Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

REFINED WORK FLOW SCENARIOS AND PROPOSED PROOF OF CONCEPT SYSTEM FUNCTIONALITY FOR THE INTERAGENCY FUELS TREATMENT DECISION SUPPORT SYSTEM

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By:
Dr. Stacy A. Drury
H. Michael Rauscher
Sean M. Raffuse
Tami H. Funk
Sonoma Technology, Inc.
1455 N. McDowell Blvd., Suite D
Petaluma, CA 94954-6503

Prepared for:
The Joint Fire Science Program
3833 South Development Avenue
Boise, ID 83705

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GLOSSARY

TERM	DESCRIPTION
Area of interest (AOI)	For IFT-DSS, a scale-independent unit of area defined by a user. Within an area of interest, project areas and vegetation units can be defined for analysis. There is no minimum size unit but a maximum unit will be limited to one million acres (approximately 400,000 hectares)
Aspatial fuels treatment analysis	A fuels treatment analysis based on a single treatment unit with the focus on learning fire behavior within that treatment unit or the biological effects of changing vegetation caused by the treatment implementation.
BehavePlus	A fire modeling system containing a collection of mathematical models that describe fire and the fire environment. BehavePlus can be used for a multitude of fire management applications including projecting the behavior of an ongoing fire, planning prescribed fire, and training.
CONSUME	A fire effects prediction model. It uses fuel loadings, fuel moisture, and weather variables to predict fuel consumption, particulate emissions, and heat energy released under prescribed fire and wildfire conditions.
FARSITE	A fire growth simulation model. FARSITE uses spatial information about topography and fuels along with weather and wind files.
FCCS	Fuel Characteristics Classification System
FFE	Fuels and Fire Extension
FFI	FEAT/FIREMON integrated
FIA	Forest Inventory Assessment
Fire hazard	For the IFT-DSS, defined as an act or phenomenon with the potential to do harm. It can be expressed as potential fire behavior (e.g., fire line intensity, crown scorch height) and/or a property of the fuels such as fuel loading or vegetation biomass. Fire hazard is independent of weather and describes the fuels at one point in time.
Fire regime	A general description of the role fire plays in an ecosystem. Fire regimes are generally described by the characteristics of fire in a given ecosystem, such as the size, frequency, predictability, intensity, biological severity, and seasonality of fire.
Fire risk	The chance that a fire might start based on the nature and incidence of its causative agents. Generally for the IFT-DSS, the probability that a fire ignites and then subsequently spreads to ignite adjacent fuels within a specified area and defined time frame (also see definition of risk from an engineering perspective).
First order fire effects	Direct or indirect immediate consequences of fire. Examples of first order fire effects are biomass consumption, crown scorch, bole damage, tree mortality, soil heating, and smoke production.

TERM	DESCRIPTION
FlamMap	A fire behavior mapping and analysis program that computes potential fire behavior characteristics (spread rate, flame length, fireline intensity, etc.) over an entire landscape for constant weather and fuel moisture conditions.
FOFEM	First Order Fire Effects Model; a set of fire effects prediction models. FOFEM uses fuels and vegetation information to provide estimates of fuel consumption, tree mortality, soil heating, and particulate emissions.
FSVeg	A USDA Forest Service database that contains point and plot vegetation data from field surveys such as Forest Inventory Assessment (FIA) exams, stand exams, forest inventories, and regeneration surveys. It includes data for trees, surface cover, understory vegetation, and downed woody material.
FSVeg Spatial	A USDA Forest Service database that contains GIS polygons linked to relevant point and plot data in the FSVeg database..
Fuels treatment	For the IFT-DSS, any mechanical, silvicultural, or burning activity whose main objective is to reduce fuel loadings or change fuel characteristics to lessen fire behavior or burn severity.
FVS	Forest Vegetation Simulator
GIS	Geographic information system
ID team	Interdisciplinary team
IFP-NIFTT-LANDFIRE	Integrated Fuels Planning using LANDFIRE-data
IFT-DSS	Interagency Fuels Treatment Decision Support System
INFORMS	Integrated Forest Resource Management System
IT	Information technology
Landscape	A spatial area composed of many individually more homogeneous vegetation units that influence the movement and behavior of fire (for the purposes of the IFT-DSS). One or more of these more homogenous vegetation units may then be grouped together into treatment units for the purpose of analysis and management.
Model	From a scientific perspective, a quantitative or conceptual specification of relations among entities.
MTT	Minimum travel time
NEPA	National Environmental Policy Act
NEXUS	A crown fire hazard analysis software that links separate models of surface and crown fire behavior to compute indices of relative crown fire potential.
NIFCG	National Interagency Fuels Coordinating Group
NIFTT	National Interagency Fuels Technology Transfer team
PHYGROW	A hydrologic-based plant growth simulation model.
Project area	Typically used to define a boundary for NEPA analysis and the area potentially affected by proposed treatments. A project area may be used to define the landscape being analyzed.

TERM	DESCRIPTION
POC	Proof of concept
Risk	From a risk-engineering perspective, the product of the probability of an event and the expected outcome of the event. The outcome is usually expressed in a negative context such as damage although fire can have positive outcomes. As applied to wildfire risk management in this context, risk is the product of the probability of a wildfire and the expected wildfire damages. Also see Values at risk.
RERAP	Rare Event Risk Assessment Process
Second order fire effects	Indirect fire effects that may be expressed days to years after the fire. Second order fire effects include tree regeneration, plant succession, changes in site productivity, soil erosion, and alterations to stream flow. Second order fire effects are dependent on first order fire effects but are also a result of other environmental influences such as weather and topography.
Spatial fuels treatment analysis	There are two types of spatial fuels treatment analyses: (1) multiple vegetation units examined across a landscape but with no explicit interaction between any of the units during the analysis; and (2) multiple vegetation units examined across a landscape but with explicit consideration of the topology of fire spread and its effects on all vegetation units in the landscape of concern; i.e., a particular vegetation unit may affect the spread and severity of fire on adjacent vegetation units to change the outcome of the analysis.
Third order fire effects	Long-term fire effects related to repeated burning and the fire regime. Third order fire effects include successional pathways, vegetation composition, vegetation structure, and vegetation patterns on the landscape.
TOM	Treatment optimization module
Treatment unit	The area within a defined spatial boundary that is to receive a single or a set of management treatments. A treatment unit is composed of either one or more vegetation units.
Vegetation unit	A parcel of land where timber, shrubland, and/or grassland plant species predominate. Stand is the term commonly used in silviculture textbooks and within the Forest Service. Patch is the common term in landscape ecology. The vegetation unit term was chosen for the IFT-DSS to be as generically neutral as possible.
WFDSS	Wildland Fire Decision Support System
WUI	Wildland urban interface; defined as the area where structures and other human development meet or intermingle with undeveloped wildland.
yaImpute	An R statistical package that performs popular nearest neighbor routines (k-NN) for imputation.

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The Joint Fire Science Program (JFSP) and the National Interagency Fuels Coordination Group (NIFCG) have been working with the Interagency Fuels Treatment Working Group (IFTWG) for the past two years on the Software Tools and Systems (STS) study. The goals of the STS study are to develop an Interagency Fuels Treatment Decision Support System (IFT-DSS) to assist the fire and fuels community and to provide a software framework to manage the many data, software applications, and tools available for fuels treatment planning. The strategic-level goals of the IFT-DSS are to

- simplify the fuels treatment planning decision support process and improve the overall quality of analysis and planning by more easily combining and reusing applications and providing new opportunities for data analysis and collaboration;
- control long-term costs by streamlining and optimizing workload and scalability;
- encourage scientific collaboration by providing a framework, registration mechanism, and tools that allow and facilitate the integration of new software applications into the framework;
- reduce agency information technology (IT) workload in deployment and maintenance of fuels applications and data; and
- promote interagency collaboration within the fire and fuels community.

The STS study has been progressing in phases over the past two years. Phases I and II of the STS study were conducted in 2008 and 2009, respectively. Phase I involved performing a strategic analysis of the fuels treatment domain, and in Phase II, a software architecture design for the IFT-DSS was developed. Phase III was initiated in May 2009. Phase IIIa will span May 2009 through May 2010 and will involve the development of a functional IFT-DSS proof of concept (POC) system to demonstrate the feasibility and usefulness of the fully implemented IFT-DSS.

In concert with the IFT-DSS POC development, the JFSP Program Manager will lead a community development effort as the success of the IFT-DSS will depend on two key factors: (1) the development of a community of key stakeholder groups—fuels treatment specialists, developers of fire and fuels software applications, fire and fuels data providers, and interagency technology and governance representatives; and (2) community-wide adoption of standards for data, metadata, and application programming interfaces (APIs) to facilitate software application integration. Assuming that the IFT-DSS prototype is successful and the program gains on-going support, full implementation of the IFT-DSS will occur in 2010 through 2012.

ES.2 PURPOSE OF THIS DOCUMENT

This document is intended to capture the work flow and problem-solving needs of the fuels treatment planning and management community to ensure that the IFT-DSS supports the needs of the fuels specialist user community. Moreover, through widespread distribution to fuels specialists, fire researchers, and fire science software developers, this document is intended to provide critical review of the needs identified herein. This document is divided into two key parts. The first part, Section 2, presents definitions and descriptions of six common work flow scenarios that have been identified and refined through survey feedback, interviews with fuels treatment specialists, and discussions with the fire and fuels science and software development community. The second part, Section 3, includes a discussion of the functionality of the IFT-DSS POC and the work flow scenarios that it will support. It is critically important that the work flow scenarios described in this document accurately capture the needs of the intended IFT-DSS users because the work flow scenarios will serve as the basis for the functionality of the system for both the POC and the fully implemented IFT-DSS.

ES.3 OVERVIEW OF IDENTIFIED WORK FLOW SCENARIOS TO BE SUPPORTED BY THE FULLY FUNCTIONAL IFT-DSS.

During the past year, several efforts have been made to understand the decision support needs and work flow processes involved in fuels treatment planning and management. These efforts include surveying the fuels treatment planning community; conducting personal interviews with several fuels treatment specialists representing different land management agencies; engaging and soliciting feedback from the IFTWG; and conducting meetings and discussions with fire and fuels software application and data developers. The following six work flow scenarios have been identified as a result of these efforts:

- **Data acquisition and preparation work flow scenario** provides a simple and efficient way to collect and prepare the vegetation data needed for input to fire behavior and fire effects models.
- **Strategic planning work flow scenario** enables identification of high fire hazard areas within an area of interest. The focus of this work flow scenario is to identify where further treatment analysis may be warranted based on potential fire hazard.
- **Spatially explicit fuels treatment assignment work flow scenario** (1) simulates fuels treatment placement in areas of high fire hazard within an area of interest, and (2) simulates post-treatment influences on fire behavior and fire effects potentials. The spatially explicit fuels treatment assignment work flow scenario extends the strategic planning analysis to applying treatments on the landscape.
- **Fuels treatment effectiveness over time work flow scenario** enables the evaluation of the temporal durability of fuels treatments, that is, how long, in years to decades, a treatment will continue to lower potential fire behavior and fire effects within an area of interest. This work flow scenario naturally follows the strategic analysis and fuels treatment assignment work flow scenarios.
- **Prescribed burn planning work flow scenario** provides the information needed to plan, document, and conduct a proposed, prescribed fire.
- **A proposed risk assessment work flow scenario** provides a probabilistic risk assessment for fuels treatment planning.

These work flow scenarios are described in detail in Section 2 of this document.

ES.4 PROPOSED FUNCTIONALITY FOR THE IFT-DSS POC

The proposed POC system will support a subset of the work flow scenarios and functionality of the fully implemented IFT-DSS. We realize that in order for the IFT-DSS to gain ongoing support and adoption, the POC system must be immediately useful and address one or more of the most common work flow scenarios. Assuming that the work flow scenarios described in this document have been accurately and adequately captured, we propose to implement the following three work flow scenarios (to varying degrees) in the POC system: (1) the data acquisition and preparation work flow scenario will be implemented first, followed shortly thereafter by (2) the prescribed burn planning work flow scenario and then (3) the strategic planning work flow scenario. **Figure ES-1** illustrates the data and software tools proposed for implementation in the IFT-DSS POC and an implementation timeline.

