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Forestry GIS Applications in Fuels Mapping With Confederated Salish & Kootenai Tribes

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Abstract

Student Conservation Association (SCA) interns, working with ESRI and GCS-Research staff, developed an ArcPad application to collect wildland fire fuels data for the Confederated Salish & Kootenai Tribes (CSKT) Montana. Data were aggregated into a coverage for the tribe's ArcGIS 8.3 database, enabling SCA interns and CSKT fire management staff to calculate the fire risk to specific areas on the Flathead Reservation. This is the first ArcPad application for the USGS and USFS FireLab FIREMON program (Fire Effects Monitoring and Inventory Protocol) designed to appraise wildfire potential. The project required CSKT Tribal Council approval for accessing Reservation data and inter-agency cooperation at local and national levels. It was supported by a consortium of members, including CSKT, ESRI, Trimble, SCA, National Interagency Fire Center, Bureau of Indian Affairs, Electronic Data Solutions, and GCS-Research.

Introduction

The Student Conservation Association (SCA) is the nation’s oldest provider of conservation internships. Its mission is to develop the next generation of conservation stewards and leaders.

Founded in 1957, SCA annually places thousands of high school and college interns across all 50 states. Interns serve in a wide range of disciplines and projects under national cooperative agreements with USFS, BLM, NPS, FWS, USGS, BIA, Army Corps of Engineers and Department of Defense agencies. Internships span the spectrum of agency needs from cultural to natural resources, and from data collection to monitoring and restoration.

As resource agency needs have changed, SCA has enhanced its ability to support those needs. Along with recruiting highly-motivated and skilled interns from across the country, SCA is now training, outfitting and supervising them as natural resource teams.

SCA and Fuel Load Mapping With Tribes

The Student Conservation Association, in partnership with the Confederated Salish and Kootenai Tribes (CSKT) deployed a team of college interns to collect vegetation data using Fire Effects Monitoring and Inventory Protocol (FIREMON) protocols. This partnership developed baseline vegetation and stand information to enable the tribes to prioritize, implement and monitor fuel reduction projects. It also supported them with modeling fire behavior, conducting burned area assessments and monitoring post-fire conditions.

The project team included staff from SCA, CSKT, ESRI, Geographic Communication Systems - Research (GCS-Research), Trimble, Systems for Environmental Management (SEM), Electronic Data Solutions (EDS), Bureau of Indian Affairs (BIA), National Interagency Fire Center (NIFC) and USDA Forest Service Fire Sciences Laboratory (FSL)

Interns served varied lengths of service from six to 12-month terms, beginning spring, 2003. They sampled plots using ESRI ArcPad 6.1 FIREMON applications, installed on Trimble GeoXT handheld computers. Data were collected on reservation lands, as identified by the tribal fire management officer, tribal fuels specialist or their designate. Training in FIREMON sampling methodology and survey protocols was provided by FSL and GCS-Research, while SCA trained in field applications, data management and GIS outputs.

The SCA FIREMON Project

FIREMON was developed by Systems for Environmental Management to provide uniform monitoring protocols for wildland fire. As stated at the FIREMON website, wildland fire monitoring is “critical for (1) documenting fire effects, (2) assessing ecosystem damage and benefit, (3) evaluating the success or failure of a burn, and (4) appraising the potential for future treatments.”

In 2003, SCA launched an effort with BIA and the National Interagency Fire Center (NIFC) to deploy interns using FIREMON for fuels mapping on the Flathead Reservation, MT. This effort resulted in developing sampling methodologies and populating a FIREMON data layer for the Reservation’s geospatial data set.

Major components of the project emerged. SCA’s interns and agency colleagues created (1) a sample design, (2) field data collection protocols, (3) data analysis protocols; and (4) techniques for populating a GIS vegetation layer using ESRI ArcPad and ArcGIS.

The materials and methods used in the 2003-04 pilot include: FIREMON for collecting plot data – aspect, treatment type, fuel model; tree data – mature, seedling, sapling; fuels data – duff/litter, vegetation; GPS for collecting points and attaching plot digital photos; GIS for enhanced data analysis and use in the field – such as running ArcPad on a handheld, field computer; Forest Vegetation Simulator – for simulation of prescribed burns and fuels reduction projects; and using Farsite for modeling fire behavior.

