R-CAT Appendix to the CFLRP 5-year Report to Congress Version 6.7

The USDA Forest Service Collaborative Forest Landscape Restoration Program Risk and Cost Analysis (R-CAT) modeling support team put this report together.

Introduction

The Omnibus Public Land Management Act of 2009 includes Title IV: Forest Landscape Restoration Act (FLRA). The purpose of this title, and the USDA Forest Service Collaborative Forest Landscape Restoration Program (CFLRP), is to conduct hazardous fuel treatments and ecosystem restoration that encourages economic and social sustainability, leverages local resources with national and private resources, reduces wildfire management costs, and addresses the utilization of forest restoration byproducts to offset treatment costs and benefit local economies.

The Forest Service intent was to take the fire management aspect of the Act very seriously in CFLRP, within the context of the multiple Act objectives. Although wildfire management cost containment is a significant component of the FLRA and CFLRP program, there has been increased insight into the drivers of fire management costs and the agency now sees costs as an outcome of both risk management decisions during the incident and land management decisions before the incident ever occurs. The Act also sets forth multiple objectives for vegetation treatments. For example, a landscape proposal:

> *"…fully maintains, or contributes toward the restoration of, the structure and composition of old growth stands according to the pre-fire suppression old growth conditions characteristic of the forest type, taking into account the contribution of the stand to landscape fire adaptation and watershed health and retaining the large trees contributing to old growth structure;*
>
> *(E) would carry out any forest restoration treatments that reduce hazardous fuels by-*
>
> > *(i) focusing on small diameter trees, thinning, strategic fuel breaks, and fire use to modify fire behavior, as measured by the projected reduction of uncharacteristically severe wildfire effects for the forest type (such as adverse soil impacts, tree mortality or other impacts); and*
> >
> > *(ii) maximizing the retention of large trees, as appropriate for the forest type, to the extent that the trees promote fire-resilient stands; and*
>
> *(F)*
>
> > *(i) does not include the establishment of permanent roads; and*
> >
> > *(ii) would commit funding to decommission all temporary roads constructed to carry out the strategy;"*

Additionally, proposals "*describe plans to-*

> *(A) reduce the risk of uncharacteristic wildfire, including through the use of fire for ecological restoration and maintenance and reestablishing natural fire regimes, where appropriate;*
>
> *(B) improve fish and wildlife habitat, including for endangered, threatened, and sensitive species;*
>
> *(C) maintain or improve water quality and watershed function;*

(D) prevent, remediate, or control invasions of exotic species;

(E) maintain, decommission, and rehabilitate roads and trails;

(F) use woody biomass and small-diameter trees produced from projects implementing the strategy."

The CFLRP funnels funding from the Forest Service budget to projects, competitively selected through requests for proposals, to cover up to 50 percent of fuel reduction and ecological restoration treatment implementation and monitoring costs on National Forest System (NFS) lands. The reporting requirements under section 4001 Purpose – Section (3) stipulate that these funds will be used to "facilitate the reduction of wildfire management costs, including through reestablishing natural fire regimes and reducing the risk of uncharacteristic wildfire." Subsection 4(A)(ii) states that projects will "affect wildfire activity and management costs," and Subsection 4(B) states that "the use of forest restoration byproducts can offset treatment costs while benefiting local rural economies and improving forest health." Section 4003 (c) 4 provides requirement that teams will analyze any anticipated cost savings, including those resulting from--(A) reduced wildfire management costs; and (B) a decrease in the unit costs of implementing ecological restoration treatments over time. Under Section 4003(d)(2)(D) selection criteria included subsection (D) whether the proposal is likely to achieve reductions in long-term wildfire management costs;

Analyses to verify the potential for attainment of these purposes and objectives can partially be met through a combination of innovative fire and economics modeling and reporting. However, to meet the wildfire management cost reporting requirements described in Title IV, spatially explicit treatment schedules for each strategy, with at least a coarse estimate of projected implementation timing, costs and revenues are mandatory from each proposal team. The proposal requirements sent to Regional Foresters on February 24, 2010 identified multiple topics, each of which needed to be addressed in each proposal. Among others, these requirements included:

- Is there a strategic placement of treatments?
- What types of treatments will occur?
- How many acres will be treated and when?
- What wildfire behavior is anticipated with current conditions?
- How will uncharacteristic wildfire be addressed?
- How will natural fire regimes be reestablished and maintained?
- What wildfire behavior is anticipated in restored conditions?
- How will wildfires be managed in a restored landscape?
- Were community wildfire protection plans incorporated?
- What long-term wildfire management cost reductions would occur?
- What value would the removed material have and how would it offset treatment cost?
- What federal investments are anticipated within the landscape?

These questions collectively implied that each team would develop a spatially explicit treatment schedule as part of their strategy. Ideally, a financial analysis would be used as a means to improve land management strategies prior to proposals submission. Since all vegetation management with the potential to affect wildfire risk are included in the financial analysis, including timber cutting for all purposes, the analysis shows the expected financial results from these investments, and therefore the investment should be interpreted as not only achieving hazardous fuels reduction objectives but myriad other objectives such as:

- Increased firefighter safety
- Increased public safety
- Hazard reduction for private property at risk
- Hazard reduction for public infrastructure at risk
- Hazard reduction for natural resources at risk, to maintain and increase resilience for ecosystem services

Some of these objectives are covered in other indicators reported within this 5-year report, such as expected reductions in flame lengths and ecological improvements. Other objectives set out in the Act and tackled by the teams, such as firefighter and public safety, maintenance and recruitment of desirable wildlife habitat and restoration for many other ecosystem services are not explicitly addressed, and in both cases, neither is quantified in dollar terms. In general, *Forest Service Manual 1970 direct U*SFS wildfire managers to:

- Include economic criteria in the decision process for evaluating proposed fuel treatment programs and activities. And for selecting the practices used to perform fuel treatment, and
- Use conventional economic evaluation procedures to determine the most cost-efficient alternative