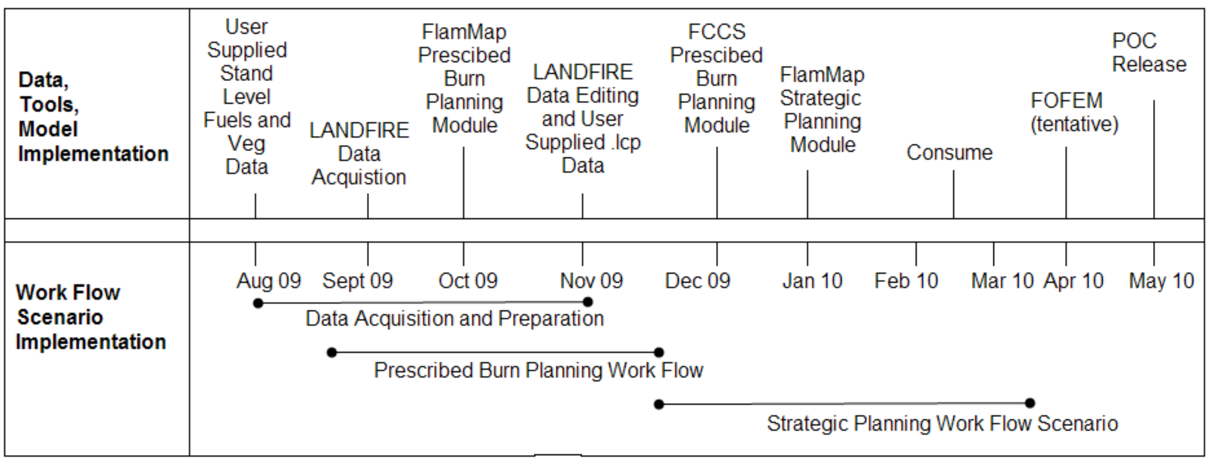

Figure ES-1. Proposed data and software applications to be implemented in the POC system and an implementation timeline.

1. INTRODUCTION

In May 2009, the Joint Fire Science Program (JFSP) initiated Phase IIIa of the Software Tools and Systems (STS) Study: Development of a proof of concept (POC) for the Interagency Fuels Treatment Decision Support System (IFT-DSS). The IFT-DSS POC will contain a subset of the most commonly performed fuels planning work flow scenarios with the goal of demonstrating the usefulness and feasibility of the IFT-DSS. This document outlines the work flow scenarios identified for performing fuels treatment planning when the IFT-DSS is fully implemented (Section 2) and the subset of functions and work flow scenarios that will be supported by the IFT-DSS POC system (Section 3).

The IFT-DSS is designed to help the Fuels Specialist on a typical Interdisciplinary (ID) Team to develop explainable and supportable project planning alternatives for the treatment of fuels from the fire hazard and risk perspective. The Fuels Specialist, working in close cooperation with other specialists on the ID Team, is expected to use the information and understanding gained through the application of the IFT-DSS to make recommendations for the decision process and to assist with National Environmental Policy Act (NEPA) analysis for a project area, if one is required. **Figure 1-1** shows the role of ID Team members in the context of the IFT-DSS.

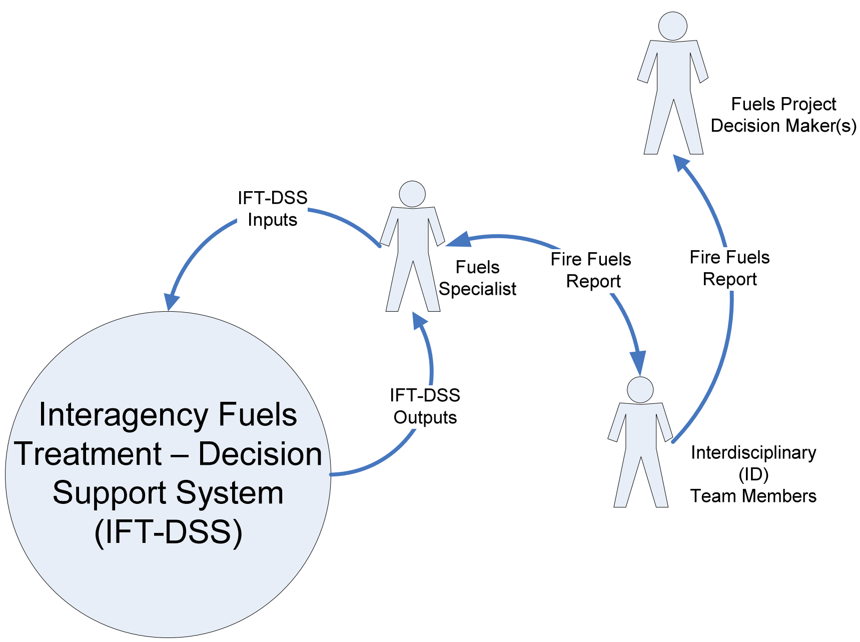

Figure 1-1. Role of the Fuels Specialist, ID Team member, and fuels project decision-maker in the context of the IFT-DSS.

1.1 BACKGROUND

In May 2008, at the onset of Phase II of the STS Study, the JFSP and the Interagency Fuels Treatment Work Group (IFTWG) developed a vision and conceptual design for the IFT-DSS . To ensure that the vision and conceptual design for the IFT-DSS are consistent with current fuels treatment planning practices and that the system supports the needs of the fuels treatment community, the JFSP, the IFTWG, and Sonoma Technology, Inc. (STI) worked collaboratively to assess the current practices and needs of the fuels treatment community. The objectives of the current practices and needs assessment were to identify and understand the work flow process, data, and software tools currently used by fuels treatment analysts and planners to support decision-making.

As part of the needs assessment conducted in Phase II, 200 fuels specialists were surveyed. Of the 200 surveyed, 44 provided detailed responses to a set of questions on current software usage in fuels planning. From these initial responses, and a set of follow-up interviews, four general fuels treatment work flow scenarios were developed that address common fuels planning practices and needs. The findings of the needs assessment, surveys, and interviews can be found on the STS Study website (http://frames.nbii.gov/portal/server.pt?open=512&objID=661&mode=2&in_hi_userid=952&cached=true).

The information contained in this document is intended to refine, augment, and supersede the findings of the Phase II needs assessment as continued interactions with fuels specialists and the fire science software application development community clarify the fuels treatment work flow scenarios.

1.2 PURPOSE OF THIS DOCUMENT

This document is intended for fuels treatment specialists and planners and fire and fuels data and software application developers. The purpose of this document is twofold. This document is intended to capture the problem-solving needs of the interagency fuels treatment analysis and planning community. Moreover, through widespread distribution to fuels specialists, fire researchers, and fire science software developers, this document is intended to provide critical review of the needs identified herein. It is critically important that the work flow scenarios described in Section 2 of this document accurately capture the needs of the intended IFT-DSS users because they will serve as the basis of the functionality of the system when fully implemented. A secondary purpose of this document is to confirm that the subset of functions and work flow scenarios that will be supported by the POC system (as described in Section 3 of this document) to be implemented in the first year of development will be immediately useful to fuels specialists.

2. REFINED WORK FLOW SCENARIOS

The work flow scenarios discussed in this section include all scenarios identified to date and the functionality that the fully implemented IFT-DSS is intended to support. Full implementation of the IFT-DSS is expected to span three to five years.

This section describes how the fully implemented IFT-DSS will aid fuels treatment planners to accomplish the variety of tasks and objectives that have been identified as critical needs. A detailed discussion of the subset of functions and work flow scenarios that will be supported by the IFT-DSS POC system (to be developed by spring 2010; Phase IIIa of the STS Study) can be found in Section 3.

The work flow scenarios presented here can be split into two categories: (1) fuels treatment work flow scenarios and (2) a prescribed burn planning work flow scenario. The prescribed burn planning scenario is often considered as one phase of a fuels treatment scenario because prescribed burns are a means of treating fuels. However, the development of a prescribed burn plan is a long and complex process, and fuels treatment specialists have indicated that the IFT-DSS could provide a useful service by supporting a work flow scenario specifically devoted to prescribed burn planning.

The work flow scenarios described in this document are not mutually exclusive; that is, there is significant overlap among the scenarios. In many cases, the work flow scenarios build on each other in a more or less linear fashion. The work flow scenarios include

- data acquisition and preparation,
- strategic planning,
- spatially explicit fuels treatment assignment,
- fuels treatment effectiveness over time,
- prescribed burn planning, and
- a proposed risk assessment.

Even though data acquisition is common to each work flow scenario, this activity was defined separately because virtually every conversation with fuels treatment specialists concerning the challenges of planning fuels treatments has centered on data acquisition and data preparation. For fuels treatment planners, the challenges of acquiring adequate data in the correct format(s) for planning fuels treatments often outweigh the perceived usefulness of the information gained. The primary goal of the IFT-DSS is to enable fuels treatment specialists to prepare and quality control the data needed to conduct fuels treatment planning with minimal time and effort.

In the sections that follow, each work flow scenario is introduced with a short description and overview table, followed by a detailed narrative.

2.1 DATA ACQUISITION AND PREPARATION

Objective: To acquire, prepare, and quality assure vegetation data for use in fuels treatment planning

Regardless of scale, fuels treatment specialists require vegetation data of high quality to support fuels treatment planning (**Table 2-1**). In addition, the appropriate data required to meet the analysis objectives must be identified prior to conducting an analysis. For many analyses, geophysical (elevation, slope, aspect) and weather data may also be required. During Phase II of the STS Study, the issues involved with obtaining and preparing vegetation data for fuels treatment planning were identified and documented (Rauscher, 2008). **Figure 2-1** provides an overview process diagram of the data acquisition and preparation work flow scenario.

Table 2-1. Overview of the data acquisition and preparation work flow scenario.

Inputs	Vegetation/ Fuels Data Types	Workflow	Outputs
Tree-lists	FSVeg point data FSVeg Spatial User upload	Growth → Imputation → QC/edit	Current, complete fuels data for further analysis
Gridded fuels	LANDFIRE User upload	QC/edit	

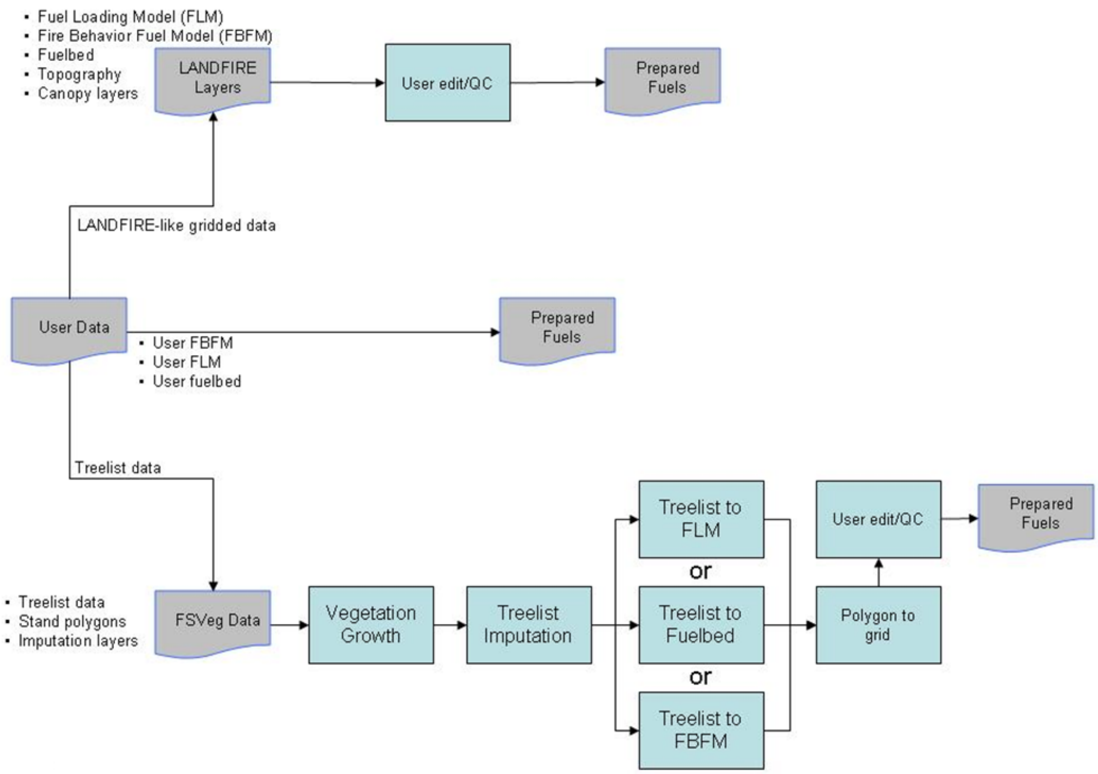

Figure 2-1. Overview diagram of the data acquisition and preparation work flow process.

Data Types

The fully functional IFT-DSS will provide users with the following data sources: tree-list data (FSVeg); the Landscape Fire and Resource Management Planning Tools (LANDFIRE) data products; user-supplied data in tree-list or LANDFIRE formats; and user-supplied data for stand-level analysis. Each data type is discussed in more detail below.

Tree-list Data

A tree-list can be defined as a census of individual tree characteristics derived from field-sampled plot data. Typically tree-lists are used to describe forest attributes. Tree-list data are often assigned or imputed into specified map units (either grids or polygons) for landscapes where data are missing. In the imputation process, tree-lists are assigned to the landscape based on landscape similarities among the original plots and the missing data locations. Tree-lists are meant to represent forest composition and structure when field data are not available for a location—not to replace existing field data.

