transmission frequencies (more than once per hour), and better data access were the most frequently expressed thoughts. We were not clear what was exactly meant by better data access as no details were given. Some RAWS have real time data access capability via telephone and can also alert local dispatch centers if critical thresholds are exceeded. Calculation and application of NFDRS more than once per day would have to be tested rigorously and higher transmission frequencies are already part of the strategic plan set forth by the RSFWSU and NFDRS output calculation more than once per day has been discussed by the FDWT.

Survey question 9. Are there other users (non federal or state) of your RAWS data that you know of ? And how is the data being used ?

Almost 30% of respondents thought there was non-governmental data use but could give no specifics, 30% indicated only that local States Departments of Environmental Quality or Forestry used the data, 20% did not know of any other users, only 4% provided specifics of non-governmental use, and 16% did not respond. Non-governmental agency use included

State and National Nature Conservancies, local fire departments, and the Province of Ontario (Canada) for hydrological purposes.

Survey question 10. Are RAWS and/or WIMS operations (maintenance, data entry and QA/QC) part of your position description? If so could you provide us with the wording as set out in your PD?

Almost without exception an explicit description of RAWS/WIMS related duties were not included in respondents Position Descriptions (87%). Four respondents replied yes but only one could give specifics as to exact wording (see Appendices K and M). Those who are involved in the RAWS program and/or perform WIMS duties have stated (to the authors) that such descriptions are usually vague; phrases such as …weather related duties… are more common than not. This question was included to provide support for our recommendation to include explicit wording in Position Descriptions of those personnel involved in the RAWS and fire weather program regardless of agency affiliation.

Survey question 11. Summary RAWS Matrix: Please fill in based on your input above, indicate potential or current use.

All meteorological data elements were generally rated of high importance by all respondents. However, NWS/WFO personnel tended to rate NFDRS products of lower importance (or not at all) than land management agency respondents. The difference in response to this part of the matrix was quite striking – a 50/50 split, although in response to question 2 some personnel from WFO's indicated that NFDRS output is looked at and evaluated. This is probably the result of two different missions. The NWS is tasked with issuing fire weather forecasts for use by land management agencies involved in generating NFDRS output for direct fire business applications. Desired data sampling frequency ranged across the spectrum; from on demand to daily (daily meaning the traditional 13:00 hour observation) and from the traditional 10 minute RAWS average to hourly averages.

Comment(s):

Function: No response from anyone

Decision: No response from anyone

Below are given the authors summary of results for this matrix

Parameter	Importance [a],	Comment(s): sampling frequency [b]
Temperature	High	on demand, hourly, daily
Relative Humidity	High	on demand, hourly, daily
Wind Speed	High	on demand, 10 min avg., hourly, daily
Wind direction	High	on demand, 10 min avg., hourly, daily
Fuel stick Temp	Overall H	on demand, 10 min avg., hourly, daily
Fuel Moisture	High	on demand, 10 min avg., hourly, daily
Pressure	High	on demand, 10 min avg., hourly, daily
Precipitation	High	on demand, 10 min avg., hourly, daily, w/3 ,6, 12, 24 hour totals
Solar Radiation	High	but some do not use it at all
Soil Moisture	M to H	but usually not part of RAWS suite
Haines index	overall M	
KBDI	overall H	on demand, 10 min avg., hourly, daily
Ventilation index	M to H	but still exptl. and some are unfamiliar with its meaning
NFDRS		
Fosberg	L to M	but not widely used or even known
Burn index	generally H	on demand, 10 min avg., hourly, daily
Ignition component	generally H	on demand, 10 min avg., hourly, daily
Energy release component	generally H	on demand, 10 min avg., hourly, daily
Spread component	generally H	but not very widely used
Adjective rating	generally H	
Other	Canadian fire danger system	Used somewhat in Alaska and Maine – applicable to those fuel types

[a] importance: H: very; M: somewhat; L: low.

[b] e.g. daily 13:00 10-minute average, hourly instantaneous record, on demand 5-minute average, daily min/max, etc.

Appendix V. Summary of Meteorological Station Instrument Specification Survey

Air Resource Specialists, Inc of Fort Collins CO (ARS) prepared a Meteorological Station Instrument Specification Survey for the U.S.Forest Service. The objective of the survey was to provide a wide-ranging summary and comparison of sensors available for RAWS fire weather use.The survey provides field technicians and project scientists with current information for instrument selection.

The survey also included a Technical Reference section listing all the above, the primary manufacturers, and contact information. Tables for each sensor type from each manufacturer are included; an electronic copy of the survey is also **attached on CD-ROM**. The sensors that were given priority (along with primary requirements) were:

- Wind Speed: able to measure horizontal component of wind
- Wind Direction: able to measure horizontal component of wind
- Ambient Air Temperature: suitable for outdoor use
- Relative Humidity: suitable for outdoor use
- Precipitation: liquid and solid precipitation
- Barometric Pressure: suitable for outdoor use
- Solar Radiation: suitable for outdoor use
- Other sensors listed (along with primary requirements) were:
- Fuel Moisture: suitable for outdoor use, able to measure fuel temperature and provide data instantaneously
- Fuel Temperature: suitable for outdoor use
- Soil Moisture: suitable for outdoor use, able to take electronic measurements below surface and report data instantaneously
- Soil Temperature: suitable for outdoor use, able to measure temperature below the surface

Quality of those instruments surveyed ranged from research quality to low-cost home-use sensors. Usually only one home-grade sensor was chosen as representative for each sensor type. The RAWS project criteria for instrument selection was primarily the instrument's long-term durability in remote and often in extreme environments. Other criteria were based on the National Wildfire Coordinating Group (NWCG) standards and EPA Prevention of Significant Deterioration Monitoring (PSD) standards.

Data was collected through Internet sources, from vendors and manufacturers, scientific journals, the EPA, the American Society for Testing and Materials (ASTM International), the International Organization for Standardization (ISO 9000), National Institute for Standards and Technology (NIST) and others. The instrument survey was conducted between January and April 2002. Data was then transferred into Microsoft Excel database tables. Specifications are listed just as the vendor reported them in many cases.

The following parameters were used to compare the sensors surveyed. An explanation/key of the parameters follows the list.

- Manufacturer / Distributor: lists the manufacturer or vendor surveyed.
- Model Number and Name: instrument identification as supplied by the manufacturer or vendor and the name of whom to contact for more information.
- Remarks: additional features and considerations for identifying sensor.

- Certifications: listed if met requirements of EPA Prevention of Significant Deterioration Monitoring (PSD); National Fire Danger Rating System (NFDRS); National Weather Service (NWS); Nuclear Regulatory Certification (NRC); and military certification operational requirements.
- Integral: indicates whether or not the sensor must be purchased as part of a combined unit of sensors.
- Method of Measurement: the approach of the sensor used to take the measurements. For each sensor there may be alternative instrument designs for measuring the same variable.
- Range of Operation: a certain state of environmental conditions within which the sensor is capable of responding accurately.
- Accuracy: the degree of the sensor's response to the known or true value.
- Resolution: the smallest change in conditions the instrument can detect.
- Starting Threshold: the lowest wind speed required for accurate anemometer readings. For wind vanes, the wind speed must be great enough to move the vane from 10˚ off axis to within 5˚ off axis.
- Time Constant: The time required for the instrument to respond to 63% of the true environmental value.
- Power Requirement: all sensors, except Solar Radiation sensors, require electrical power. This is listed for volts and for watts. If a heater is available the power consumption of the heater is reported under the parameter of Heater Power Consumption or Heater Power Requirements.
- Output Signal: the available options of electrical signals that transfer measured data to the data logger.
- Regular Maintenance Interval and Long Term Stability: the ruggedness of the instrument. The Regular Maintenance Interval is recommended by the manufacturer to be the time intervals between maintenance other than the regular calibration intervals. Barometric Pressure uses the Long-Term Stability parameter to show the accuracy maintained over prolonged periods of operation.
- Sensor Materials: construction material(s).
- Dimensions: measurements appropriate for the sensor such as height, length, diameter and orifice diameter as reported by manufacturer. Operational Dimensions allow planning for the placement of the instrument.
- Weight: the reported weight of the instrument by the manufacturer.
- Cost / Spring 2002: the cost of the sensor as of spring 2002. If the sensor is integrated with another sensor, the cost listed covers entire unit.
- Comments: any information that could not be placed in previous cells.

In addition to the above, other unique sensor properties were used to compare sensors on an individual basis.

Sensor Properties

- Wind Speed sensors:
  1. The Distant Constant is the length of an air column needed to pass the sensor to respond exponentially to 63% of a sudden step change in wind speed.
  2. The Survival is the maximum wind gust that can be withstood by the instrument without damage.
  3. The Maximum Scan Rate for sonic anemometers is the maximum rate at which the sensor can record accurate measurements.