If one were interested in assessing the economic efficiency of the overall fire programs, it would be necessary to compare all financial investments in the fire program under existing and post treatment conditions to the expected benefits, where expected benefits and expected costs are adjusted by probability modeling. This probability-based approach to benefit estimation is consistent with agency adoption of a risk management paradigm, consistent with language of act focusing on risk, and consistent with state-of-the-art in fire science. Most critically–although fire is an inevitability, the occurrence of fire in any particular location in any particular time is highly uncertain, and this uncertainty must be captured to assess the likely success of spatial fuel treatment strategies–assuming fire will occur with 100% probability could grossly overstate benefits and lead to inefficient allocations of resources

The costs would ideally include fuel treatment costs, as well as investments to maintain personnel and firefighting assets, small fire costs, large fire costs, and post fire costs. The net financial investments from the Risk and Cost Analysis Toolkit (R-CAT) analysis are therefore not a comprehensive set of fire program costs nor does R-CAT include any financial estimate of expected benefits beyond changes in small, large and postfire costs. The CEQ has specifically instructed the Forest Service not to attempt this analysis during planning efforts with Title 40, Code of Federal Regulations for the National Environmental Policy Act (40 CFR 1502.23), which indicates:

For the purposes of complying with the National Environmental Policy Act (NEPA), the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are qualitative considerations. Following this rationale, there has been no attempt to convert the achievement of any of these other objectives into dollar terms to estimate benefits. There are emerging techniques used for valuation of a handful of these benefits but they are limited in application and often lead to contentious results. The Forest Service has instead attempted to quantify the expected changes in fire behavior and conditional risk. For example, the Deschutes Collaborative Forest Project used the Large Fire Simulator in combination with pre-identified high value assets at risk (mapped as blue portions of the project area in the left side of Figure 1) to show how their fuel treatment package could reduce exposure by moderating burn probability and conditional flame lengths. Planned fuel treatment shift to the left from existing conditions (represented by gray bars) to lower levels of exposure after treatment (represented by red bars).

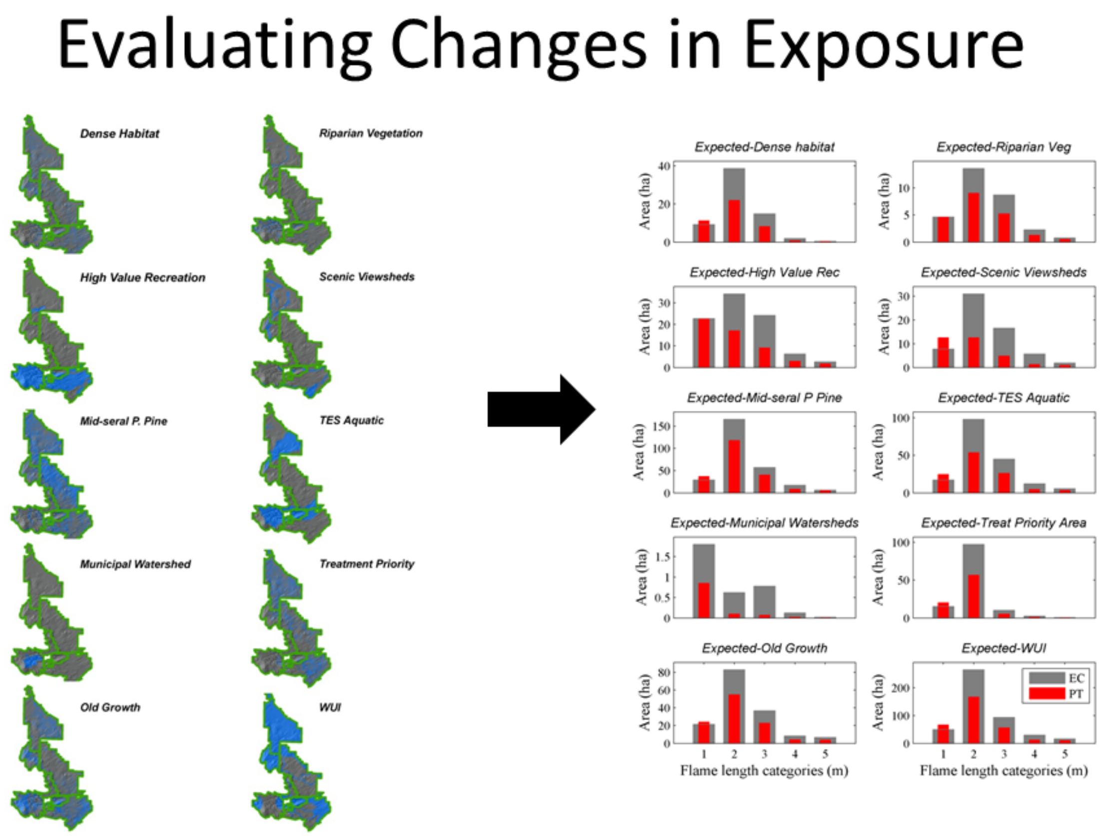

Figure 1: Representation of the geographic location (left side) and the expected changed in conditional flame length exposure to High Value Assets.

Fire Program Cost Analysis Methodology

History of R-CAT Process Development

To facilitate the level of analysis specified in Title IV, a team of fire modelers from the Rocky Mountain Research Station and the Western Wildland Environmental Threat Assessment Center met with economists from the National Forest System. Table 1 shows analysis procedures capable of meeting the intent of Title IV and intended to synchronize with the Cohesive Strategy rewrite were crafted; moving beyond worst-case scenario modeling to probability-based modeling. Figure 2 shows how the Risk and Cost Analysis Toolkit (R-CAT) fits into a conceptualization of fire management costs analysis. By applying standard analysis procedures to specific data from each proposal team, these tools allow the responsible agencies to evaluate each proposal independently and potentially to aggregate the projected and actual results of Title IV projects across the national Title IV program, which was designed to help support multi-party monitoring requirements found in 4003 Subsection (h).

Table 1: Possible risk reduction and cost savings opportunities that could result from CFLRP hazardous fuels treatments.