The IFT-DSS will allow users to use tree-list data to impute existing FSVeg Spatial data sets (stand-exam data) or user-supplied tree-list data onto landscapes following the processes and procedures currently implemented in INFORMS (Twombly, 2009). Imputation functionality allows the fuels specialist to create complete (wall-to-wall) spatial coverages of vegetation for the area of interest that can then be entered directly into vegetation growth and yield models such as the Forest Vegetation Simulator (FVS) and the Fuels and Fire Extension to the Forest Vegetation simulator (FFE-FVS). If the user has geographically referenced, field-sampled tree-list (or tree-list type) data that meet basic stand inventory, FEAT/FIREMON integrated (FFI), or Forest Inventory Assessment (FIA) standards, the user will have the ability to populate grid cells or polygons for the area of interest with tree-list data using the yaImpute process.

The tree-lists in the populated landscape can then be imported into the FVS or the FFE-FVS to simulate tree growth and forest fuel development over time. FVS simulations can yield fuel conditions and fuel models representing current conditions from older, out-of-date plot data. In addition, the tree-list-FFE-FVS process will allow users to simulate fuel treatments and to assess possible changes in vegetation conditions and fuel loadings. The tree-list-FVS process can also model future forest attributes if a user is interested in assessing vegetation changes over time. Once the user has completed data preparation and quality assurance to ensure that the data meet the standards determined by the user, the vegetation and fuels data are ready for input into fire behavior and/or fire effects models.

A second option to provide vegetation data input for fuels treatment analysis using tree-list data processes will be the FSVeg Spatial database (plot or stand-exam data and associated polygons). The IFT-DSS will provide access to the FSVeg Spatial database. Users will have the ability to query an area of interest and retrieve a subset of the FSVeg Spatial data for use in their fuels treatment analysis. Similar to tree-list data, FSVeg Spatial data can be imputed using the yaImpute process to create seamless (wall-to-wall) vegetation coverages. If needed, the FVS and FFE-FVS can be utilized to prepare and condition the data for entry into fire behavior and/or fire effects models. Tree-list data can only be used for forested areas as they lack information about non-forest vegetation.

Although the tree-list data creation and assignment process can produce locally relevant fuels and vegetation data needed for fuels treatment planning, FSVeg data are not universally available and FVS processing on multiple polygons is currently very slow using the existing version of the FVS software application. If processing time is a concern or if tree-list or FSVeg data are not available for the area of interest, an alternative option for fuels treatment planners is to use LANDFIRE data.

LANDFIRE Data

For many locations and uses, the LANDFIRE map layers provide spatially explicit, consistent, and national topographical, vegetation, and fuels data. The consistency in the LANDFIRE map layers is highly advantageous when making spatial comparisons between or among areas of interest.

The IFT-DSS will have connections to the nationally standardized LANDFIRE data products (LANDFIRE National) for use as base data layers, updates for which are planned for every two to three years by the LANDFIRE program. LANDFIRE data products, or map layers, were produced in response to a known need for nationally consistent and locally relevant geospatial data for use in fire management planning such as fuels treatment planning. The LANDFIRE data development process utilized information from field-referenced data plots, remote sensing, ecosystem simulation, and biophysical modeling to produce spatially consistent vegetation and fuels data for the contiguous United States at 30-m grid resolution. The LANDFIRE database could serve as the default data set as it has nationwide coverage; crosses agency boundaries; and provides vegetation and fuels data for non-forested areas.

In addition to using the LANDFIRE National data set with the LANDFIRE data option, users will have the ability to edit existing LANDFIRE data or to upload customized LANDFIRE layers that have been validated and calibrated for use in a local area. Moreover, if users have LANDFIRE-like gridded data for their area, the IFT-DSS will support the use of those data. In short, the IFT-DSS will support any user-supplied data in tree-list-like or LANDFIRE-like formats. In addition, since LANDFIRE National is intended for national and regional analyses (Ohmann et al., 2008), the IFT-DSS will enable the user to validate and calibrate LANDFIRE National data layers to better represent local conditions.

At the present time, there is no specific way to simulate fuels and vegetation growth or change using gridded LANDFIRE data. However, the IFP-LANDFIRE team is developing a methodology for using LANDFIRE data to project vegetation growth and fuel development into the future and to simulate fuels treatment on the landscape using a set of tools currently being developed by the National Interagency Fuels Technology Team (NIFTT). These tools could potentially be integrated into the IFT-DSS. Moreover, with the development of a LANDFIRE-based tree-list (currently being developed by Drury and Herynk, 2009) the links between the tree-list FVS process may be used to simulate change over time using LANDFIRE data.

After the LANDFIRE data have been prepared and quality assured, the LANDFIRE data set is ready for use in fire behavior and fire effects simulations.

User Supplied Data

In addition to supporting user-supplied data in tree-list or LANDFIRE format, as described above, the IFT-DSS will allow users to enter their own data for their areas of interest manually through an interactive graphical user interface. This option is important as local area expertise and field-sampled data are always preferable to default data options. The option to manually enter specific, stand-level data is critical when a rapid, aspatial analysis for fuels treatment or prescribed burn planning is required.

Global Data

A global data set will be available to the user for geographic information about administrative boundaries, watersheds, roads, and other geographic features. Topographic data (elevation, slope, aspect) are needed for several IFT-DSS processes such as imputation and vegetation simulation. These data will be available at 30-m resolution and will reside locally in an IFT-DSS geo-database so that IFT-DSS users are not required to supply this information to the system. Weather data are also needed for many models; however, since IFT-DSS is intended for strategic planning and not real-time decision making, appropriate weather information will be entered by the user.

2.2 STRATEGIC PLANNING WORK FLOW SCENARIO

Objective: The objective of the strategic planning work flow scenario is to identify high fire hazard areas within an area of interest. The focus of this work flow scenario is to identify where further analysis may be warranted based on potential fire hazard. High fire hazard is expressed by high potential fire behavior and/or undesirable fire effects. The strategic placement of fuels treatments in a landscape is discussed in Section 2.3.

A literature review and discussions with fuels treatment planners indicated that prioritizing treatment areas based on hazard reduction is an important task for fuels treatment planners. The strategic planning work flow scenario (**Table 2-2**) may be viewed as an initial step in the planning process and crosses many geographic scales (e.g., national, district, watershed). **Figure 2-2** provides an overview process diagram of the strategic planning work flow scenario.

The products and outputs of this type of analysis range from a digital map of spatially explicit information about the variability of fire hazard across a landscape to simple data tables comparing two or more single treatment areas. The most effective product for strategic planning is likely a set of digital maps. The identification of potential high fire hazard areas is a crucial first step in the fuels and resources planning process that can be used in conjunction with other ecological and natural resource information to rapidly assess areas within the landscape that may warrant fuels treatment.

Table 2-2. Overview of the strategic planning work flow scenario.

Inputs	Vegetation/ Fuels Data Types	Workflow	Outputs
Current, complete fuels; topography	Tree-list Polygon data LANDFIRE grid data	Fire Behavior → Fire Effects → QC	Maps and data of fire behavior and fire effects

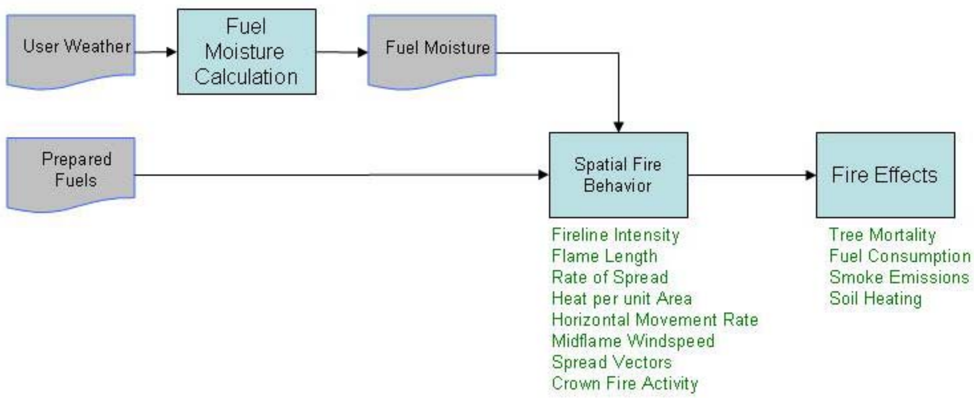

Figure 2-2. An overview process diagram of the strategic planning work flow scenario.

Data Acquisition and Preparation

For the strategic planning work flow scenario, the following data are needed:

- Fuels (vegetation)
- Fuel moisture
- Weather
- Topography

In addition, these optional data layers provide context and aid in analysis:

- Administrative boundaries
- Watersheds
- Roads

In this work flow scenario, the data options are user-supplied data in grid or polygon form, FSVeg Spatial polygon layers, or gridded LANDFIRE data layers. If the FSVeg polygon layers are missing data, the user will have the option to construct a complete FSVeg coverage using the imputation method discussed in Section 2.1. One advantage of using tree-list data (FSVeg-FVS compatible) is that the fuels planner can take advantage of the FFE-FVS tree growth and fuels development capabilities to examine the landscape as it currently exists and to investigate possible fire hazard potentials under future or changing conditions.

For this work flow scenario, the most appropriate topographical, vegetation, and fuels data may be the data layers in the LANDFIRE database because these data layers are spatially explicit, consistent, and available nationwide. A drawback of using the LANDFIRE data is that users will only have the ability to examine fire hazard potential at a single point in time. Nevertheless, as mentioned in section 2.1, the overall consistency in LANDFIRE is highly advantageous when making spatial comparisons between one area and the next.

For the purpose of this discussion, it should be clear that for each point in the landscape where potential fire hazard is assessed, the fire behavior and fire effects values will be simulated independently with respect to the surrounding conditions. Fire behavior in adjacent locations, roads, or hazardous fuel types in close proximity to the area under assessment do not affect the burning potential of the point location being assessed.

Fire Behavior and Fire Effects Analysis

The IFT-DSS will incorporate fire behavior models such as FlamMap, FARSITE, BehavePlus, and NEXUS to assess fire behavior potentials. The fire effects models, CONSUME and First Order Fire Effects Model (FOFEM), will be available for estimating fire effects. For the strategic planning work flow scenario, the spatial nature of the fire behavior outputs available in FlamMap (or FlamMap-like models) will provide information about the distribution of possible fire behaviors across an area of interest. This information, when coupled with estimates of tree mortality, fuels consumption, soil heating, and emissions from fire effects models, provides the fuels treatment specialist with a range of spatial data to use in assessing potential fire hazard across a landscape.

Example Output

For this work flow scenario, the IFT-DSS will provide digital maps and/or summary graphs and tables. An example map is provided to illustrate potential output products and how this type of analysis may be used (**Figure 2-3**). Figure 2-3 shows a map illustrating the use of fire behavior output to identify potential fire hazard. Areas that would not warrant further investigation are shown in green while areas with high fire hazard potentials are shown in red.