Project Team

This project is reviewed and guided by an interagency team representing federal, corporate and non-governmental organizations. This includes representatives from each participating tribe, BIA, NIFC, USFS Fire Sciences Lab, SEM, GCS-Research, ESRI and the Student Conservation Association.

SCA supervises and coordinates its role in this partnership through an interdepartmental team comprised of western operations director, director of national program development, FIREMON/LANDFIRE program manager, FIREMON/LANDFIRE technology specialist, and others

Pilot Area Description:

The Flathead Indian Reservation, 1.3 million acres in size, was created by the Hellgate Treaty in 1855 between the U.S. Government and the Bitterroot Salish, Pend d'Oreille, and Kootenai tribes. Land for the tribes' pre-European contact stretched for greater than 20 million acres from western Montana into Idaho, Wyoming, and Canada. [www.cskt.org] Just north of Missoula, Montana, and south of Kalispell, Glacier National Park, the Flathead Indian Reservation's diverse landscape includes the Mission Mountains to the east, a large freshwater glacial lake known as Flathead Lake to the north, the Mission Valley in the center carved by glaciers, the National Bison Range, Flathead River, timber resources, and various streams and reservoirs. The campus of Salish Kootenai College, a nationally renowned tribal college, and S&K Technologies, a tribally owned technology company and one of the largest employers in western Montana, stand in the reservation boundaries.

Fire plays an integral role to many tribal communities, as it has historically. Fire was used to keep the forest understory clear for greater visibility to avoid potential attacks from other tribes, and for better visibility for hunting. Fire was also used as a tactic in conflicts. Many important cultural plants, such as camas and huckleberry, are fire dependent. [Curtis Matt, conversation]

The pilot areas, determined by the CSKT Fire Management Officer and Fuels Manager, focused on the project level in the Wildland Urban Interface (WUI). WUI communities and human developments possess extreme risk to wildfires as they are in juxtaposition or mixed with undeveloped wildland or vegetative fuel. (NWCG Glossary and the 10-year Comprehensive Implementation Plan.) In these areas, fuels, such as down woody debris on the forest floor or little spacing between trees, can create a threat or increase wildfire hazard. Fuels reduction projects, such as thinning and prescribed burning in the forest understory, are part of forest management to help restore the forest to pre-European state and to provide protection to WUI communities in the threat of a wildfire. These treatments are known as WUI and Hazardous Fuels Reduction (HFR).The data collection occurred in these WUI/HFR treatment areas or potential areas for treatment, falling within an elevation of 3000-3500 feet, close to WUI communities, and in timber where shade intolerant ponderosa pine, as the major tree species during pre-European contact, experienced encroachment of shade tolerant Douglas fir species.

Figure 1: Montana with highlighted Flathead Reservation Study Area. (CSKT GIS Program)

Field sampling occurred in Schley, Jette, and Hot Springs areas on the reservation. Previous to the data collection by Student Conservation Association (SCA) interns, fuels monitoring efforts consisted of digital photo records before, during, and after fuels reduction and prescribed burn treatments, as well as Brown's transects to record down woody fuels data before and after these treatments. Brown's transects measure down woody debris that can sustain a forest fire, and measure these fuels by their diameter. (Brown's Transects) CSKT Forestry or Division of Fire utilized GPS and GIS in their treatments by walking with GPS unit around treatment areas, or digitizing by hand with GIS using land ownership coverage boundaries and a road coverage.

As WUI/HFR treatments and prescribed burning projects gained necessity and visibility on the reservation, data showing their effectiveness becomes increasingly useful. Based on the sampling needs and area for CSKT, obtaining the data could be very time and resource costly. A team of interns from SCA could be beneficial to conduct field sampling, and prove to be cost effective.