Cost Category	Category	Mechanism	Recommended R-CAT Evaluation Approach	Alternate Methods
Fuel treatment	Net unit costs decrease	Processing demand increases as volume offered spurs processing infrastructure, byproduct value increases, net costs per acre decrease	Show increases in annual treatment revenues and decreases in net treatment costs through time in R-CAT Spreadsheet tool	
Fuel Treatment	Unit costs decrease	Maintenance slashing and burning replace thinning, net costs per acre decrease	Show reductions in annual net treatment costs through time in R-CAT Spreadsheet tool	
Suppression	Small fire costs	Reduced initial attack costs as small fires become easier to extinguish*	Adjust future small fire costs in R-CAT Spreadsheet Tool based on expert opinion	
Suppression	Large fires costs	New fuel patterns lead to changes in fire behavior and fires sizes, including those in proximity to WUI, are reduced following treatment	Changes in FSim outputs to SCI, captured in R-CAT Spreadsheet Tool	

Cost Category	Category	Mechanism	Recommended R-CAT Evaluation Approach	Alternate Methods
Suppression	Large fire costs	Modified fire behavior leads to enhanced strategic suppression options	Use FSim fire intensity information and a GIS exercise with Fire Management Plans to adjust median SCI fire season estimates based on estimates of enhanced suppression and fire size-cost relationships	
Suppression	Large fire costs	New fuel patterns lead to increased fire management options	Use FSim fire intensity information and a GIS exercise with Fire Management Plans to estimate Low, Moderate, and High rate reductions to adjust median SCI fire season estimates based on estimates of contiguous area and monitoring: full suppression cost relationships	Use expert opinion to estimate low, moderate and high percentages and the portion of monitoring costs compared to full suppression in contiguous areas where this will now be possible
Resource Protection	Large fires costs	New fuel patterns lead to changes in fire behavior near WUI / communities, and fires cause less damage to VAR	Use FSim to demonstrate changes in burn probability and reduced risk, where risk equals probability of threat times value at risk	
Post-fire	Post fire costs	New fuel patterns lead to reduced fire intensity, and create less need for post-fire expenditures	Change the BAER, Rehabilitation, and/or Reforestation Costs in R-CAT Spreadsheet Tool using expert opinion	

* This logic is the subject of debate and must be well documented for your specific location using examples of recently observed situations.

Figure 2 provides a conceptual framework describing how the biophysical and socioeconomic context, treatment objectives, and treatment impacts can all be integrated within a modeling approach. The likelihood, extent, and intensity of fire, along with the density and spatial pattern of values-at-risk, jointly influence treatment strategies and design objectives. In some contexts, this may entail creating areas of low fire intensity and hazard, and fire sizes might actually increase as part of restoring historical fire regimes. In other contexts, treatment strategies are oriented more towards resource protection and the inhibition of fire growth across the landscape. The grey box highlights the computer-based modeling approach developed for the R-CAT package.

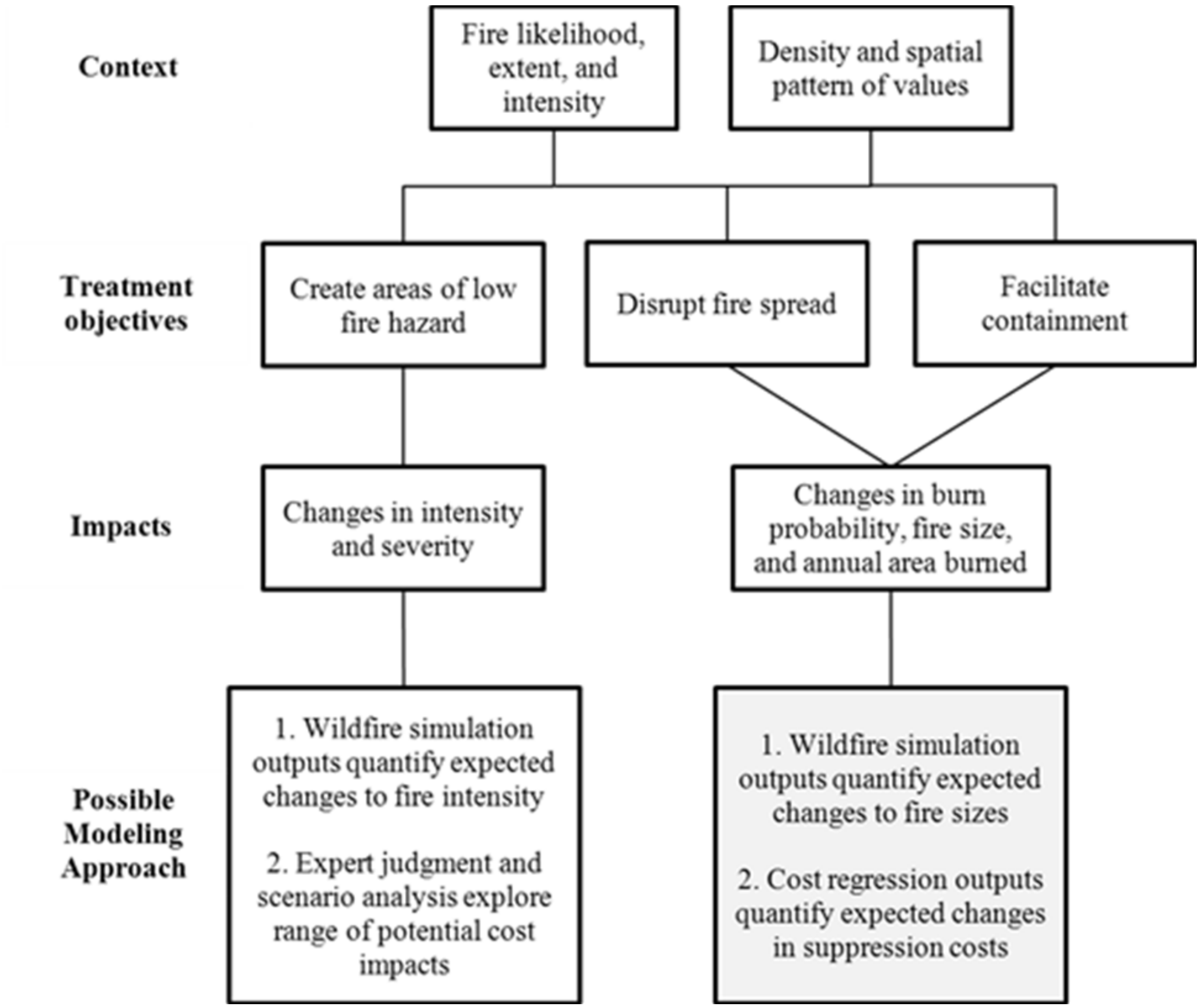

Figure 2: Conceptual framework for R-CAT modeling approach.