- Wind Direction sensors:
  1. The Dead Band is the magnitude that must be subtracted from 360∞ to correct for the gap between magnetic north and true north.
  2. The Delay Distance parameter is the length of the column of air needed to pass the sensor to return the vane to 50% of the initial 10% displacement angle.
  3. The Damping Ratio relates the number of oscillations and the length of the overshoot of the vane upon a shift in wind direction.
  4. The Damped Natural Wavelength / Undamped Natural Wavelength is the free oscillation of the wind vane after a directional change in wind. The wavelength is either damped by the friction of the bearings, or undamped when only affected by it's own inertia.
- Precipitation sensors/gauges: precipitation type; either solid or liquid.
- Barometric Pressure sensors: Output Impedance is an indication of the amount of impedance or resistance between the sensor transducer and the data logger over the output terminals.
- Solar Radiation:
  1. The Light Spectrum Waveband is the energy wavelength that the sensor is able to detect.
  2. The Sensitivity is the ratio of the magnitude of sensor signal per unit of irradiance.
- Fuel Temperature:
  1. The Stick Size Available (related to fuel size) is the size of the dowel that the temperature sensor is placed in.
  2. The Temperature Storage Range is the highest and lowest temperatures that the instrument can endure without damage.
  3. The Interchangeability Error is the maximum amount of error between any two sensors of the same make and model.

Appendix W. Super-RAWS Data Element List

This is the data element list for the Super-RAWS, which is the experimental RAWS at Fernberg, MN.

Order	Parameter Description	Units	Format
1	continuous accumulative precipitation ending at :15	inches	xx.xx
2	10-minute average scalar wind speed from :05 to :15	mph	xxx
3	10-minute average wind direction from :05 to :15	degrees	xxx
4	single scan of 3 meter ambient air temperature at :15	F	xxx
5	single scan of fuel temperature at :15	F	xxx
6	10-minute average relative humidity from :05 to :15	%	xxx
7	minimum data logger battery voltage	DC Volts	xx.x
8	single scan of barometric pressure at :15	inHg	xx.xx
9	wind direction during peak wind speed for the hour	degrees	xxx
10	peak wind speed for the hour	mph	xxx
11	single scan of fuel moisture at :15	%	xxx
12	single scan of solar radiation at :15	W/m^2	xxxx
13	6-meter cup/vane scalar wind speed (hourly avg.)	m/s	xx.x
14	6-meter cup/vane vector wind speed (hourly avg.)	m/s	xx.xx
15	6-meter cup/vane wind direction (hourly avg.)	degrees	xxx
16	6-meter cup/vane standard deviation wind direction	degrees	xxx.x
17	6-meter cup/vane standard deviation of scalar wind speed	m/s	xxx.x
18	6-meter sonic scalar wind speed (hourly avg.)	m/s	xx.x
19	6-meter sonic vector wind speed (hourly avg.)	m/s	xx.xx
20	6-meter sonic wind direction (hourly avg.)	degrees	xxx
21	6-meter sonic standard deviation of wind direction	degrees	xxx.x
22	6-meter sonic standard deviation of scalar wind speed	m/s	xxx.x
23	15-meter sonic scalar wind speed (hourly avg.)	m/s	xx.x
24	15-meter sonic vector wind speed (hourly avg.)	m/s	xx.xx
25	15-meter sonic wind direction (hourly avg.)	degrees	xxx
26	15-meter sonic standard deviation of wind direction	degrees	xxx.x
27	15-meter sonic standard deviation of scalar wind speed	m/s	xxx.x
28	3-meter ambient air temperature (hourly avg.)	C	±xx.x
29	3-15 meter delta air temperature (hourly avg.)	C	±xx.x
30	standard deviation of 3-meter ambient air temperature	C	xx.x
31	3-meter relative humidity (hourly avg.)	%	xxx
32	standard deviation of 3-meter relative humidity	%	xx.x
33	barometric pressure (hourly avg.)	mmHg	xxx.x
34	standard deviation of barometric pressure	mmHg	xx.x
35	hourly average of solar radiation	W/m2	xxxx
36	standard deviation of solar radiation	W/m2	xx.x
37	hourly precipitation	mm	xxx.x
38	fuel temperature (hourly avg.)	C	±xx.x
39	fuel moisture (hourly avg.)	%	xxx.x
40	duff moisture 1 (hourly avg.)	%	xxx.x
41	duff moisture 2 (hourly avg.)	%	xxx.x
42	soil moisture (hourly avg.)	%	xxx.x
43	soil temperature (hourly avg.)	C	±xx.x
44	2.5 to 5 soil delta temperature (hourly avg.)	C	±xx.x
45	leaf wetness (hourly avg.)	% time wet	xxx.x
46	calendar year	2002	xxxx
47	julian day	xxx	xxxx
48	Hour (GMT)	xxxx	xxxx

Appendix X: Comparison of RAWS and Super-RAWS Data Sets

Presented here are the results of a comparison between the RAWS and super-RAWS data sets. Super-RAWS is the experimental RAWS at Fernberg, MN, discussed in the main text. This study compares traditionally collected RAWS data elements and the hourly averages of those same elements described in appendix W. Data elements compared were wind speed, wind direction, solar radiation, ambient temperature, and relative humidity.

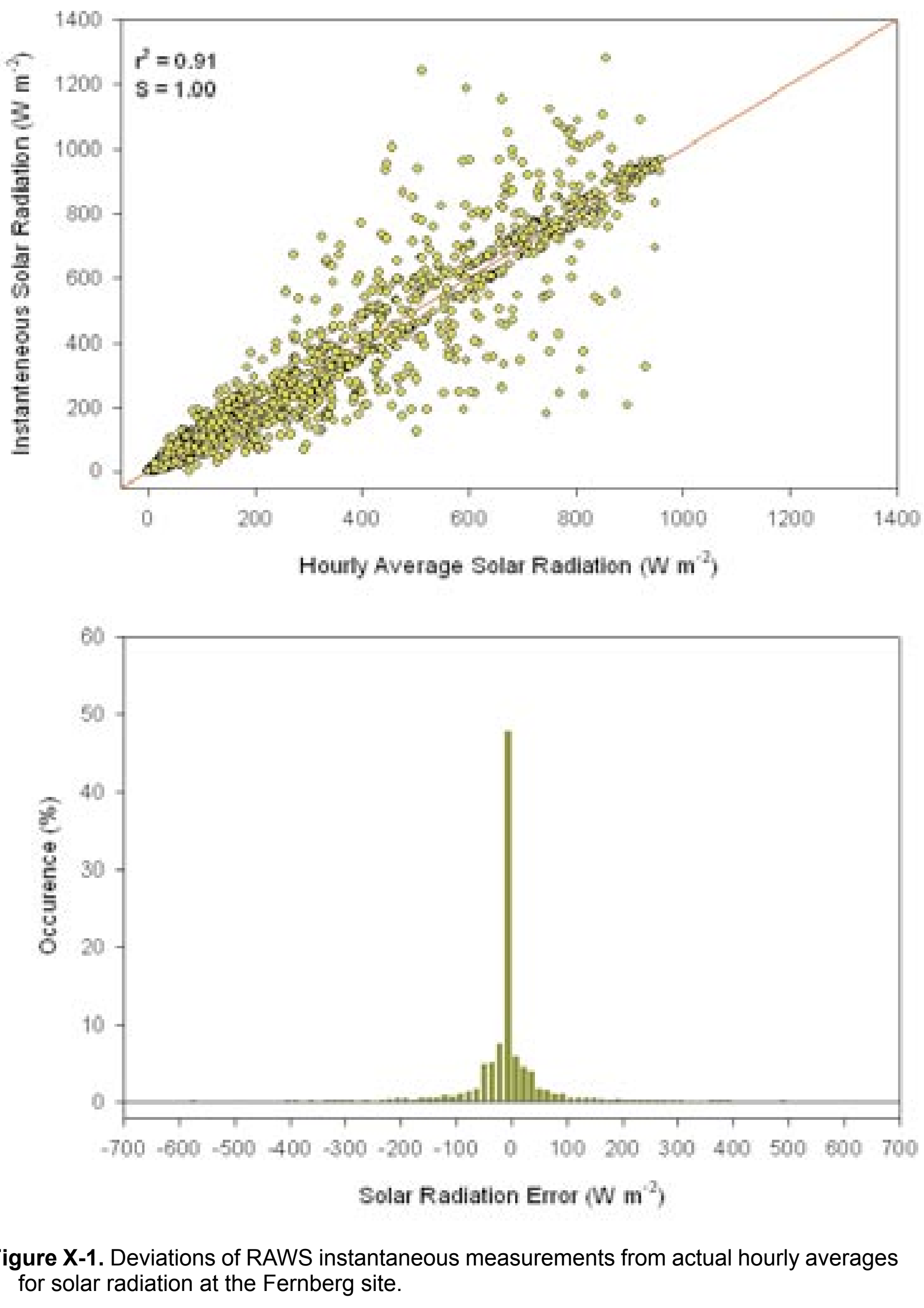


Figure X-1. Deviations of RAWS instantaneous measurements from actual hourly averages for solar radiation at the Fernberg site.

