January 21, 2009

To: The Interagency Fuels Treatment Work Group (IFTWG) STI-908038.01

From: Tami Funk, Mike Rauscher, Sean Raffuse, and Lyle Chinkin

Re: Findings of the Current Practices and Needs Assessment for the Interagency Fuels Treatment Decision Support System (IFT-DSS) Project

INTRODUCTION

Due to a proliferation of software systems and analysis tools in the fire and fuels management domain over the past decade, the task of managing and guiding the development of new tools and data sets is very challenging. Awareness, access, and distribution of data and software tools in the fire and fuels planning and management community has decentralized due to the heterogeneity of available data, data formats, software systems, ad-hoc tools, and workflow processes. As a result, fuels treatment analysts and decision makers are left with an assortment of unconnected systems in various stages of development and little guidance with respect to the strengths and weaknesses of these systems. There is currently a need for a software architecture framework to integrate and facilitate the use of these software models and tools for more effective and efficient fuels treatment planning.

The interagency Joint Fire Science Program (JFSP), through both formal and informal interactions with its partners and clients, became convinced that the need for an integrated model management framework is a pressing issue currently facing fire and fuels analysts and decision makers. Acting in concert with the National Interagency Fuels Coordination Group (NIFCG), the JFSP initiated the Software Tools and Systems Study (STS) in 2007. The JFSP funded the Carnegie Mellon Software Engineering Institute (SEI) to perform a strategic analysis of the problem. This analysis was completed in March 2008, and SEI submitted a written report to the JFSP. A key finding of the SEI study was that the fire and fuels management community would greatly benefit from a platform and systems architecture that supports collaboration (Palmquist, 2008).

BACKGROUND

Following Phase I of the STS study, the JFSP initiated Phase II of the STS study with the ultimate objective of designing a software architecture for an Interagency Fuels Treatment Decision Support System (IFT-DSS). An Interagency Fuels Treatment Working Group (IFTWG) was formed to help guide the Phase II project and a team from Sonoma Technology

Inc. (STI) was commissioned to help. The overall effort of Phase II of the STS involves three tasks:

Task 1. Performing an assessment of current practices in the fuels treatment community;

Task 2. Assessing selected existing software system architectures for possible application in the fuels treatment domain; and

Task 3. Recommending and designing a software architecture for the IFT-DSS.

At the onset of Phase II of the STS, the JFSP and the IFTWG developed a vision and conceptual design for the IFT-DSS (JFSP, 2008). 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 STI worked collaboratively to perform an assessment of current practices and needs of the fuels treatment community. The objectives of performing the current practices and needs assessment were to

- identify and understand the business, or work flow process, data, and software tools that are currently used by fuels treatment analysts and planners to support decision-making,
- document and reconcile the work flow processes currently in use in the field against the vision and conceptual design of the IFT-DSS, and
- inventory and document the most commonly used software tools and data sets for fuels treatment planning.

At the most basic level, the fuels treatment analysis and planning process involves performing environmental assessments of fuels treatment options as mandated by the National Environmental Policy Act (NEPA). This decision process centers on managing outcomes by modifying vegetation. The processes required to arrive at an outcome involves preparing a detailed vegetation dataset, modeling vegetation changes based on growth, treatments, and/or disturbance, and analyzing the outcomes of the modeled vegetation. The fuels treatment specialist then recommends which treatment option to apply. Due to the abundance and decentralization of available data sources, tools, and software modules for fuels treatment planning, there does not appear to be one standard way of arriving at a fuels treatment action decision. Therefore, it was necessary to understand how fuels treatment analysts and planners actually conduct a fuels treatment analysis and to identify the data, tools, and software packages most commonly used in practice. The overall goal of Task 1 is to ensure that the vision and conceptual design for the IFT-DSS are consistent with fuels treatment practices and needs.

APPROACH

The JFSP, the IFTWG, and STI worked collaboratively to identify current practices used by fuels treatment specialists. The overall approach to performing the assessment of current fuels treatment planning practices involved (1) conducting a survey of the fuels treatment planning community, (2) conducting interviews with select fuels treatment specialists, and (3) assessing four comprehensive systems that currently exist to aid in fuels treatment planning.

At the onset of Task 1, a survey was conducted to understand the current practices used by fuels treatment specialists for planning and decision-making. It was discovered through discussions with fuels treatment planners and from the preliminary survey results that fuels treatment practitioners commonly use ad hoc approaches for planning and decision-making rather than one or more of the four comprehensive fuels treatment planning systems. To understand these ad hoc practices, interviews were conducted with four fuels treatment specialists to understand the methods and tools used in their analyses. In parallel with the survey and interview process, four comprehensive software systems (or processes)—(1) INFORMS, (2) ArcFuels, (3) IFP-NIFTT-LANDFIRE, and (4) Starfire—were identified and assessed to understand the work flow process, data inputs, data outputs, and requirements of each system. The remainder of this section is a discussion of the approach used to perform the assessment of current practices and needs in the fuels treatment community.

Survey of the Fuels Treatment Planning Community

An interagency survey of the fuels treatment planning community was conducted to identify software tools and/or systems currently used in the field by fuels treatment planners. Two questions were distributed to fuels treatment representatives of the Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), the Forest Services (FS), the National Park Service (NPS) and the U.S. Fish and Wildlife Service (FWS):

1. Are fuels specialists, planners, ecologists etc. using any software system(s) for fuels treatment planning (e.g., prescribed fires, mechanical removal, etc.)?
2. If so, what software systems are they using to perform their fuels treatment planning work?

The survey yielded 29 responses from various fuels treatment specialists representing the agencies surveyed. The raw survey responses are included in Appendix A and the findings from the survey are discussed in the Summary of Findings section of this document.

Interviews with Fuels Treatment Specialists

Although at least four comprehensive systems are available to aid in fuels treatment planning, it was learned through the preliminary responses from the fuels treatment community survey that, as of 2008, most practitioners do not use any of the four systems and instead employ an ad hoc approach to fuels treatment planning. As a result, we felt that it was important to interview fuels treatment planners from different agencies to understand how they conduct fuels treatment planning to ensure that the design of the IFT-DSS meets the requirements and needs of the community.

Based on the fuels treatment specialist survey responses, five specialists representing four federal agencies (two from BLM, one from FS, one from NPS, and one from FWS) were interviewed to understand how they conduct fuels treatment planning. Interview notes were synthesized to develop a conceptual understanding and diagram of the work flow processes and current practices and to develop an inventory of data and software tools used. Appendix B includes copies of the interview transcripts. Appendix C includes a list and description of the most commonly used data, software models, and tools for fuels treatment planning. The Summary of Findings section of this document includes a discussion of the findings of the fuels treatment specialist interviews.

Assessment of Four Comprehensive Fuels Treatment Analysis and Planning Systems

Four comprehensive fuels treatment planning systems—INFORMS, ArcFuels, IFP-NIFTT-LANDFIRE, and Starfire—were assessed by STI to understand how each system is used in practice and the overall approach and work flow process employed by each system. The data requirements, sub-models, and software tools contained in (or accessible by) each system were also identified. Before conducting the system assessment, STI developed evaluation guidelines for assessing the four systems. The evaluation guidelines were developed to ensure that the four systems were assessed on the same criteria and that the appropriate information was obtained to inform the design of the IFT-DSS vision and conceptual design. STI worked collaboratively with the JFSP to perform the system evaluation using the following four steps:

Step 1: Identify and establish contact with the developer (or development team) for each comprehensive system.

Step 2: Gather information about the system, including system documentation, user guides, tutorials, and the software itself when available.

Step 3: Meet with the developer or development team to understand each system and its data inputs and outputs, work flow process, and software sub-models. In-person meetings were conducted when possible.

Step 4: Summarize the information gathered about each system, including the data inputs and outputs, work flow process diagrams, and sub-models.

Appendix D has supplementary information about the systems that will be important for the IFT-DSS design. A discussion of the overall findings of the comprehensive system evaluation is included in the Summary of Findings section of this document.

SUMMARY OF FINDINGS

This section presents an overall summary of the findings from the fuels treatment planning survey, the interviews conducted with fuels treatment specialists, and the assessment of the four comprehensive fuels treatment planning systems.

Overall Findings from the Fuels Treatment Survey and Interviews

To understand and define the work flow processes used in practice by fuels treatment specialists, the findings from the fuels treatment specialist survey, interviews, and assessment of the four comprehensive systems were synthesized to identify common-use cases and to develop a work flow process diagram identifying and defining major analysis steps and sub-processes used in fuels treatment analysis and planning. Through discussions with fuels treatment specialists, we found that several types of analytical use cases with specific analysis objectives are commonly performed. These use cases range from comprehensive assessments in which the risks associated with different treatment approaches are examined to analyses to identify appropriate conditions to perform specified treatments. While there are variations in analysis approaches, general use cases were identified through the fuels treatment survey, interviews, and system evaluations:

Use Case 1. Analyses performed at the strategic management level to identify and prioritize treatment areas for multiple vegetation units or landscape. This objective is to identify and prioritize areas within a landscape where treatment may be warranted for planning purposes.

Use Case 2. Comprehensive risk analyses and treatment strategies are applied for multiple vegetation units or landscape. This is an end-to-end analysis expanding on Use Case 1 by designing and evaluating treatment strategies following a risk assessment.

Use Case 3. Analyses to simulate treatment over time for a single vegetation unit or collection of individual units without taking spatial juxtaposition into account. This objective is to understand the fire and fuels related characteristics of specific fuels treatments and the duration of effectiveness for each vegetation unit.

Use Case 4. Analyses to determine under what weather conditions a prescribed burn should be conducted on a single vegetation unit.

The fuels treatment decision support process involves the following six steps:

1. <u>Define vegetation data, landscape, and scale</u> – Prior to a fuels treatment analysis, the appropriate vegetation data (i.e., treelist vegetation data versus gridded vegetation data, data parameters, geographic coverage, and resolution) must be identified to meet the analysis objectives. Geophysical data such as topography and weather data may also be required. For some use cases, no explicit data are input at all and those data that are required are input directly by the user based on expert judgment.

2. <u>Prepare and quality assure current year data</u> – In many cases, the fuels treatment specialist must manipulate raw vegetation data to produce a data set that is more representative of real world conditions and/or that provides geographic coverage adequate to meet the analysis objectives. This step might include imputation of treelist data for a multi-unit analysis and/or updating gridded LANDFIRE data to better reflect actual vegetation conditions.

3. <u>Simulate and analyze fire behavior or effects</u> – Next, an analyst might simulate fire behavior or effects of fire on values at risk either for a vegetation unit or on a landscape (spatial data).

4. <u>Analyze risk</u> – If a risk analysis is required, the analyst would use risk assessment tool(s) to identify those areas within a landscape that are at risk given specified risk parameters or values. Expert judgment is then used to identify those areas at greatest risk and prioritize treatment areas.

5. Design treatment strategies – Based on the results of the fire behavior modeling and risk analysis, the analyst would determine if geophysical, ecological, and/or socioeconomic target conditions have been met. If target conditions are met, the analyst may conclude the analysis. If the target conditions are not met, the analyst would design treatment strategies and re-simulate vegetation or weather conditions (or both) to assess treatment effects for a single unit or landscape.

6. Simulate vegetation, geophysical, and fuel conditions – If the target conditions are not met, the analyst would design a treatment strategy and re-simulate vegetation data and/or simulate weather conditions to generate data for use in a fire behavior model(s). This process is repeated as necessary until target conditions are met.

Section 5 of the IFT-DSS conceptual design document provides a more detailed discussion of the six steps listed above (Joint Fire Science Program, 2008).