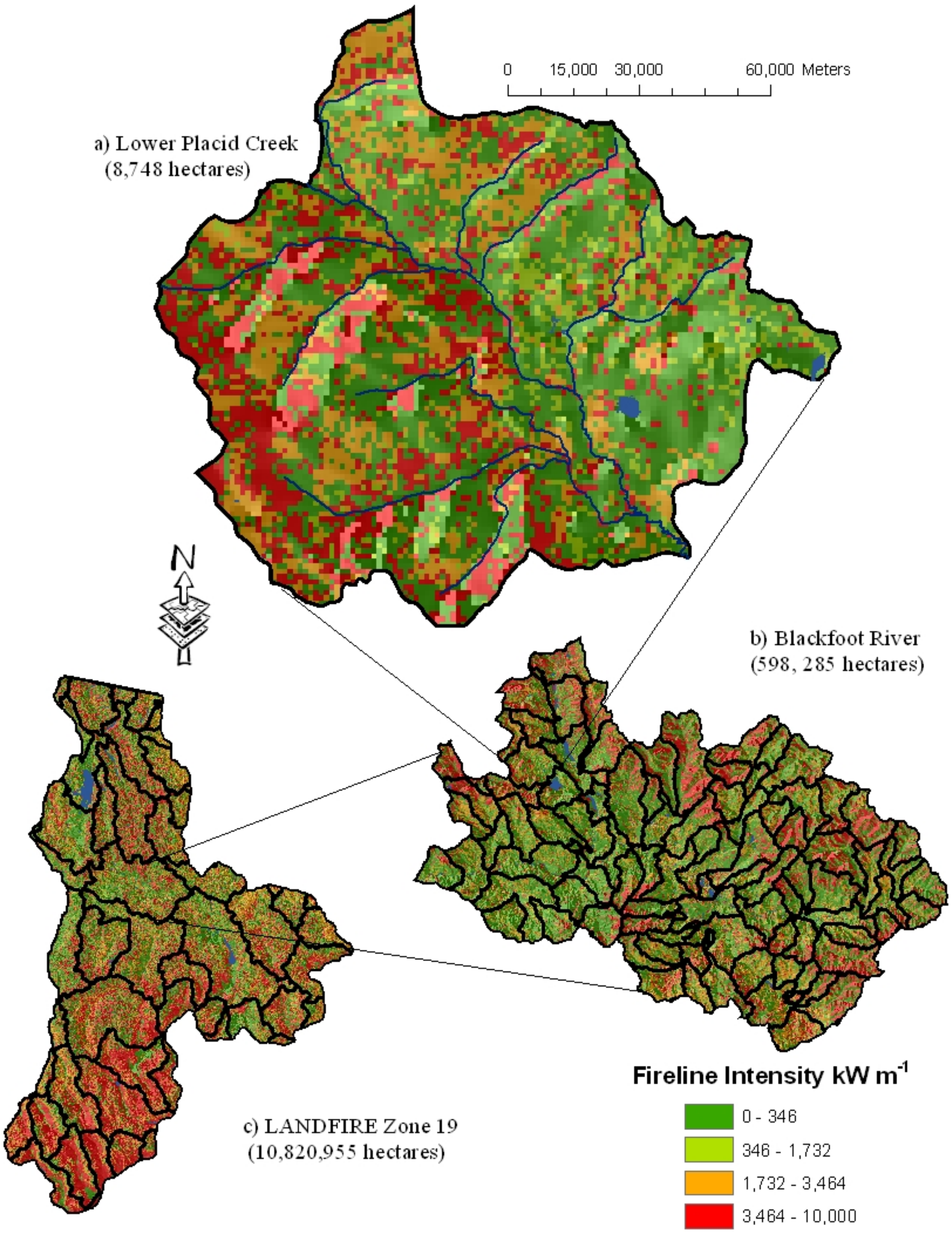

Figure 2-3. Map illustrating use of fire behavior output to identify potential fire hazard. Each fireline intensity value (green, light green, orange, and red) represents a level of attack familiar to fire fighters—green represents conditions where direct attack may be feasible, while red refers to conditions where only indirect means of attack are warranted (Keane et al., 2009).

2.3 SPATIALLY EXPLICIT FUELS TREATMENT ASSIGNMENT WORK FLOW SCENARIO

Objective: The objectives of the spatially explicit fuels treatment assignment work flow scenario are to (1) simulate fuels treatment placement in areas of high fire hazard within an area of interest, and (2) simulate post-treatment influences on fire behavior and fire effects potentials.

The spatially explicit fuels treatment assignment work flow scenario (**Table 2-3**)extends the strategic planning analysis described in Section 2.2 to applying treatments on the landscape. In this work flow scenario, fuels treatments are simulated in high fire hazard areas to examine how these treatments may modify potential fire behavior. **Figure 2-4** provides an overview process diagram of the spatially explicit fuels treatment assignment work flow scenario.

While applying fuels treatment to the landscape is conceptually straightforward, several layers of complexity are associated with this type of analysis including the preparation of technical reports. These technical reports form the basis of legal documentation such as environmental assessments, environmental impact statements, and decision approval manuscripts needed to fulfill legal obligations outlined in the NEPA.

Table 2-3. Overview of spatially explicit fuels treatment assignment work flow scenario.

Inputs	Vegetation/Fuels Data Types	Workflow	Outputs
Current, complete fuels; topography	Tree-list polygon data LANDFIRE	Fire Behavior/Effects/MTT → User Treatment → Fire Behavior/Effects/MTT	Maps and data of treatment locations and pre- and post-treatment fire behavior and fire effects
		Fire Behavior/Effects/MTT → FVS Treatment → Fire Behavior/Effects/MTT	
		Fire Behavior/Effects/MTT → TOM → Fire Behavior/Effects/MTT	

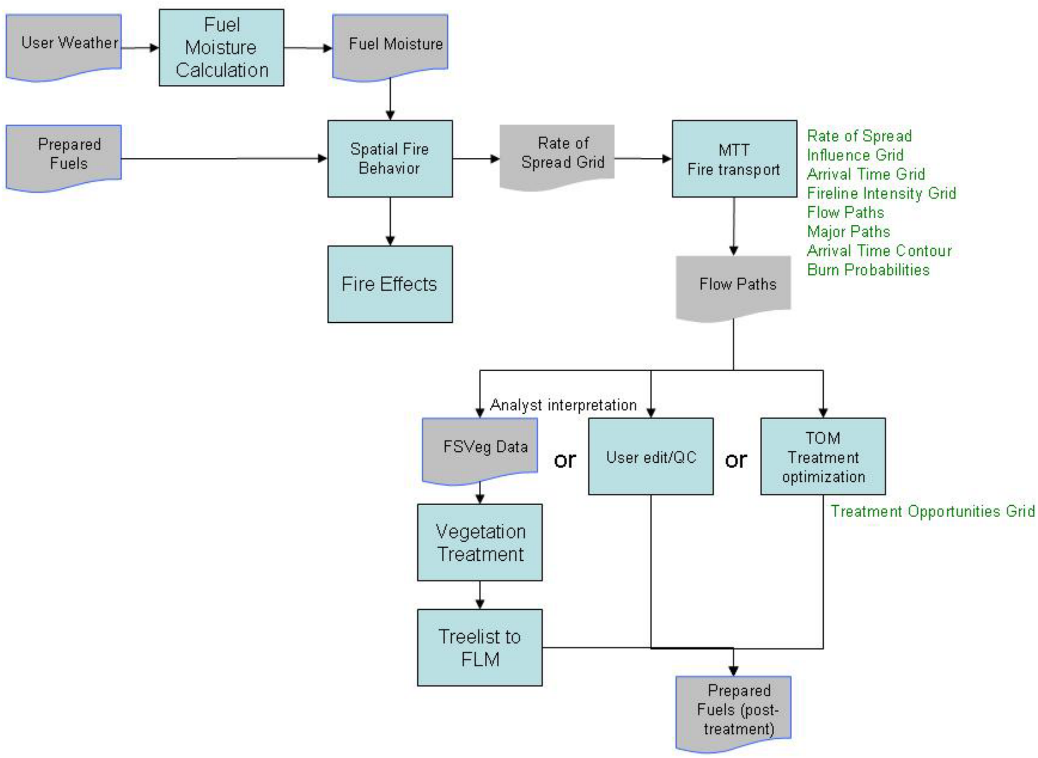

Figure 2-4. An overview process diagram of the spatially explicit fuels treatment assignment work flow scenario.

Data Acquisition and Preparation

In this work flow scenario, FlamMap, or a FlamMap-like fire behavior model, will be implemented to simulate fire behavior and FOFEM or CONSUME will be used to estimate potential fire effects. Therefore, the data needs and restrictions for this work flow scenario are similar to those discussed in the strategic planning work flow scenario in Section 2.2.

Fire Behavior and Fire Effects

Fire behavior will be simulated over the area of interest using a FlamMap-like fire behavior model and a fire effects model as described in the strategic planning work flow scenario. One difference is that the minimum travel time (MTT) module in FlamMap will also be run over the area of interest. This step provides information about fire movement across the landscape from the MTT module which is needed for the fuels treatment placement step described below.

Fuels Treatment Placement

The IFT-DSS will provide users with three options for placing treatments on the landscape. First, the user will be able to define treatment areas by drawing polygons on the landscape using an interactive mapping tool or by uploading a set of user-supplied polygon layers. The user can then indicate the level of treatment and adjust the fuel loading models and the fire behavior models to fit the treatment. The second option will be to simulate treatment effects using the FFE-FVS for user-selected areas. The final, default option will be to allow the treatment optimization module (TOM) in FlamMap to evaluate and place treatments within the landscape.

Treatment Evaluation

Once the treatments have been applied to the landscape, a FlamMap-like fire behavior model and a fire effects model will be used to simulate potential fire behavior and fire effects on the treated landscape. At this stage only the treated areas will be evaluated for potential changes, that is, the user will have the ability to view digital maps and data tables showing how the treatment changed fire behavior and fire effects potentials within the treated areas.

The next step in the treatment evaluation analysis will be to use the MTT function within FlamMap to evaluate potential changes in fire behavior potentials within the treated areas and, more importantly, in the untreated areas. This caveat is important because many fuels treatments are conducted not only to lower potential fire behavior and mitigate fire effects within the treated areas, but also to mitigate fire hazard in untreated areas.

Example map outputs from FlamMap are shown in **Figure 2-5** to illustrate how fuels treatments on the landscape can alter potential fire behavior in both treated and untreated areas. It is important to consider how a treated area influences fire behavior and fire effects on the surrounding landscape for several reasons: (1) treating the entire landscape is cost- and resource-prohibitive; (2) there may be land ownership issues; and (3) other resources such as wildlife habitat or timber may be at risk in the landscape and treatment may not be an option in some areas. Maps of the MTT output will allow the fuel treatment planner to evaluate treatment effectiveness at reducing potential fire behavior and potential fire hazard within the treated and untreated areas.

Outputs

As with the strategic planning work flow scenario, the most useful output will be a set of digital maps that can be used to identify where to place treatments on the landscape. This work flow scenario will also provide users with information to evaluate the potential effectiveness of selected treatments throughout the landscape.

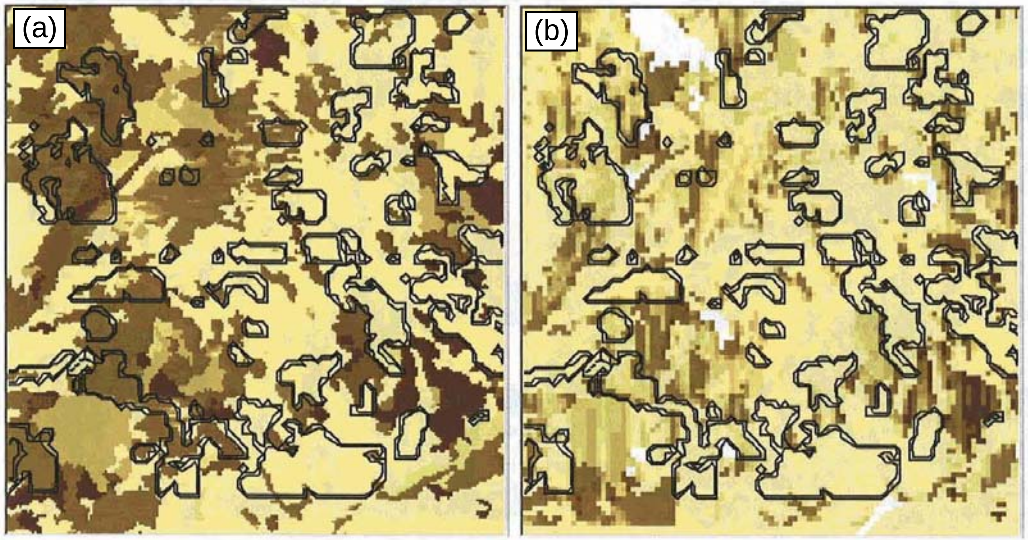

Figure 2-5. Digital maps from the FlamMap tutorial showing the effects on fire behavior when the treatment optimization model (TOM) in FlamMap is used to select treatment areas. Map (a) shows simulated pre-treatment fireline intensity values and map (b) shows simulated post-treatment fireline intensities. Light colored areas indicate low fireline intensity potentials and dark colors represent high fireline intensity potentials. Note that fire behavior potentials where lowered both inside and outside of the fuels treatment boundaries (Finney et al., 2006).

2.4 FUELS TREATMENT EFFECTIVENESS OVER TIME WORK FLOW SCENARIO

Objective: The objective of the fuels treatment effectiveness over time work flow scenario is to evaluate the temporal durability of fuels treatments, that is, how long, in years to decades, a treatment will continue to lower potential fire behavior and fire effects within an area of interest**.**

The fuels treatment effectiveness over time work flow scenario (**Table 2-4**) adds a temporal component to the work flow scenarios described in Sections 2.2 and 2.3. **Figure 2-6** provides an overview process diagram of the fuels treatment effectiveness over time work flow scenario. The capacity of fuels treatments to lower fire hazard potentials is transient because vegetation and the natural environment are constantly changing. Generally, fuels treatment effectiveness diminishes over time as forest vegetation ages and fuels continue to accumulate. Therefore, a common set of questions that fuels treatment planners must address relates to how long a particular treatment will be viable and how frequently the area will need to be treated. The most effective way of determining how long fuels treatments are effective at lowering fire potentials and fire hazard is to conduct field monitoring of treated areas; however, simulating treatment effectiveness before treatments are applied can provide useful information for decision making.