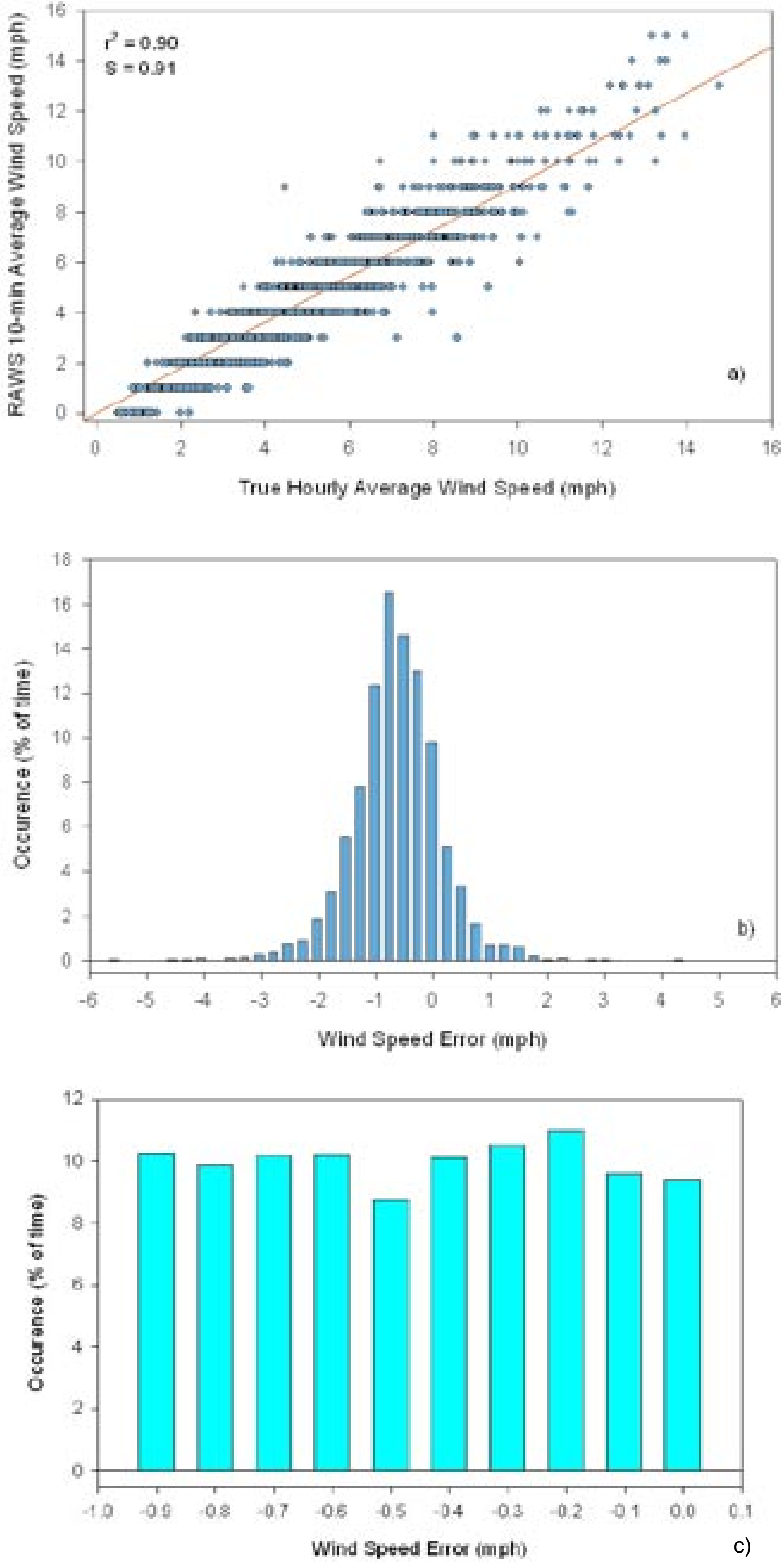


Figure X-2. a & b: Deviations of reported RAWS 10-minute measurements from actual hourly averages for wind speed at the Fernberg site. **c:** Deviations of RAWS 10-minute as reported minus RAWS 10-minute as measured.

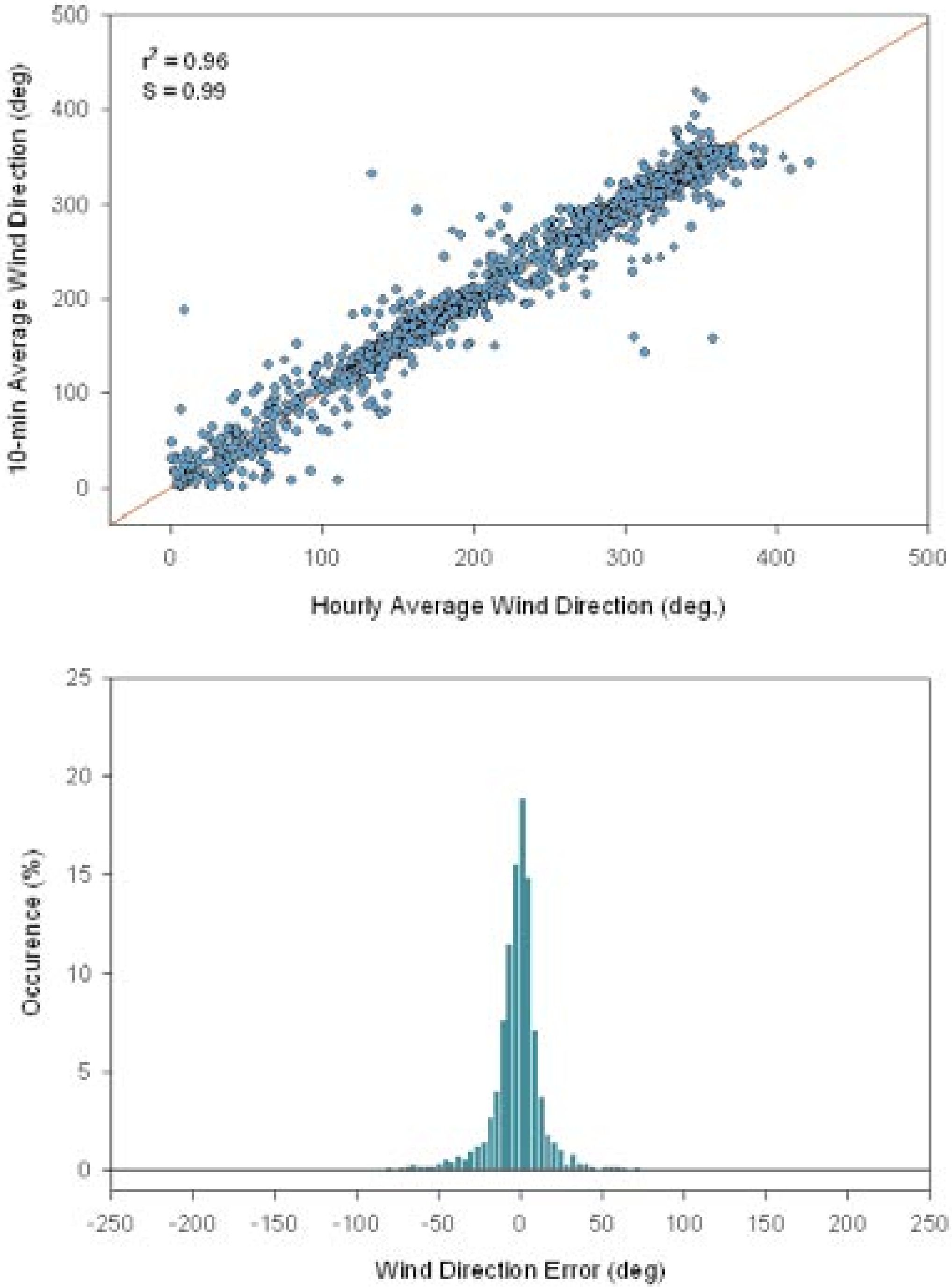


Figure X-3. Deviations of reported RAWS 10-minute measurements from actual hourly averages for wind direction at the Fernberg site.

