Fire Management Tech Tips

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Equipment and Software for Determining Fireline Production Rates

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PROJECT PROPOSAL

Project Description

The goals of this project were to identify and test equipment and software for use in determining the fireline production rates of handcrews and heavy equipment. The equipment and software should be easy to use, lightweight, affordable, and capable of working in the fire environment. The purpose is to have equipment that could measure production rates for new types of heavy equipment which are being used to construct fireline, and to update the production rates for dozers, and handcrews. It is expected that there would be different types of measuring equipment used for handcrews and equipment.

Problem Statement

There are new types of equipment being used for line construction; traditional logging equipment, and modified logging equipment, yet there are no widely accepted production rates for this equipment. Also, existing production rates for dozers and crews have not been updated in many years. Since the existing production rates were determined there have been changes in crew qualification standards, training, and tool complements. Dozers also have been improved and have more horsepower and capabilities than they did in the past. It would be expensive and inefficient to launch right into a study of production rates without knowing the best equipment and procedures to use. This proposal is only to determine the most reliable equipment to use in a study of production rates. A separate project is necessary for a production rates study; however the information learned here would make it possible to develop an accurate cost estimate and timeframe for a production rate study.

Prior Development

The U.S. Department of Agriculture (USDA) Forest Service's, Missoula Technology and Development Center (MTDC) has an ongoing program for global positioning system (GPS) equipment and some heavy equipment manufacturers have developed equipment that could be used to help determine production rates. Considerable work has been

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done at the USDA Forest Service's, San Dimas Technology and Development Center (SDTDC) to identify mobile computing equipment that could be used in the data collection process.

Project Origin
During our study of new equipment for line construction, we have heard the concern several times that without knowing production rates, people are hesitant to put much reliance on the heavy equipment. Making the production rate information available would help fire managers to know which new equipment could be cost effective. Many fire managers and planners are concerned that the production rate values currently in the Fireline Handbook (PMS 410-1) are outdated and unreliable. Production rates are also being used in the Fire Program Analysis Preparedness Module and the Wildland Fire Situation Analysis program. Accurate production rate values are important so that planners can make reasonable decisions for fire suppression activities and for fire program planning and budgeting. Cost containment and performance based requirements also rely on knowing the expected production rates of various pieces of equipment and different crew types.

EQUIPMENT

The project's primary goal is to find equipment that can be used to accurately determine production rate. The equipment should be easy to use, affordable, able to withstand the extreme conditions of the fire environment, and provide extended service. SDTDC has determined that the following equipment is necessary to complete an accurate production rate study.

1. GPS unit that actively records and stores GPS information. Stored information must be easily accessible and downloadable to a computer. This equipment must also be lightweight and able to withstand the conditions often experienced on the fireline. Both high accuracy and recreational grade GPS receivers are necessary.
2. Customized forms that will record information necessary to complete an accurate production rate study. Ideally, forms will be in an electronic format.
3. Geographic information systems (GIS) database software that will integrate topographic maps and other background images with data collected in the field and can support digital image association.
4. Weather instrument that can accurately measure current weather conditions.

The equipment listed above is readily available in the market today. SDTDC purchased and evaluated several types of equipment and determined the pros and cons of each product as related to usage in measuring production rates.

The following are the descriptions and overviews of the hardware and software products evaluated.

GPS Units
Timex Speed+Distance
The Timex Speed+Distance Program is a personal training device with global positioning capabilities intended to aid in athletic workouts. This system consists of three small devices worn simultaneously for data acquisition to occur. These components are the Timex wristwatch unit, GPS receiver, and the data recorder. Each device runs off batteries. It is cumbersome to operate three separate units compared to other GPS units that have the functionality in a single unit.

Additionally, the Timex came with its own personal training software, Timex Trainer. Unfortunately,

the information obtained from the data recorder is only compatible with the Timex Trainer software, and it is not exportable to other programs.

Garmin Navigation Devices

The Forerunner 301, the Forerunner 201, and the Foretrex 201 were the Garmin devices evaluated in this study. They are all similar in design. Each unit is slightly larger than a typical watch and is intended to be worn on the wrist with an adjustable Velcro strap. The units are self-contained with a built in data recorder and GPS antenna. These units require an AC cable for charging, and with a complete charge, each unit lasts approximately 14 hours. The Garmin Forerunner 301, Forerunner 201, and the Foretrex 201 are all consistent in GPS navigation capabilities when compared to each other.

Forerunner 301

The Garmin Forerunner 301 is an athletic training device with GPS capabilities. The most significant drawback using the Forerunner 301 is that it is only compatible with the accompanying Garmin Training Center Software. This software does not allow users to export data. This makes it impossible to accurately compare or analyze the data. However, an interesting feature found only on the Forerunner 301 is that it comes equipped with a chest-strap heart rate monitor. This may be beneficial in future studies where physical effects of fireline production may be a concern, but for primary purposes of this production rate study, it is unnecessary.