The SCA team worked with tribal forestry and Division of Fire, as well as the tribal GIS program. Established about 15 years ago in the Natural Resource Department, the GIS program provides mapping and data analysis services for several tribal departments like Forestry, Fire Control, Fisheries, Wildlife, Recreation, Tribal Lands, and others. The CSKT GIS Program currently has over 400 GIS databases at its disposal, generated, mostly 'in-house' for a variety of projects. The GIS data is stored mainly in ESRI coverage format to be used in ESRI's ArcInfo. The Tribal GIS Program is moving towards an Enterprise GIS solution using ArcSDE and ArcGIS(ArcIMS).

Fuels Monitoring Project Methods

The pilot fuels monitoring team began its work in May/June of 2003. After a series of meetings with the interagency partners and some intensive research, the decision to utilize FIREMON was made. It offers monitoring guidelines flexible for any level of monitoring – from well funded, multiple personnel intensive efforts with minimal project resource limitations, to very basic monitoring objectives with low resource availability, such as time, personnel, and money. [www.fire.org/firemon]

The team, under the direction of CSKT fire management officer and fuels manager, established plots for current and potential treatment areas using FIREMON as a method of organizing data. The team beta tested different implementations of FIREMON sampling, from time intensive, statistically sound levels to less time intensive, stratified or representative based sampling called relevé. The goal of relevé plots was to show any general change through a comparison of pre- and post-treatments, not with the intention of using the data for statistical purposes, utilizing "representative" areas of the treatments fitting the classification of the variables needed to monitor.

Field data collection with FIREMON was flexible. Extensive field data collection for a multitude of variables could slow down the collection rate, but neglecting to collect key pieces of information could also eliminate potential applications useful in the future for CSKT. Data that could be used in determining torching and crowning potential, fuels data, and sometimes tree seedling and sapling frequency were important to CSKT. Thus information about tree crowns, tree height, live crown base height (the distance to the first live branch), general tree health, and in some cases a count of tree species seedlings and saplings would be necessary variables to collect in order to achieve these analysis options.

The team's goal was a realistic 20% confidence level on plots that were being collected for statistical purposes. Originally data was collected on paper in the field, then entered into the FIREMON database in the office. FIREMON plots, 0.1 acre in size, were inventoried for basic plot data (PD), fuel load information (FL), and tree data (TD) forms. GPS units collected coordinates for each plot center, marked with flagging and reinforcement bar. Fuels were measured with Brown's transects for down woody debris, duff and litter, and live/dead vegetation cover percentages. A number associated with the general fuel loading of the plot described as an Anderson Fuel Model (ranked 1 through 13 depending on the fuel type and amount) was assigned. Species, health, diameter breast height (dbh), height, live crown base height, and crown percentage was measured for mature trees with a 4.5 foot height or greater, and tree seedlings and saplings (classifications of trees either under 4.5 feet tall or with a dbh less than 4 inches) were measured for species, health, height classes, and crown percentage in one 0.01 acre microplot for each 0.1 acre plot.

Before entering the field for WUI/HFR sampling areas, with the goal of obtaining statistically sound data, plot placement was randomly determined on paper maps to decrease any bias that might occur in the field. Distance between plots and azimuths were predetermined on paper using a compass or a protractor, and keeping elevation in account. This was done for both Schley and Jette WUI treatments, which were sampled with the intention of collecting statistically sound data.

Relevé plot sampling was initiated near Hot Springs in parts of the Corona Road treatment. The representative characteristic that CSKT fuels management targeted in this case was the density of Douglas fir seedling, sapling, and mature trees. Like the statistical sampling plots, potential azimuths and distances between plots were determined on maps before entering the field taking into account small elevation changes. Then in the field plot locations were altered to capture areas representative of heavy Douglas fir seedling and saplings. This flexibility was accomplished by setting azimuths off easily identifiable starting points then adjusting chains between plots as needed.

Basic field equipment, recommended by FIREMON or utilized by the pilot project, included: bright colored flagging, measure tape for transects and plot diameter, diameter/loggers tape to measure dbh, metal ruler for duff/litter depth, clinometers to measure tree heights and slope, go/no go gauge for measuring 1, 10, 100 hour fuels along transects, calipers for 1000 hr fuel diameters, a compass for azimuth readings, digital camera to take north and east photos of plots, a photo board to identify plot numbers in each photo, and a GPS unit for plot location. The team utilized Trimble GeoXT GPS units, donated by Trimble, and ArcPad 6.0.2 software donated by ESRI. ESRI ArcView 3.3, ArcGIS 8.3, and Trimble Pathfinder Office 2.9 were also critical for the pilot project's development[AP2].