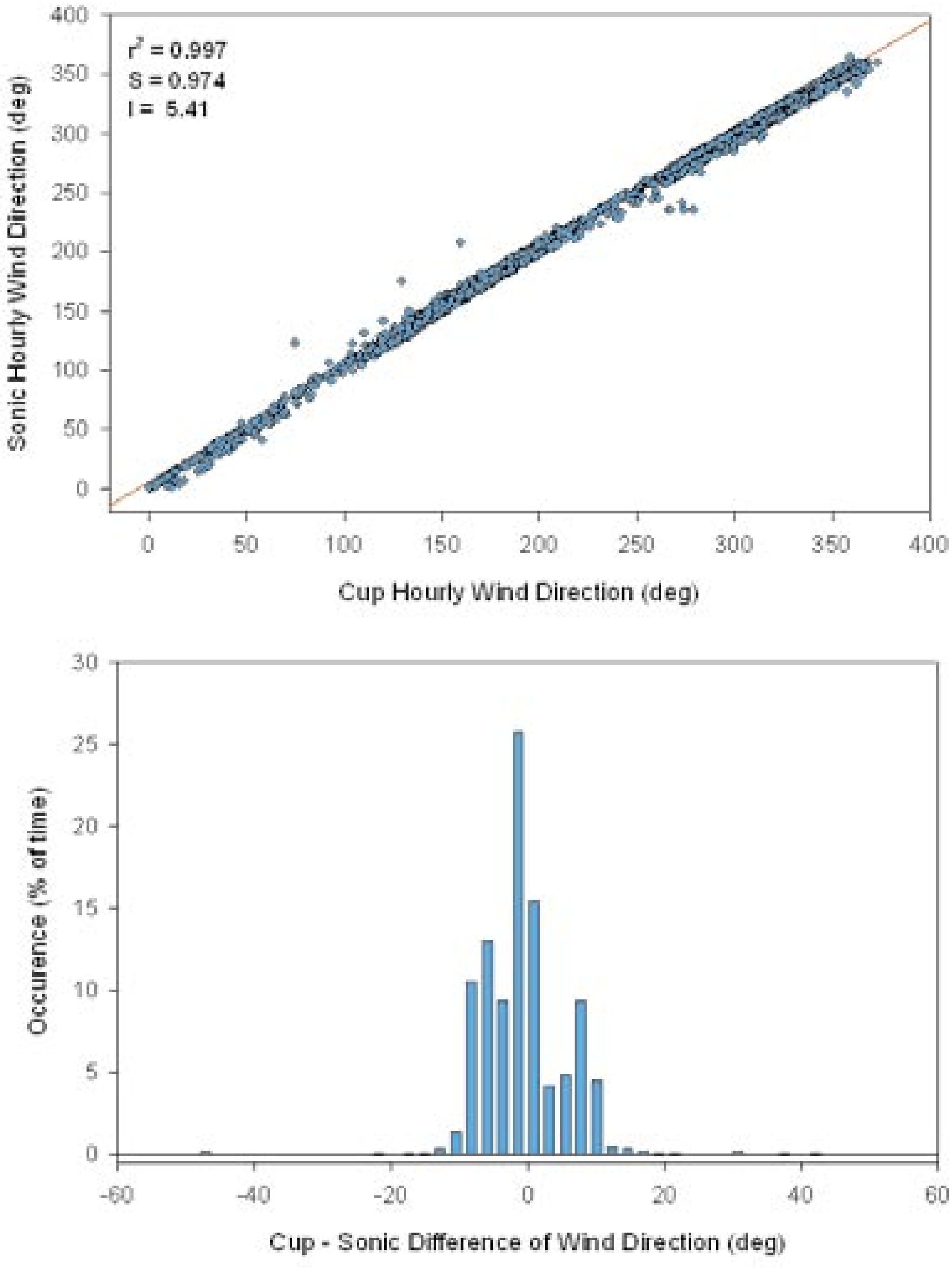


Figure X-4. Discrepancies in hourly averages of wind direction between the cup and the sonic anemometer at the Fernberg site.

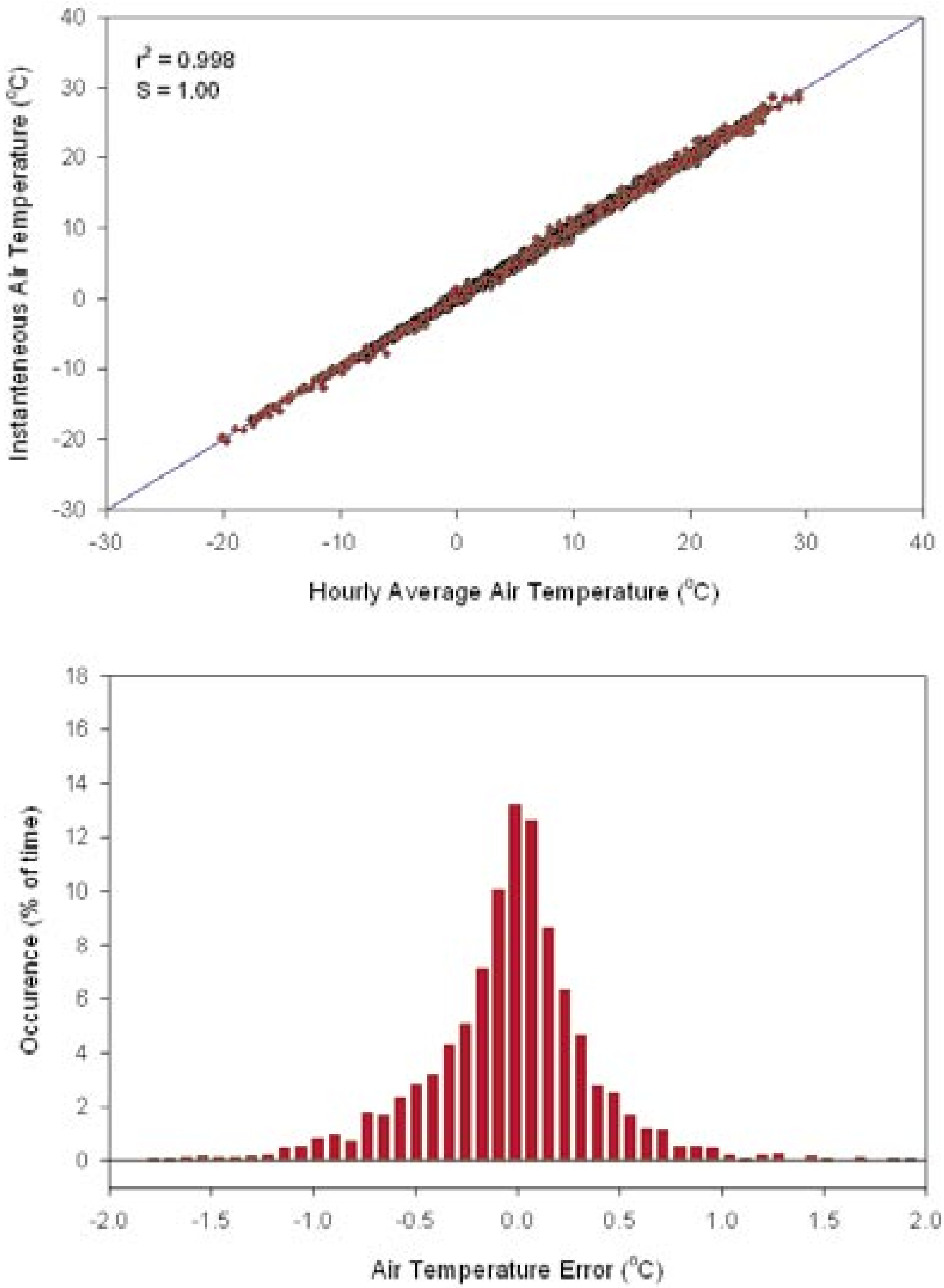


Figure X-5. Deviations of RAWS instantaneous measurements from actual hourly averages for ambient temperature at the Fernberg site.

