Table 1. Background Hazardous fuel treatment models and tools currently in development.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Tool Name</th>
<th>Brief Description of Tool</th>
<th>Analyst Requirement</th>
<th>Data Requirements</th>
<th>Linkage to other Models/Tools</th>
<th>Partners</th>
<th>Current Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand – 6th Field HUC</td>
<td>Behave Plus</td>
<td>Basic fire behavior predictions</td>
<td>L</td>
<td>L</td>
<td>Used in most other fire behavior tools</td>
<td>RMRS, SEM</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>FOFEM</td>
<td>Fuel consumption, tree mortality, emissions, soil heating</td>
<td>L</td>
<td>L</td>
<td>None</td>
<td>RMRS, SEM</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>FMA Plus</td>
<td>Crown fire risk</td>
<td>M</td>
<td>M</td>
<td>FVS</td>
<td>Commercial software</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>NEXUS</td>
<td>Crown fire risk</td>
<td>M</td>
<td>M</td>
<td>None</td>
<td>RMRS</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>FVS-FFE</td>
<td>Fire effects and crown fire risk</td>
<td>I</td>
<td>I</td>
<td>FMA Plus</td>
<td>RMRS</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>FRCC</td>
<td>Departure from historic conditions</td>
<td>M-I</td>
<td>M-I</td>
<td>None</td>
<td>FS, DOI, TNC</td>
<td>A, T</td>
</tr>
<tr>
<td>5th Field HUC</td>
<td>FRCC</td>
<td>Departure from historic conditions</td>
<td>M-I</td>
<td>M-I</td>
<td>None</td>
<td>FS, DOI, TNC</td>
<td>A, T</td>
</tr>
<tr>
<td></td>
<td>FARSITE</td>
<td>Fire spread simulator</td>
<td>I</td>
<td>I</td>
<td>FlamMap2</td>
<td>RMRS, SEM</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>FlamMap2</td>
<td>Fire risk assessment</td>
<td>I</td>
<td>I</td>
<td>FARSITE</td>
<td>RMRS, SEM</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>Fire Family Plus</td>
<td>Historical weather analysis</td>
<td>M</td>
<td>M</td>
<td>None</td>
<td>RMRS, SEM</td>
<td>A</td>
</tr>
<tr>
<td>4th Field HUC</td>
<td>FRCC</td>
<td>Departure from historic conditions</td>
<td>M-I</td>
<td>M-I</td>
<td>None</td>
<td>FS, DOI, TNC</td>
<td>A, T</td>
</tr>
<tr>
<td></td>
<td>FARSITE</td>
<td>Fire spread simulator</td>
<td>I</td>
<td>I</td>
<td>FlamMap2</td>
<td>RMRS, SEM</td>
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<tr>
<td></td>
<td>FlamMap2</td>
<td>Fire risk assessment</td>
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<td>A</td>
</tr>
</tbody>
</table>

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Table Key:
**Analyst Requirement:**
- Low (L) – Resource specialist or local GIS specialist can run the model or tool locally with minimal changes needed for local situation.
- Medium (M) – Requires a mid-level analyst or GIS specialist in order to run the model or tool or make it usable for local situations.
- High (H) – Requires a high level analyst or programmer in order to run the model or tool or make it usable for local situations.

**Data Requirements:**
- Low (L) – Requires base resource data readily available at the regional or local level.
- Moderate (M) – Requires some specialized data in addition to the base resource data readily available at the regional or local level.
- Intense (I) – Requires specialized data and formats that will take a major commitment of resources to compile.

**Current Status:**
- Currently Available (A) – Model is currently available for use.
- In Testing (T) – Model is currently in the testing phase.
- Ready for testing in 6 months (R6) – Model will be ready for testing within 6 months.
- Ready for testing in 6 mo-1 year (R1) - Model will be ready for testing within 6 months – 1 year.
- Ready for testing in 1-2 years (R2) - Model will be ready for testing within 1-2 years.
- Ready for testing 3-5 years (R3) - Model will be ready for testing within 3-5 years.

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Hazardous Fuels and Vegetation Treatment Processes and Tools Currently in Use

1. **Tool Name:** BEHAVE Plus 2.0.2

2. **Brief Description of Tool:** BehavePlus fire modeling system is a Windows ® application to predict wildland fire behavior for fire management purposes. It is designed for use by fire and land managers who are familiar with fuels, weather, topography, wildfire situations, and associated terminology.