Figure 1 illustrates a composite or generic work flow process diagram that reflects the different use cases and analysis methods identified from the current practices assessment. Note that along the left side of the diagram, each major step in the fuels treatment planning process is labeled in blue and indicated with blue lines. Within each major step of the process, sub-steps may be required to move from one major step to the next. Our first task was to focus on identifying and validating the six major functional steps that define the fuels treatment analysis and planning process. We fully realize that within each major step, we may need to specify additional functions that have not yet become clear. In particular, we believe the fire behavior and effects step and the risk analysis steps will need much more work to provide more clarity.

The work flow process diagram in Figure 1 represents a synthesis of the four use cases in one diagram. **Figures 2 through 5** illustrate the work flow diagrams for each use case (listed above) with the specific process highlighted for each case. The fuels treatment interview transcripts are included in Appendix C.

Interviews with fuels treatment specialists at the BLM, the FS, the NPS, and FWS indicate that, while fuels treatment specialists do make some use of software models and tools for analysis and planning, they also rely heavily on experience and expert judgment in planning and decision making. In almost all the interviews, it was noted that the vegetation data required to perform fuels treatment analyses require a substantial amount of time to prepare and are often generated manually. Work flow processes diagrams (similar to those shown in Figures 1 through 5) were developed based on the interview transcripts and are shown in **Figures 6 through 10**.

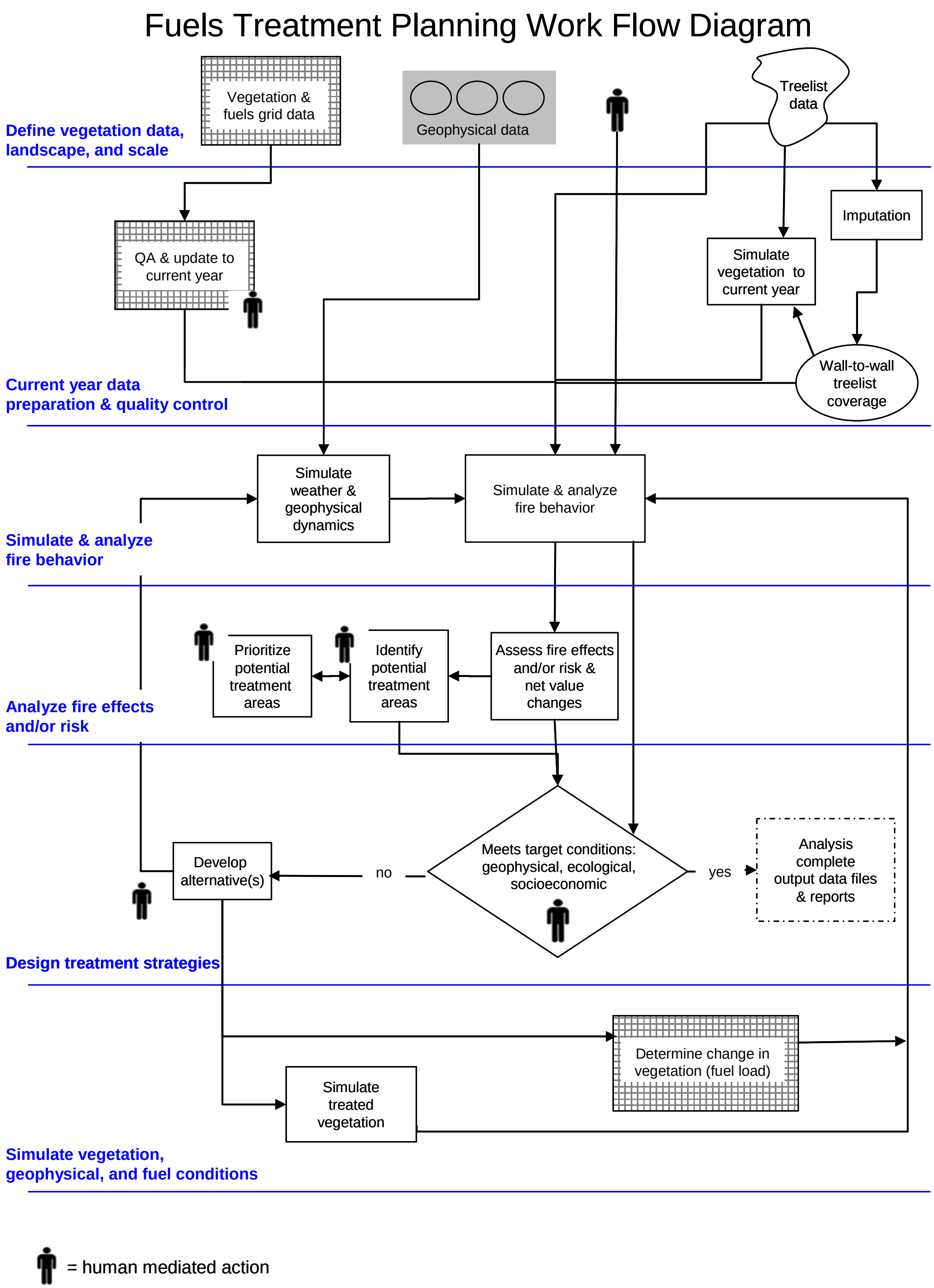

Figure 1. Work flow process diagram for fuels treatment analysis and planning.

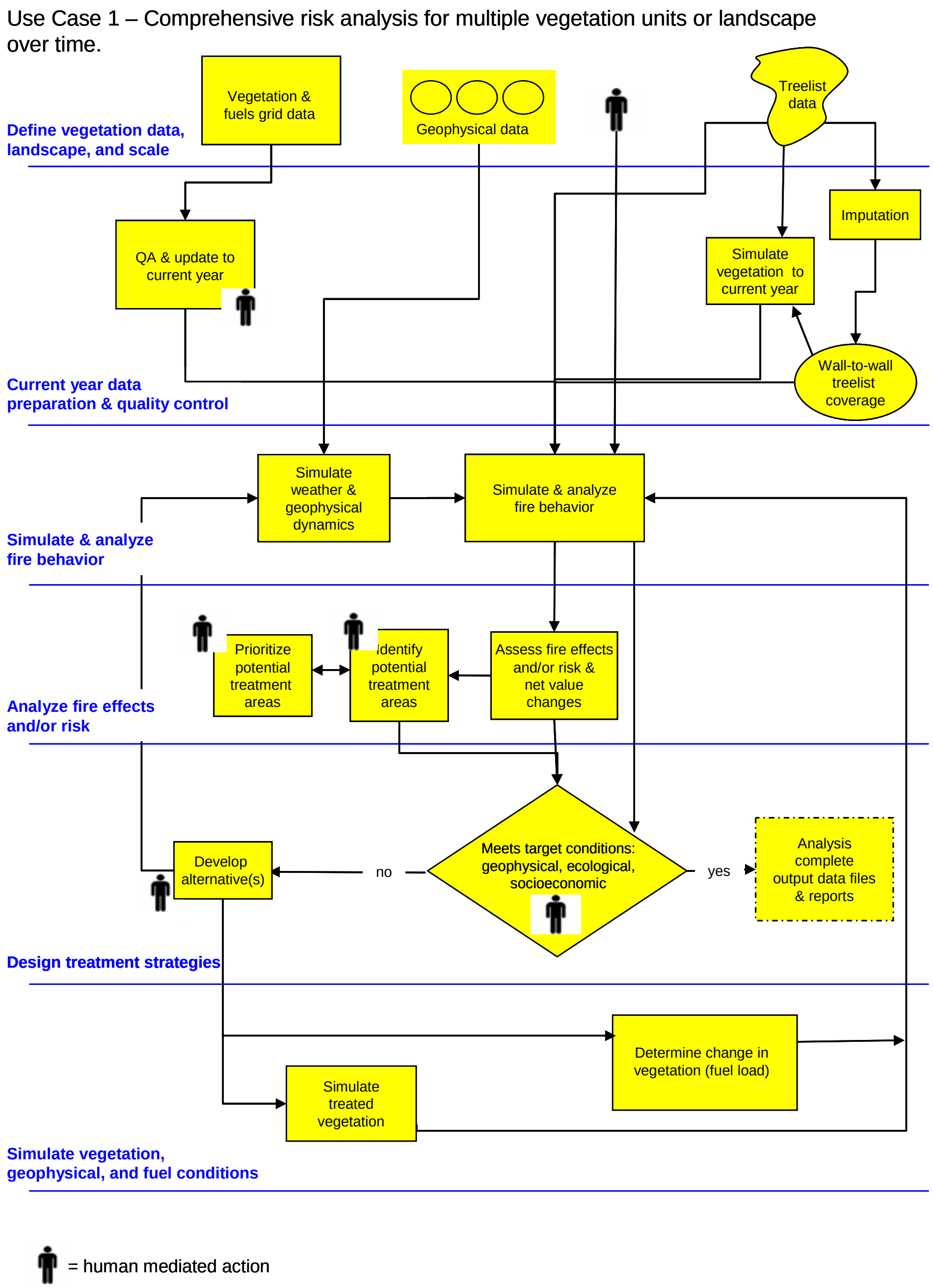

Figure 2. Work flow process diagram for Use Case 1, a comprehensive risk analysis to examine treatment strategies applied to multiple vegetation units or landscape.

Use Case 2 – Strategic planning analysis to identify and prioritize treatment areas for multiple vegetation units or landscape.

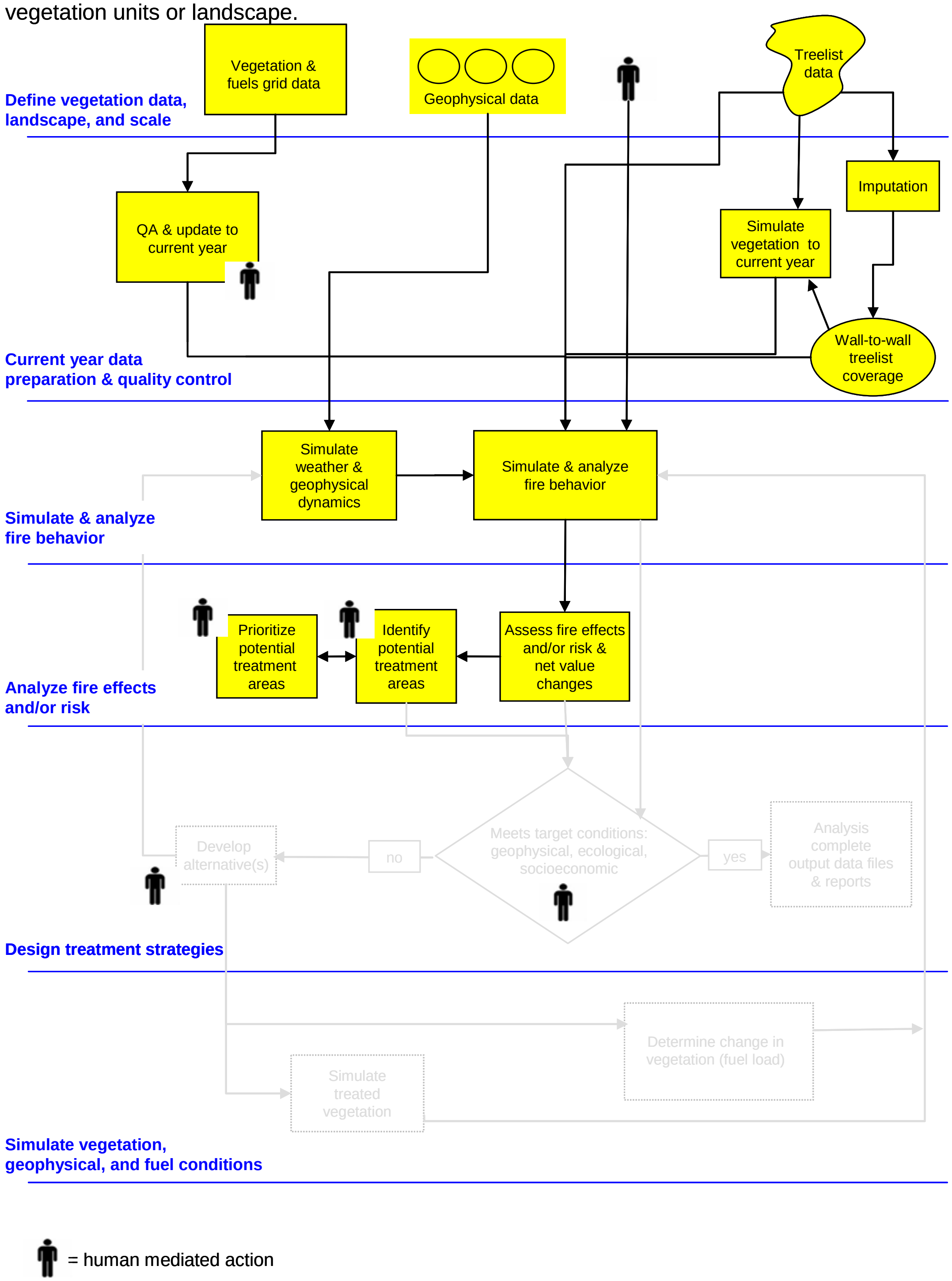

Figure 3. Work flow process diagram for Use Case 2, a strategic analysis to identify and prioritize treatment areas for multiple vegetation units or landscape.