Forerunner 201

The Garmin Forerunner 201 is an earlier version of the Forerunner 301, and has most of the same training and navigation features as the 301. The primary difference between these two units is that the data gathered from the Forerunner 201 can be exported as *.xml, *.txt, or tab-delimited file types. Therefore, data analysis and interpretation can be conducted in Microsoft Excel or Access.

In order to get the information from the device onto a PC and into Excel, an intermediary program, either Garmin MapSource or Forerunner Logbook, is required. Once the data is in either Garmin MapSource or Forerunner Logbook, it can be exported to Excel.

Foretrex 201

While the Forerunner models are intended to be used for personal training, the Garmin Foretrex 201 was designed primarily with personal navigation in mind. The Foretrex 201 has a significantly less complicated user interface compared to the other Garmin devices and the Timex. Once the unit is turned on, it automatically begins collecting GPS data. The Forerunner models require the user to navigate through several menus to activate the navigation and GPS systems.

Through testing it was determined that the Foretrex could be placed inside the firefighters web gear and still obtain a good GPS fix. This placement helps protect the unit and also eliminates the need to have the device on the firefighter's wrist, where it could be exposed to damage or interfere with the firefighter's work. Placing this device on the crewmembers, provided a daily log of the firefighters movement. This data can then be used to supplement the GPS data acquired with the GeoXT.

Garmin MapSource is used to transfer the GPS data from the Foretrex 201 to the PC. From Garmin MapSource, the data can then be exported to Microsoft Excel or Access.

Trimble GeoXT

The Trimble GeoXT is a personal digital assistant (PDA) with an integrated GPS receiver and antenna. The unit has a 206 MHz Intel StrongArm Processor and runs the Windows Mobile 2003 or Windows Mobile 5 operating system. The unit is relatively larger than the smaller wrist GPS systems such as the Garmin and the Timex units. It weights approximately 1.5 pounds and is carried by hand. GPS data collected with the GeoXT is more accurate than the Garmins' and can be differentially corrected to achieve higher accuracy. This improves the data that is used for determining distance and elevation change.

The GeoXT offers the functionality of a personal computer, containing programs such as Pocket Word and Pocket Excel. Windows Mobile 2003/5 also allows the user to install third party software or customized software to aid in collecting data.

The Trimble GeoXT is also a ruggedized PDA, meaning that it can withstand most of the harsh outdoor conditions. It has an IP54 rating, so it is protected against dust and splashed water. It can also withstand a 3-foot drop onto concrete. Due to the ruggedness of the GeoXT, it is a good device for use on heavy equipment. The GeoXT can be mounted on a piece of heavy equipment and will be able to withstand the constant vibration and shock.

Because of its ability to install customized software and its durability against harsh conditions, this is an ideal unit for data collection and GPS tracking in the field.

Weather Meter
Kestrel 4000 Pocket Weather Tracker
In determining production rates, every effort will be made to identify factors that influence the rates. It is anticipated that there will be a correlation between production rates of handcrews and weather conditions. Therefore, weather observations will be recorded hourly, at a minimum, while observing crews constructing firelines.

The Kestrel 4000 Pocket Weather Tracker is a handheld weather meter that measures, records, and displays the following readings:

1. Barometric Pressure
2. Humidity
3. Temperature
4. Wind Speed
5. Altitude
6. Dewpoint
7. Wind Chill
8. Wet Bulb Temperature
9. Heat Stress
10. Density Altitude

The measurements can be recorded in set intervals; weather conditions can be recorded as often as once every 2 seconds or once every 12 hours. All of the measurements that are saved in the unit's internal memory can be downloaded to a personal computer (PC) or PDA via a serial communication connection. The Kestrel provides several advantages to the field observer who is following handcrews. Since several pieces of equipment are needed for this project, size and weight are important. The small size and light weight of the Kestrel makes it ideal for carrying along the fireline. Its simple user interface, and easy to read screen allow the user to acquire the necessary information easily and quickly.

This is also a rugged unit that is rated at an IP67, which means protection against dust and submersion underwater. Additionally, it has an operational temperature range from 0 °F to 140 °F.

DATA COLLECTION PROTOCOL

Data Information Forms
Although having the appropriate equipment is essential to the success of accurately determining production rate values, it became apparent that direct observation of crews constructing fireline was necessary in order to track the variables that may impact production rates. A matrix was developed to gather the necessary data that would allow researchers to have access to the variables of interest. This form is appendix A. Working with the National Interagency Coordination Center and the Incident Commanders/Area Commanders Group, procedures were developed to have an SDTDC observer dispatched to a fire and work with the Incident Management Team to facilitate the observation of crews constructing fireline.