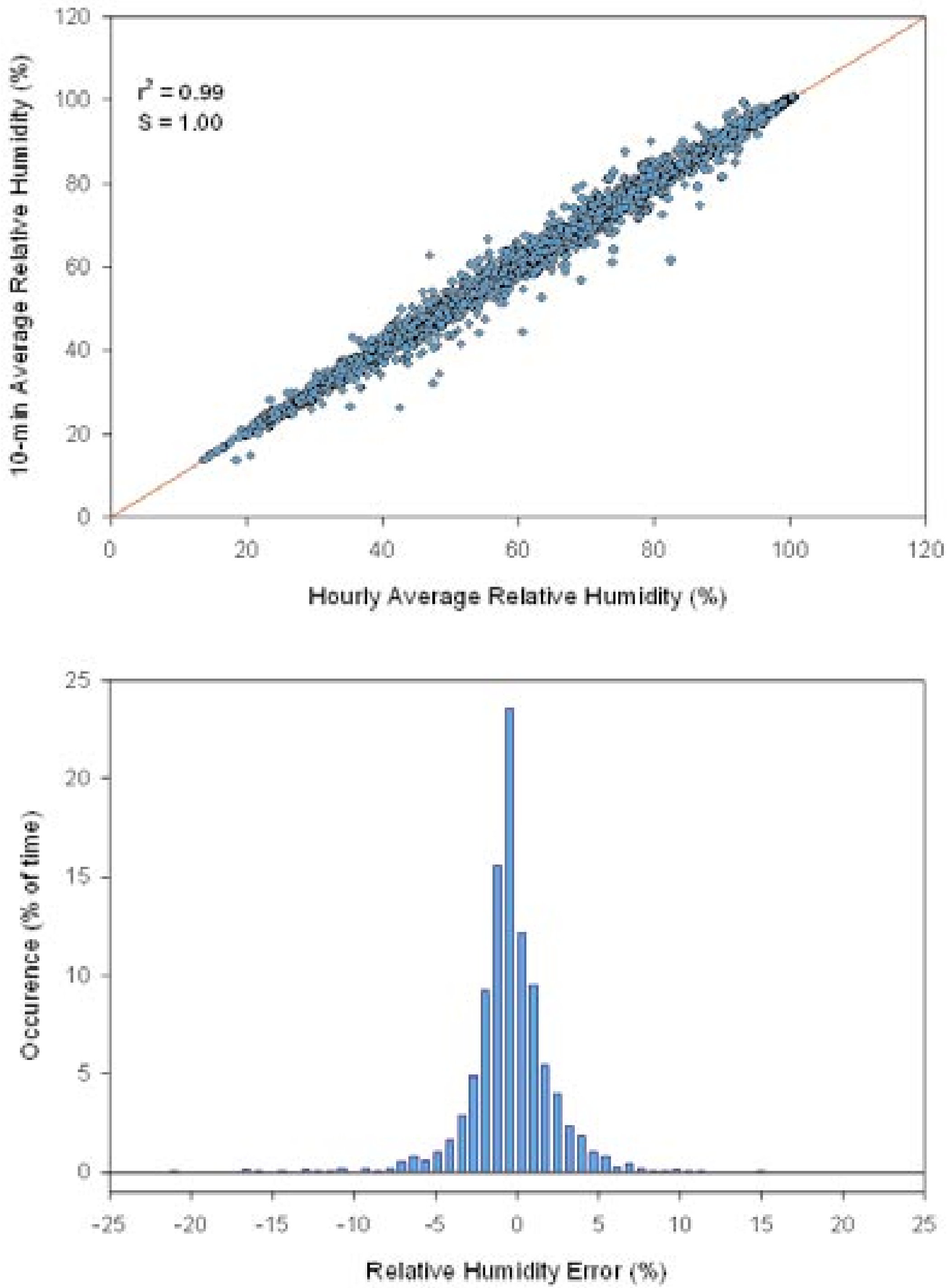


Figure X-6. Deviations of reported RAWS 10-minute measurements from actual hourly averages for relative humidity at the Fernberg site.

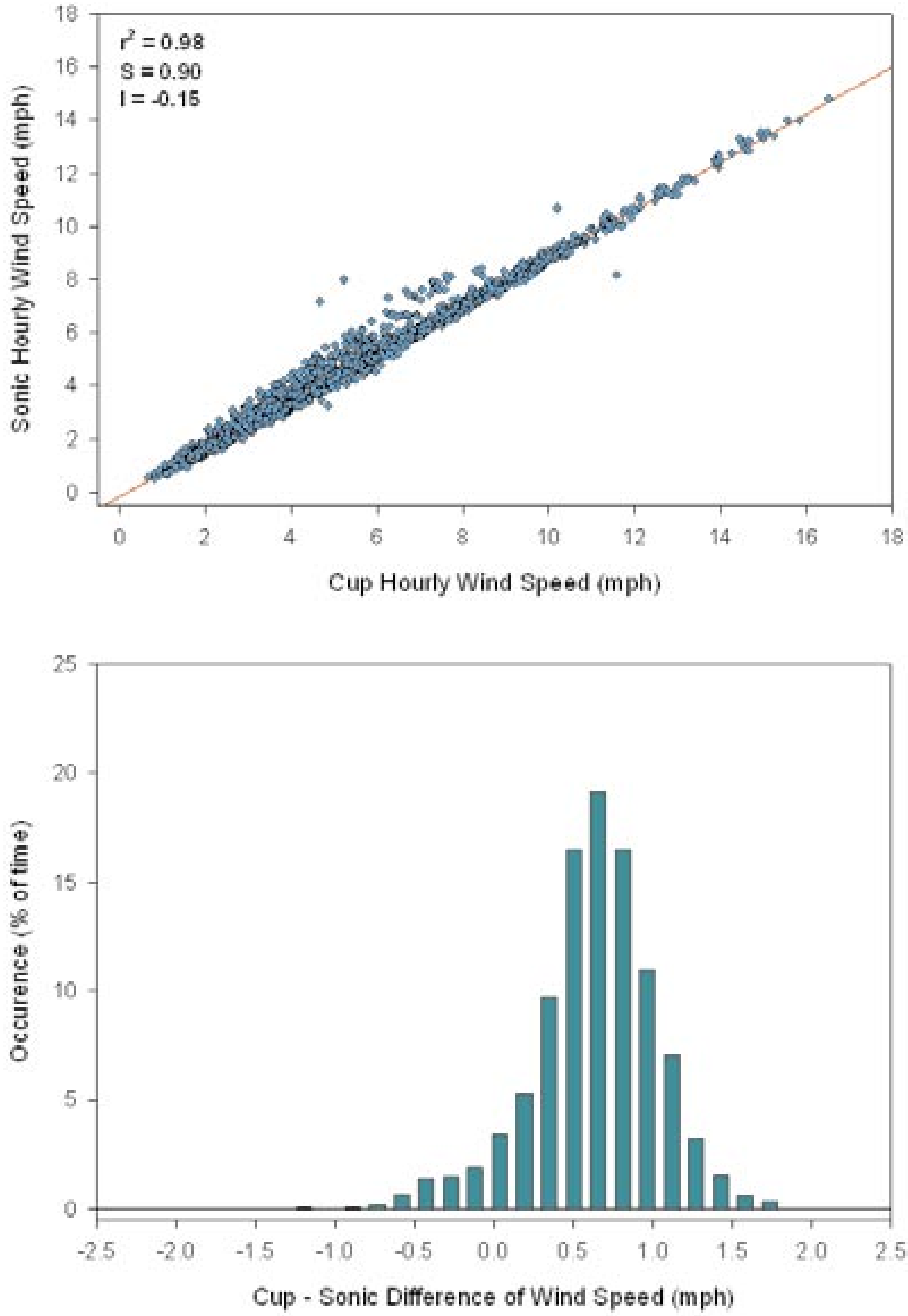


Figure X-7. Discrepancies in hourly averages of wind speed between the cup and the sonic anemometer at the Fernberg site.

Appendix Y. Comparison of KCFast and WRCC Data Sets

The table below presents the results from a study comparing the KCFast and WRCC data sets (i.e., supposedly the same data) from four RAWS: Lake George, Cheeseman, and Redfeather in Colorado and Doyle in California. The figures below present the results from a study comparing the KCFast and WRCC data sets from two RAWS: Cheeseman in Colorado and Doyle in California.

Table Y-1. Correlation coefficients (R^2) and regression slopes (S) between values of NFDRS indicies and components estimated from KCFast and WRCC data archives.

		Cheeseman	Lake George	Redfeather	Doyle
Spread Comp.	Mean Values	$R^2 = 0.85$ S = 0.97	$R^2 = 0.94$ S = 0.99	$R^2 = 0.90$ S = 0.99	$R^2 = 0.86$ S = 1.08
	Maximum Value	$R^2 = 0.70$ S = 0.96	$R^2 = 0.92$ S = 1.00	$R^2 = 0.69$ S = 0.99	$R^2 = 0.66$ S = 1.04
Energy Release Comp.	Mean Value	$R^2 = 0.98$ S = 0.99	$R^2 = 0.99$ S = 1.00	$R^2 = 0.99$ S = 1.00	$R^2 = 0.99$ S = 1.01
	Maximum Value	$R^2 = 0.95$ S = 1.00	$R^2 = 0.99$ S = 1.00	$R^2 = 0.98$ S = 1.00	$R^2 = 0.98$ S = 1.00
Burning Index	Mean Value	$R^2 = 0.94$ S = 0.98	$R^2 = 0.97$ S = 0.99	$R^2 = 0.95$ S = 1.00	$R^2 = 0.96$ S = 1.04
	Maximum Value	$R^2 = 0.73$ S = 0.99	$R^2 = 0.95$ S = 0.97	$R^2 = 0.74$ S = 0.99	$R^2 = 0.83$ S = 1.03
Ignition Comp.	Mean Value	$R^2 = 0.93$ S = 0.97	$R^2 = 0.97$ S = 0.99	$R^2 = 0.94$ S = 0.99	$R^2 = 0.95$ S = 1.04
	Maximum Value	$R^2 = 0.78$ S = 0.99	$R^2 = 0.94$ S = 0.99	$R^2 = 0.80$ S = 1.00	$R^2 = 0.82$ S = 1.01