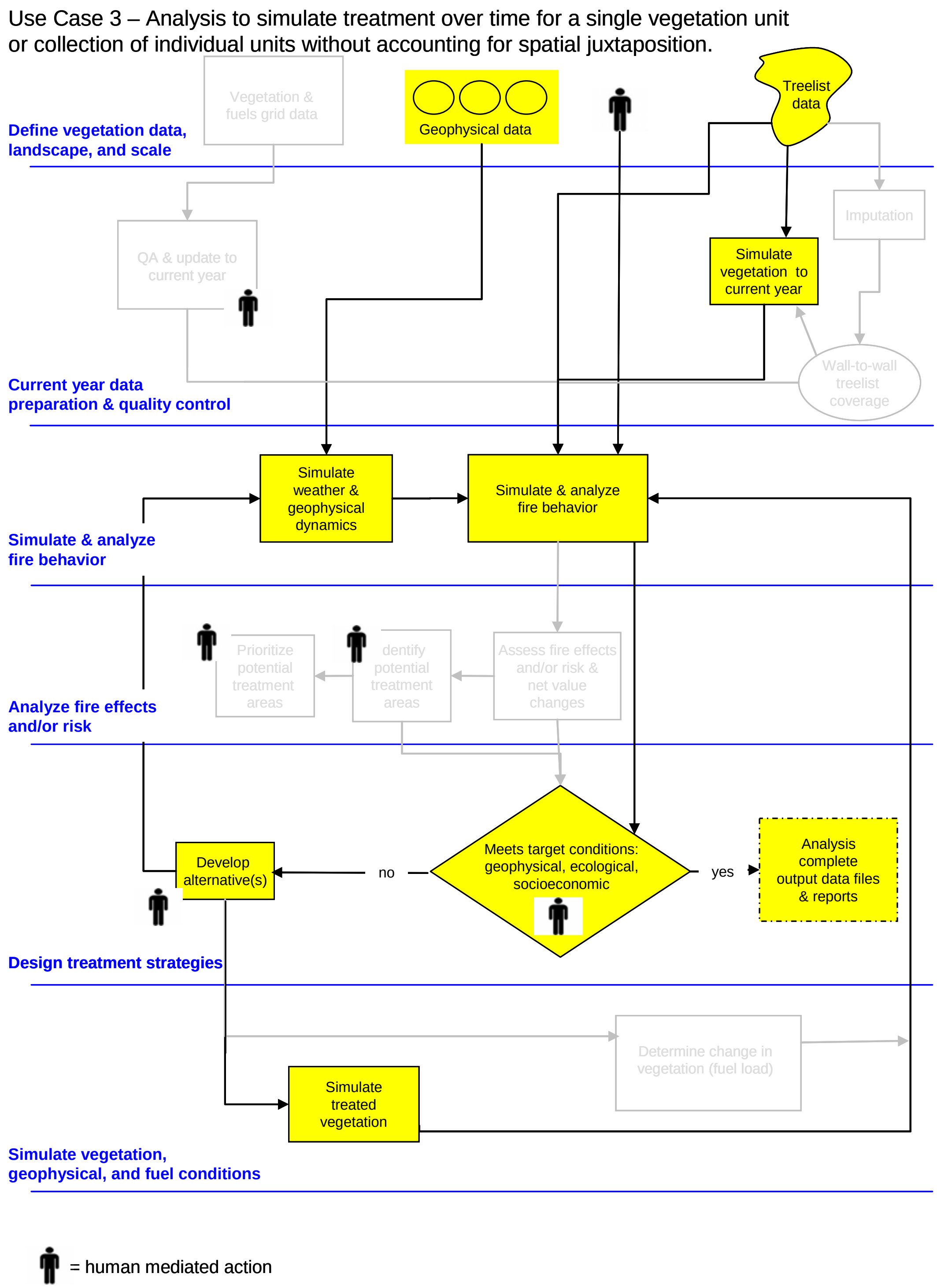

Figure 4. Work flow process diagram for Use Case 3, an analysis to simulate treatment over time for a single vegetation unit or collection of individual units without taking spatial juxtaposition into account.

Use Case 4 – Analysis to determine under what weather conditions to conduct a prescribed burn on a single vegetation unit.

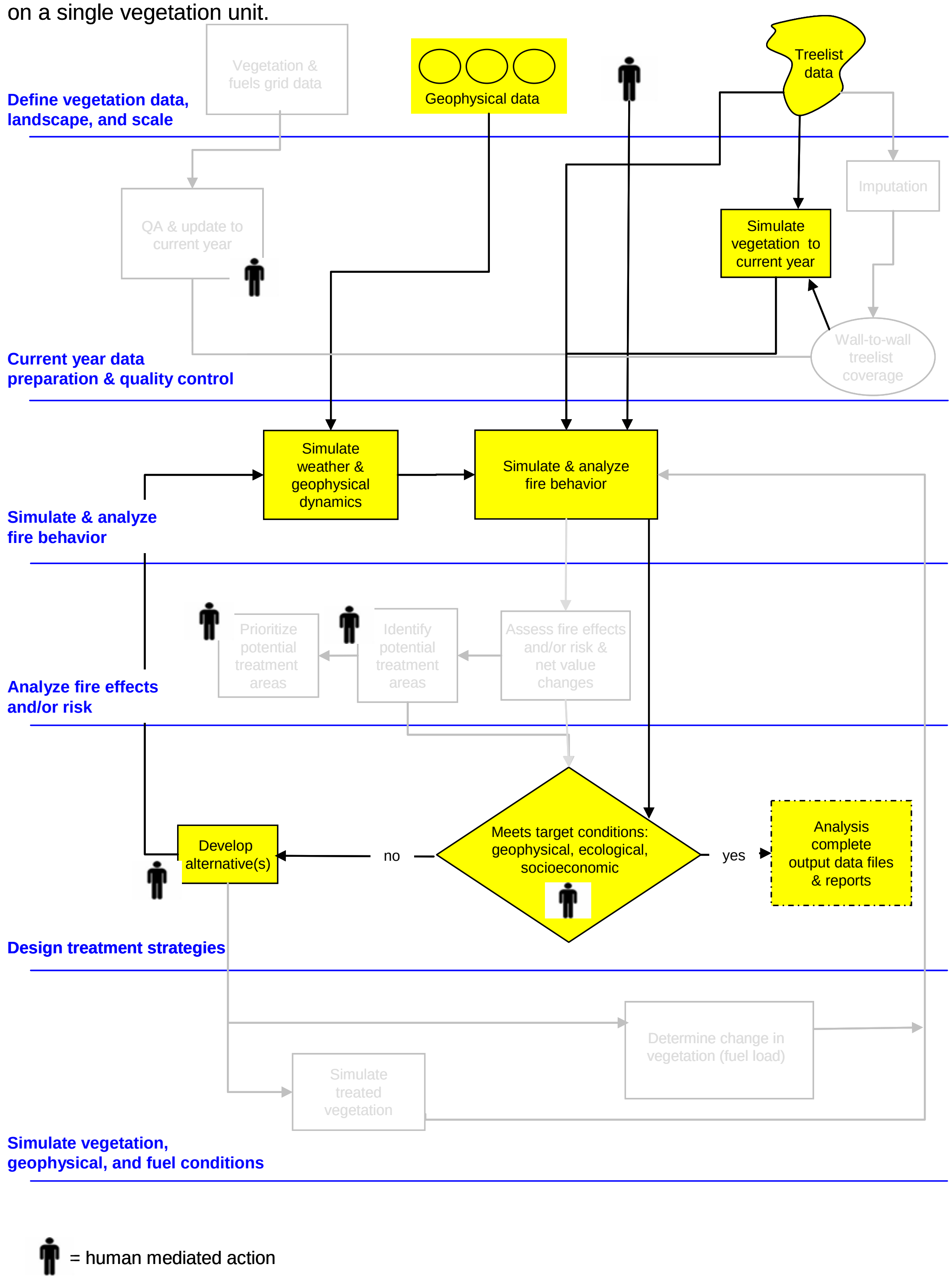

Figure 5. Work flow process diagram for Use Case 4, an analysis to determine under what weather conditions to conduct a prescribed burn on a single vegetation unit.

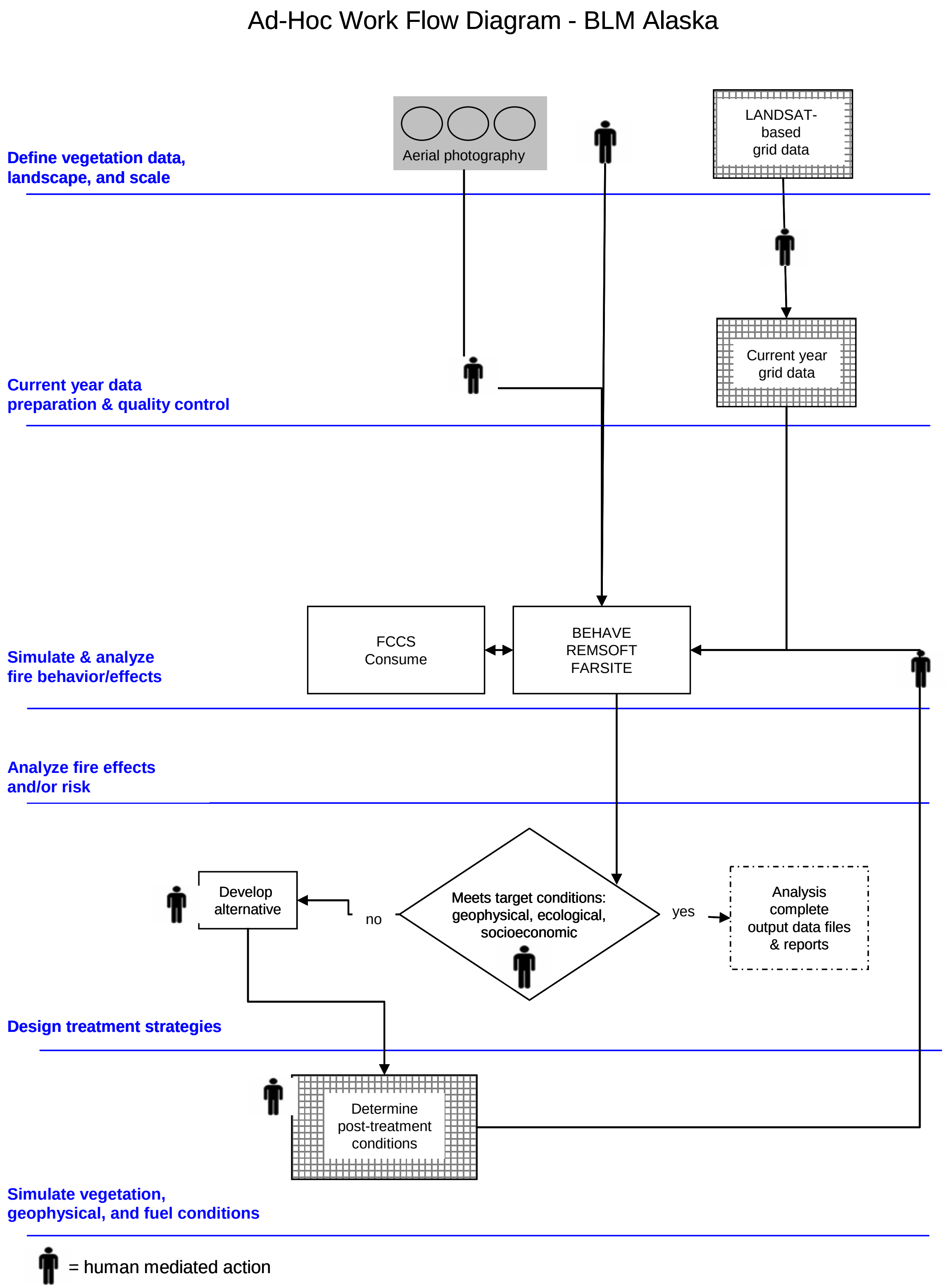

Figure 6. Work flow process diagram developed from an interview with a fire ecologist at the BLM in Alaska.