This modeling framework focuses on how treating fuels can affect fire size distributions, which is a major determinant of suppression costs within the model. The foundation of this approach is the coupling of two peer-reviewed models used by the Forest Service and other federal land management agencies: FSim (Thompson et al 2013a; Thompson et al. 2013b; Scott et al 2012a; Thompson et al. 2011, Finney et al. 2011), a spatially explicit large fire occurrence and spread model, and SCI, a large fire cost model (Gebert et al. 2007). The use of a fire growth simulation model approach allows users to directly model disruptions in fire spread and subsequent impacts to fire size. Therefore in this approach, all else being equal, treatments resulting in reduced fire spread will tend to decrease fire size, in turn reducing fire cost. Figures 3 and 4 show the suggested modeling approach and the breakdown of responsibilities.

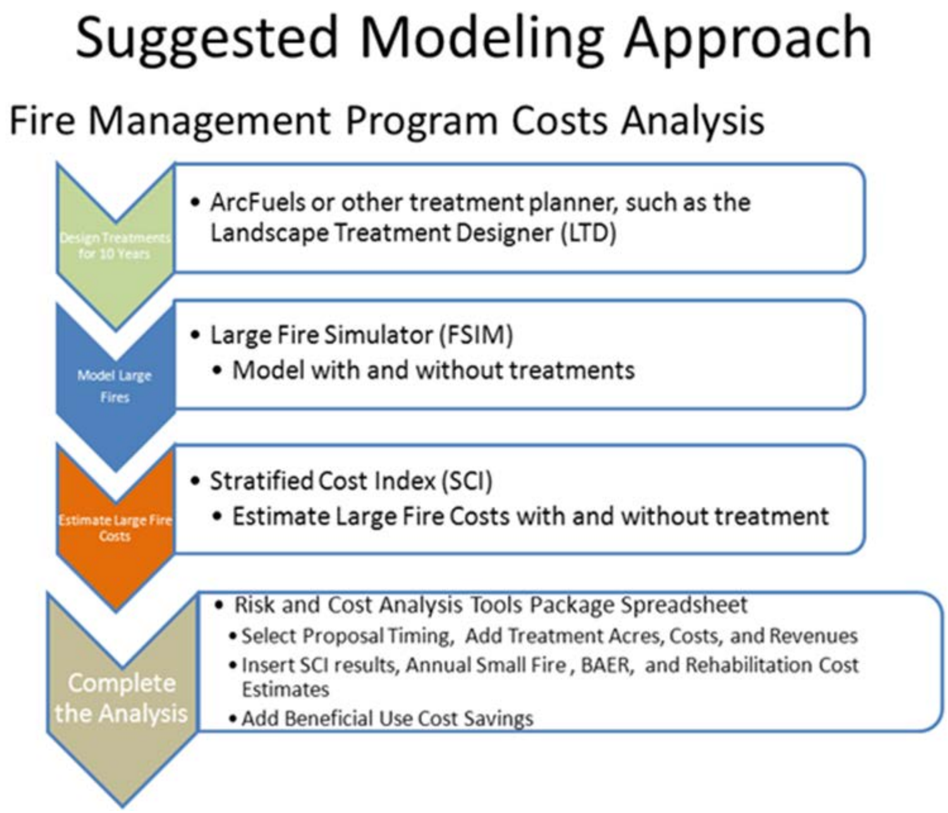

Figure 3: The R-CAT Modeling Approach.

Overview of R-CAT analysis responsibilites

Task 1: Create baseline landscape files for use in Fsim, pick weather station
Who: Fire and Fuels specialists working for each CFLRP team, in consultation with WWETAC modelers.
Task 2: Determine spatial layout of various fuels treatments, timing, costs and revenues
Who: Fire and Fuels specialists working for each CFLRP team, working with their collaborative and line officers, in consultation with WWETAC modelers.
Task 3: Running FSim to estimate fire seasons for baseline and treated
Who: Western Wildland Environmental Threat Assessment Center (WWETAC),
Task 4: Calculating suppression cost savings for all fire seasons using SCI
Who: Rocky Mountain Research Station
Task 5: Putting it all together in the R-CAT spreadsheet
Who: Specialists working for each CFLRP team/ NFS Economists
Task 6: Communicate results
Who: Specialists working for each CFLRP team/ NFS Economists/ WO / USDA

Figure 4: Overview of R-CAT tasks and who accomplishes each task.