Field Test
During the 2005 fire season several observations were made of Type I, Interagency Hotshot Crews, during fire suppression activities on fires in Arizona, Oregon, and Washington. Working with the Incident Management Teams' Operations Section Chief and Division Supervisors, crews that would be constructing handlines were identified for a specific operational period. An observer from SDTDC then spent the entire operational period "shadowing" the crew. Throughout the operational period, weather, topographical, fuel model, and

loading, and other data were collected on an hourly basis. GPS measurements were recorded constantly and distance measurements also were recorded using a steel tape. The Trimble GeoXT was carried by the observer and used to collect a GPS line feature. One or more Garmin Foretrex 201's were placed in the web gear of individual firefighters. At a minimum, digital pictures were taken at each hourly observation point.

These field tests provided an opportunity to test the equipment, software, and data matrix developed for this project. The field tests proved invaluable in refining the field methods as well as improving the data collection forms. Important feedback was received from the Interagency Hotshot Crews that were observed and the incident management teams that supported these efforts.

SOFTWARE

National Geographic TOPO! Software

TOPO!Pro 3.8

TOPO!Pro 3.8 is a PC software program that allows the user to view and customize U.S. Department of the Interior, U.S. Geological Survey topographic maps. TOPO!Pro 3.8 allows the user to create GPS waypoint lists, add coordinate specific notes and pictures, map and measure routes, and create elevation profiles. This information can be downloaded onto a GPS unit or PDA unit via a universal serial bus (USB) or serial communications with the PC.

TOPO! quad maps are available for each State and can be purchased separately. The State is divided into sections and there are maps on one compact disc for each section. ESRI shapefiles can also be brought into TOPO which allows the field observer to import fire perimeter maps or other files of interest.

National Geographic TOPO!Field Pro

TOPO!Field Pro is an auxiliary software that accompanies the TOPO!Pro 3.8 software that runs on a PC or a portable device such as an iPAQ or the GeoXT running Windows Mobile 2003 or Windows Mobile 5. Using TOPO!Field Pro, users can create customized forms to aid with collection of data. The PDA version of Field Pro is used to interact with these forms while collecting GPS data and viewing the associated background map. FieldPro is intended to integrate information collected in the field with the maps and topographic information created using the TOPO!Pro 3.8 software.

TOPO!Field Pro utilizes Microsoft SQL (MSSQL) Server to create a main database for all the collected information. MSSQL Server allows the user in the field to remotely push data to an office database. Using the reverse process, if changes are made to the forms, or additional maps are required, these files can be sent to the laptop or mobile device from the office. Field Pro has a publish/subscribe function that facilitates the transmission of data among the devices being used.

Once the information is stored in the SQL Server, the data can be queried and reports can be created. MS Access or Excel can also be used to query and create reports.

All the information in the database is linked to features on the topographic map created with TOPO!Pro 3.8. This provides an excellent visual aid for analyzing and determining production rates.

ESRI Arcpad

Arcpad is software intended for mobile GIS applications using PDA's and other handheld devices. Field data can be collected in the field and integrated with other inputs from GPS units, laser rangefinders, and digital cameras. All this information can be overlaid onto a topographic map or other background image.

Arcpad is a very powerful tool for creating GIS applications for the mobile device. However, extensive training is necessary to create the desired forms and functions needed for determining production rates.

SDTDC EXAMPLE EQUIPMENT SETUP

The following is an example of how SDTDC chose and setup their equipment for the production rate study. Ruggedness, ease of use, and the ability to use electronic forms were the main factors in SDTDC's choice of equipment and setup.

1. Main database is created using Microsoft SQL server.
2. Electronic forms are created using TOPO!Field Pro. Hard copy forms are also available.
3. The electronic forms are pushed to the Trimble GeoXT, a ruggedized PDA with an internal GPS receiver and antennae.
4. The Trimble GeoXT is used to collect the following data in the field:
    a. GPS coordinates, line features.
    b. Topographic and weather information related to determining production rate.
5. The Kestrel Weather Tracker is used to determine weather conditions.
6. Digital camera to capture images which are associated with the GPS coordinates.
7. At the end of the day, field data on the Trimble GeoXT is transferred to a laptop.
8. A laptop with internet connection pushes newly collected information to a desktop server located in a remote office.
9. Information can be viewed through TOPO!Pro 3.8 and the appropriate State map.
10. MSSQL, Excel, or Access can be used to analyze data and create the reports to determine production rates.

Although the system as a whole may be considered user-friendly, the initial setup and routine maintenance may require technical support. Some knowledge of SQL language and basic database design is needed to create and setup MSSQL.