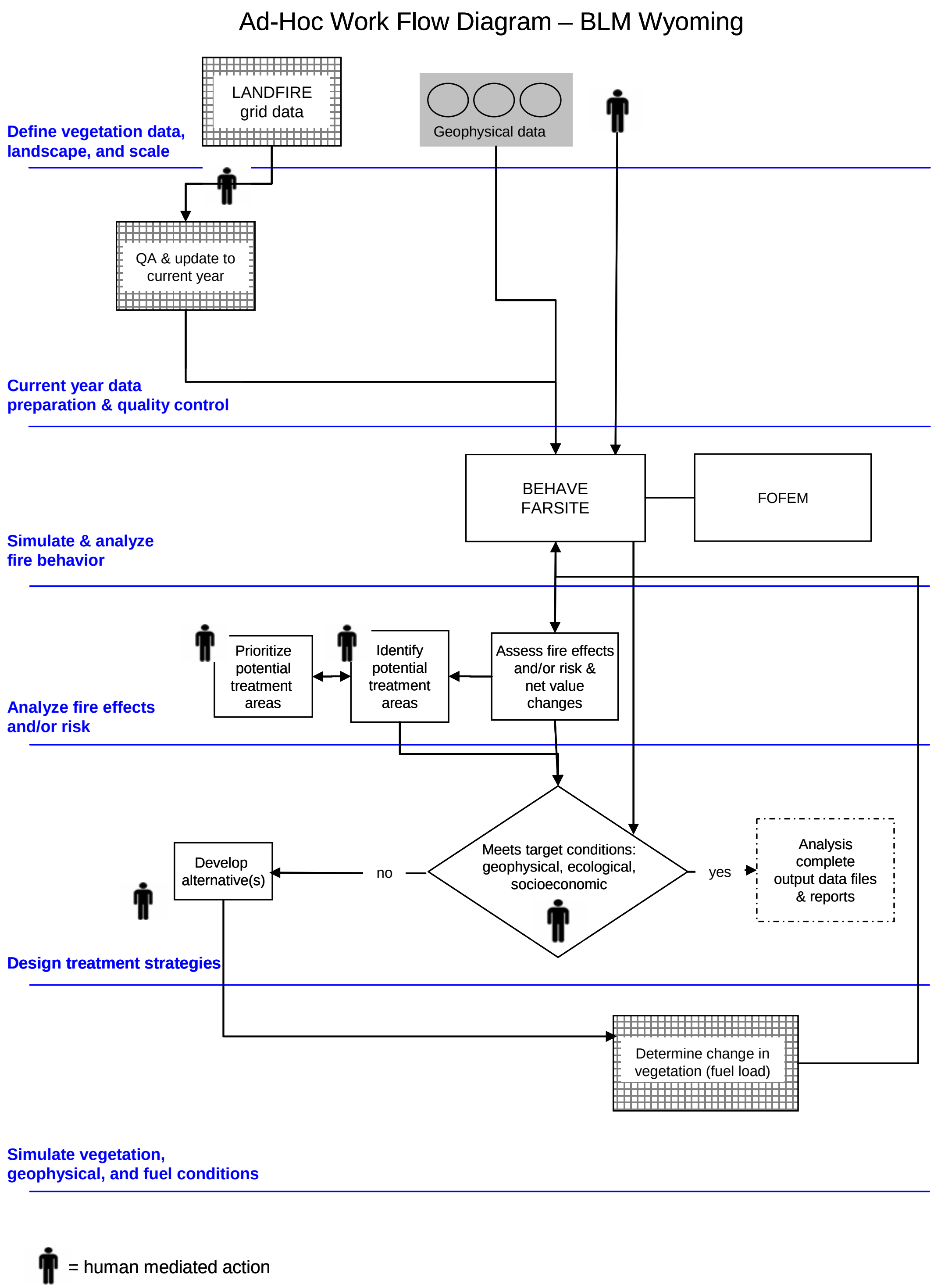

Figure 7. Work flow process diagram developed from an interview with a fuels treatment specialists at the BLM in Wyoming.

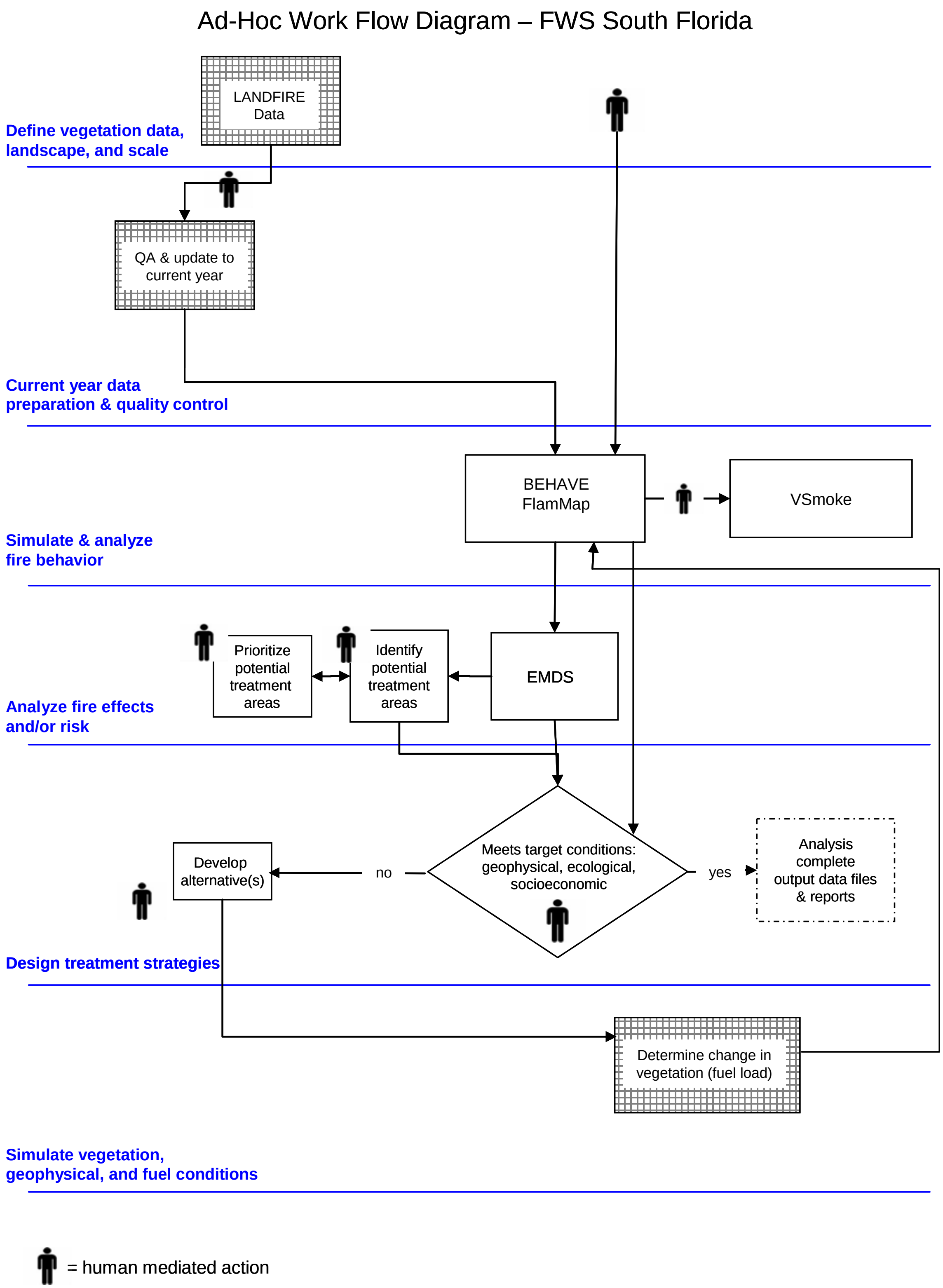

Figure 8. Work flow process diagram developed from interviews with a prescribed fire specialist at the FWS in South Florida.

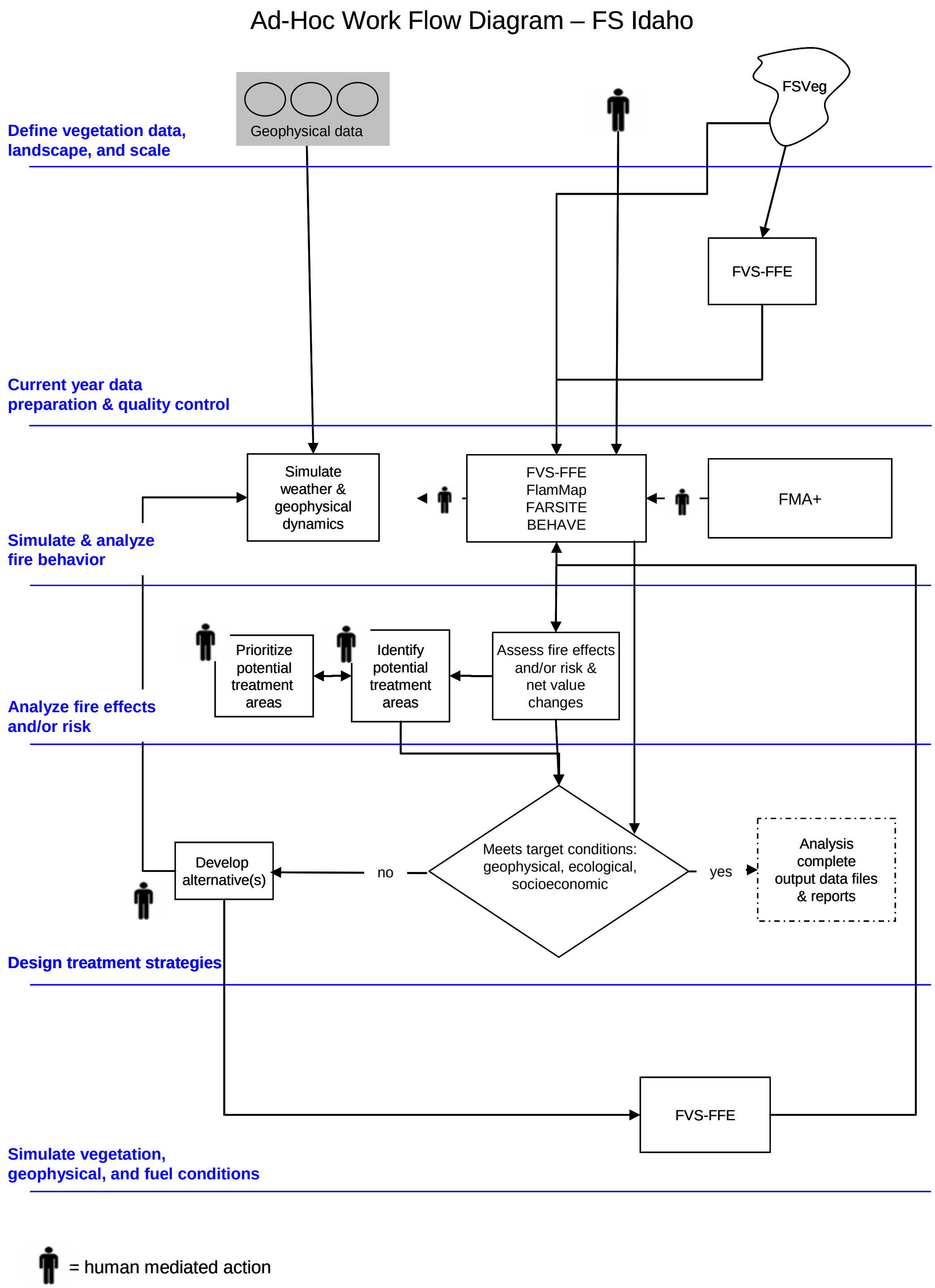

Figure 9. Work flow process diagram developed from an interview with a fuels planner at the FS in Idaho.