For both statistical and relevé plots, easily accessible starting points to reach the predetermined plots were assessed based upon road access. Distances and azimuths between plot centers were recorded using a compass and string box. Distance was measured in chains (1 chain = 66 feet) using a string box and recorded on the field sheet. Azimuths were calculated using a compass, taking into account magnetic declination. The azimuths from plot center to plot center were recorded on the field sheet.

Each plot center was marked with reinforcement bar, hammered so that a couple of inches showing above the ground. The rebar was spray painted red and/or had bright flagging attached to it or surrounding trees.

SCA interns had to keep in mind magnetic declination differs depending upon location and that field maps may have declination from Public Land Survey (PLS) lines that would alter azimuths in the field if they were predetermined on paper.

The monitoring team would always collect fuels data first, next the tree seedling and sapling field data, and finally mature tree data, and always collected data in the plots starting from magnetic north working to the east. This prevented some trampling bias and confusion and saved time.

All plot centers were georeferenced by GPS equipment. Trimble Geo Explorer XT units were utilized with the ArcPad program and GPS Correct, and data was collected in WGS 84, UTM

Zone 11N. At each plot center a minimum of 60 points of data was collected with PDOP of 6 or less (when possible). Orthophotos and parcel data (landownership) acquired from the Natural Resource Information System (NRIS) of the Montana State Library were used as a backdrop (and in ESRI ArcPad 6.0.2 for navigation purposes) during the FIREMON plot data collection. Digital photos were taken facing the north and east directions, with the plot number labeled on a board and placed near the plot center. The photos were hyperlinked to the FIREMON database.

The pilot team experimented with uses of CSKT FIREMON data for Forest Vegetation Simulation (FVS) simulations and projections. FVS, a project of the U.S. Department of Agriculture and the U.S. Forest Service, focuses on forest growth and yield modeling. Since its inception it has grown to include simulations for forestry and fire effects purposes. [http://www.fs.fed.us/fmsc/fvs/] The team utilized FVS through the FIREMON extension, and through FVS Writer to compare the effects for some of the WUI/HFR treatments sampled.

The pilot team also experimented with uses of CSKT FIREMON data for Farsite, which stands for Fire Area Simulator [www.farsite.org]. Farsite is a model that simulates forest fire spread by utilizing a combination of spatial and time sensitive information such as weather, fuels, slope of terrain, and elevation. Farsite runs utilize GIS to grow fire perimeter predictions. The pilot project explored Farsite as a potential use for the data. Tribal GIS department extensively helped the interns create preliminary coverages for Farsite runs, and CSKT fire management officer and fuels manager shed some light on the preliminary runs with their fire behavior experience.

Findings and Recommendations

After one year of this pilot fuels monitoring, several products resulted from the pilot project: improvements to the FIREMON database structure; a FIREMON personal geodatabase for CSKT; a custom built ArcPad application; utilization of fire behavior and forest simulation applications; and expansion of the fuels monitoring project through SCA teams for additional tribes and Indian Reservations.

Through the exploration of the FIREMON methodology and database, the SCA interns dialogued often with the FIREMON lead staff and programmers. Through this symbiotic relationship, the interns received support with their monitoring efforts and enhanced FIREMON through their suggestions. For instance, suggestions in interface improvements for the computer database and in analysis content such as enhancing the export options for Forest Vegetation Simulator (FVS) resulted in the staff's plans to change or in new change to the overall appearance and functions of FIREMON. Questions about fuel loading averages uncovered a calculation error which would have greatly affected fuels management decisions.