3. **Scale Tool is Applicable:** Primarily stand scale but can be used to assess 6th field HUCs.

4. **Analyst Requirement:** BEHAVE Plus is a basic fire behavior processor requiring only a basic understanding of fire behavior inputs and outputs to use. The tool is not data intensive, but the user needs to be familiar with the differences in fuels models and underlying assumptions of the mathematics in the model to provide accurate inputs and to interpret the outputs.

5. **Data Inputs:** Inputs vary with the modules used. Typical modules used for fuels planning include SURFACE, CONTAIN, SPOT, SCORCH, and MORTALITY. Users can run each module separately or link the runs through SURFACE.

   **SURFACE Inputs:** Fuel model, live and dead fuel moistures, wind speed (midflame or 20-foot with adjustment factor), direction at which to calculate maximum rate-of-spread or upslope direction of spread, wind direction (upslope or degrees clockwise from either upslope or north), and slope steepness.

   **CONTAIN Inputs:** Maximum rate-of-spread, fire size at report, length-to-width ratio of the fire, suppression tactic, line construction offset, resource name, resource line production rate, resource arrival time, and resource duration.

   **SPOT Inputs (for torching trees):** Mean cover height, tree height, spotting tree species, diameter at breast height, 20-foot wind speed, ridge-to-valley elevation difference, ridge-to-valley horizontal distance, spotting source location (valley bottom, midslope, ridgetop, lee side of ridge, windward side of ridge), and number of torching trees.

   **SCORCH Inputs:** Midflame wind speed, air temperature, and flame length.

   **MORTALITY Inputs:** Tree height, crown ratio, mortality tree species, bark thickness, scorch height.

6. **Model Outputs:** Users can specify the types of outputs provided in modules with more than one output option. For fuels planning, the most common outputs used include the following.

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SURFACE Outputs: Rate-of-spread, flame length, direction of maximum spread if not uphill, midflame wind speed if 20-foot wind speed used, wind/slope/spread direction diagram if direction of maximum spread is not uphill, and fire characteristics chart. The fire characteristics chart provides a graph of heat per unit area verses rate-of-spread with flame length categories, allowing readers to note when fire behavior is expected to exceed the limitations of hand crews, mechanical equipment, erratic fire behavior, and landscape-scale fire.

CONTAIN Outputs: Containment status (contained or escaped), contained area, fireline constructed, number of resources used, and containment diagram. The containment diagram displays the fireline constructed relative to the fire length-to-width ratio along with other output data related to the fire.

SPOT Output: Spotting distance from torching trees.

SCORCH Output: Scorch height.

MORTALITY outputs: Bark thickness, tree crown length scorched, tree crown volume scorched, and probability of mortality.

7. Application of Model for Fuel Treatment work: In fuels projects BEHAVE Plus can be used to predict surface fire flame length, rate-of-spread, tree mortality, crown scorch height, spotting distance, and fire containment.

8. Linkage to Other Models/Tools: There are no direct linkages to other tools, but the BEHAVE Plus equations are the basic underlying equations used in FOFEM, FMA Plus, FVS-FFE, NEXUS, and FARSITE/FlamMap2.


10. Current Status: BEHAVE Plus 2.0.2 is fully functional. Additional information is available at http://www.fire.org/. Future versions are expected to add 40 or more additional fuel models, dynamic movement of live fuels to dead, table shading for use in prescribed fire planning, crown fire modeling, post-frontal combustion, and soil heating, potentially resulting in a merging of FOFEM and BEHAVE Plus.

11. Training Availability: There is a self-directed tutorial available at the site where the program files can be downloaded (see item 10 above). S-390 Intermediate Wildland Fire Behavior provides students with training on use of SURFACE, CONTAIN, and SPOT. Concepts useful for the SCORCH and MORTALITY modules in BEHAVE Plus can be obtained from RX-310 Introduction to Fire Effects.

12. Additional Information: BEHAVE Plus can be used to provide basic analyses of potential fire behavior before and after fuel treatments. The present 13 fuel models are considered too coarse to display some of the differences in potential fire behavior that can be present both before and after fuel treatments.

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Potential fire behavior in certain fuel types, such as juniper, is not well represented in the currently available models. The planned addition of 40+ fuel models is intended to address these problems.