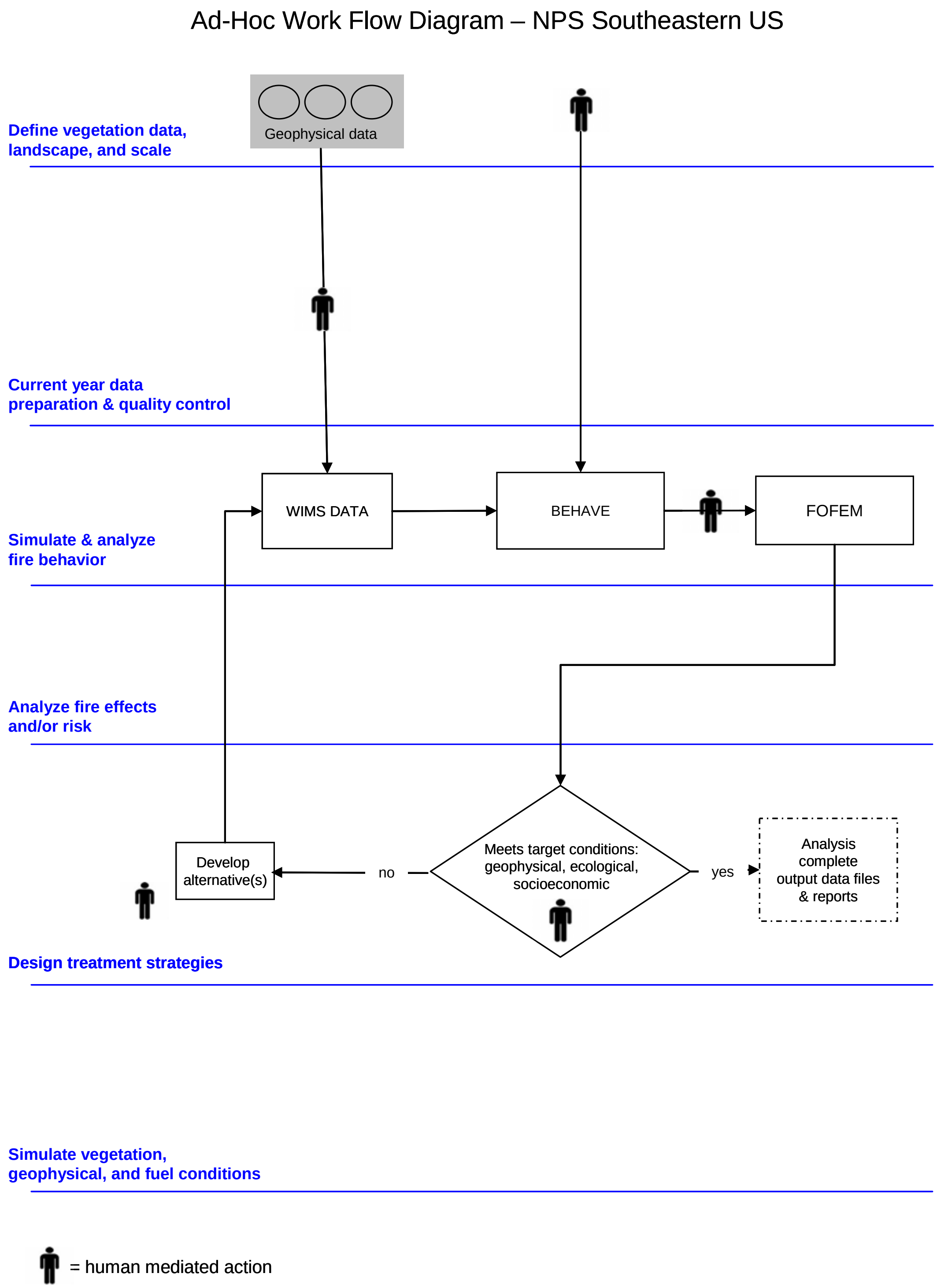

Figure 10. Work flow process diagram developed from an interview with the fire management officer and fire use module leader at the NPS in the southeastern United States.

Summary of Data Sources and Base Models to Support Fuels Treatment Planning

Part of the current practices and needs survey involved creating an inventory of data, software models, and tools that are commonly used in fuels treatment planning. Based on information from the fuels treatment specialist survey, interviews, and the assessment of the four comprehensive systems, an inventory of the most commonly identified data, software models and tools was compiled. **Table 1** lists the most commonly used data sets and software tools identified through the fuels treatment specialist survey. **Table 2** categorizes each of the data sets and software tools based on where they are used in the fuels treatment planning process. Appendix D contains a complete list of data, software models, and tools and their descriptions as they will be referred to throughout the remainder of this section.

Table 1. A list of the most commonly used data sets and software tools identified through the fuels treatment specialist survey.

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Names and Descriptions of the Data and Software Tools Commonly Used for Fuels Treatment Planning		
Data	Aspect	Direction to which a mountain slope faces
	Digital Elevation Model (DEM)	Digital representation of ground surface topography or terrain.
	FEAT/FIREMON Integrated (FFI)	Designed as a comprehensive, database-driven framework that organizes sampling protocols, stores field data, and provides analysis tools for vegetation sampling and monitoring programs.
	Field Sample Vegetation Database (FSVeg)	FSVeg contains plot vegetation data from field surveys such as FIA data, stand exams, inventories, and regeneration surveys.
	GNN-FVS	Vegetation data for the Pacific Northwest
	LANDFIRE (grid)	LANDFIRE data products are designed to facilitate national- and regional-level strategic planning and reporting of wildland fire management activities.
	Slope	Slope is used to describe the steepness, incline, gradient, or grade of topography or terrain.
	Weather	Weather Information Management System (WIMS) weather data.
Tools and Models	Area Change Tool (ACT)	Tool used to help design and delineate fuel and vegetation prescriptions as well as edit raster layers to accurately portray treatment outcomes. The ACT is part of the IFP-LANDFIRE tool kit.
	BEHAVE-Plus	Fire modeling system comprised of a collection of models that describe fire behavior, fire effects, and the fire environment and produces tables, graphs, and simple diagrams.
	CONSUME	Decision-making tool, designed to assist resource managers in planning for prescribed fire, wildland fire for use, and wildfire by predicting fuel consumption, pollutant emissions, and heat release.
	Ecosystem Management Decision Support System (EMDS)	Integrates GIS, logic, and decision modeling to provide decision support for a substantial portion of the adaptive management process of ecosystem management.
	FARSITE	Fire growth simulation model that uses spatial information on topography and fuels with weather and wind files
	Fire and Fuels Extension for FVS (FVS-FFE)	Integrates FVS with elements from existing models of fire behavior and fire effects. It predicts the effects of stand development and management actions on fuel dynamics, fire behavior, and fire effects
	Fire Behavior Assessment Tool (FBAT)	Provides an interface between ArcMap and FlamMap3, a fire behavior mapping and analysis program that computes potential fire behavior characteristics at a pixel level. The FBAT is part of the IFP-LANDFIRE tool kit.
	Fire Regime Classification Class (FRCC)	Discrete metric that quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions
	First Order Fire Effects model (FOFEM)	Program developed to meet the needs of resource managers, planners, and analysts in predicting and planning for fire effects.
	FlamMap	Basic fire behavior calculations intended for characterizing fuel hazard in fire management planning.
	Forest Vegetation Simulator (FVS)	Individual-tree, distance-independent growth and yield model
	Fuel Characterization and Classification System (FCCS)	Program that builds, characterizes, and classifies wildland and managed fuels throughout North America.

Table 1. A list of the most commonly used data sets and software tools identified through the fuels treatment specialist survey.

Names and Descriptions of the Data and Software Tools Commonly Used for Fuels Treatment Planning		
Tools and Models (continued)	FuelCalc	Tool to compute surface and canopy fuel loads and characteristics from inventory data, to support fuels treatment decisions, and to provide linkages to stand visualization, fire behavior and fire effects programs.
	Most Similar Neighbor/Nearest Neighbor (MSN/NN)	Program is used to impute attributes measured on some sample units to sample units where they are not measured.
	Multi-scale Resource Integration Tool (MRIT)	Characterizes the composition of feature layers (i.e., spatial themes added to an ArcMap document) within user-defined reporting units (e.g., landscapes), then classifies those reporting units according to their relative status. The MRIT is part of the IFP-LANDFIRE tool kit.
	NEXUS	Crown fire hazard analysis software that links separate models of surface and crown fire behavior to compute indices of relative crown fire potential.
	PHYGROW	Hydrologic based plant growth simulation model. PHYGROW is still under development and testing.
	Smoke Impact Spreadsheet (SIS)	Simple-to-use planning model for calculating particulate matter (PM) emissions and concentrations downwind of wildland fires.
	Stand Visualization System (SVS)	Generates graphic images depicting stand conditions represented by a list of individual stand components, e.g., trees, shrubs, and down material.
	Vegetation Dynamics Development Tool (VDDT)	Tool that provides a modeling framework for examining the role of various transition agents and management actions in vegetation change.

Table 2. Summary of the most commonly used vegetation data sets, software applications, and/or tools used in the fuels treatment planning process and where they are applied in the fuels treatment analysis process.

	Define Vegetation Data, Landscape and Scale	Current Year Data Preparation and Quality Control	Simulate Vegetation, Geophysical, and Fuel Conditions	Simulate and Analyze Fire Behavior	Analyze Fire Effects and Risk	Design Treatment Strategy
Vegetation data	FSVeg (treelist) FFI (treelist) GNN-FVS (treelist) LANDFIRE (grid)					
Software models and tools		MSN/NN SVS	FVS PHYGROW VDDT FRCC FCCS-CONSUME ACT FuelCalc	FVS-FFE FlamMap FARSITE NEXUS BEHAVE-Plus FOFEM Firefamily+ FBAT SIS	MRIT Starfire SFRAS RAVAR FlamMap FCCS/ CONSUME Vsmoke	EMDS MTT/TOM
Geophysical data	DEM Slope Aspect Weather (WIMS)					

Discussion of Data Issues

Almost every direct contact with field fuels treatment specialists as well as discussions with developers of fuels treatment systems indicated that data issues present enormous challenges to the deployment of software support systems for fuels treatment planning. Recognition of this problem prompted a preliminary review and summary of the data-related issues as they affect the IFT-DSS project. This preliminary review and summary can be found in the Appendix to the IFT-DSS Conceptual Design document (Joint Fire Science Program, 2008). This section contains a brief overview of those findings.