GPS data collected in the field by the SCA FIREMON team was stored in a personall geodatabase, currently stored on a server at tribal GIS. With the ability to hyperlink the digital north and east photos to each respective plot, this geodatabase serves as a reference for WUI/HFR projects with the convenience of storage in one place. In conjunction with other necessary GIS data, this database will be used in current and future planning efforts of WUI/HFR projects at the CSKT Division of Fire. The project level scale of this endeavor is also important to note, as most of the fuels data stored in GIS throughout many agencies is of medium or large raster scale (30 meters or larger). The pilot fuels project also served as a call to the need for increased spatial and field data organization, and strengthened the relationship between the tribe's GIS department and Division of Fire.

The pilot team began data collection on paper forms in the field and then entered the collected data into the database on a computer in the office. As this process was cumbersome, the team needed a solution that would save time in the field and office, and prevent data entry error. In response, GCS Research and ESRI embarked on the development of a custom ArcPAD 6.0.2 application for the collection of FIREMON data in the field. First, a personal geodatabase structure was developed upon the FIREMON Access database for the PD, TD, and FL FIREMON protocols. Database relationships were maintained through a custom Import – Export function developed for ArcCatalog. This personal geodatabase structure (associated .dbf files), ArcPad Applet with custom tools for collecting FIREMON plot data, and reference shape files were designed to "check-out" from ArcCatalog using Microsoft ActiveSync 3.7.1.

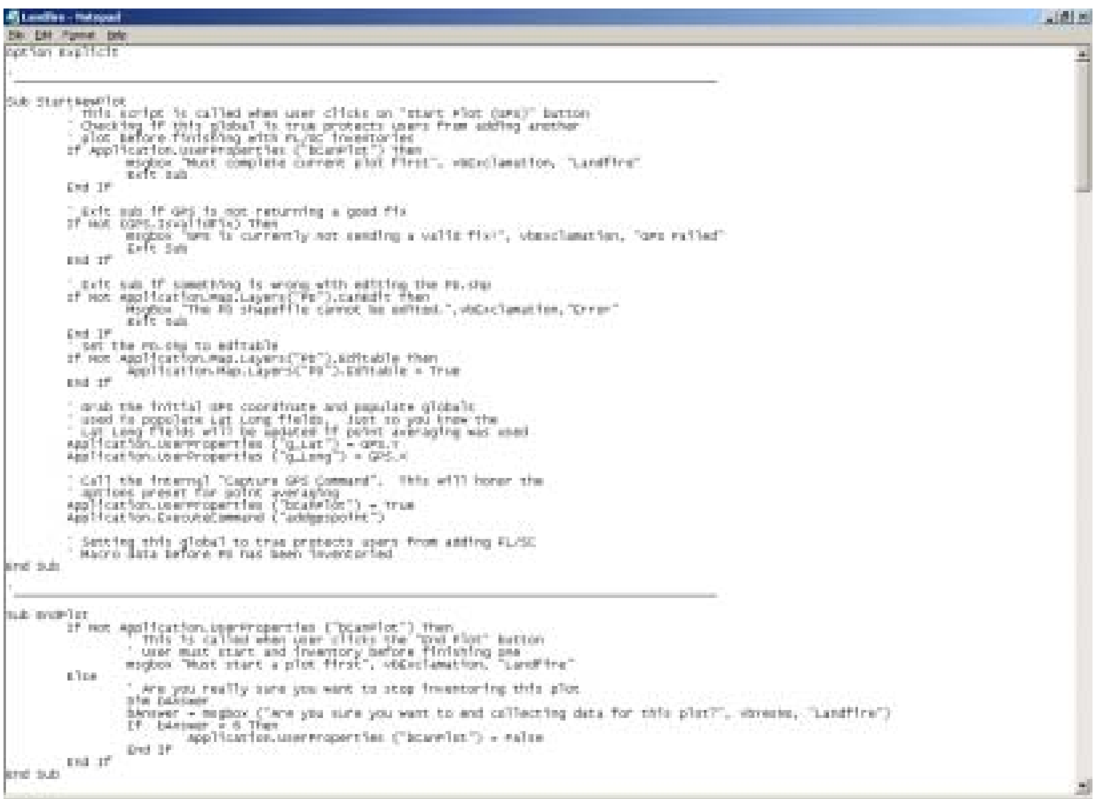

Figure 2: FIREMON ArcPad Applet: GCS Research and ESRI developed a custom ArcPad application for FIREMON. Figure 1 shows the VB-Script coding for the application, which is also being deployed for other federal field data collection efforts based upon the FIREMON Access database structure.