The first step in the process is constructing a baseline or pretreatment representation of fuel conditions across each CFLRP landscape. The next step is development of the strategic fuel treatment schedule. Once both are completed, teams can work with agency fire modelers and economists, using our best modeling tools to validate their expectations of risk reduction for a fully implemented treatment plan, and the expected annual savings associated the escalation, maintenance and waning years of treatment effectiveness. The following is a description of modeling inputs to FSim:

CFLRP FSim and GIS Data Descriptions

The following is required for FSim:

- Landscape files (*.lcp) for existing conditions and post treatment alternative.
    - These need to include a buffer (rectangular preferred, but not necessary depending on the CFLRP shape) around the CFLRP landscape that **extends at least 5 miles** beyond the project area and they need to be the same size.
    - The existing conditions landscape needs to represent the pre-CFLRP landscape. Data often needs to be updated so all disturbances (i.e., treatments, fires) that happened between the data version and the pre-CFLRP period are included.
    - The post-CFLRP landscape will include all the treatments proposed under the CFLRP. While you might not know the exact spatial location, strive to do your best based on the known target acres. You will need to update the fuel model and canopy layers (canopy cover, canopy base height, canopy bulk density, and canopy height) to represent the various treatments.
- Desired resolution of outputs (i.e., 30 m input data and 90 m output data, this might be limited by the computer and the size of the landscape).
- Most representative RAWS station (or a SIG if needed) for the project area – preferably 20-30 years of historic data available.
- Fire season start date (can be green up date, or when fire season typically becomes active).
- Crown fire method for calculations (Finney vs. Scott/Reinhardt).
- Maximum fire size (ac) allowable. This would be the largest fire potential within the CFLRP and the buffered area. This may or may not be a fire that has occurred in the past as fires are tending to get larger and larger each year. When the historic fire is larger than what is sent to me I will use the largest historic fire in the landscape.

Other GIS data for analysis/fire costing:

- CFLRP boundary shapefile
- Treatments shapefile
- Shapefile of LCP extent (buffered area)
- Shapefile of areas that have fire use allowed vs. full suppression (if applicable)

Optional data for FSim:

- Ignition density grid (*.asc file that is same resolution, projection, extent, and snapped to the LCP grids). If no Ignition density grid is used, then the program will randomly locate the fires across the whole landscape.
- Definition of a "large" fire. FSim is a large fire simulator and uses information on historic fire occurrence to determine how many "large" fires will be simulated. Typically in forested landscapes this is 300 ac, but can be quite variable. This can also be determined from the fire occurrence data.
- Live fuel moisture files for 80th, 90th, and 97th percentiles.
- Rate of spread adjustment file (*.adj). This is used to adjust the ROS for specific fuel model(s). Not common.
- Custom fuel model file (*.fmd) – only if custom fuel models are used. Not common.
- Barrier file (*.shp) - barriers can either be filled or unfilled and impede fire spread. Not common.
- Ignition mask (*.asc file that is same resolution, projection, extent, and snapped to the LCP grids). Not common.

The Rocky Mountain Research Station processed the FSim results using the Stratified Costs Index[1] to evaluate the differences between existing conditions and post treatment conditions. The differences in these large fire costs were entered in the R-CAT spreadsheet, sometimes in addition to optional cost inputs, where the maximum annual savings were multiplied with the cumulative portion of the treatment package that was effective each year; growing from the small portion of the total package effective after the first year to the final years of effectiveness where the last year of treatments remain effective for the last year of average treatment duration.

Ideally, this process would have been used as a means to improve land management strategies prior to proposal submission**.** No team actually completed this task during the proposal phases. However, results are helping teams consider the balance of financial and non-financial aspects of fire and land management.

Noteworthy R-CAT Challenges

Several challenges emerged during the analysis efforts, which should be recognized as important context for the results. A primary challenge was due more to the limited qualified personnel capable of supporting FSim fire modeling with LCP representation of landscapes across the country. While many western teams have fire and fuels staff that use the FARSITE family of modeling tools two problems emerged. Many of the younger staff with these skills are constantly moving between positions to gain experience, thus leaving teams without these skills at times, and teams east of the Mississippi rarely use FARSITE type fire models. Collectively,

---

[1] Abt, K.L., J.P. Prestemon, and K. Gebert. 2009. "Wildfire suppression cost forecasts for the US Forest Service". *Journal of Forestry* 107(4):173-178. *Note: models have been and are continuously being updated since publication of this article, and only changes that result in improved fit statistics are used for the forecasts.*

only 10 of the 23 teams made it through the Risk and Cost Analysis Toolkit (R-CAT) process with results that were deemed representative enough to report to Congress.

Second, despite the requirements in the CFLRP request for proposals for teams to use strategic placement of treatments, and detail-planned activities with acreage and volume estimates, getting teams to speculate where and when treatment would occur was not possible for any of the teams during the proposal phase. Part of the explanation is that the tone of the legislation and the realities of collaboration combined to slow down the planning efforts to ensure all partners were invited, involved and comfortable with proposed plans. This resistance to spatially and temporal planning has persisted through the 5 year mark, and many teams reluctantly mapped locations and provided only rough estimates of timing, often citing objections, litigation and other real obstacles during the first 5 years which make accurate prediction difficult. Other teams emphasized how unpredictable prescribed burn windows dictate which acres of the many planned are actually treated each season.

A third challenge was the tension between national consistency needed for program wide analysis and flexibility needed to accommodate the nuances of each teams landscape fuels, treatment plans and staff configuration. One of the most basic decisions in R-CAT modeling was the selection of the base layer used to represent the landscape. Although LANDFIRE was available for all teams, its freshness varied across the country as did its perceived accuracy. Many teams elected to use this as a starting point, others relied on regional products.

In addition, teams across the country vary in how much they embrace the ‘all lands’ aspect of the act, and few teams were able to work with partners to obtain recent activities, let alone future plans. As a result, teams were asked to model the existing conditions to the best of their ability and then to model post treatment changes from FS treatments (and fires) only, using FS costs only. A more expanded analysis would be worth pursuing in addition to this consistent approach. Getting consistent modeling of all landscapes was also difficult due to the variable in shapes of project areas. Buffer guidelines were offered to capture the fires entering the CFLRP landscape and encountering existing conditions or post treatment conditions to show the entire effect of treatments in project areas. However, for the first set of teams that completed the fire modeling, the project areas represented dissimilar proportions of their total modeling area. Eventually the stratified cost analyses were redone limiting all analyses to 2km buffer around each CFLRP landscape. This helped standardize the analyses but the variation in ignition density that resulted from variable buffer areas was a weakness of this modeling that could be improved in future analyses to enhance consistency.