Two general types of data (both in content and format) are currently used for fuels treatment analysis and planning: (1) treelist vegetation data with reference to spatial polygons and (2) gridded vegetation data with reference to mapped pixels. In addition to the treelist polygon and gridded vegetation data, it is fairly common that the input data for a fuels treatment analysis comes exclusively or primarily from local human experts. For an example of this situation, see the interview transcripts from a group of NPS fuels treatment planners in Appendix B of this document.

Treelist Data

Forest growth and yield models have evolved gradually over the past 40 years to provide effective and trustworthy predictions for the biological dynamics of the tree canopy layer of forested ecosystems. The response of trees to a large variety of treatments, including the likely mortality due to fire events, has been established through research and has been included in the forest growth and yield models. Over 25 growth and yield models have been incorporated into the Forest Vegetation Simulator (FVS) model management system of the USDA Forest Service. FVS has the capability of simulating forest vegetation dynamics for essentially all forested ecosystems in the United States. Unfortunately for the fuels treatment planning problem, FVS cannot simulate the herbaceous and shrubby vegetation layers in forest ecosystems nor can it simulate the vegetation dynamics of non-forested areas. The essential input to the FVS simulator consists of a list of trees, species, and diameter at the minimum, and the size of the plot of land that the treelist represents.

Obtaining treelist data by examining forested vegetation units across large landscapes is a very expensive process. This results in the situation where fuels treatment specialists typically begin a project analysis with some vegetation units having treelists available and many where no treelists are available. Thus, fuels treatment specialists may typically begin a project analysis with some vegetation units having treelists available and many vegetation units with no treelists available. The date of the field survey usually varies by many years for those vegetation units with available treelists. So the challenge for the fuels treatment specialist who wishes to use an FVS-based planning system is to create a wall-to-wall treelist data layer by (1) using various imputation techniques to use available treelist data to predict treelists for polygons with missing treelist data; and (2) to use the FVS simulator to “grow” all treelist data to the current year so that the project analysis can begin from that point in time.

Gridded Vegetation Data

The Landscape Fire and Resource Management Planning Tools Project, also known as LANDFIRE, is a five-year, multi-partner project producing gridded maps and data layers describing vegetation, wildland fuel, and fire regimes across the United States. LANDFIRE data products include map layers of vegetation composition and structure, surface and canopy fuel characteristics, and historical fire regimes. The LANDFIRE data products are designed to facilitate national- and regional-level planning and reporting of wildland fire management activities. Data products are created at a 30-m grid spatial resolution in raster data format (www.landfire.gov).

The fuels treatment analysis and planning process using LANDFIRE grid data is inherently different in the way vegetation dynamics are addressed compared to the process that relies on wall-to-wall treelist data. Wall-to-wall treelist data are used in programs such as FVS to simulate vegetation dynamics. The grid-based approach examines changes or departures in fire regime from a historical reference point, namely, pre-Euroamerican settlement when people did not actively practice fire suppression. Tools such as the Fire Regime Condition Class (FRCC) and the Fire Return Interval Departure (FRID) are used to assign an indicator of departure from natural fire regime by grid cell. These data can then be used in fire behavior models.

The LANDFIRE data are intended to address national-, regional-, and landscape-level analyses that typically require lower, or coarse, spatial resolution. The data issues of interest concerning LANDFIRE data are how to assess suitability for a particular project level analysis and match the correct questions to those that the data accuracy is able to address. The LANDFIRE data are intended for broad- and mid-scale analyses; however, with local evaluation and editing, the data can be used for fine-scale analyses of fire incidents and for project fuels planning. For local planning, LANDFIRE data should be revised and calibrated based on available local data. NIFTT currently offers processes for achieving such updating or editing. The time required to update the LANDFIRE National data is a concern, and data currently available for download represent circa 2000. A program to enhance fuel layers was kicked off with the Rapid Refresh in the western United States, for which data are now available for download that include enhancements for vegetation and fuel layers with updates for wildland fires through 2007. All vegetation and fuel layers for treatments and disturbances will soon be enhanced to circa 2008. There are plans to enhance and update select LANDFIRE data products every two years beginning in 2010. These updates alone may or may not be sufficient for current year analyses or for analyses of small project areas. The IFP-NIFTT fuels treatment process offers tools to perform a fuels treatment analysis, along with training in how to use them.

Vegetation Data Implications for the IFT-DSS

As discovered during the assessment of the four comprehensive fuels treatment planning systems and processes, INFORMS utilizes treelist data as the principal vegetation input for a fuels treatment analysis, ArcFuels utilizes both treelist and gridded vegetation and fuels data, and the IFP-NIFTT-LANDFIRE process and the Starfire approach both utilize only gridded vegetation data. Survey responses from fuels treatment specialists generally indicated that the type of vegetation data used for fuels treatment planning varies based on vegetation characteristics. For example, in forested parts of the country, fuels treatment specialists use treelist data available within their particular agency (e.g., FSVeg at the USFS, DataStore at the NPS, FIREMON/FFI at the BLM) and in non-forested regions analysts are beginning to use the LANDFIRE data.

From the fuels treatment specialist's point of view, the data-related issues are as follows:

- If the treatment area is a forested landscape and treelist data are available, the challenge is to update all treelists to the current year by using the FVS simulator and use the available imputation methods to assign treelists to those vegetation units that do not have them;
- If treelist data are not available and/or the imputation process is too expensive, LANDFIRE data can be used. The challenge in this situation is to modify the available LANDFIRE data to improve their accuracy for local conditions to better support the fuels treatment project analysis;
- If the vegetation unit is not a non-forest ecosystem, LANDFIRE data can be used. The challenge in this situation is to update the LANDFIRE data to better reflect rapidly changing local conditions. For example, LANDFIRE classifies many grassland vegetation units as unburnable or barren and most of the time this is true. However, given the right weather conditions, that landscape can occasionally support million-acre fires.
- Finally, there are situations, such as planning for a prescribed fire, when the location is already known and the time and cost of using either treelist data or LANDFIRE data is just not warranted. Locally available human expertise has been an excellent source of input data for models such as BEHAVE in order to obtain the necessary analysis required for prescribed burn plans.

The implications of data availability, accessibility, and structure are that the IFT-DSS must be capable of handling both vector (polygon, or aspatial data) and raster (grid, or spatial) data. Another, more important, implication is that the architectural design of the system must account for the fact that users may want to use a hybrid of vector and raster data and the design must include a mechanism for merging and standardizing the two data types. Having a mechanism to merge the two data types for input to a fire behavior model would allow the user the ability to work with higher resolution treelist data and/or grid data. Also note that geophysical data, such as digital elevation model (DEM) data and weather data, can be pre-loaded into the system and made available as needed for use with the two different data preparation methods. Region-specific data such as vegetation and values at risk could be handled through a mechanism that allows users to integrate regional data. Finally, the IFT-DSS must be able to accept data for a fuels treatment analysis from human experts directly.

Overview of the Four Comprehensive Fuels Treatment Planning Systems

The following four comprehensive fuels treatment planning systems (and processes) were assessed: (1) INFORMS, (2) ArcFuels, (3) IFP-NIFTT-LANDFIRE, and (4) Starfire. The comprehensive system assessment involved understanding what each system or process was intended for and the associated work flow process and software models. As part of the comprehensive system evaluation, STI collected a large amount of information about each system through literature reviews, the Internet, and personal interviews with system developers. Much of the detailed information collected is not included here but will be referred to in the IFT-DSS design phase. Appendix E includes more detailed summary information for INFORMS, ArcFuels, and the IFP-LANDFIRE process. This section offers a summary of the findings of the comprehensive systems evaluation.

INFORMS

The Integrated Forest Resource Management System (INFORMS) was developed to facilitate project- and landscape-level planning and to support NEPA-related analyses. INFORMS was developed to run in ESRI ArcView 3.x software and requires a connection to the USFS FSVeg forest inventory (treelist) database. INFORMS is not currently accessible outside the USFS firewall and is currently applied mostly to national forest lands. The INFORMS process is based on the FVS family of base models (including regional variants) for simulating forest vegetation dynamics. The INFORMS system does not offer complete flow control across the entire fuels treatment problem space but guides the analyst through the programs and analysis steps in sequence and assists users in the quality control of their data. INFORMS also provides tools for producing the input files needed for fire behavior models such as FARSITE, FlamMap, and FS Pro.

INFORMS contains the imputation tool MSN and allows sampled treelist data to be imputed across the landscape and made available to FVS-FFE. The FVS-FFE approach allows users to perform sensitivity analyses of different treatment prescriptions and to determine whether the result achieved the desired outcome in terms of desired fire behavior. In other words, INFORMS allows users to examine how different treatment options will change fire behavior. The FVS-FFE approach is also useful for comparing different prescriptions and alternative treatments based on NEPA requirements. INFORMS data can also be useful for examining and understanding the current condition of the landscape in terms of tree species, canopy cover, volume, etc.

While INFORMS is a mature system, it is also in active development. Specifically, the INFORMS team is completely redesigning INFORMS using a modern, object-oriented, three-tier architecture. The new INFORMS will be built as an extension to ArcMap 9.2+ using ArcObjects coded in C#. The new version of INFORMS will enable disconnected operation (i.e., a user will be able to operate the INFORMS software without a continuous connection to the central INFORMS Oracle database. This improvement paves the way for potential use outside the USFS. In addition, new modules are being added to INFORMS as the science is developed. For example, PHYGROW, a model that simulates non-forest vegetation dynamics on a short timescale, is in the early stages of incorporation into INFORMS. Other modules being added to INFORMS include Vegetation Structural Stage, connection with the FSVeg Spatial geodatabase, and Nearest Neighbor imputation. **Figure 11** illustrates the work flow process for INFORMS.