This work flow scenario would naturally follow the strategic analysis and treatment assignment work flow scenarios. Areas that warrant fuels treatments would have already been identified and a set of fuels treatment locations would have been proposed and evaluated. The next step is to estimate how long a particular fuels treatment will be effective.

Table 2-4. Overview of fuels treatment effectiveness over time work flow scenario.

Inputs	Vegetation/Fuels Data Types	Workflow	Outputs
Current, complete fuels; topography	Tree-list polygon data User supplied data	Growth → Fire Behavior → Fire Effects → Growth → Fire Behavior → Fire Effects → Growth…	Graphs and data of fuels, fire behavior, and fire effects over time

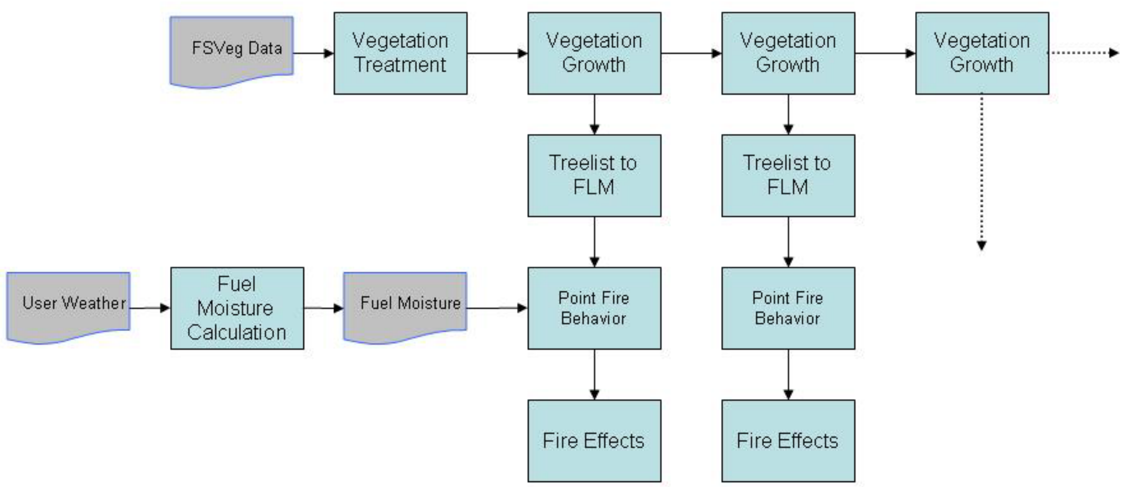

Figure 2-6. An overview process diagram of the fuels treatment effectiveness over time work flow scenario.

Data Acquisition and Preparation

A FlamMap-like fire behavior model will be used to simulate fire behavior and models such as FOFEM or CONSUME will be used to simulate fire effects; therefore, data acquisition in this work flow scenario follows the pathways outlined in the strategic planning and fuels treatment assignment work flow scenarios. One notable exception is that there is currently no direct way to grow or simulate fuel accumulation using the LANDFIRE National data. If LANDFIRE data layers are used, the user will manually change fuels in the data layers to reflect vegetation growth and fuels development (discussed further below). The user will have the ability to edit the LANDFIRE layers based on expert judgment about how the treated landscape will change over time. While this process is fairly subjective, it is commonly applied in practice and can be valuable if the user has knowledge about the development of vegetation and fuels over time in a specific area.

If tree-list-data are used for this analysis, the FVS and FFE-FVS process can be used to simulate treatment durability over time. With the tree-list process, the user will have the ability to age a forest sequentially in 10-year increments for up to 40 years. This process will enable users to "grow" the forests and let fuels accumulate (see discussion below).

<u>Fire Behavior and Fire Effects Analyses</u>

As described in the strategic planning and the spatially explicit fuels treatment assignment work flow scenarios, potential fire behavior will be simulated over the entire landscape using a FlamMap-like fire behavior model in the fuels treatment work flow scenario. In addition, FOFEM or CONSUME will be used to simulate fire effects.

<u>Fuels Treatment Location Assignment and Evaluation</u>

In the spatially explicit fuels treatment assignment work flow scenario, treatment locations are assumed to have been selected and evaluated to determine which treatments will be used to produce acceptable reductions in fire behavior and fire hazard potentials.

<u>Treatment Durability</u>

The IFT-DSS will offer users several options for assessing the treatment effectiveness over time. One option will be to allow the user to input vegetation changes in fuel models based on expert knowledge of the successional pathways that lead to structural changes in vegetation and fuel accumulation. Based on local knowledge and expert judgment, the user will have the ability to manually change vegetation and fuel data for specific time periods and intervals. This option would be applied if the LANDFIRE data were used for the analysis.

A second, and less subjective, vegetation simulation technique will be to use the tree-list-FSVeg data and the FFE-FVS to simulate vegetation growth and fuel accumulations following logic processes developed in INFORMS. Using this approach, fuels treatment planners will have the ability to calculate potential patterns in vegetation growth and fuels accumulations in 10-year increments (40-year maximum time frame; see **Figure 2-7**). Fire behavior and fire effects simulations will be conducted after each 10-year interval of vegetation growth and fuels accumulation. A fuels treatment planner can then determine (using either tabular output data or digital maps) when a treatment no longer effectively mitigates potential fire behavior and or fire hazard.

<u>Output</u>

The output products from this work flow scenario will be tabular data and digital maps of pre-treatment fire behavior and fire effects data, post-fuels treatment fire behavior and fire effects data, and fire behavior and fire effects data for each 10-year increment of simulated vegetation growth and fuels accumulation.

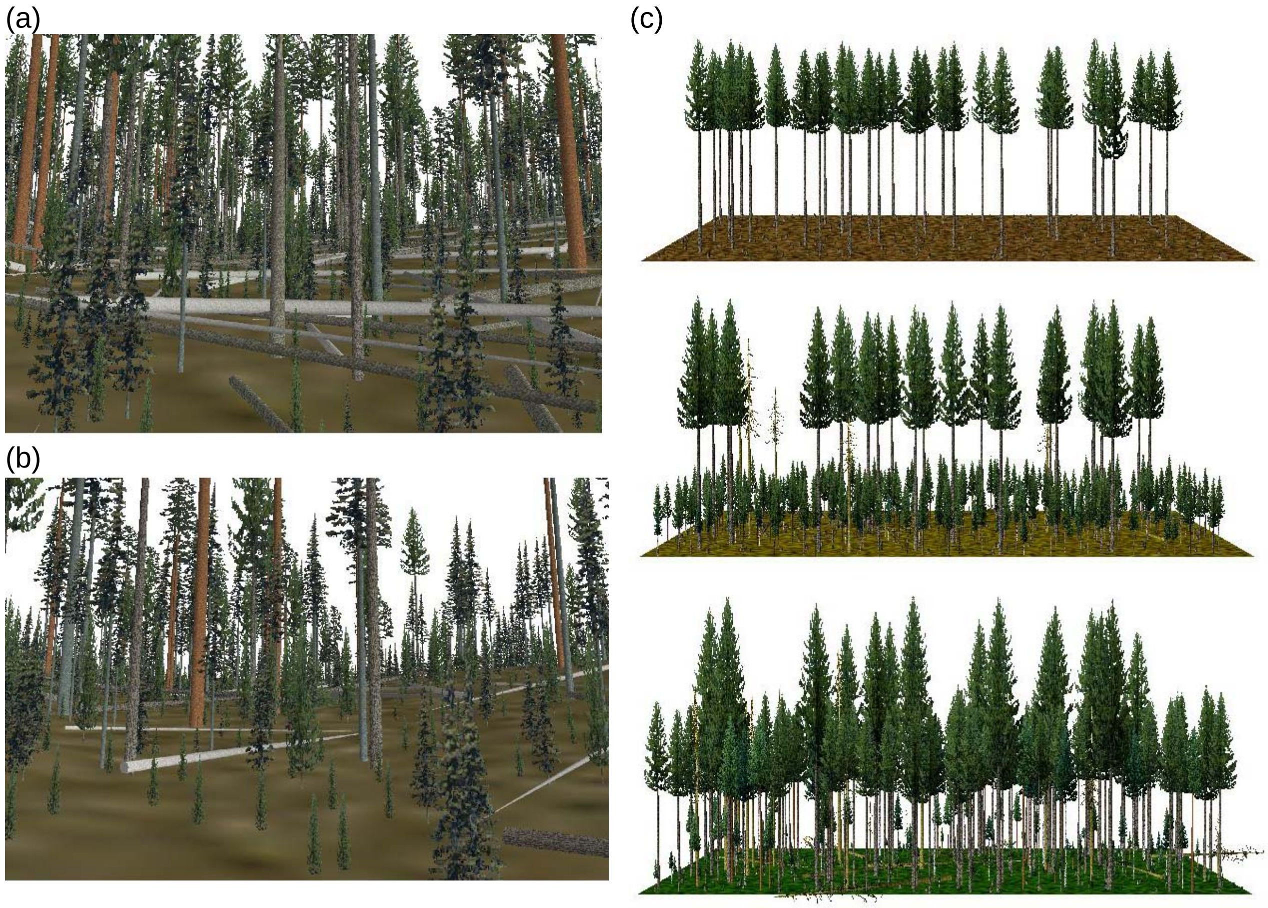

Figure 2-7. Stand visualization illustrations for (a) pre-treatment stand, (b) post-treatment stand, (c) simulation of tree growth and fuels accumulation over time using the FFE-FVS and the stand visualization system (source: U.S. Department of Agriculture Forest Service, 2006). The top stand in (c) illustrates potential vegetation immediately after fuels treatment, the middle stand shows growth over some unit of time, and the bottom stand is continued growth over a sequential unit of time.

2.5 PRESCRIBED BURN PLANNING WORK FLOW SCENARIO

Objective: The objective of the prescribed burn planning work flow scenario is to provide the information needed to plan, document, and conduct a proposed, prescribed fire.

Prescribed burns are planned to meet management and operational objectives in accordance with “The Interagency Prescribed Fire Planning and Implementation Procedures Guide” (U. S. Department of Agriculture and U. S. Department of the Interior, 2008).

All prescribed fires require an approved plan that must be followed when a burn is conducted. The prescribed fire burn plan is the legal document that provides an agency administrator with the information needed to approve a prescribed fire. The size and complexity of a prescribed fire project will determine the level of effort and detail to be included in the plan; however, each plan must specifically address 21 standard elements (required information) in the prescribed fire template (U. S. Department of Agriculture and U. S. Department of the Interior, 2008). The IFT-DSS will provide information needed to address several of these elements including Element 3 (Complexity analysis), Element 4 (description of burn area), Element 5 (burn objectives), Element 7 (burn plan prescription), Element 15 (ignition plan), Element 16 (holding plan), and Element 19 (smoke management and air quality restrictions).

The prescribed burn work flow scenario (**Table 2-5**) as implemented in the IFT-DSS will aid fuels specialists and prescribed burn planners by providing the tools needed to construct a prescribed burn plan in a single location. Currently, prescribed burn planning requires a prescribed burn planner to collect data, run fire behavior and fire effects simulations over a range of environmental variables, and make decisions that enable the burn plan objectives to be met while maintaining control of the fire. To complete these tasks, prescribed burn planners must use an array of software with various data requirements. In the IFT-DSS, model use and data structures will be consolidated to greatly streamline the process and save time. Modeled output of fire behavior and fire effects will also be provided in a concise format that can be easily exported to Microsoft office formats. **Figure 2-8** provides an overview process diagram of the prescribed burn planning work flow scenario.

The prescribed burn planning work flow scenario assumes that the location and objectives for the planned burn have already been determined. The area of interest is a single unit in time and is treated as scale-independent, that is, the planned burn could vary in size from several square meters to hundreds of hectares.

Table 2-5. Overview of the prescribed burn planning work flow scenario.

Inputs	Vegetation/ Fuels Data Types	Processes	Outputs
Fuels; range of weather conditions	User entered single stand level data	Fire Behavior → Fire Effects → QC	Graphs and data of fire behavior and fire effects over a range of conditions

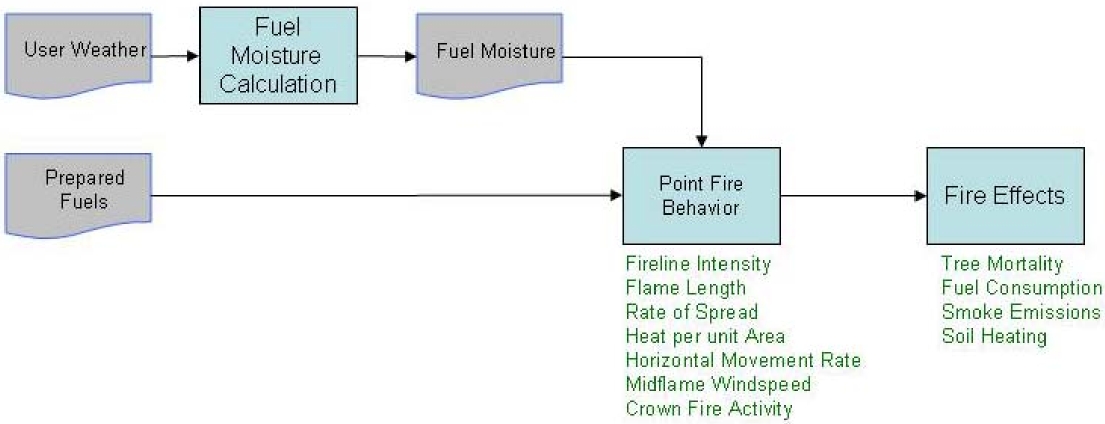

Figure 2-8. An overview process diagram of the prescribed burn planning work flow scenario.