The exported personal geodatabase was then stored on a Trimble GeoXT device along with any other reference data necessary for navigation to the selected field plots. Field data and associated GPS coordinate for the plots were then collected with the GeoXT device. Once data collection had been completed, students used ArcCatalog "Check-In" routine to import the FIREMON plot data and automatically updated the FIREMON Access database maintained on a local laptop computer. Student interns then had the ability to both update and edit the FIREMON data using ArcMap and/or the FIREMON application as well as analyze the spatial data associated with plot locations and the study areas located select areas of the wildland-urban interface (WUI).

The ArcPad application has undergone multiple iterations over the course of 2003-2004 beta program. Enhancements and improvements to the ArcPad Applet were developed through an interactive process involving SCA, GCS Research, and ESRI. Improvements and workflow were developed. The ArcPad Applet was developed using ESRI's ArcPad Developer platform and custom Visual Basic scripting language.

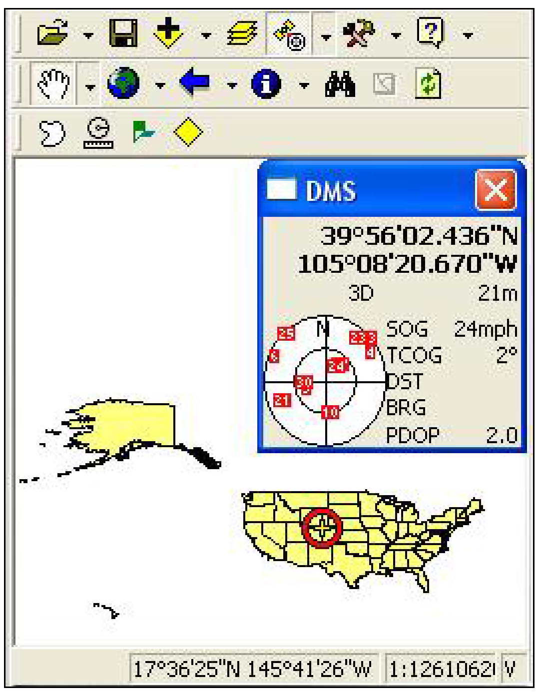

Figure 3: ArcPad Application – Custom Tool Bar. This view shows FIREMON application in process. The FIREMON tool bar has been customized to mirror the FIREMON Access database forms, respective fields, tables, and overall database structure.