BEHAVE Plus is the best available tool to assess potential spotting distance without resorting to nomograms. BEHAVE Plus is the best tool for assessing how initial attack success is likely to change after fuel treatments for those treatments designed to increase suppression effectiveness. Some aspects of suppression effectiveness remain qualitative and are not captured in any fire processor.

BEHAVE Plus can be used to assess potential fire behavior at the landscape scale when data is insufficient to support the use of other tools, such as FlamMap2. In those cases, estimates are made for each stand for key fire behavior elements, classes of behavior identified (i.e. low, moderate, high, and extreme rates-of-spread), and maps prepared using stands as the basic unit. This approach requires averaging certain stand features such as slope steepness and exposure to wind.

Since crowning potential is tied to flame length, BEHAVE can be used as a coarse assessment of crowning potential when data is not available to support tools such as FlamMap2, FMA Plus, and NEXUS. The flame length output should be compared to some indication of canopy base height to indicate the probability of a surface fire transitioning into a crown fire and to canopy closure to indicate the probability of a spreading crown fire.

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1. **Tool Name:** First Order Fire Effects Model (FOFEM) 5.2

2. **Brief Description of Tool:** First Order Fire Effects Model (FOFEM) predicts fuel consumption, soil heating, smoke production, and tree mortality. The model contains a planning mode for prescription development.

3. **Scale Tool is Applicable:** Primarily stand scale but can be used to assess 6th field HUCs.

4. **Analyst Requirement:** A low-level analyst can run FOFEM; it is non-spatial.

5. **Data Inputs:**

   **MORTALITY Inputs:** Region (Interior west, Pacific west, Northeast, Southeast); general burning conditions (Low – Extreme); for each species and dbh class species, density (trees/acre), diameter at breast height, tree height, crown ratio; and flame length or scorch height.

   **FUEL/SMOKE/SOIL Inputs:** Region; cover classification system (SAF/SRM, NVCS, old FCC); cover type; season of burn; general burning condition (Low-Very High); fuel type (natural, slash, piles); fuel loading by size class (litter, 0-1/4, ¼-1, 1-3, 3+, duff, herb, shrub, foliage, branchwood) with adjustments permitted from defaults (typical, light or sparse, heavy or abundant); fuel moisture for ¼-1, 3+, and duff; percent of 3+ that is rotten and how it is distributed; duff depth and type of duff moisture (entire, lower, NFDR, adjusted NFDR); and percent crown burned. The SOIL module also includes soil texture and soil moisture percent.

6. **Model Outputs:**

   **MORTALITY Outputs:** Percent tree mortality by species and size class, and pre- and post-fire canopy cover.

   **FUEL Outputs:** Preburn loading, consumed loading, postburn loading, percent reduction, duff depth consumed, percent mineral soil exposure.

   **SMOKE Outputs:** Same as FUEL outputs plus emissions for PM10, PM2.5, carbon monoxide, carbon dioxide, sulfur oxides, nitrogen oxides, and CH4 from flaming and smoldering combustion; total consumption in flaming and smoldering combustion; and duration of flaming and smoldering combustion.

   **SOIL Outputs:** Same as FUEL outputs plus soil layer maximum temperatures and duration of heating between 0-13 cm depth by 1 cm increments, maximum depth reaching 60°C, and maximum depth reaching 275°C.

7. **Application of Model for Fuel Treatment work:** Potential uses include wildfire impact assessment, development of salvage specifications, design of fire prescriptions, analysis of first order treatment effects in environmental analyses, and fire management planning.

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8. **Linkage to Other Models/Tools:** No current linkages but a possible linkage to Fuel Characteristic Class System may be added in the future. BEHAVE Plus and FOFEM may merge into a single tool in the future.

9. **Partners:** Rocky Mountain Research Station – Missoula Fire Sciences Lab and Systems for Environmental Management

10. **Current Status:** Model is fully functional. For further information, go to [http://www.fire.org/](http://www.fire.org/).

11. **Training Availability:** No formal training is available. Self-directed tutorials can be downloaded from the site listed in item 10 above.

12. **Additional Information:** One of the best uses of FOFEM currently is to evaluate potential soil heating with and without salvage in dry forests burned with uncharacteristic severity. Equations used in FOFEM to estimate scorch and mortality are more robust than those used in FVS-FFE; the equations are the same as those used in BEHAVE Plus. Scorch and mortality information may be displayed in a more useful format in FOFEM than in BEHAVE Plus, although BEHAVE Plus produces graphs as well as tables.