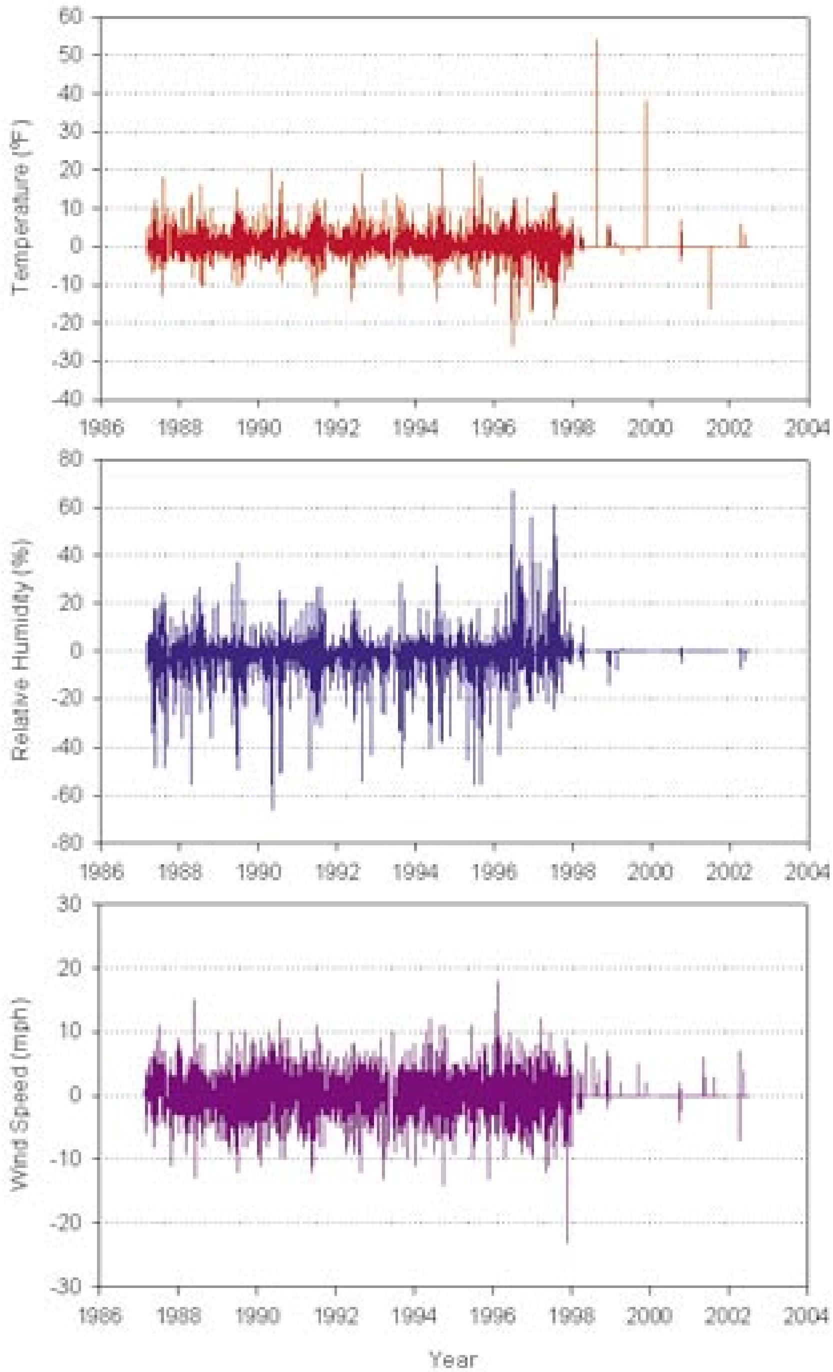


Figure Y-1. Temporal dynamics of the discrepancy (i.e., the arithmetic difference) between 1300-hour meteorological observations for the same data provided separately by WRCC and by KCFast for Cheeseman RAWS in Colorado.

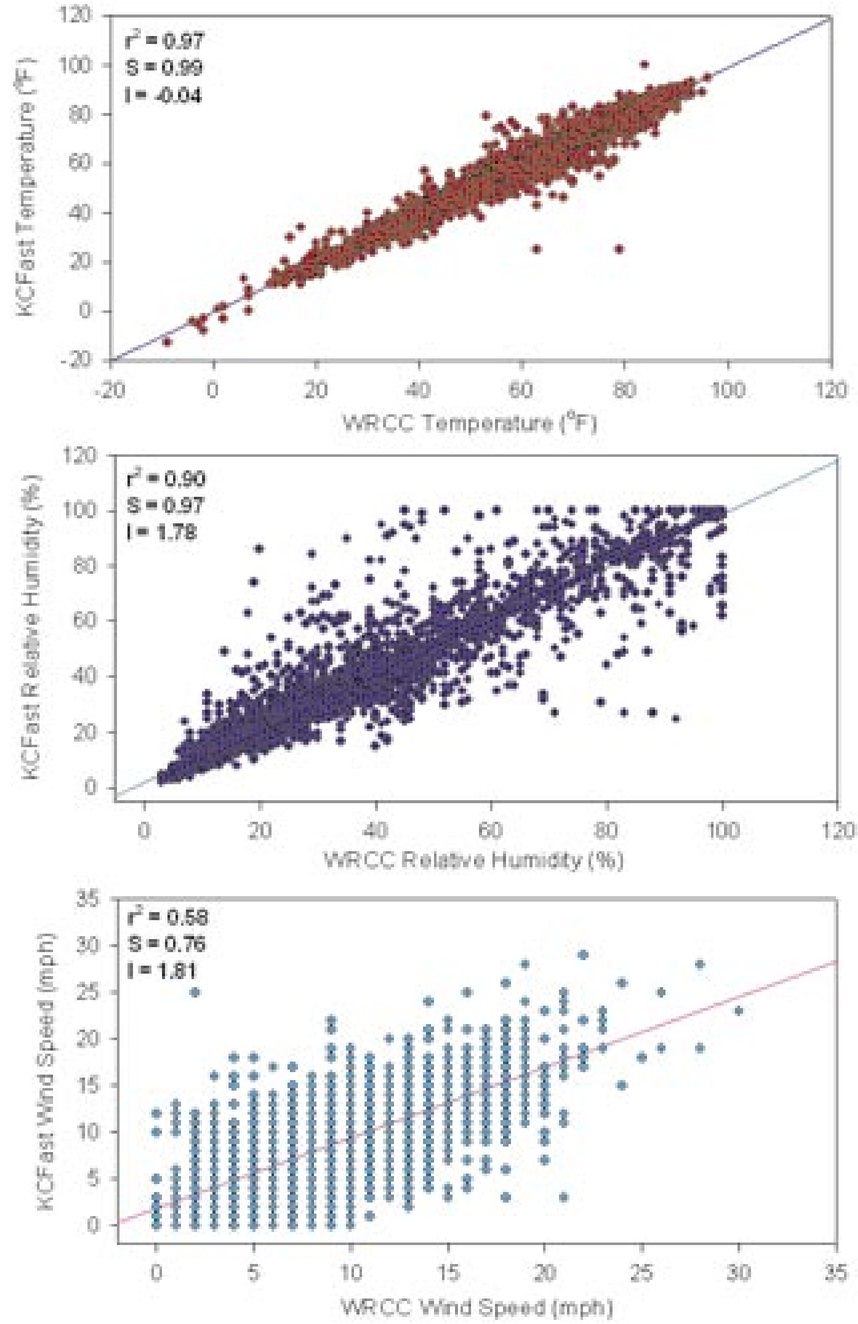


Figure Y-2. Comparison between 13:00-hour meteorological observations provided by WRCC and KCFast for Cheeseman RAWS in Colorado. Statistics include: r^2 = correlation coefficient, S = regression slope, and I = intercept.