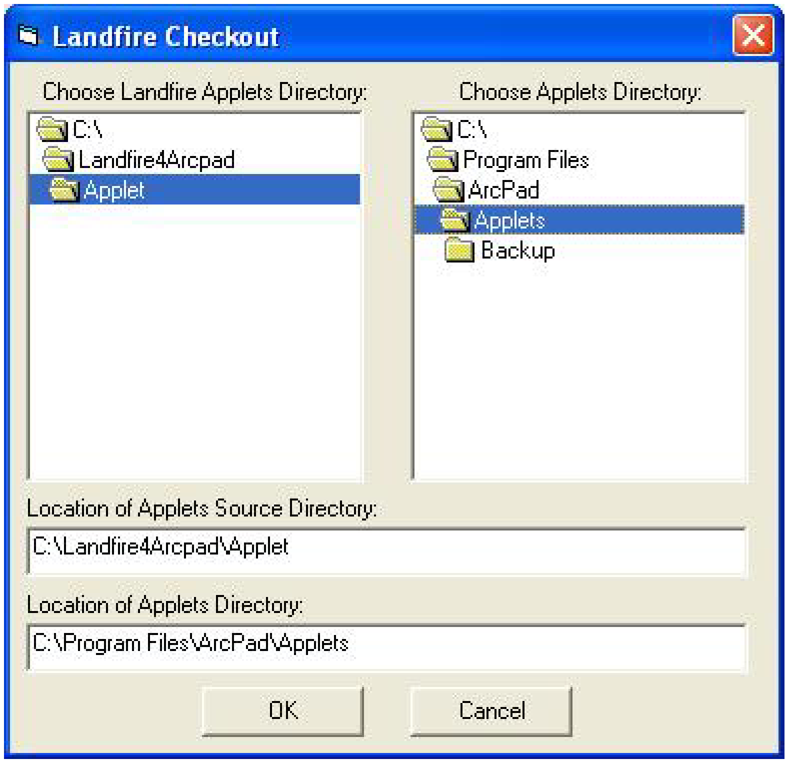

Figure 4: ArcCatalog Checkout Process. In addition, FIREMON is synchronized with field-ready PDAs through the use of a custom "Check-in" and "Check-out" procedure developed as ArcCatalog tool. The user determines the location of the FIREMON application residing on the desktop and the directory destination on the PDA, which is synchronized using Microsoft ActiveSync 3.7+.

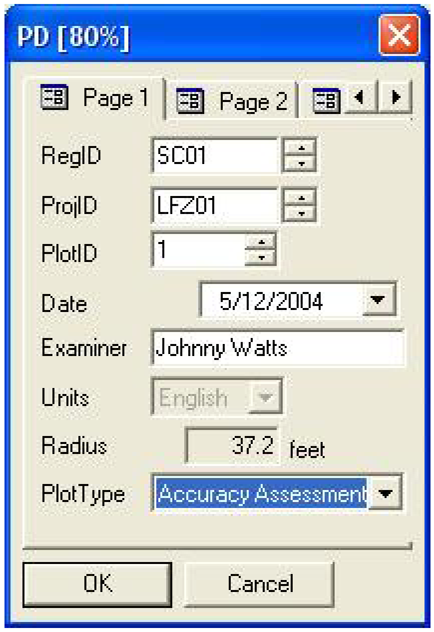

Figure 5: Plot Description Form – Personal Geodatabase Master File. Once an active GPS signal has been acquired and location has been determined, it is now possible the end-user to begin collecting data vis a vis the mobile FIREMON application. The PD (Plot Description) form is the first form that must completed during the data collection process, as all data is referenced off the primary fields – RegID, ProjID, and PlotID, which are linked to a unique geospatial coordinate.

Figure 6: PD Form Continued. The FIREMON application was built to record coordinates Latitude and Longitude (decimal degrees) and WGS 84, as default settings for the ArcPad and the Trimble RECON and GeoXT-XM devices currently being utilized.

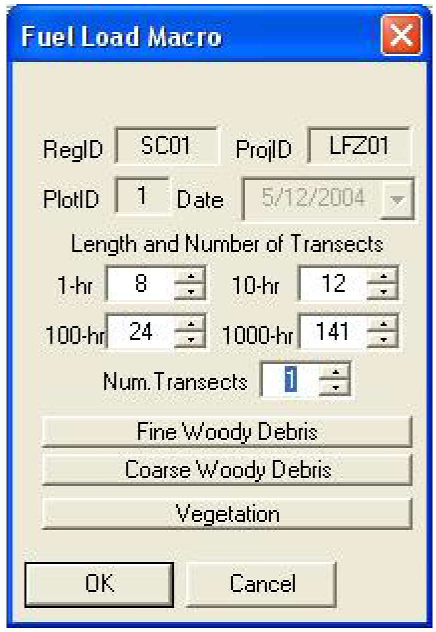

Figure 7: Fuel Load Macro. Field data collectors are then asked to move through a series of additional FIRMON protocols that have been designed and developed by GCS Research and ESRI. Again, these match the exact FIREMON Access database structure for the various protocols.