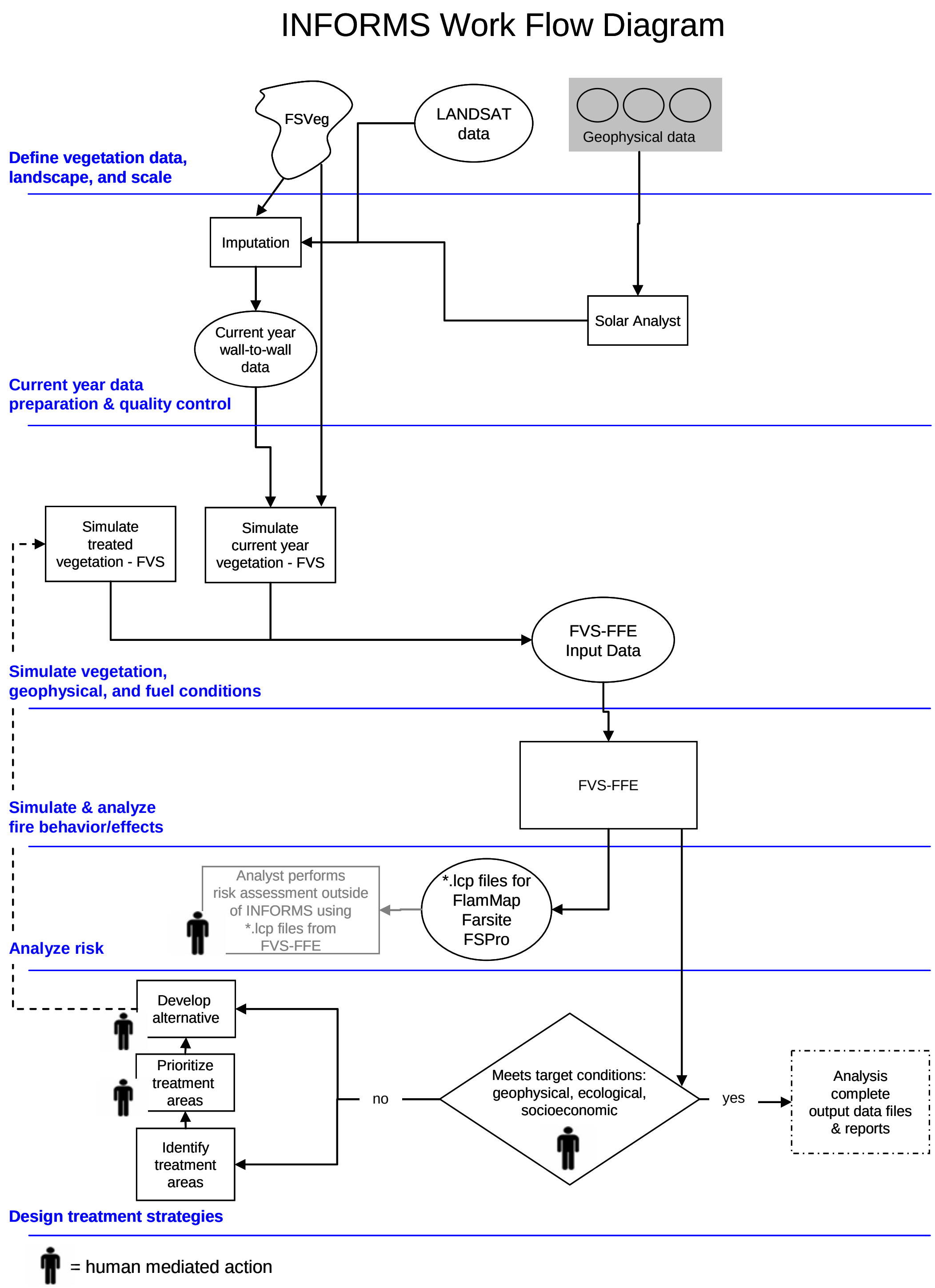

Figure 11. Illustration of the work flow process and models for the INFORMS system.

ArcFuels

ArcFuels is a stand alone desktop geographic information system (GIS)-based system developed to streamline fire behavior modeling and spatial analyses for fuels treatment planning. It functions as a toolkit of ArcGIS macros (programmed in VisualBasic) that provides a process for fuels treatment analysis including treatment-unit simulation, fire-risk assessment, and treatment-effectiveness assessment. The macros available in ArcFuels link fuels and vegetation data, fire behavior models, MS Office tools, and ArcGIS. ArcFuels was designed to perform project-level and landscape level analyses.

The ArcFuels work flow process supports both the FVS-FFE family of base models and a methodology for using gridded LANDFIRE data to simulate vegetation dynamics. The user has the option to run FVS to simulate fuels treatment effects or to use LANDFIRE grid data and a look-up table of treatment impacts to determine treatment effects. This functionality allows the user to use LANDFIRE grid data to simulate vegetation dynamics without requiring the use of the Vegetation Dynamics Development Tool (VDDT).

ArcFules does not contain an imputation tool so the user must provide FVS-ready input data. In addition to, or alternatively, the user can provide LANDFIRE grid data. ArcFuels differs from INFORMS in that it provides the choice of working with either treelist or grid data or both. Users must also provide all underlying geophysical data such as topographic features. **Figure 12** illustrates the work flow process for ArcFuels.

IFP-NIFTT-LANDFIRE

The Integrated Fuels Planning – LANDFIRE (IFP-LANDFIRE) process is a somewhat different approach to fuels treatment planning than the previous two systems. Rather than an end-to-end software system, IFP-LANDFIRE is a well-defined process that provides guidance, training, software, and tools to assist fuels treatment planners. The IFP-LANDFIRE process utilizes LANDIFRE grid data and a five step analysis: (1) identify, (2) analyze, (3) prioritize, (4) change, and (5) evaluate. The data, software, tools, and training materials are available online and can be downloaded to a PC and operated locally with ArcGIS. The software and tools used for the IFP-LANDFIRE process link fuels and vegetation data, fire behavior models, risk analysis tools, and ArcGIS. The IFP-LANDFIRE process can be used for project-level and landscape analysis. Accuracy is expected to be less than optimum for local-scale analyses unless data is locally evaluated and edited. The NIFTT provides instructions on how to localize the generic LANDFIRE data for improved project scale accuracy.

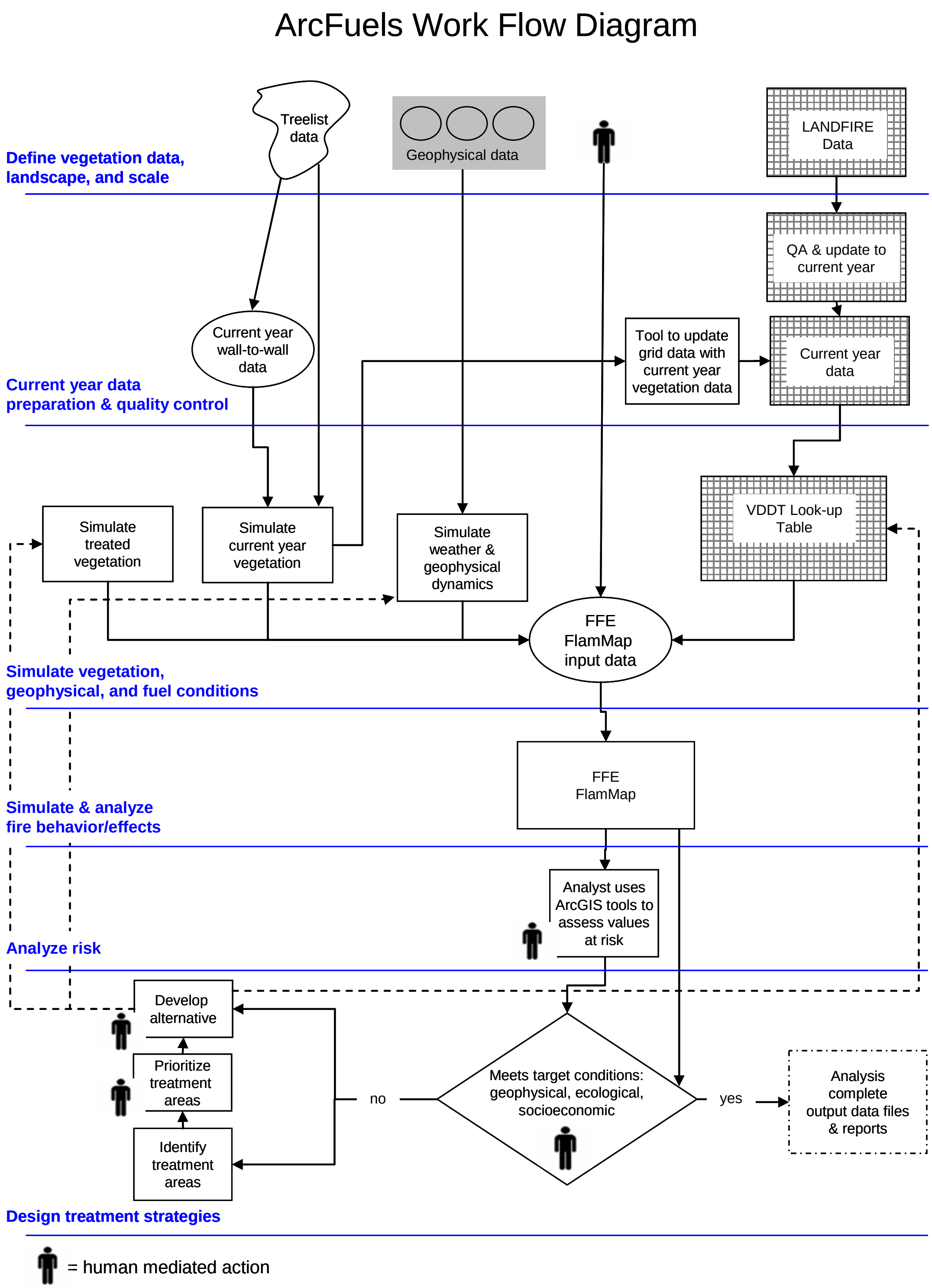

Figure 12. Illustration of the work flow process for ArcFuels.

The IFP-LANDFIRE work flow process supports the use of the LANDFIRE data products to simulate fire behavior using a suite of software tools specifically developed for the IFP-LANDFIRE process. The five steps that constitute the IFP-LANDFIRE approach are summarized below.

- **Identification –** The fuels treatment analyst first identifies the analysis objectives and issues. Next, the analyst identifies and acquires the appropriate data to address the analysis objectives using the LANDFIRE data tool which allows the LANDFIRE data to be downloaded via the internet.
- **Analysis –** The analyst then determines the appropriate analysis method(s) and tools to address the analysis objective. For example, if a fuels treatment specialist wanted to know where on a landscape potential fire behavior is likely to be most problematic with respect to specific land management objectives, FBAT (a program that runs FlamMap functions within ArcGIS) would be used to model fire behavior across the area of interest. For this example, the output of FBAT would be a set of fire behavior classifications across the landscape.
- **Prioritization –** Next, the analyst uses the Multi-scale Resource Integration Tool (MRIT) to summarize the FBAT outputs and to identify priority treatment areas.
- **Change –** Continuing with this example, if the analyst wanted to examine pre- and post-treatment fire behavior, the analyst would use the Area Change Tool (ACT) to modify the grid values in the vegetation and fuel condition input data and re-run the FBAT analysis.
- **Evaluation –** The analyst evaluates the pre- and post-treatment results to identify the treatment impact on fire behavior. The analyst then determines if the treatment resulted in the desired outcome given land management objectives.

While the IFP-LANDFIRE process steps are fairly well-defined, and the tools appear to be straightforward and well-documented, the analyst is directly involved in each step of the analysis and, to a certain extent, designs the appropriate analysis for the given objective or use case. Consequently, many points in the process require the analyst's active involvement in data processing, analysis, interpretation, modification, and evaluation. In contrast, while the INFORMS and ArcFuels systems also rely on analyst judgment and evaluation, they provide tools to handle the analysis overhead (i.e., data conversion and processing steps). **Figure 13** illustrates the work flow process for the IFP-LANDFIRE process.

<u>The Strategic Treatment Assessment Response Spectrum and Fire (Starfire)</u>

The Strategic Treatment Assessment Response Spectrum and Fire (Starfire) is another analytic process-based approach that assists fuels treatment managers to identify and prioritize potential treatment areas within a landscape. It generates strategic analsis information for integrating fuels optimization and appropriate management response (AMR). The Starfire approach was developed by researchers at Colorado State University in Fort Collins, and the methodology is intended for use in the early planning stages prior to designing treatment strategies.