With the entire modeling areas, teams also had some variation in how they captured recent wildfires. Most teams were able to update their existing condition layers to show how fires had changed the base layer they used (typically the most recent LANDFIRE layer). Likewise wildfires were shown as changes in LCP files for post treatment fire modeling. The real problem arose trying to sort out if a wildfire had been considered a desirable or undesirable event, and therefore showing it as a cost to the agency or not.

A fundamental reality of R-CAT modeling is that it is designed to make large fire modeling mandatory and makes other aspects of fire program costs optional. This design resulted from the reality that large fires represent the majority of suppression costs each year nationally (with the 2-3 percent of all fires escaping leading to a few dozen very expensive fires each season) as well as the lack of a national approach to estimate other cost elements. As a result, many of the teams opted to restrict their analysis to just the large fire component. This could be justified when no changes in small fires, Burned Area Emergency Response (BAER) and rehabilitation (normally resulting from large fires only) or less expensive strategies allowing beneficial fire were expected after implementing treatments. All of this meant that most of the analysis hinged on FSim and the Stratified Cost Index showing that changes between existing conditions and post-treatment, and more explicitly cost differences, were driven by expected changes in fire sizes, not fire intensity. The problem is that many of the treatments across the nation are designed to reduce fire size and change fire behavior in the areas that do burn. So teams that did not expect much large fire, didn't expect much change in the sizes of large fires would not show a strong return on their hazardous fuels investments. Another thing that happened is because teams created treatments that would likely reduce the fire severity (a good idea) they ended up with fires that were larger in the end because of fuel model changes to a faster moving flashier fuel type, skewing the costs to often be higher. Adding to this problem, a small bug in FSim also underestimates the likelihood of crown fire and overestimates the spread of fires in flashier fuels, which is being addressed by the FSim modeling team. These are problems that arise when attempting to use the best available science just as it is emerging.

Summary of R-CAT Inputs

It is important to reiterate that less than half of the teams were able to complete R-CAT analyses in time for the 5-year report. Therefore, summary information portrays a portion of the CFLRP program, and is not a program-wide analysis. More information describing and justifying inputs can be found on the documentation page of each R-CAT workbook, as well as the FSim input page that facilitated communication between CFLRP personnel and the FSim modelers.

The R-CAT User Guide instructed teams to include all vegetation treatments that have the potential to affect fire behavior. In many cases reducing hazardous fuels was the primary objective of treatments that require expenditures and sometimes produce revenues, especially in the WUI. However, many of the silvicultural treatments with the potential to impact fire behavior have a wider set of land management objectives, where changing fire behavior may or may not rank high in the list. As a result, the set of treatments included varied across the country. In some cases new approaches and suites of treatments were proposed which made projection of changes to LCP characteristics and estimation of costs and revenues difficult. The personnel limitations added to challenges of estimating these key inputs to the R-CAT analyses.

Table 2 shows a summary from 10 of the 23 teams that completed the R-CAT analysis. The scale of estimated treatment varied across all teams, ranging from 38,319 to 179,594 acres, averaging 124,000 acres. The average duration of treatment effectiveness within each large landscape treatment package ranged from 10-20 years. Expected revenues ranged from $0 to more than $31 million, and expected treatment costs ranged from $11.7 million to $72.6 million over the life of the project. These represent different proportions of total CFLRP investments that had at least some capacity to affect hazard levels.

Table 2: Summary the inputs for the ten CFLRP teams that completed R-CAT.

CFLRP Landscape	Total Treatment Acres	Average Treatment Duration (years)	Total Nominal Treatment Revenues	Total Nominal Treatment Costs	Median Annual Fire Season Cost (EC)	Median Annual Fire Season Cost (PT)	Mean Annual Fire Season Cost (EC)	Mean Annual Fire Season Cost (PT)
Southwestern Crown of the Continent	89,710	20	$10,075,554	$14,358,564			$2,312,945	$2,268,107
Kootenai Valley Resource Initiative	38,319	20	$31,046,666	$24,351,447			$275,767	$250,478
Uncompahgre Plateau	69,646	20	$1,705,429	$11,935,520			$310,419	$292,226
Southwest Jemez Mountains	72,566	15		$72,556,000			$145,325	$145,198
Weiser-Little Salmon Headwaters	151,272	13	$19,999,239	$28,873,546			$2,152,455	$2,185,390
Deschutes Collaborative Forest Project	66,808	10	$2,816,005	$16,863,201	$2,675,639	$2,282,279	$5,401,950	$4,512,393
Lakeview Stewardship	145,391	15	$9,367,484	$13,461,011	$314,763		$8,149,172	$6,794,263
Southern Blues Restoration Coalition	309,880	15	$3,647,868	$30,500,000			$1,818,445	$2,153,282
Northeast Washington Forest Vision 2020	119,827	15	$10,559,074	$24,391,141			$1,959,841	$1,846,806
Missouri Pine-Oak Woodlands Restoration	179,594	10	$15,799,593	$11,674,610	$161.808	$168,808	$401,485	$414,843

Large Fire Costs

It is important to highlight that Large Fire Simulator (FSim) results indicate median annual large fire season costs were estimated at $0 under both existing and post-treatment conditions for seven of the ten teams. Modeling for one team shows median annual large fire costs falling to zero after treatments. Modeling indicates the median annual large fires season costs from one team are expected to decrease slightly, and for one team they are expected to increase very slightly. As a result, and in order to complete the analysis, seven teams used mean annual large fire season costs, which are considered less accurate due to the influence of rare but extremely expensive seasons. A summary of these costs is shown in Table 2. For five of these seven teams, modeling shows lower mean annual large fire season costs following treatment, and for two teams mean costs are expected to increase slightly. Although these numbers drive the R-CAT results it is very hard to substantiate their legitimacy given that CFLPRP project area boundaries do not correspond to classic jurisdictional boundaries under the purview of fire managers that normally track annual costs. In addition, there was a programming bug in FSim that prevented the selection of crown fire logic for several teams that would have preferred to model with an alternative crown fire spread logic.