Data Acquisition and Preparation

To prepare a prescribed burn plan, the burn planner requires a series of maps or digital data layers that illustrate the following:

- Administrative boundaries
- Watersheds
- Roads
- Topography
- Vegetation
- Fuels
- Fuel Moisture
- Weather

There are three data options for use in the prescribed burn planning work flow scenario: (1) user supplied data, (2) tree-list-FSVeg data, and (3) LANDFIRE data. If a user chooses to provide data, the user would manually enter specific field-sampled data inputs. If the FSVeg data option is used, and FSVeg data exist for the area, tree-list or plot data for the stand of interest will be selected. If the data are outdated, the user will have the ability to update stand characteristics and fuels data using FFE-FVS as described in Section 2.1: Data Acquisition and Preparation.

If LANDFIRE data are used, topography, vegetation, and fuels for the area of interest will be selected. The user will then have the ability to edit or condition the LANDFIRE data to provide more accurate and representative stand-level, local data.

A global data set will be available to the user for obtaining data about administrative boundaries, watersheds, and roads.

Fire Behavior Analysis and Outputs

Once the data have been acquired and prepared, a prescribed burn planner will have the ability to run multiple fire behavior scenarios over a range of environmental conditions. For example, the influence of changing fuels under constant weather can be compared if multiple fuel types exist within the burn unit. Or the prescribed burn planner may be interested in determining under what fuel moisture ranges the fire containment team can maintain the fire within the unit boundaries while simultaneously meeting the burn objectives.

The user will be provided with two options for simulating fire behavior in the single treatment prescribed burn planning workflow scenario. One option is a BehavePlus-type fire behavior simulator. A second option is the Fuel Characteristics Classification System (FCCS) suite of tools. As the IFT-DSS matures, other available tools will also be implemented.

Fire Effects Analysis and Outputs

Two options will be available for performing fire effects analysis. The first option is a model such as CONSUME to estimate fuel consumption, smoke emissions, and heat release. Another option is a model such as FOFEM to estimate fuel consumption, smoke emissions, tree mortality and soil heating.

2.6 RISK ASSESSMENT WORK FLOW SCENARIO

Objective: The objective of the risk assessment work flow scenario is to provide a probabilistic risk assessment for fuels treatment planning.

There is general consensus within the user community that providing risk assessment tools is essential to the fully implemented IFT-DSS. Much has been written about defining and assessing fire risk, yet a generally agreed upon definition of fire risk remains elusive (Hardy, 2005). Moreover, while all risk assessment approaches provide an estimate of risk based on variants of the likelihood that an area will burn and the consequences to values affected, the procedures for assessing risk differ greatly.[1]

Determining and prioritizing values at risk from wildfires can be difficult and may vary from one region of the country to another. It can be argued that a common currency such as monetary value should be applied to all values at risk (Finney, 2005). This approach is straightforward for things with tangible economic value such as structures or natural resources with known economic value but becomes more difficult when the values at risk possess ecological, environmental, or intangible value that is difficult to measure (Finney, 2005).

Throughout the development of the IFT-DSS, the IFT-DSS team will continue to examine how practitioners assess risk and how risk is evaluated in wildfire situations. Other methodologies for evaluating risk will continue to be considered as the science develops or if a consensus opinion is reached regarding how wildland fire risk should be assessed in the context

[1] Rauscher, H.M. (2009) IFT-DSS Benefit/Risk Assessment: An examination of how current software systems implement benefit/risk assessment, January 7.

of fuels treatment planning. Current fire hazard and risk systems that are being considered for inclusion into the IFT-DSS include the Ecosystem Management Decision Support System (Hessburg et al., 2007; Reynolds, 2006) and the Wildland Fire Risk Assessment (Sanborn Total Geospatial Solutions, 2009) which extends the Southern Wildfire Risk Assessment (SWRAOnline, 2009) to a national level (see Rauscher 2009 for complete description of the functionality of these models).

Although, a risk assessment work flow scenario (**Table 2-6**) is not planned to be included in the IFT-DSS POC; an explicit risk evaluation tool is proposed for the fully implemented IFT-DSS. While a generally agreed upon methodology for assessing risk does not exist, an alternative path for determining risk in the risk assessment work flow scenario is proposed:

$$\text{Fire risk} = (\text{burn probability}) \times (\text{fire hazard index}) \times (\text{value at risk}) \qquad \textbf{(2-1)}$$

Where

- The burn probability is defined as the probability that a given pixel or polygon will burn under extreme wildfire conditions given a random ignition within the area of interest. Burn probability is one of the outputs of the burn probability module in FlamMap where the user performs multiple simulations to determine how often a pixel would burn. This is not an index of the likelihood that a wildfire will occur; burn probability is a measure of the likelihood that a subset of the area of interest will burn given a random ignition within the area of interest.
- Fire hazard index = (rate of spread × crown fire activity × flame length × fireline intensity) and is expressed as high potential fire behavior
- The values at risk will be ranked on a scale of 1 to 9 by the user.

Table 2-6. Overview of the risk assessment work flow scenario.

Inputs	Vegetation/ Fuels Data Types	Processes	Outputs
Current, complete fuels; topography	Tree-list Polygon data LANDFIRE data User supplied data	Fire Behavior → MTT Burn Probability Mode → QC	Maps and data for fire behavior, burn probability, and values at risk

Data Acquisition and Preparation

The data needs and restrictions in the risk assessment work flow scenario will be very similar to those discussed in the strategic planning work flow scenario as a FlamMap-like model will be implemented to simulate fire behavior and burn probabilities for risk assessment. Data options include user-supplied data in grid or polygon form, FSVeg Spatial polygon layers, or gridded LANDFIRE data layers. To define an area of interest for the fire risk assessment work flow scenario, the user will have the option to draw polygons on the landscape using the IFT-DSS map viewer and editor that identify areas with values at risk or to upload a map layer of values at risk. In the future, an optional default data set of values at risk may be available as more data of this type become available.

Fire Behavior and Burn Probabilities Outputs

For this work flow scenario, fire behavior will be simulated over the area of interest using FlamMap (or other FlamMap-like models) as described in earlier work flow scenarios. The user will be prompted to run the MTT within FlamMap in burn probability mode to calculate the probability of burning for every pixel in the analysis area.

After a burn probability map has been constructed within FlamMap, a fire hazard index will be calculated using the FlamMap-produced fire behavior potentials as discussed earlier. The user will be prompted to add or select values-at-risk data for analysis and an index of fire risk will be calculated using the equation above: fire risk = burn probabilities × fire hazard index × value at risk. The output of the risk assessment will include a set of digital maps and data tables of fire risk, fire behavior, burn probability, and values at risk.

3. PROPOSED IFT-DSS PROOF OF CONCEPT FUNCTIONALITY

Assuming that the work flow scenarios described in Section 2 have been accurately captured, this section describes the functionality and work flow scenarios that are tentatively proposed for the IFT-DSS POC. The IFT-DSS POC development effort will span approximately one year beginning in May 2009. The POC system will contain a subset of the functionality described in Section 2. We realize that in order for the IFT-DSS to gain ongoing support and adoption, the POC system must be immediately useful and address one or more of the most common work flow scenarios. Based on user feedback, discussions with developers, and input from the POC Test User group, we propose to implement the following three work flow scenarios (to varying degrees) in the POC system: (1) the data acquisition and preparation work flow scenario, (2) the strategic planning work flow scenario, and (3) the prescribed burn work flow scenario.

3.1 OVERVIEW OF THE DATA AND SOFTWARE APPLICATIONS PROPOSED FOR IMPLEMENTATION IN THE IFT-DSS POC

Several key data sources, tools, and models will be implemented in the IFT-DSS POC during the first year of development. The implementation of these elements will be staged in a way that allows the POC Test User group to periodically view the progress and provide feedback on distinct system functionality. **Figure 3-1** shows an overview of the data, tools, and models proposed for the IFT-DSS POC and the approximate timeline for implementation of the functionality and work flow scenarios.

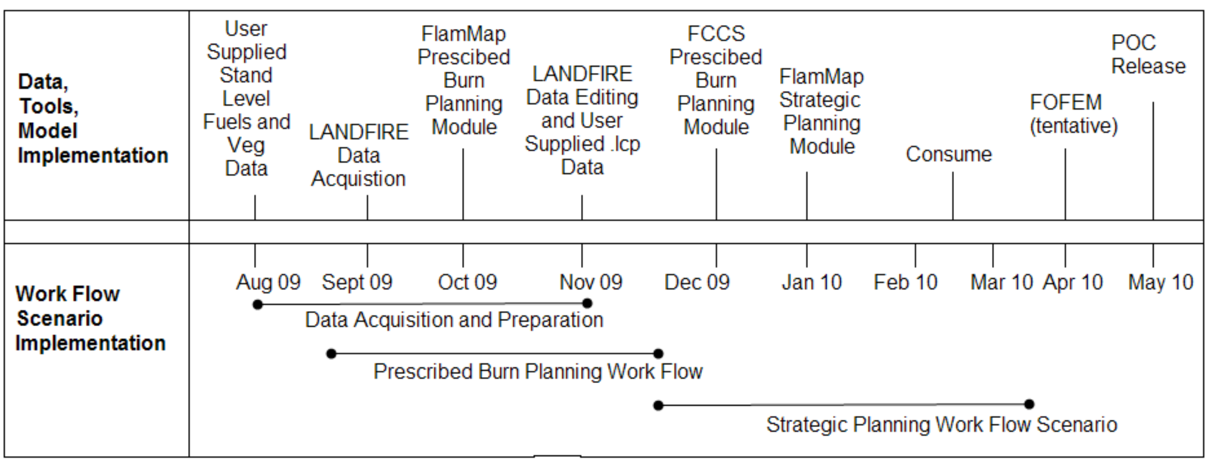

Figure 3-1. Target schedule and software tools implementation timeline for the IFT-DSS POC. Data, Tools, and Model Implementation will begin in Aug 2009 and continue until May 2010.

Implementation will begin with the ability to access LANDFIRE National data for use with fire behavior and fire effects models. The LANDFIRE data will serve as the main data source for the strategic planning work flow scenario in the POC and will be the default data set for the prescribed burn planning scenario. Next, FlamMap will be implemented to simulate fire behavior in the prescribed burn planning work flow scenario. Following implementation of the prescribed burn planning scenario using FlamMap, the FCCS will be implemented as an alternative pathway for simulating fire behavior in the prescribed burn planning scenario. As the POC develops, data-editing and user-input functionality will enhance user ability to upload local data and/or to modify existing LANDFIRE data layers (see Figure 3-1).

In the POC system, FlamMap will also be implemented to simulate fire behavior for strategic planning (Figure 3-1). Later in the development of the POC system, fire effects models will be added—initially CONSUME and, as time permits, FOFEM.

Although not shown in Figure 3-1, the IFT-DSS development team is currently working closely with the Integrated Forest Resource Management System (INFORMS) team to gain access to data (FSVeg) and software applications (yaImpute and FFE-FVS) that constitute the INFORMS system. The tentative plan is to stage the implementation of these tools immediately following the implementation of the strategic planning work flow scenario to support the use of tree-list vegetation and fuels data.

3.2 DATA ACQUISITION AND PREPARATION IN THE POC

In the IFT-DSS POC, the data acquisition functionality will provide the user with three options: (1) to manually enter data needed for prescribed burn planning (i.e., fuel model, fuel loadings, wind speed, etc.) into a form via the user interface,(2) to upload local data in .lcp file format, and (3) access to LANDFIRE National data. The ability to manually enter data will be implemented first, followed by LANDFIRE National data, and then the import functions to upload local .lcp files. As the POC is developed, additional functionality, such as the ability to edit .lcp files and LANDFIRE data for local conditions, will be added.