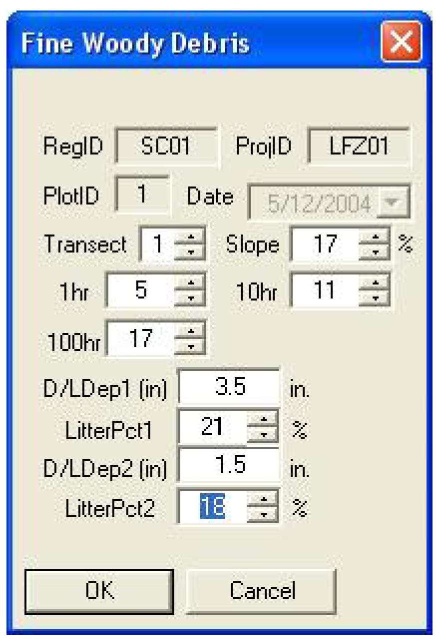

Figure 8: Fine Wood Debris. Additional field form for Fine Woody Debris, which is related to the Fuel Load Macro form.

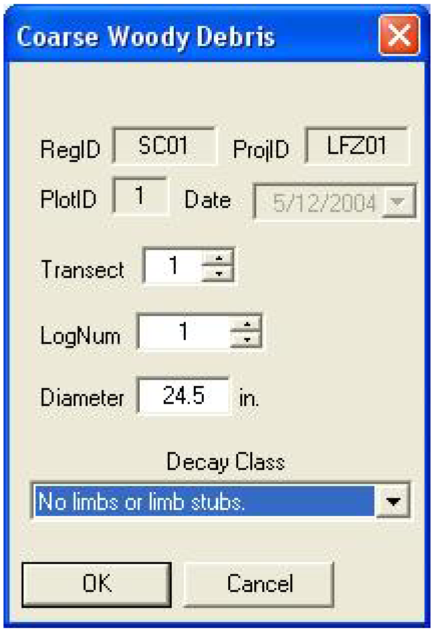

Figure 9: Course Woody Debris. Additional field form for Fine Woody Debris, which is related to the Fuel Load Macro form.

It is possible once the FIREMON data has been collected for this reference data to be incorporated and utilized by other projects interested in monitoring fuel load conditions on the ground. This includes assessing fuel load conditions on the ground prior to a fuel treatment and then revisiting the location after treatment to determine fuel load conditions. This allows for an assessment of predictive fire behavior as a result of fuel treatments, which is critical to the successful implementation of the National Fire Plan and the Healthy Forest Restoration Act. Most importantly, the use of FIREMON, associated mobile GIS-GPS technologies, and management of the data within a personal geodatabase allows fire managers to better assess risk within WUI areas located on the Flathead Reservation.

The pilot project's work provides data for runs with Forest Vegetation Simulator (FVS). FVS can be utilized to show how changes from WUI/HFR treatments can affect future forest growth, and how the absence of these treatments may also affect the forests' response to wildfires with the Fire and Fuels Extension (FFE). This FIREMON data can be prepared for additional use in fire behavior applications dependant upon GIS such as Farsite through FVS to baseline data with different collection timeframes.

It was during the work with the SCA FIREMON team that the tribal GIS program was introduced to wildfire related models like FARSITE. This type of modeling demonstrates that GIS can play a vital and powerful role in wildfire related planning and management efforts. As valuable project level fuels and tree data such as this pilot project's collection with FIREMON continue, over time the increase in data collected contribute to a better picture of the variables necessary to run fire behavior programs like Farsite. Large sets of data, collected in an accurate manner, allow risk assessment and fire behavior programs to become more effective.

Another way in which the FIREMON program data are currently being utilized regards the USGS-USFS LANDFIRE project. Given the similarity between the FIREMON database structure and the modified FIREMON protocols utilized for the LANDFIRE project, it is possible to include the FIREMON data sets as reference data for the LANDFIRE project. Indeed, the protocols are very similar with the addition of a Species Composition (SC) field method be added to the LANDFIRE protocols.

Due to the success and potential for additional growth with this fuels data collection, Student Conservation Association partnered with additional reservations and the LANDFIRE program to task other interns with fuels data collection. Without a doubt, those interns will continue to provide their placement agencies, such as the pilot agency of CSKT, with a wealth of important decision-making data, while saving them time. All of this occurs through experiences that are personally and professionally fulfilling.

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Martin Zobel, CSKT GIS

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FIREMON www.fire.org/firemon

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Curtis Matt. Personal interview. 1 June 2004.

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