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1. **Tool Name:** Fuels Management Analyst Plus (FMA Plus) (Commercial software)

2. **Brief Description of Tool:** Used to determine dead, downed woody fuel loading using either Brown’s inventory methods or photo guides, assess crown fire risk, and predict slash resulting from thinning and logging operations. The tool consists of three modules – DDWoodyPC for estimating dead, downed woody fuel, Photo Series Explorer to view scanned images of older photo guides to fuel loadings, CrownMass to predict crown fire risks and estimate slash loadings, and Fuel Model Manager to create custom fuel models for use in CrownMass.

3. **Scale Tool is Applicable:** Primarily stand scale but can be used to assess 6th field HUCs.

4. **Analyst Requirement:** Moderate level of analysis skill needed, non-spatial in nature, but can be applied to several stands and mapped. For downed woody fuel estimates, users should be familiar with Brown’s fuel inventory methods and equations. For crown fire risk assessment and slash predictions, users should be familiar with the common stand exam procedures, equations that support debris prediction or the former DEBMOD program used on the Data General system, and elements of the fuel complex associated with the start and spread of crown fires.

5. **Data Inputs:**
   - **DDWoodyPC Inputs:** Slope; number of pieces counted in 0-1/4, ¼-1, and 1-3 inch size classes; two duff depths, diameter of each sound and rotten pieces greater than 3 inches in diameter, three fuel bed depths, and predominate species.
   - **CrownMass Inputs:** Merchantable tip diameter, slope steepness (in two locations), for each tree: plot ID, tree number, diameter breast height, species, height, crown ratio, trees per acre, structure stage, proportion in crown of foliage through 1000 hour fuels, proportion cut, proportion deposited on surface, proportion boles left, percent rotten, equation set (intermountain or pacific northwest coast), surface fuel loading, fuel moistures, 20-foot wind speed, wind adjustment factor, burn day temperature.

6. **Model Outputs:**
   - **DDWoodyPC Outputs:** Fuel loading by size class and total loading.
   - **CrownMass Outputs:** Statistics and graphs on canopy and surface loadings, graphs and data on canopy characteristics by plot, expected fire behavior, canopy bulk density, critical flame length and fireline intensity to initiate crowning, rate of crown fire spread and rate needed for active crowning, fire type (surface, passive crown fire, active crown fire), scorch height, and probability of mortality and percent crown scorch by species and diameter.

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7. **Application of Model for Fuel Treatment work:** FMA Plus replaces tools formerly available on the Data General system that were not otherwise migrated over to the PC environment. Using either data collected through Brown’s planar intercept fuel inventory method or photo series data used as sample data, DDWoodyPC calculates fuel loading by size class for use in assigning fuel models and assessing general fuel loadings. CrownMass allows the user to assess pretreatment crown fire risk, thin the stand, and assess post-treatment crown fire risk with or without subsequent fuels treatment.

8. **Linkage to Other Models/Tools:** Can use tree tables developed through the Forest Vegetation Simulator as input files for CrownMass.

9. **Partners:** None.

10. **Current Status:** Tool is fully functional and supported by developer – Fire Program Solutions. Future versions will include newer photo guides and enhancements to crown fire assessment based on current research. For more information, go to [http://www.fireps.com/fmanalyst/index.htm](http://www.fireps.com/fmanalyst/index.htm).

11. **Training Availability:** Requests for training should be coordinated through the Regional Fuels Specialist (Tim Rich) and software developer (Don Carlton). The Regional Office is covering tuition costs in FY2004 and may cover tuition costs in FY2005.

12. **Additional Information:** Crown fire results differ from the results provided through NEXUS and FVS-FFE. When stand exam data is available, CrownMass provides a method to test different cutting prescriptions where reduction of crown fire risk is an objective. At the landscape scale, representative stands can be sampled and evaluated and results applied to similar stands to determine patterns and identify target areas for treatment when data layers are not available to support the use of FlamMap2 or landscape sizes are too small for effective use of FlamMap2.

The program allows many user adjustments to account for site differences. Defaults are provided for many of these potential adjustment factors. For example, users can adjust canopy loadings based structure stage (co-dominant, intermediate, and suppressed) based off an assumption of 1.0 for dominant trees. The model contains variations on both the fire behavior prediction system and fire danger rating system fuel models where loading and fuel bed depth have been adjusted up and down by 1/3 and some custom models, providing 109 “standard” fuel models. These adjustments have been peer-reviewed for conformance with the assumptions in the fire behavior equations.