3.3 IMPLEMENTATION OF THE PRESCRIBED BURN PLANNING WORK FLOW SCENARIO IN THE POC

The IFT-DSS POC will have two options for performing fire behavior simulations: (1) ability to run FlamMap for a single point location, and (2) the FCCS fire behavior calculator. For both options, users will manually input data parameters such as wind, fuel models, fuel moisture, and fuel loadings. If a user selects the FlamMap pathway, FlamMap will function behind the scenes on a point location. In the FCCS pathway, the FCCS fire behavior calculator will function on individual fuelbeds. Fire effects will be simulated using either CONSUME or FOFEM. Simulations of possible fire behaviors provide essential information for describing the burn plan prescription (Element 7), the ignition plan (Element 15) and the holding plan (Element 16) (see Section 2.5).

FlamMap Pathway

Using the FlamMap pathway in the POC, the user will input data parameters required by FlamMap. FlamMap outputs will include fireline intensity, flame length, rate of spread, heat per unit area, horizontal movement rate, midflame windspeed, spread vectors, and crown fire activity; this information is crucial to determining how and when a prescribed burn should be conducted to meet specific objectives. As mentioned previously, CONSUME and FOFEM will be added to provide information about fire effects.

The POC will allow users to use the LANDFIRE National data layers for this workflow scenario if needed. The user will need to specify the prescribed burn geographic coordinates. The appropriate data will be retrieved, and the fire behavior and fire effects programs will simulate fire behavior and fire effects for the specified geographic location. **Figure 3-2** summarizes the process steps in this pathway.

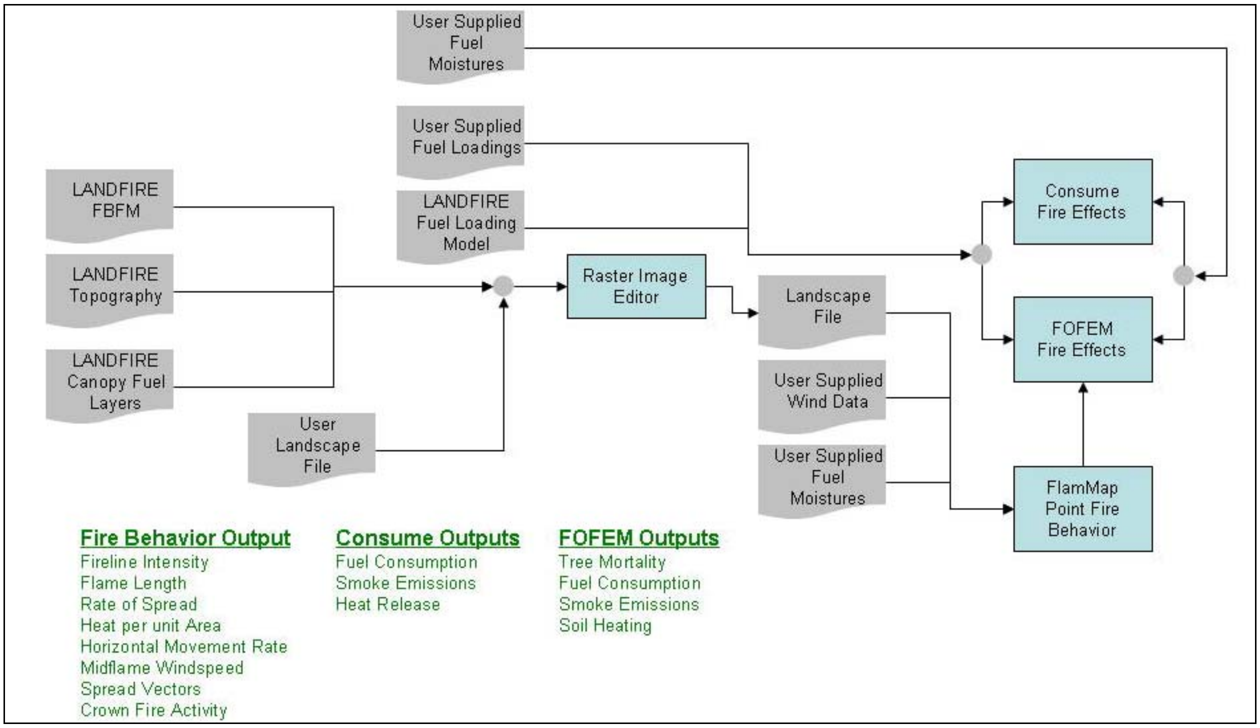

Figure 3-2. IFT-DSS POC prescribed burn planning work flow scenario: Option 1, the FlamMap pathway. Initial functionality will provide fire behavior output for prescribed burn planning. As functionality is increased, the ability to estimate fire effects using CONSUME and FOFEM will be supported.

Fuel Characteristic Classification System (FCCS) Pathway

The POC will provide the surface and crown fire behavior outputs currently found in the desktop version of the FCCS. Of most use for prescribed burn planning are reaction intensity, flame length, rate of spread, and crown fire potential. **Figure 3-3** summarizes the FCCS option for meeting the prescribed burn planning work flow scenario needs and provides more information about the data inputs and specific fire behavior outputs from the FCCS calculator.

In the POC, users will have the ability to manually enter fuelbeds into the FCCS, in a manner similar to manually entering fuelbeds into the current desktop version. In addition, a default set of gridded fuelbeds will be provided. As functionality increases, users will have the ability to manually edit fuelbeds within the FCCS using a FCCS fuelbed editor similar to that available in the standalone version of the FCCS; however, this functionality may not be available in the POC at the end of year 1 development.

In addition to fire behavior, the FCCS pathway will eventually include linkages to CONSUME and FOFEM. The CONSUME outputs (fuel consumption, smoke emissions, and heat released) or the FOFEM outputs (tree mortality, fuel consumption, smoke emissions, soil heating) provide information to address the manner in which a burn should be conducted to meet the prescribed burn objectives described in the burn plan.

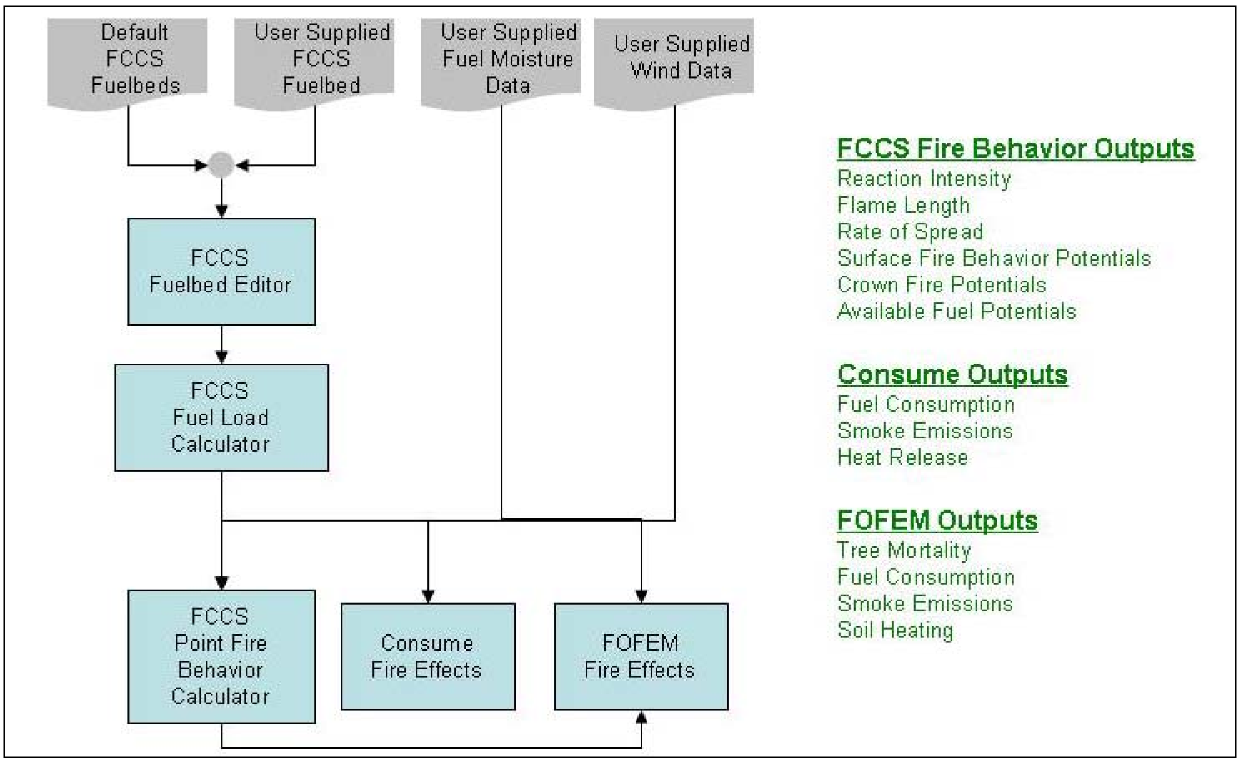

Figure 3-3. IFT-DSS POC prescribed burn planning work flow scenario: Option 2, the FCCS pathway. Initial functionality will provide fire behavior output for prescribed burn planning. As functionality is increased, the ability to estimate fire effect using Consume and FOFEM will be supported.

3.4 IMPLEMENTATION OF THE STRATEGIC PLANNING WORK FLFOW SCENARIO IN THE IFT-DSS POC

In the IFT-DSS POC, FlamMap will be implemented to perform fire behavior simulations across all pixels in an area of interest. Once FlamMap is functional, work will begin to implement the fire effects models CONSUME and FOFEM. CONSUME will be implemented first, followed by FOFEM.

FlamMap fire behavior outputs include fireline intensity, flame length, rate of spread, heat per unit area, horizontal movement rate, midflame windspeed, spread vectors, and crown fire activity. CONSUME fire effects outputs are fuel consumption, smoke emissions, and heat release, while FOFEM simulates tree mortality, fuel consumption, smoke emissions, and soil heating. **Figure 3-4** summarizes the strategic analysis work flow scenario as proposed for the POC.

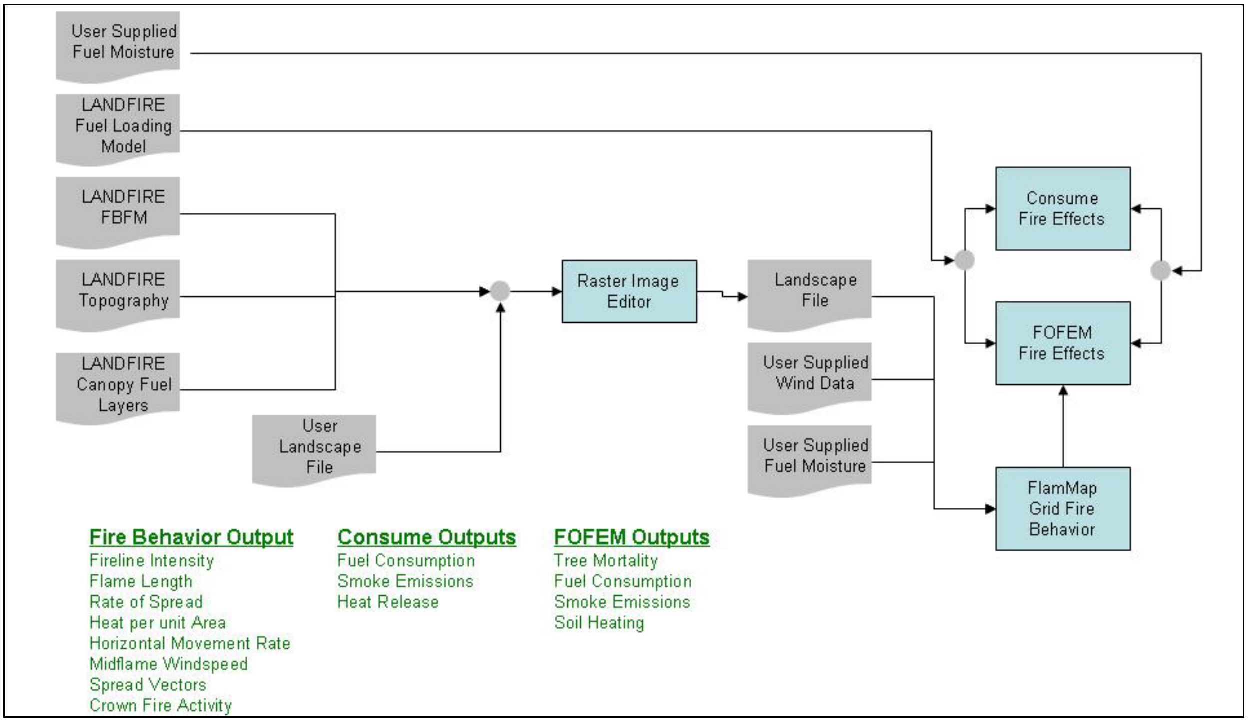

Figure 3-4. IFT-DSS POC strategic planning workflow scenario: Option 1, the FlamMap pathway. Initial functionality for the POC will support the use of LANDFIRE National Data. As functionality is increased users, will be able to upload LANDFIRE-like data and edit existing LANDFIRE data. In Option 1, FlamMap will be the fire behavior engine. Later POC implementation will include the fire effects models CONSUME and FOFEM.