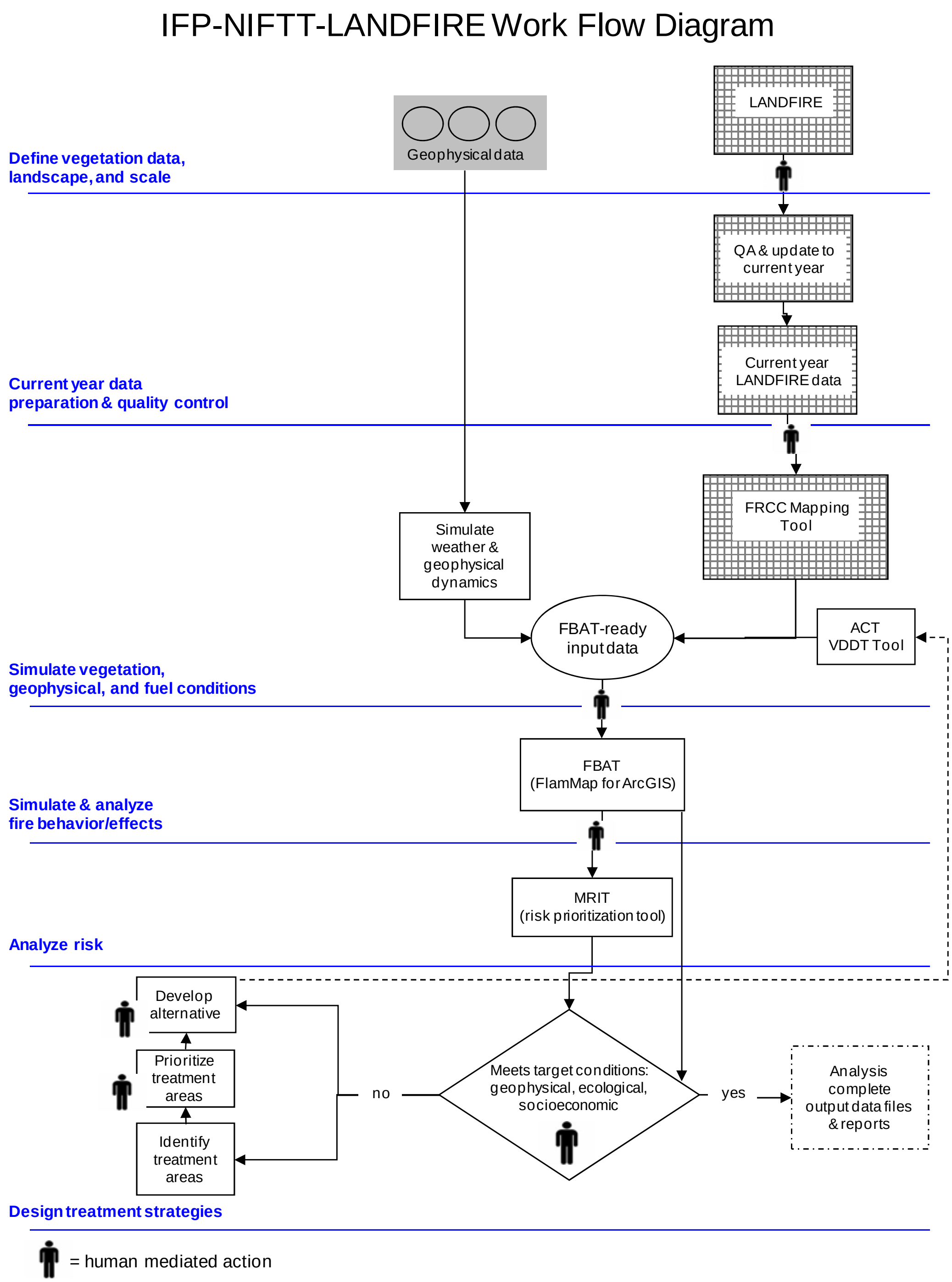

Figure 13. Illustration of the work flow process for the IFP-LANDFIRE process.

The Starfire work flow process supports gridded vegetation and fuel condition data. The process is complex and utilizes a combination of custom processing tools and algorithms developed specifically for Starfire analysis as well as existing software tools (i.e., FlamMap). A unique feature of the Starfire analytical approach is that it is based on a probabilistic spatial model that allows for generating predictions across a gridded surface taking all grid cells into account. In simple terms, it can generate risk-based predictions at a grid cell location based on information from neighboring grid cells. Another unique aspect of the Starfire approach is that it incorporates algorithms and tools for performing fairly through assessments of risk. In designing the IFT-DSS, we will investigate the potential applicability of the risk assessment methods and algorithms used in the Starfire process.

The Starfire approach is also unique in that it provides analysis methods and tools to examine both hazardous fuel reduction *and* ecosystem improvement. Most fuels treatment planning tools and methods only address hazardous fuel reduction. Three general outputs are generated by a Starfire analysis: (1) information to assist in fuels treatment prioritization, (2) information to assist in AMR decisions, and (3) information to assist in assessing potential smoke impacts. The information produced by Starfire can be used for assessing risk related to fire management planning, environmental assessments and to support NEPA reporting.

To date, Starfire has only been applied in Sequoia National Park, California and local data were provided as input to the analysis. At this point, there is no plan to develop an end-to-end software system to support Starfire. However, there are future plans to continue to apply the approach in other national parks (e.g., Yellowstone). **Figure 14** illustrates a system flow diagram for the Starfire approach (personal communication, Doug Rideout, 2008).

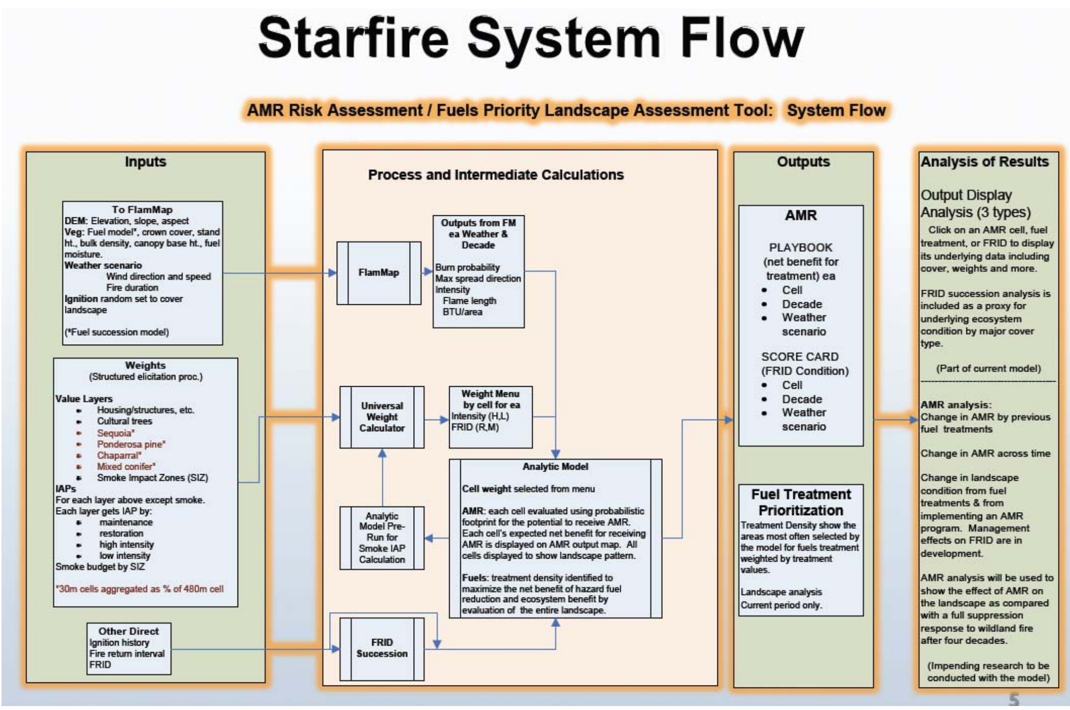

Figure 14. Illustration of the system flow diagram for the Starfire approach.

CONCLUSIONS AND IMPLICATIONS

An assessment of current practices was performed for the fuels treatment analysis and planning community to support the design of a software architecture for an IFT-DSS. The assessment was carried out by conducting a survey and interviews with fuels treatment specialists. The main goal of the assessment was to understand the process, tools, and resources that fuels treatment planners use for analysis and decision-making and to use this information to inform the design and implementation of the IFT-DSS. Before designing any software system, it is important to understand the key characteristics, the work process, and the needs of the community that will use the software.

Too often, software systems are designed from the top down and the practical needs of the user community are not fully considered in the design and planning phase. The result is a tool or system that may be scientifically robust but has little value to the user community because of a lack of accessibility and resources, an overwhelming level of complexity, and/or poor functionality. To design a useful and practical system, the characteristics and needs of the user community should be identified and considered at the planning stage.

Several important characteristics of the fuels treatment planning community have been identified through the survey and interviews that will inform the design of the IFT-DSS including:

- No central governing body is providing direction and organization regarding the development and use of fuels treatment planning tools. As a result, a plethora of data, software, and tools currently exist to support fuels treatment analysis and planning. A system is needed that can organize and manage the many models and data sets in a way that provides value to the fuels treatment community.
- While fuels treatment specialists use common tools and approaches for analysis and planning, a one-size-fits-all approach is not feasible, given the regional diversity and uniqueness of each situational analysis. Therefore, it is critical that the IFT-DSS easily accommodate a degree of customization and allow users to choose the data, software models, and tools that are most appropriate to address their particular objectives.
- Fuels treatment planners often use expert judgment combined with model(s) or model functions for fuels treatment planning. Therefore, it is critical that the IFT-DSS be designed in a way that supports user interaction. In addition, the IFT-DSS should be a modular system, that is, a user can independently use individual models, or functions within the system.
- New models and methods are always in development. Therefore, the IFT-DSS should be expandable and modular and should support the addition of new data, software models, and tools as they become available.
- There are issues regarding software installation and accessibility within many federal agencies. Therefore, the IFT-DSS must be accessible without requiring installation of proprietary software and/or other resources that may present barriers to use.

Furthermore, the IFT-DSS should be portable in the sense that it can be easily accessed by a standard desktop computer.

- Due to the geographic nature and complexity of fuels treatment analysis, it is critical that the IFT-DSS support the visualization and manual manipulation of both vector (point, line, and polygon) data and raster (gridded) data. Fuels treatment specialists often use expert judgment when designing treatment alternatives; therefore, the user interface and visualization tools must support interactive data manipulation.
- As is the case with any community of people facing similar problems and issues, the fuels treatment community will benefit from a system that supports work collaboration or analytical collaboration. The IFT-DSS should support analytical collaboration by allowing users to publish and share their methods and algorithms within a system library.
- Fuels treatment specialists are often responsible for many tasks beyond fuels treatment planning and do not have the time or resources required to learn and maintain familiarity with dozens of software models and tools. Therefore, the IFT-DSS should provide analysis guidance, choices, and reporting tools to streamline fuels treatment decision-making.

In summary, the information collected regarding the work flow processes and characteristics of the fuels treatment planning community is invaluable. The work flow diagram depicted in Figure 1 aims to identify and define the steps and various pathways that a fuels treatment specialist might use during an analysis. In the IFT-DSS design phase, we will focus on each of the six major analysis steps (shown in Figure 1) and decompose them into detail to identify the specific functions and components associated with each step. Specifically, we will dissect the data requirements, formats, inputs, and outputs required at the beginning and end of each step as well as the models and tools (listed in Tables 1 and 2) used in each step. This information will dictate the architectural requirements for the IFT-DSS and will form the basis of the IFT-DSS functional design. This information will be extremely useful in functional design, user interface design, and implementation of the IFT-DSS.

In addition to the characteristics of the fuels treatment planning community listed above, there are practical considerations for the IFT-DSS architecture design. Specifically, at least two other systems are in use in the fire and fuels community that provide access to common resources: the Wildland Fire Decision Support System (WFDSS) and the BlueSky Framework. Both systems share overlapping components and functionality with the requirements of the IFT-DSS but were developed for different user communities. For example, the WFDSS was developed to support strategic and tactical decisions regarding real-time fire management, and the BlueSky Framework was developed to analyze and manage smoke impacts from fires. The JFSP and STI have been in communication with the managers of both systems to understand the potential overlap of these systems with the IFT-DSS and to explore the possibility of leveraging system components and services where appropriate.

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APPENDIX A – SUMMARY OF FUELS TREATMENT SPECIALIST SURVEY

APPENDIX B – FUELS TREATMENT SPECIALIST INTERVIEW TRANSCRIPTS

APPENDIX C – WORK FLOW PROCESS DIAGRAMS FOR THE AD-HOC APPROACHES DESCRIBED IN THE INTERVIEW TRANSCRIPTS

APPENDIX D – INVENTORY AND DESCRIPTION OF DATA, SOFTWARE, AND TOOLS USED FOR FUELS TREATMENT PLANNING

APPENDIX E – SUPPLEMENTARY INFORMATION FOR INFORMS, ARCFUELS, AND THE IFP-NIFTT-LANDFIRE PROCESS