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1. **Tool Name:** NEXUS

2. **Brief Description of Tool:** This spreadsheet is used to assess crown fire potential in up to six stands at a time.

3. **Scale Tool is Applicable:** Primarily stand scale but can be used to assess 6th field HUCs.

4. **Analyst Requirement:** Moderate level of analyst skill is needed to provide certain inputs. User must be able to obtain an estimate of canopy characteristics such as canopy bulk density and canopy fuel loading.

5. **Data Inputs:** Fuel model; live and dead fuel moistures; canopy bulk density; canopy foliar moisture; canopy base height; canopy fuel load; slope steepness; 20-foot wind speed; wind direction from uphill; wind reduction factor; multipliers for surface and crown fire rates-of-spread, surface loading and depth, and surface fire intensity; temperature; elapsed time; and map scale.

6. **Model Outputs:** Type of fire, crown fraction burned, surface fire behavior, scorch height, fire length-to-width ratio, perimeter growth rate, fire area, spread distance, map spread distance, potential crown fire rate-of-spread, torching index, crowning index, surfacing index, and critical parameters for crown fire initiation, active spread, and cessation.

7. **Application of Model for Fuel Treatment work:** The model can be used to estimate surface, transition, and crown fire behavior, generate site specific indices of torching and crown fire potential, and evaluate alternative treatments for reducing risk of crown fire.

8. **Linkage to Other Models/Tools:** No direct links to other tools or models.

9. **Partners:** Rocky Mountain Research Station – Missoula Fire Sciences Lab and Systems for Environmental Management.


11. **Training Availability:** No training is available or planned. Assessing Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior (RMRS-RP-29) released in September 2001 provides the technical documentation for NEXUS.

12. **Additional Information:** Crown fire results differ from the results provided through CrownMass and FVS-FFE. CrownMass has been used to generate canopy characteristics for use in NEXUS.

A separate help file is included in the download package.

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1. **Tool Name:** Forest Vegetation Simulator-Fire and Fuels Extension (FVS-FFE)

2. **Brief Description of Tool:** FVS-FFE is designed to simulate the effects of fire on forest vegetation and the effects of different treatments on fire potential.

3. **Scale Tool is Applicable:** Primarily stand scale but can be to assess 6th field HUCs.

4. **Analyst Requirement:** Requires a high level analyst or programmer in order to run the model and produce usable results. Users should be familiar with the concepts used in FVS and the data used to develop snag longevity and surface fuel loading outputs. These outputs are based on a mix of scientifically based equations and expert opinion.

5. **Data Inputs:** In addition to the data required to initialize a run of FVS, users can provide detailed snag records; adjustments to defaults for snag breakage rates, decay rates, fall rates, and burn-up rates; initial surface fuel loading; adjustments to decay rates and duff production rates; custom fuel models; static or dynamic fuel models; changes in fuel loading resulting from mechanical treatments such as crushing; burning conditions; fuel moistures; wind speed; pile burning; and flame adjustment factors.

6. **Model Outputs:** Images of resulting stand structures before and after treatment and fires; “movies” of fires burning through stands; graphs of potential surface fire flame length, crowning index, surface fuel loadings, snag numbers, canopy cover, stand structure, canopy ceiling height, and timber volume through time; detailed or summary reports of snags, surface fuels, type of fire; scorch height; tree mortality; fuel consumption; and PM2.5 and PM10 emissions.

7. **Application of Model for Fuel Treatment work:** Silviculturists have long used the Forest Vegetation Simulator to analyze forest growth and yield under a variety of treatment options. The Fire and Fuels Extension also allows the user to evaluate potential fire behavior and stand mortality and resulting effects on snag longevity and subsequent tree growth at the same time.

8. **Linkage to Other Models/Tools:** Tree tables generated by FVS can be imported into CrownMass.

9. **Partners:** Forest Service and Joint Fire Sciences Program.

10. **Current Status:** Model is fully functional. Go to [http://forest.moscowfsl.wsu.edu/4155/ffe-fvs.html](http://forest.moscowfsl.wsu.edu/4155/ffe-fvs.html) for additional information. Variants are available for all portions of the Pacific Northwest.

11. **Training Availability:** Requests for training should be coordinated through the Regional Silviculturalist (Bill McArthur).