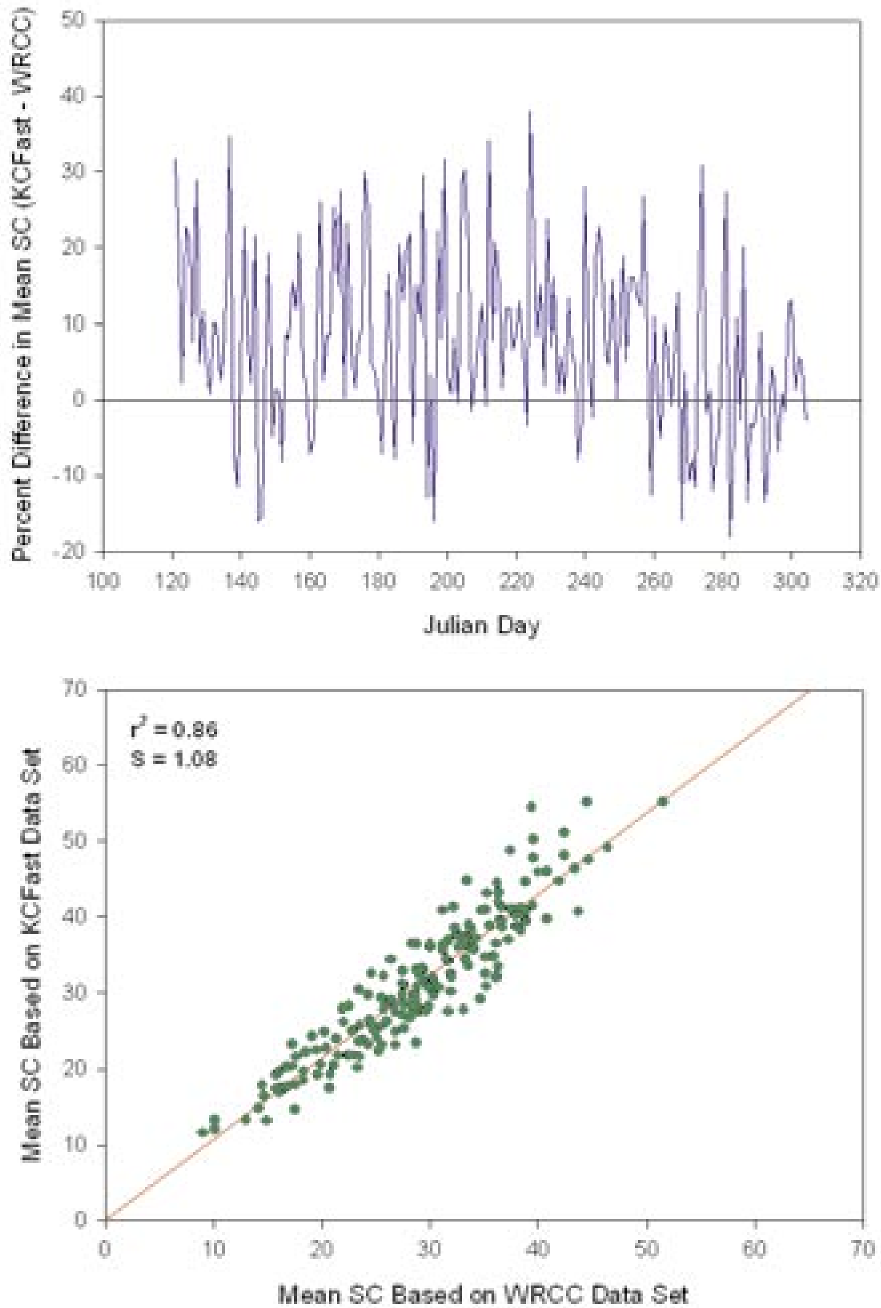


Figure Y-3. Comparison between mean values of the Spread Component (SC) computed from meteorological data provided by WRCC and KCFast for Doyle RAWS in CA: (a) daily dynamics of the difference (in %) between the two estimates; (b) correlation between the two estimates (r^2 = correlation coefficient, *S* = regression slope).

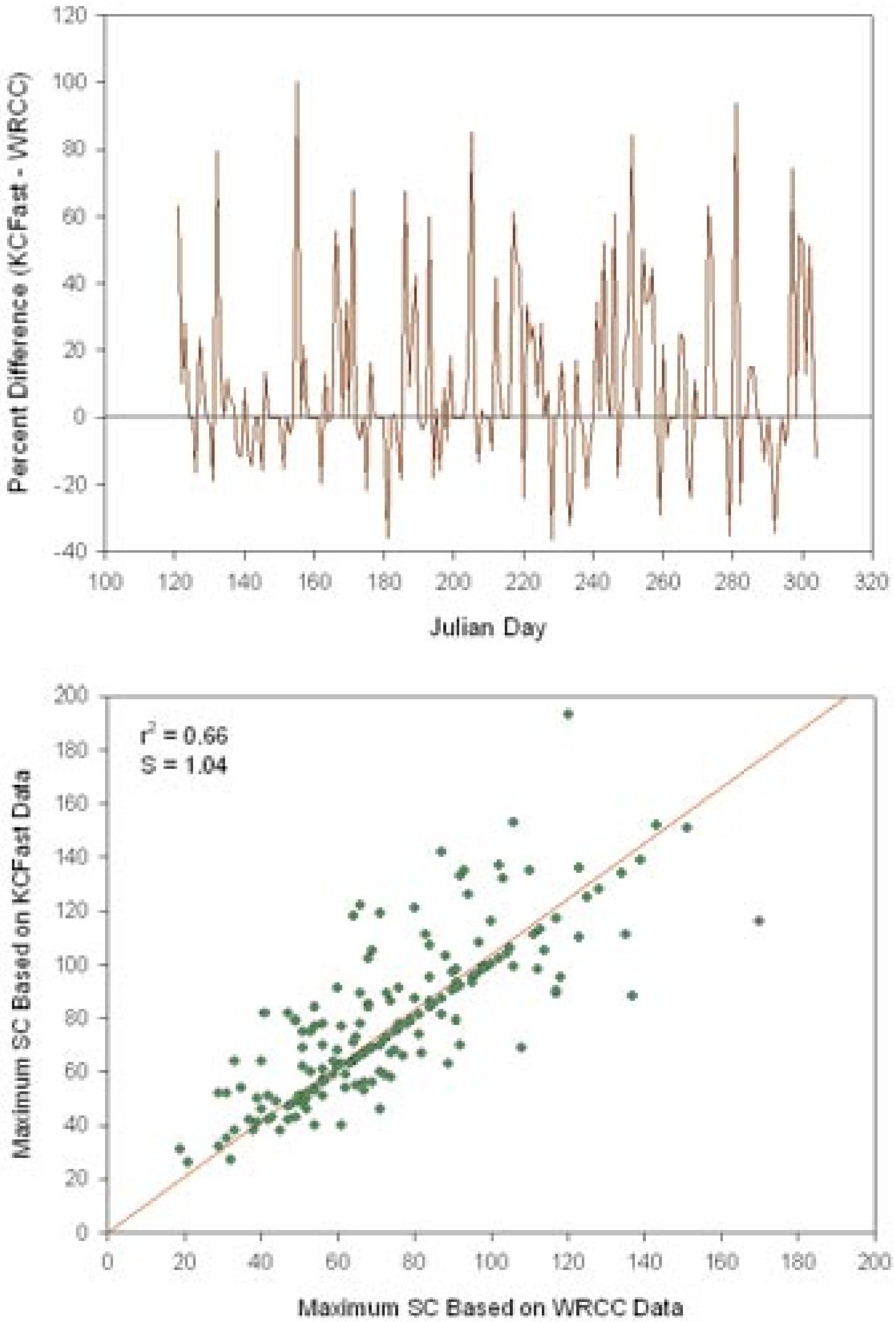
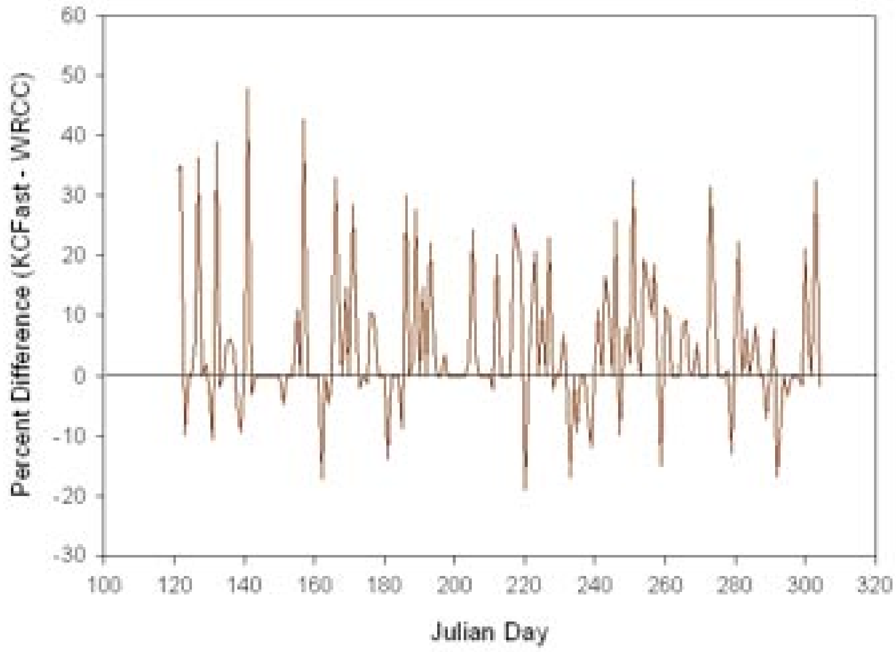


Figure Y-4. Comparison between maximum values of the Spread Component (SC) computed from meteorological data provided by WRCC and KCFast for Doyle RAWS in CA: (a) daily dynamics of the difference (in %) between the two estimates; (b) correlation between the two estimates (r^2 = correlation coefficient, S = regression slope).