Optional Cost Inputs

Four of the ten teams entered small fire cost estimates, and two of the teams showed an expected reduction, ranging from $6,583 (21%) to $21,216 (12.5%) each year. Three of the teams expected a reduction in BAER and rehabilitation costs, ranging from $13,463 (2.4%) to $169,443 (100%) each year. Five of the teams analyzed changes in costs that could be accomplished by achieving one of the intents laid out in the Act language - "facilitates the reduction of wildfire management costs, including through *reestablishing natural fire regimes* and reducing the risk of uncharacteristic wildfire." Teams were asked to "estimate the potential contiguous percent area of your proposal landscape where full suppression could be replaced with low-cost monitoring of fire for beneficial use." Estimated costs used in the analyses ranged from 20% to 38% relative to full suppression costs and the maximum possible, based on the guidance in the user guide, ranged from 5% to 74% of the five large landscapes. More detail from the R-CAT User Guide is provided below explain what the analysis covered.

"You have an opportunity to estimate a low, moderate, and high percent reduction in the area where large fires could be monitored instead of requiring full suppression. These are areas where large fire cost savings and post fire costs savings could occur once you have returned the landscape to natural fire regimes, and you have substantially reduced the potential for catastrophic or ecologically undesirable fire…what aerial proportion of your proposal area could benefit from this change in management from full suppression to monitoring fire for beneficial use. This requires that you reference a valid fire management plan and consult your Fire Management Officer. "

Summary of R-CAT Results

Figure 5 provide an overview of the R-CAT modeling process and the calculations that lead to the results found in Table 3. The results of the modelling indicate that you could expect the various fire management program components, small fire costs, large fires costs and post fire costs to be reduced with the investment you make in fuel treatments, shown as the net of annual treatment revenue and annual hazardous fuel treatment costs on the right side of the diagram. Also note that the blue section in the lower post treatment fire cost pentagon is the optional reduction in fire management costs when less expensive strategies other than full suppression can be used allowing fire to play more of its historic role on part of the CFLRP landscape, essentially reestablishing natural fire regimes.

Table 3 shows that nearly all teams had a treatment package modeled as having the ability to reduce total discounted (4% annually) suppression costs savings over the full duration of treatment effectiveness. The potential ranged from $5.3 million in total suppression savings to a net increase in suppression costs of $3.5 million. The ranges shown for five of the ten teams reflect the estimated influence of using less expensive fire management strategies than full suppression. It is noteworthy that in two cases, allowing less than full suppression could shift change expectation from increased to decreased suppression costs over the life of treatment effectiveness.

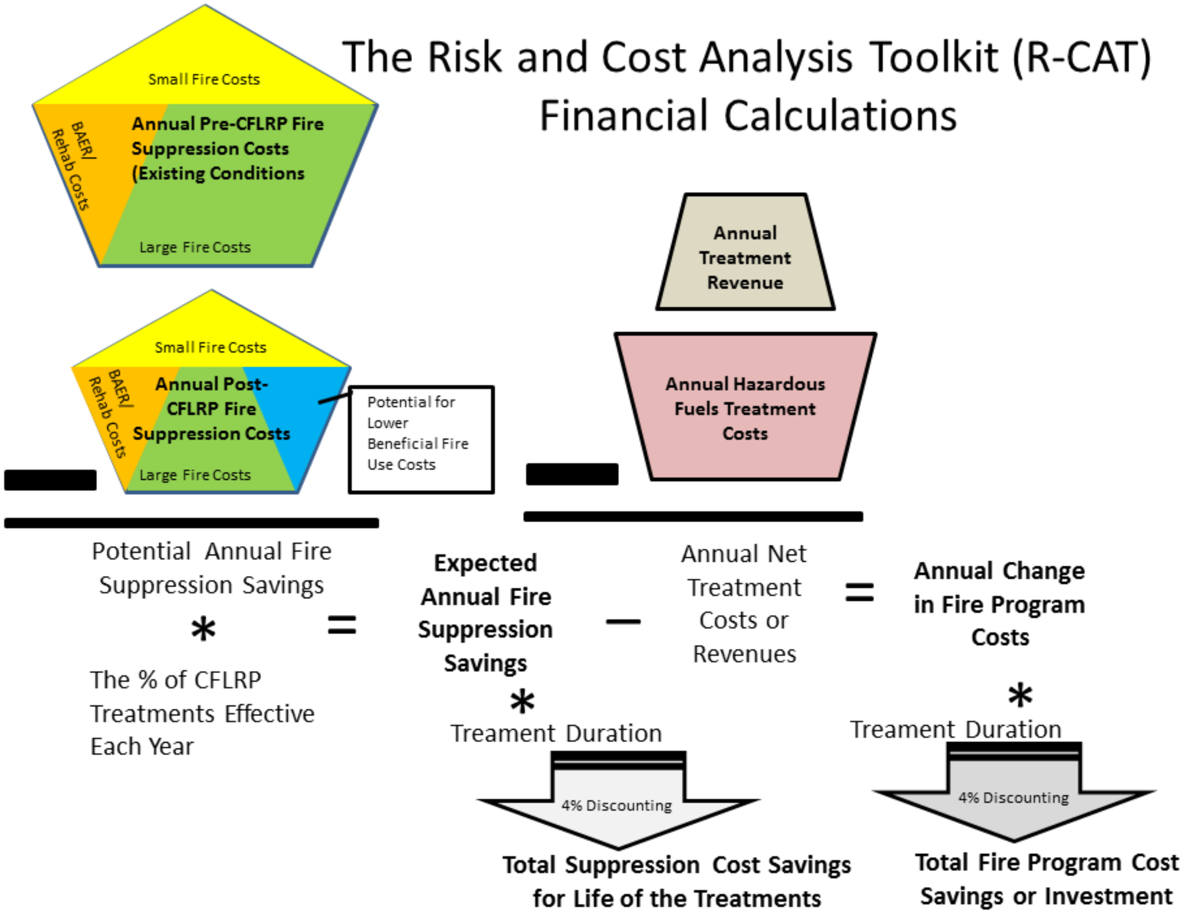

Figure 5: R-CAT modeling process overview.