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12. **Additional Information:** FVS-FFE produces different crown fire results than CrownMass and NEXUS and different estimates of mortality and fuel consumption than FOFEM. Since FFE works on a single year time step and FVS works normally works on a 10-year time step results can be skewed. Live fuels are poorly represented in FVS-FFE. Decomposition rates are not sensitive to aspect, elevation, or potential vegetation type.

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1. **Tool Name**: Fire Regime Condition Class (FRCC)

2. **Brief Description of Tool**: Fire Regime Condition Class (FRCC) is an interagency, standardized tool for determining the degree of departure from natural vegetation, fuels, and disturbance regimes. Assessing FRCC can help guide management objectives and set priorities for treatments. Two methods for assessing FRCC are available – a qualitative “scorecard” method and a quantitative “guidebook” method.

3. **Scale Tool is Applicable**: 4-6th field HUC, although marginal for smaller 6th field HUCs.

4. **Analyst Requirement**: Moderate to high. The scorecard method requires a moderate skill level by the user. The guidebook method requires a high skill level by the user. The FRCC process is not intended to be completed by a single person, but by a team consisting, at minimum of a vegetation management specialist conversant in successional concepts and a fuels management conversant in fire ecology. While not required by the tool, maps of stand types and fire regimes can aid in determining fire regime condition class. In the near future, a GIS-based mapping tool to help automate some of the calculations will be available.

5. **Data Inputs (Guidebook method)**: Total acres of the assessment area, total acres within a given fire regime (stratum), historic cover type (known as potential natural vegetation group or PNVG), baseline/historic percentages of each of 5 seral structure stages, slope steepness, insolation class, location information, reference fire severity, reference fire frequency, current percentages of the characteristic seral structure stages and up to 7 uncharacteristic stages, current fire severity, current fire frequency, canopy closure breakpoints between “open” and “closed” stages, and whether Native American burning practices are considered as part of the historic fire frequency and severity. Stand exams, FIA/CVS, and ecology plots often collect the necessary data needed to adequately characterize existing conditions.

6. **Model Outputs**: Departure from historic conditions (fire regime condition class) for each fire regime and the landscape as a whole in tabular and graphic form.

7. **Application of Model for Fuel Treatment work**: At the 6th field HUC scale or equivalent, FRCC can aid in determining in which stand types to focus treatment efforts. At the 5th field HUC scale or equivalent, it can aid in prioritizing in which 6th field HUCs and fire regimes as well as which stand types to focus treatment efforts. At the 4th field HUC level or equivalent, it can aid in prioritizing which 5th field HUCs and fire regimes for treatment.

8. **Linkage to Other Models/Tools**: At present, there is no direct linkage to other models and tools. The Fuel Characteristic Class System (FCCS) can be used to describe the different seral structure stages – present, past, and

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desired. LANDFIRE is expected produce seamless maps of FRCC at 30 m resolution by 2008 in the western United States using the guidebook method.


10. **Current Status:** The first generation guidebook and scorecard methods have been published. Baseline reference conditions for historic seral stages have been developed for most historic cover types in the western United States. A guidebook for mapping is still in development. For additional information, go to [http://www.frcc.gov/](http://www.frcc.gov/). This process is undergoing peer review.

11. **Training Availability:** Three national level Train-the-Trainer courses have been held in Tucson, Arizona. One local training will be held in Welches, Oregon on May 25-27. Additional training will be scheduled beginning in fall 2004. Requests for training should be coordinated through the Regional Vegetation Ecologist (Tom DeMeo). Web-based training is under development. A certification process for users of FRCC is also under development.

12. **Additional Information:** Example analyses using FRCC are available on the FRCC website (see item 10 above). While non-spatial in nature, the overall approach can include spatial considerations.

The FRCC process is heavily biased towards dry forests with short fire return intervals historically. At longer fire return intervals, the process begins to break down as the likelihood of having a landscape large enough on an individual Forest, much less Ranger District, that meets the size requirements specified in the process and is likely to have all five seral stages present at any given time decreases. In the long-interval, high severity fire regimes, time since the last ecologically significant disturbance is more important than the spatial arrangement of the different seral stages. One seral stage is likely to dominant the landscape at any given time. These considerations are not included in the reference baselines.

Adequate explanations of how to use the uncharacteristic seral stages are not included in the documentation. These “stages” include a mix of spatial considerations, other disturbance types, patch sizes, and road densities.