3.5 IMPLEMENTATION APPROACH FOR THE IFT-DSS POC

Overview of Fully Functional IFT-DSS

Figure 3-5 lists the data and services that the fully implemented IFT-DSS will support. The work flow scenarios described in the previous sections have been simplified and are presented in the work flow process diagram shown in **Figure 3-6**. Figure 3-6 illustrates how the work flow scenarios described above fit within the fully functional IFT-DSS.

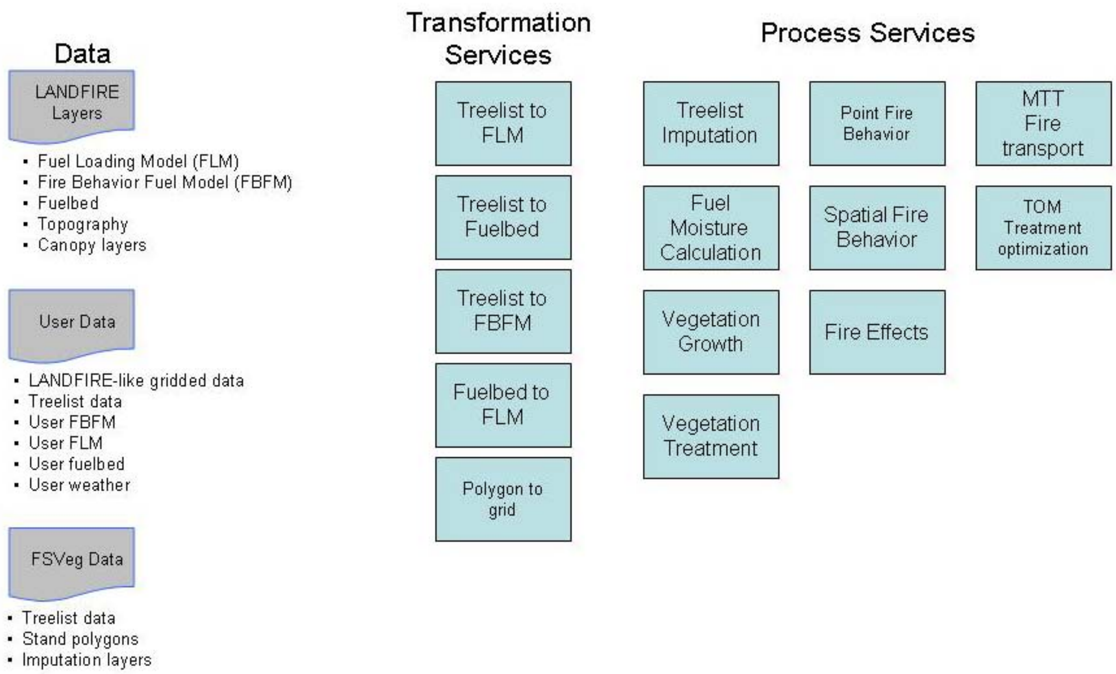

Figure 3-5. List of data and services that the fully implemented IFT-DSS will support.

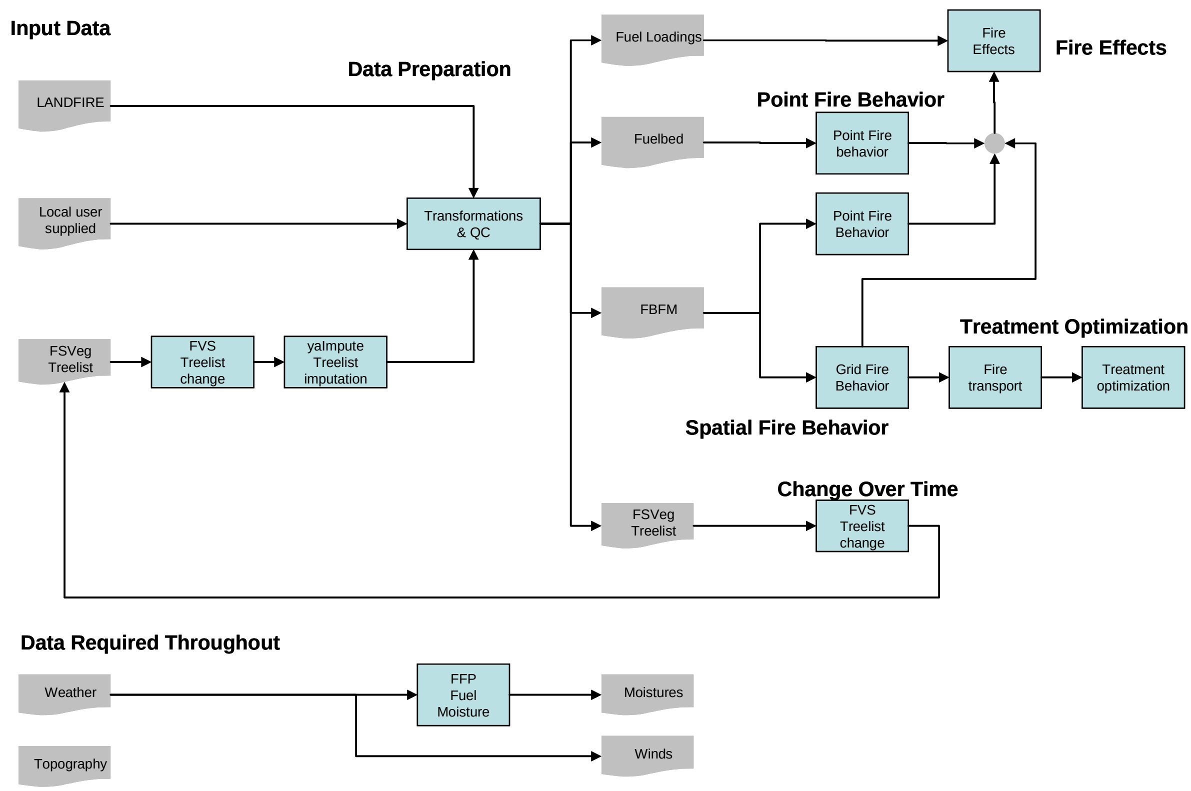

Figure 3-6. Overview of how the fuels treatment planning work flow scenarios fit within the fully functional IFT-DSS.

Overview of the Proposed IFT-DSS POC

The ultimate goals for the IFT-DSS POC at the end of the first year (May 2010) are to demonstrate the feasibility of the system and to deliver a product that is useful for the fuels treatment planning community. To maximize the functional capabilities of the POC within the limited, one-year time frame, we have tentatively chosen to focus on the implementation of three input data types and three work flow scenarios. **Figure 3-7** illustrates the pathways (colored lines) and the order of implementation (numbers) proposed for the POC during the first year of development.

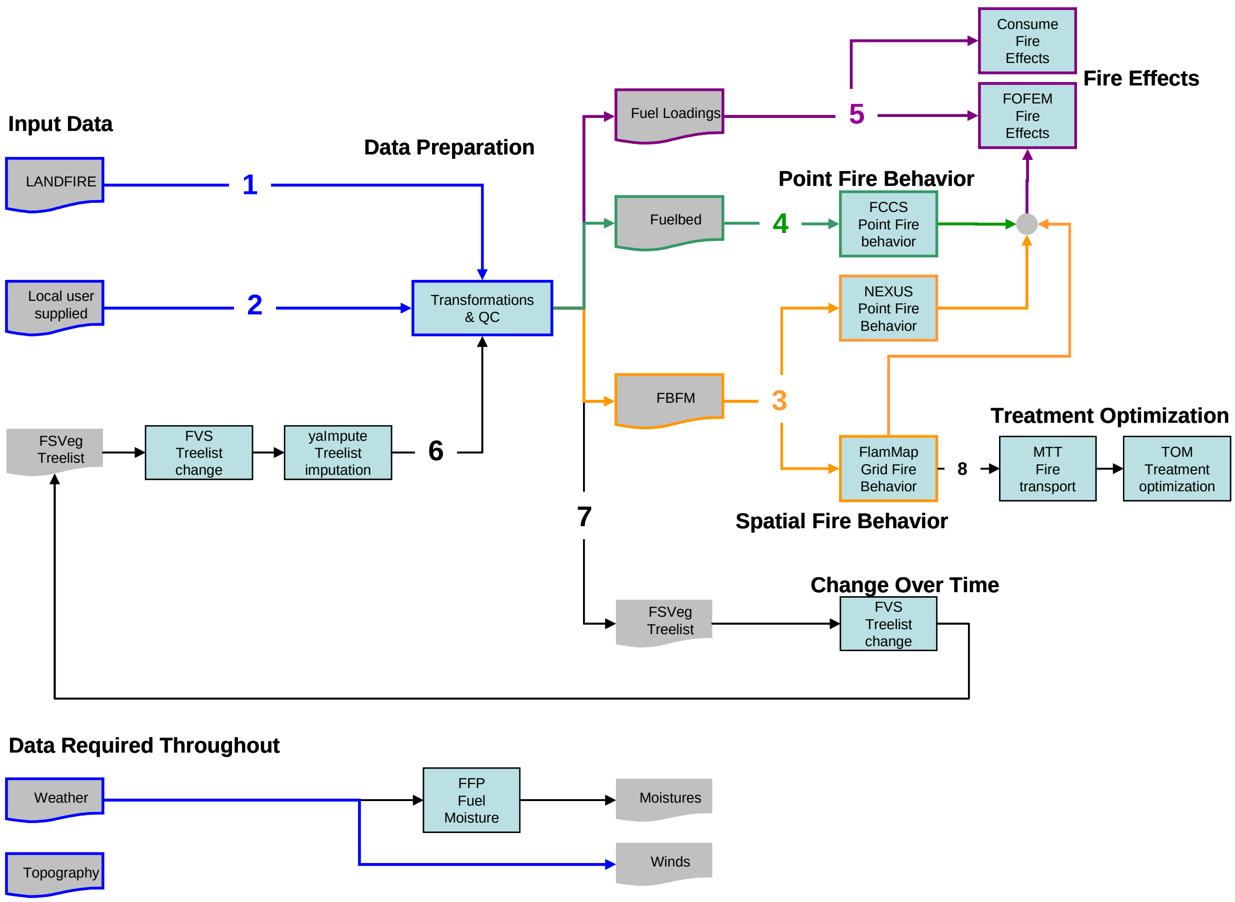

Figure 3-7. Illustration of the pathways (colored lines) and implementation order (numbers) proposed for the IFT-DSS POC.

The pathways indicated by black numbers are proposed for the second year of development. It should be noted that the risk assessment work flow scenario is not shown on this diagram; however, the tentative plan is to implement that portion of the system in the third year of development.

The implementation plan and priority for the POC system and the implementation approach presented here is based on a variety of factors. The following summarizes the rationale for the proposed POC implementation approach in the context of the two key objectives of the POC which are to demonstrate the feasibility of the IFT-DSS and to deliver a product that is useful for the fuels treatment planning community. To satisfy these objectives, we have chosen to implement those work flow scenarios that have been identified as the most immediately relevant based on feedback from the fuels treatment planning community: (1) data acquisition and preparation, (2) the strategic planning work flow scenario, and (3) the prescribed burn planning work flow scenario.

For the data acquisition and planning work flow scenario, we have initially chosen to focus on three types of data for input and preparation: (1) manually entered data for a single treatment unit analysis, (2) local data in .LCP file format that can be uploaded to the system, and (3) LANDFIRE National default data. These data choices will allow the IFT-DSS POC development team to implement useful, complete workflow scenarios rather than focus all efforts on implementing both data types (gridded LANDFIRE and tree-list) at the risk of not being able to implement complete work flow scenarios at the end of the first year. We chose to start with user-provided .LCP file formats and the LANDFIRE National data set because .LCP files are commonly used for fuels treatment planning and can be developed from tree-list data for importation to grid-based fire behavior applications such as FlamMap. In addition, the LANDFIRE National data are available for immediate use, and the data set provides complete coverage of the United States and is suitable for use in the strategic planning work flow scenario. The LANDFIRE data set also provides fuel information for non-forested areas.

Implementation of the tree-list data pathway is tentatively planned early in the second year of development because we are currently working with the INFORMS team to acquire the necessary data, software tools, and algorithms needed for implementing the tree-list pathway. FSVeg data are currently expected to be available for access outside the Forest Service firewall sometime between fall 2009 and spring 2010.

We have chosen to implement the software applications indicated in Figure 3-7 because (1) they have been identified as widely adopted and used by the fire and fuels community, and (2) they are likely to be the most technologically feasible for implementation into the system in the first year of development.

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