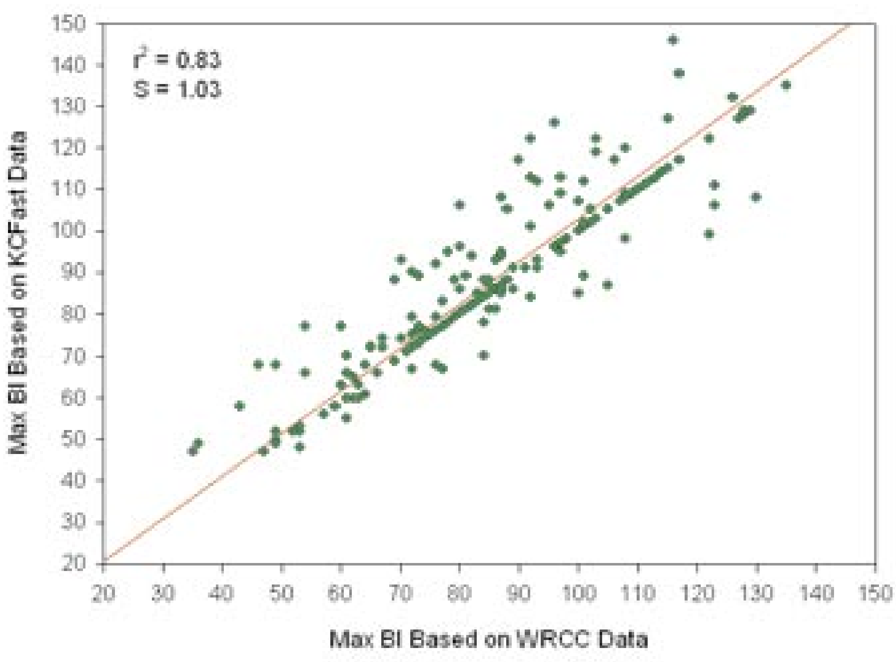


Figure Y-5. Comparison between maximum values of the Burning Index (BI) computed from meteorological data provided by WRCC and KCFast for Doyle RAWS in CA: (a) daily dynamics of the percent difference between the two estimates; (b) correlation between the two estimates (r^2 = correlation coefficient, *S* = regression slope).

Appendix Z. RAWS Contacts at Regional and National Levels of USFS, NPS, and FWS

This Appendix contains a contact list for personnel at regional and national levels for USFS, NPS, and FWS. The e-version contains e-mail links via Lotus Notes. This list as of July 3, 2002.

Forest Service

RAWS Contacts

Name	*Phone*	*e-maillinks, via Lotus Notes*
	BLM Remote Sensing Support Unit:	
Buddy Adams	208-387-5475	buddy_adams@nifc.blm.gov
	USFS National RAWS Coordinator:	
Kolleen Shelley	208-476-8362	kshelley@fs.fed.us
Linnea Keating	208-476-8312	lkeating@fs.fed.us
	USFS Regional RAWS Coordinators:	
R01 - Bruce Thoricht	406-329-4875	bthoricht@fs.fed.us
R02 - Dave Clement	303-275-5791	dclement@fs.fed.us
R03 - Chuck Maxwell	505-842-3419	cmaxwell@fs.fed.us
R04 - Tenna Biggs	208-373-4179	tbiggs@fs.fed.us
R05 - Beth Little	530-226-2710	blittle@fs.fed.us
R06 - Neal Wurschmidt	541-416-6820	nwurschmidt@fs.fed.us
R08 - Eddy Holt	423-476-9700	eholt@fs.fed.us
R09 - Steve Marien	612-713-7300	stevemarien@fs.fed.us
R10 - Sharon Alden	907-356-5691	Sharon_Alden@blm.gov

NPS Fire Weather Program

Committee Membership

Name / Phone	*Address*	*e-mail links, via Lotus Notes*
Dick Bahr 208 387-5217 NIFC Coord.	FMPC-NIFC 3833 S. Development Ave. Boise, ID 83705-5354	Dick Bahr
Mike Warren 208 387-52 NIFC	FMPC-NIFC 3833 S. Development Ave. Boise, ID 83705-5354	Mike Warren
Marhsa Lutz 907 822-5234 Alaska Region	Wrangel-St. Elias NP P.O. Box 439 Mile 105.5 Old Richardson Hwy Copper Center, Ak 99573	Marsha Lutz
Tim Stubbs 505 785-2232 x367 Intermountain Region	Carlsbad Caverns NP 3225 National Parks Hwy Carlsbad, NM 88720	Tim Stubbs
Doug Alexander 402 221-4994 Midwest Region 605 673-2061x1254	Midwest Regional Office 1709 Jackson St. Omaha, NE 68102 Temp> Jewell Cave NM	Doug Alexander

Don Boucher 202 619-7065 National Capital Region	National Capitol Regional Office 1100 Ohio Dr. SW Room 357 Washington, DC 20242	Don Boucher
Dave Bartlett 307 768-3191 Northeast Region	New River Gorge NR P.O. Box 246 Glen Vern, WV 25846	Dave Bartlett
Mike_Worthington 415 331-6374 Pacific West Region	Golden Gate NRA 1069 Ft. Cronkhite Sausalito, CA 94965	Mike Worthington
Dan Mapstone 601 680-4029 Southeast Region	Natchez Trace Parkway 2680 Natchez Trace Parkway Tupelo, MS 38801	Dan Mapstone
Michelle Hawley 208 387-5475 Technical Spec.	NIFC – RAWS 3833 S. Development Ave. Boise, ID 83705-5354	Michelle Hawley

FISH AND WILDLIFE SERVICE
REGIONAL RAWS COORDINATORS

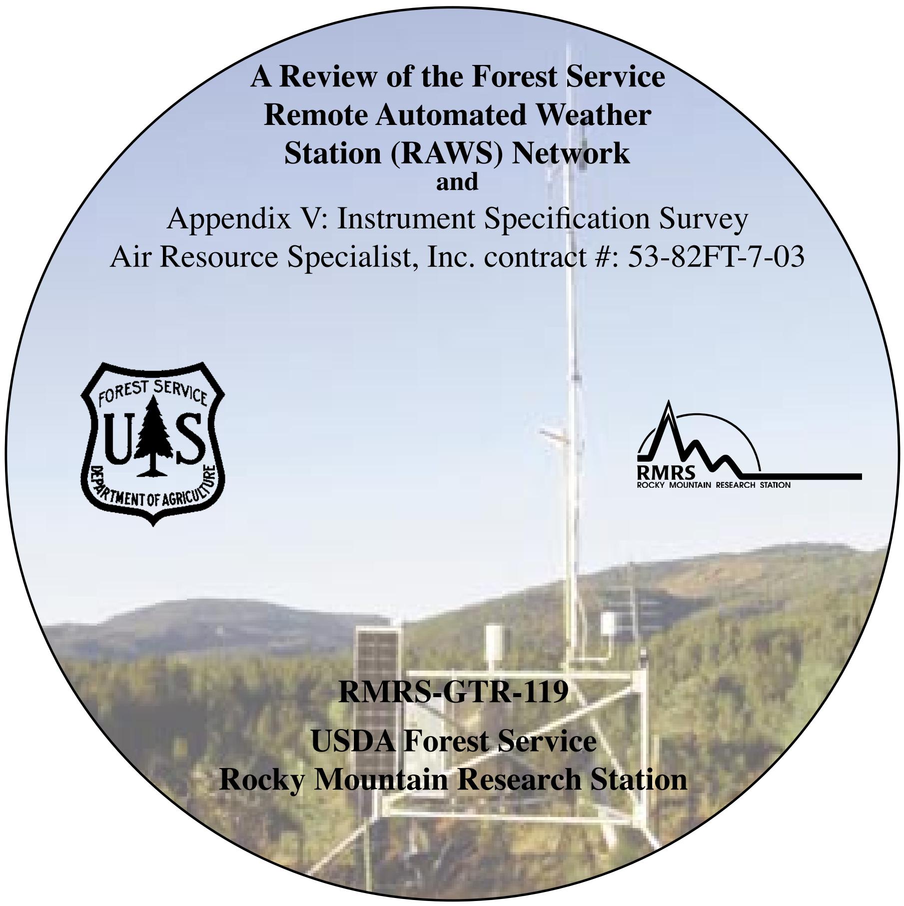
Region	*Coordinator*	*Phone*
R01	Roddy Baumann	503-231-2075
R02	Jeff Whitney	505-248-6474
RAWS Tech / Field Coordinator	Dean Ross	936-875-4786
R03	Meredith Weltmer	612-713-5445
R04	Lynn Howard	404-679-7190
R05	Allen Carter	757-986-3706
R06	Angie Braun	303-236-8145 ext 617
RAWS Tech / Field Coordinator	Shannon Swanson	406-789-2305 ext 111
R07	Larry Vanderlinden	907-786-3654
National Coordinator	Rod Bloms	208-387-5599

Index

A Review of the Forest Service Remote Automated Weather Station (RAWS) Network

and

Appendix V: Instrument Specification Survey
Air Resource Specialist, Inc. contract #: 53-82FT-7-03



RMRS-GTR-119

USDA Forest Service
Rocky Mountain Research Station

RMRS
ROCKY MOUNTAIN RESEARCH STATION

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of the National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

Research Locations

Flagstaff, Arizona	Reno, Nevada
Fort Collins, Colorado*	Albuquerque, New Mexico
Boise, Idaho	Rapid City, South Dakota
Moscow, Idaho	Logan, Utah
Bozeman, Montana	Ogden, Utah
Missoula, Montana	Provo, Utah
Lincoln, Nebraska	Laramie, Wyoming

*Station Headquarters, Natural Resources Research Center, 2150 Centre Avenue, Building A, Fort Collins, CO 80526.