The difference in small fire costs, annual fire suppression costs (pre CFLRP versus post CFLRP), large fire costs, BAER and rehabilitation costs, plus the addition of the potential for lower beneficial fire use costs results in the potential annual fire suppression savings. This amount is multiplied by the percentage of CFLRP treatments effective each year, resulting in the expected annual fire suppression savings. Multiplying this by the treatment duration, with a 4 percent discounting, results in the total suppression cost savings for life of the treatments.

The difference between annual treatment revenue and the annual hazardous fuels treatment costs results in the annual net treatment cost of revenues. This amount subtracted from the expected annual fire suppression savings results in the annual change in fire program costs. Multiplying this by the treatment duration, with 4 percent discounting, results in the total fire program cost savings of investment.

Table 3: Summary of Potential Savings Modeled with R-CAT.

Region	CFLRP Landscape	Total Discounted Suppression Cost Savings for Life of Treatments	Total Discounted Fire Program Costs Savings (Investment)
1	Southwestern Crown of the Continent	$630,046	($2,924,780)
1	Kootenai Valley Resource Initiative	$355,354	$5,311,461
2	Uncompahgre Plateau	$1,774,504 to $4,146,800	($6,412,727) to ($3,770,432)
3	Southwest Jemez Mountains	$1,339	($58,976,870)
4	Weiser-Little Salmon Headwaters	($300,816)	($7,983,348)
6	Deschutes Collaborative Forest Project	$2,763,695	($8,904,446)
6	Lakeview Stewardship	$5,102,945 to $5,255,665	$1,853,698 to $2,006,418
6	Southern Blues Restoration Coalition	($3,528,781) to $1,577,147	($25,365,306) to ($20,259,378)
6	Northeast Washington Forest Vision 2020	$1,420,695 to $4,086,243	($9,528,851) to ($6,863,343)
9	Missouri Pine-Oak Woodlands Restoration	($53,003) to $24,935	$2,771,361 to $2,849,299

When the modelled suppression savings picture is combined with the net of treatment revenues and costs, the fire program cost savings (investment) picture is provided. Three teams that completed the analysis are projecting net fire program savings without any beneficial fire use, one of those indicates potential increases in net savings with all three levels of beneficial fire use. Four teams expect to see a net increase in fire program expenditures and did not analyze the potential for beneficial fire use. While three teams expect an increase in net fire program costs but do expect a smaller net investment to achieve other objectives when less than full suppression strategies are employed. The range of net fire program costs is from a savings of $5.3 million to an investment of $59 million over the life of the project.

The range of potential opportunity to affect fire management costs with beneficial fire use (from teams who conducted this analysis) is from $152,720 to $5.1 million, depending on the difference in costs between full suppression strategies and the amount of the large landscape which could be suitable for different fire strategies.

Here are cautionary warnings about interpreting R-CAT results. The potential for non-financial risk reduction and different decisions is not presented, which omits potentially lower cost outcomes from different risk decisions. Dollar estimates for many of the expected benefits are not included in the estimates. Not all fire management costs are included in the financial analysis, yet investments for all treatments with any aspect of hazard reductions are included. The best use of the R-CAT results is to evaluate the potential for all hazardous fuel treatments to reduce the risks that can lead to catastrophic wildfire in the project landscape, and then to consider if potential savings in implementing risk based fire management strategies offset the entire investment in other objectives or whether they partially offset the investment in other objectives. In rare cases where fire suppression savings are not expected, modeling should first be reviewed to ensure it is representative of expert opinion and then treatment packages should be reviewed to look for other ways to achieve the bundle of objectives while also attaining wildfire program management savings. The results from each team are also described in a set of concise statements which are available.

The model although robust, does not incorporate all factors that can influence the final costs of fire suppression efforts. Each wildfire receives an appropriate, risk informed and effective response. There is not one standard for how any one wildfire is responded too hence the significant range in costs for fires in similar areas and environmental/ecological factors. Additionally, the influence of WUI development, climate change and increased socio-political factors has and will continue to change the cost outcomes significantly from historical averages.

Future Work That Can Improve the Analyses and Lead To Better Treatments

The request for proposals asked if teams used the strategic placement of treatment. This refers to a process Forest Service Research and Development has been promoting to interactively use fire modeling to locate treatment units in areas with strong potential to change fire behavior and outcomes (not only inside treatment units but between then as well) to reduce wildfire risk to high valued resources and assets. In our experience there is room for growth in fuel treatment planning to leverage emerging tools to enhance reliance on concepts such as the strategic placement of treatments. Although the modeling support team recommended ArcFuels analysis in R-CAT, very few teams used this in their planning. As agencies attempt risk and financial analyses in the future, efforts to assess programmatic influence will require both stronger guidance and more oversight and support nationally to ensure consistency. This necessitates that protocols be not only effective in part of the country but be workable under the broad range of environmental and personnel situations in NFS and partner landscapes. The modeling support team has observed through this effort that simply using the same modeling tools is not enough to allow aggregation of results to a programmatic level. In order for this type of analysis to be useful in funding competition and program assessment more standardization of modeling tools and parameters is needed.

Beyond the technical challenges, the agency is reaching to find a more holistic reporting format that leverages the probability foundation of contemporary fire modeling instead of relying solely on single values or best estimates (i.e., the mean or the median). Exploring the statistical distributions of costs and the entire range of possible cost savings can do a more complete job showing expected benefits from hazardous fuel treatments. For example, using the distributions statements such as “after treatment, there is a 1-in-10 chance of saving $100,000, a 1-in-20 chance of saving $1M, and a 1-in-50 chance of saving $10M" which may be more informative than a statement such as "on average (there is no 'average' fire) costs were reduced by $150,000." That is, using the full range of costs provides a fuller set of financial analysis results. . And while that would represent a marked improvement in the story of expectations, it still needs to be more clearly coupled with indicators showing progress investments make in achieving the multiple objectives of nearly all vegetation manipulation. Only by linking the financial and non-financial benefits can the prudence of fuel treatment investments be compared against each other and against other spending options.