CONCLUSIONS

In order to determine fireline production rates accurately, a combination of reliable equipment and direct observations are required. The equipment discussed in this report can be obtained easily and will provide reliable service in the fire environment. Although the TOPO! Software requires more effort to customize initially it will improve the efficiency and quality of the data collected. Data analysis is simplified using a well designed database.

The equipment used in the field test will be utilized in determining fireline production rates for handcrews and equipment in a future SDTDC project when funding is available.

APPENDIX A

Fireline Production Rate Observation Forms **Date**_____

Observation Crew Information

Crew Leader _____

Crew Members _____

Time on shift _____

End of shift_____

Incident Information

Fire Name _____

Fire Number _____

ICP Phone Number_____

ICP Location _____

Complexity Level_____

Equipment

GPS

Model_____

SDTDC #_____

KESTREL

Model _____

SDTDC #_____

PDA

Model_____

SDTDC #_____

Incident Management Team

Team Name	Name	Phone	e-mail
Incident Commander			
Deputy IC			
Safety Officer			
Operations Section Chief			
Operations Section Chief			
Point of Contact			

Fire Location

State(s) _____ _____

Ownership(s) _____ _____

Fireline Production Rate Observation Forms

Fire Suppression Crew Information **Date** _____

Crew Name _____

Crew Type I (IHC) I II III II (IA) Other _____

Contact _____ _____

Home Unit _____ Year Established _____

# of crew members _____

Crew Superintendent_____

Phone _____

e-mail_____

Years Experience*	# of Crew	Qualifications**	# Years
1		Superintendent	
2		Asst. Sup. / Captain	
3		Asst. Sup. / Captain	
4		Squad Boss	
5		Squad Boss	
5 – 10		Squad Boss	
10 – 15		Squad Boss	
15 +		Other	

***Years Experience**

List number of crew members by years of experience on this type of crew.

****Qualifications**

List number of years the individual has been qualified and actively engaged in this position. Include years with other crews, not just the current crew assignment.

Days on current assignment _____

Number of assignments this season _____

Number of days on assignments this year _____

Fireline Production Rate Observation Forms

Daily Fire Suppression Crew Report **Date** _____

Operational Period ❑ 0600-1800 ❑ 1800-0600 ❑ 24 Hour

Tool Type	Amount
Pulaski	
McLeod	
Rake	
Shovel	
Lookouts	

Tool Type	Amount
Combi	
Specialty	
Specialty	
Chainsaw	

Time on Shift _____ _____

Drive time to fire _____ _____

Hiking time to line _____ _____

Hiking distance _____ _____

Time arrived on line _____ _____

Line construction start time _____ _____

End of shift _____ _____

Comments _____

_____

_____

_____

_____

Fireline Production Rate Observation Forms

Hourly Observations* **Date** _____

Time_____ Temp_____

Lat _____ RH _____

Long _____ Wind Speed _____

Fuel Model_____ Wind Direction _____

Slope %_____ Slope Aspect_____

# of Lookouts_____ Elevation_____

Safety Issues

Fire Behavior	❑ Crowning	❑ Torching	❑ Spotting	❑ Ground
Flame Height	❑ 0 – 1 FT	❑ 2 – 4 FT	❑ > 4 FT	
Fire activity	❑ Backing	❑ Head	❑ Flank	
Slash	❑ Heavy	❑ Moderate	❑ Light	❑ None
Brush Height	❑ 0 – 2 FT	❑ 2- 4 FT	❑ 4 – 6 FT	❑ > 6 FT
Canopy	❑ Open	❑ Closed		
Fuel Loading	❑ Continuous			
Image Reference Number(s)				

Fireline specifications

Direct	❑ Scratch	❑ Under Slung	❑ Cup Trench	
Indirect	❑ Scratch	❑ Under Slung	❑ Cup Trench	
Width	❑ 0 – 12 in	❑ 1 – 2 ft	❑ 2 – 3 ft	❑ > 3 ft
Brush/Ladder Fuel Removal **Width**	❑ 1 – 2 ft each side of line	❑ 2 – 3 ft each side of line	❑ 3 – 5 ft each side of line	❑ > 5 ft each side of line
Brush/Ladder Fuel Removal **Height**	❑ 1 – 2 ft	❑ 2 – 3 ft	❑ 3 – 5 ft	❑ > 5 ft

Fireline specifications

Felling # of Sawyers _____ # of Brushers _____

Line Scouting _____

Measured Distance from Last record _____

Rest periods

Start _____ Start _____ Start _____ Start _____ Start _____

End _____ End _____ End _____ End _____ End _____

*If there are significant changes in any of these conditions the observation crew will record a new data point to log that information, such as, if wind speed increases or decreases significantly, the crew will take a new reading of all the values to help correlate these factors with production rates.