There is potential for much confusion over the use of the term “potential vegetation.” To date, “potential vegetation” has referred to the theoretical climatic climax, as used in the Region’s plant association guide. This use refers to the potential vegetation in the absence of disturbance. The FRCC process uses Kuchler “potential vegetation.” This use refers to the potential vegetation in the presence of the characteristic disturbance regime, what others may refer to as the “fire climax.” It may reduce confusion to refer to the Kuchler potential vegetation as the historic cover type.

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Despite these flaws, the FRCC process provides a logical and organized method for assessing changes in landscape function and environmental risks and for evaluating the potential sustainability of desired conditions. Since each seral stage can also be assigned other resource values, such as hydrological function or habitat for a given species, this process also provides a method to integrate other resource considerations and to examine how the mix of environmental functions and services may change between historic, current, and desired conditions.
1. **Tool Name:** FARSITE 4.0.4/FlamMap2 Beta 3.0.1

2. **Brief Description of Tool:** FARSITE is a fire growth simulation model that uses spatial information on topography and fuels along with weather and wind files. It incorporates the existing models for surface fire, crown fire, spotting, and fire acceleration into a 2-dimensional fire growth model. FlamMap2 creates raster maps of potential fire behavior characteristics (ROS, flame length, crown fire activity, etc.) and environmental conditions (dead fuel moistures, mid-flame wind speeds, & solar irradiance) over an entire FARSITE landscape. These raster maps can be viewed in FlamMap2 or exported for use in a GIS, image or word processor.

3. **Scale Tool is Applicable:** 4th and 5th field HUC, may be used in larger 6th field HUCs.

4. **Analyst Requirement:** Both FARSITE and FlamMap2 require a high level of expertise for the analyst and for GIS support. Users can self-teach themselves to run FARSITE, but not easily and are likely to miss how certain parts of the model relate to each other, what inputs to tweak to best address aspects of fire behavior that do not appear to match reality, and to recognize when outputs are unrealistic. FlamMap2 can be self-taught if the user already understands FARSITE, but cannot be self-taught otherwise. FlamMap2 is organized differently from FARSITE using an expanding tree structure rather than command and menu structure.

Creating the necessary data layers to support FARSITE and FlamMap2 requires a relatively high level of GIS expertise. Most data layers are created through remote sensing to provide wall-to-wall coverage at the same resolution. The usefulness of both tools increases greatly when the data layers include inholdings and adjacent lands.

5. **Data Inputs:** Both FARSITE and FlamMap2 use the same base data layers of which five are mandatory and three are optional. The five mandatory layers include slope, aspect, elevation, canopy cover, and fuel model. The three optional layers include canopy base height, canopy ceiling height, and canopy bulk density. These layers must be in raster format and are combined to create a landscape file. The three optional layers are needed to include spotting from torching trees and crown fire simulation. In the absence of these three layers, the models assume fully stocked stands of fully crowned Douglas-fir.

Both models allow importing of auxiliary grid and vector files for such features as roads, streams, barriers, point locations, and so forth. Both require weather and wind files. In FARSITE, these files can be quite extensive and should overlap the analysis period by at least 24 hours on each side. In FlamMap2, these files are much simpler. In FARSITE, a large number of run parameters must be specified, such as time step to be used in calculations, visible steps to display, perimeter resolution, and distance resolution. Crown fire can be enabled or disabled. Spotting can be enabled or disabled, include or exclude

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torching trees, and a specified frequency of ignition. FlamMap2 does not require these parameters. FARSITE requires a fire start location; FlamMap2 does not.

6. **Model Outputs:** Both models can produce maps of fire behavior parameters in exportable form. FARSITE includes graphs and tables of fire area, perimeter, fire characteristics chart plots, post-frontal combustion, wind gauge, and weather station locations.

7. **Application of Model for Fuel Treatment work:** FARSITE can be used to test different landscape level treatments potential effects on a fire or group of fires burning under a given weather stream. FlamMap2 can be used to identify those portions of the landscape where expected fire behavior and certain fire effects are potentially within or outside of acceptable levels, indicating where fuel treatments may be justified.

8. **Linkage to Other Models/Tools:** FlamMap2 uses FARSITE landscape files. Current development efforts include a landscape level fuel treatment optimization model that uses features from both FARSITE and FlamMap2.

9. **Partners:** Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, and Systems for Environmental Management

10. **Current Status:** FARSITE 4.0.4 is fully functional and stable. FlamMap2 is still in formal beta test. Go to [http://www.fire.org/](http://www.fire.org/) for more information.

11. **Training Availability:** Use of FARSITE is taught in S-493 Fire Area Simulation and the program includes a tutorial in the help files. No training is available for FlamMap2, but users of FARSITE can self-teach since most functions remain the same and a tutorial is included in the help files.

12. **Additional Information:** FARSITE is intended to simulate fire spread for a single start or group of starts using a weather stream for the days to be assessed. FlamMap2 is intended to estimate potential fire behavior and fire effects for the entire landscape using a single set of environmental conditions.

FARSITE is most accurate when calibrated using previous weather data and fire perimeters for a particular fire. The model will run simulations for any time desired, but cumulative errors leave the results suspect after about five days. When spotting is enabled, several simulations should be run using the same weather streams and model parameters since spotting is stochastic and each run will produce different results.

Both models will produce output files that can be imported into GIS and analyzed further or displayed with different layers, such as a recreation map or other important layers stored in polygon format.

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1. **Tool Name:** Fire Family Plus

2. **Brief Description of Tool:** Fire Family Plus conducts analyses of historical fire weather and fire occurrence using databases in the National Integrated Fire Management Interagency Database (NIFMID). Weather files can be extracted for use preparing input data for the Rare Event and Risk Analysis Process (RERAP) or for FARSITE.

3. **Scale Tool is Applicable:** 5th field HUCs, occasionally individual stations used for 4th field HUCs.

4. **Analyst Requirement:** A moderate skill level is needed by analyst to examine weather and station catalog data for quality, correct errors, and interpret results.

5. **Data Inputs:** Weather data files and station catalog files extracted from the interagency Weather Information Management System (WIMS) database, data years to use for the analysis, months and days to use in the analysis, analysis period length.

6. **Model Outputs:** Primary outputs of concern for fuels management are percentile weather and winds analysis.

7. **Application of Model for Fuel Treatment work:** Percentile weather can provide scientifically based burning conditions for use in other models such as CrownMass, BEHAVE Plus, NEXUS, and similar tools used to evaluate potential fire behavior. Data cannot be used by FVS-FFE. Wind data can be used to determine percentage of days winds are from a given quadrant and potential wind speeds for use in smoke dispersion analysis. Climatology analyses can aid in determining which weather elements are most closely associated with large fire growth.

8. **Linkage to Other Models/Tools:** Provides data for input into RERAP, FARSITE, CrownMass, and NEXUS.

9. **Partners:** Forest Service, Department of the Interior, Systems for Environmental Management.


11. **Training Availability:** Use of Fire Family Plus is taught in S-491 Introduction to NFDRS.

12. **Additional Information:** When coupled with data on fire occurrence, users can analyze area-specific weather conditions associated with large fire spread. Analysis of fire occurrence data also provides information on predominant statistical causes and distribution of fire size classes to support purpose and need statements.

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Weather data for some stations extends into the 1960s; however, data taken before the mid-1970s is usually incomplete and can result in erroneous results. Weather data must be checked for quality control and errors removed or corrected. Days with incomplete data should be completed when possible or deleted. Missing records do affect resulting analyses. Weather and fire occurrence data sets analyzed for use in fire planning usually have had errors corrected and should be preferred over raw data extracted from WIMS.

Weather records covering at least 20 years are preferred. There is debate among meteorologists and long-term analysts over weather data from before the mid-1980s should be used as this period is cooler and wetter than general weather since the mid-1980s. Stations with less than 10 years of data should be used very cautiously and avoided when possible. Data from older manual stations and newer Remote Automated Weather Stations (RAWS) can be merged through use of a Special Interest Group (SIG) and analyzed.

The Predictive Services Group at the Northwest Coordination Center (meteorologists Terry Marsha and Paul Werth) have conducted extensive analyses of weather factors associated with large fire growth using SIGS of key stations at the equivalent of 4th field HUCs. They have found a strong correlation between large fire growth days and 100-hour fuel moisture and energy release component (ERC) for G model. Critical values for both 100-hour fuel moistures and ERC are listed as part of predictive analyses for 10-day and seasonal fire danger. Go to http://www.or.blm.gov/nwcc/index.htm and click on Predictive Services in the left column. Fire Family Plus allows for analyses using both variables simultaneously to estimate the number of days when large fire growth is possible.

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