Surveying Decision Support Tools for Forest and Shrubland Management in California

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Authors

Jennifer Smith, USDA California Climate Hub
John Battles, UC Berkeley
Patricia Manley, Pacific Southwest Research Station
Steven Ostoja, USDA California Climate Hub
Carlos Ramirez, Pacific Southwest Research Station
Peter Stine, Pacific Southwest Research Station

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Context and Purpose

At the request of the California Wildfire and Forest Resilience Task Force, the Science Advisory Panel, in collaboration with the US Forest Service Pacific Southwest Research Station and Region 5, curated and characterized select decision support tools and systems (hereafter, tools) that have been developed and are available to inform land management decisions.

Tools for land management are scientifically-based resources that can sort and analyze massive amounts of spatial and non-spatial data, evaluate a wide variety of landscape features and consider potential management outcomes based on differing objectives, constraints, treatment options, or other management considerations. Such tools are often used to compare current with future or desired conditions or examine trade-offs among alternative land management actions.

However, end users (e.g., land managers) frequently do not have the bandwidth to monitor the availability, varied applications, technical capabilities, and required user skills of these tools. As a result, it can be challenging for land managers to easily select which is most appropriate for their situation and need.

This project's overview of tools characterizes their purpose, application, and key features to: 1) inform state and federal agency leadership of existing tools and relevant gaps and 2) help managers understand and navigate the many tool choices and determine which best meet their particular needs.

Process

The project team curated a list of available tools for land management in California (Table 1) and characteristics to summarize for each. For several characteristics, the project team defined the scope; for example, the scope of suitable management applications for a tool was limited to five categories representative of typical applications within the "pipeline" process of land management decision making. A voluntary group of reviewers, composed of state, federal, and private sector land managers and ecologists, provided iterative feedback and revision on the proposed characteristics and their defined scopes. This process ensured the information gathered about each tool was relevant to and aligned with the needs of land managers.

Survey

The lead developer of each selected tool was sent a survey about the tool's suitable applications and objectives, strength and limitations, required data input and resulting outputs, and ease of use (see Appendix 1 for complete list of survey questions).

The survey included questions about:

- the appropriate spatial scale for a tool's use, which was defined as regional or the project or tree stand scale;
- the geographic domain in California to which the tool is applicable, as defined by the four multi-regions of the Wildfire and Forest Resilience Task Force Action Plan.
- the suitable management applications of the tool, which were grouped into five categories: assessing current conditions, forecasting future conditions, evaluating current vs. desired conditions, developing management scenarios and comparing alternatives, and monitoring outcomes;
- the major management objectives of the tool, which were defined by the Framework for Resilience's pillars and elements of resilience

- the input data and tool's outputs;
- key strengths and limitations of the tool;
- the ease of using the tool; this question series gathered information on the length of time and expertise to train new users, as well as the upfront financial cost.

Key Caveats

The scope of the characterization did not include the source data relied upon by each tool; it must be recognized that the quality of input data is paramount in the performance of any tool. Additionally, this project did not vet the developer's survey responses for any discrepancies.

Key Results

Developers of 24 different tools responded to the survey (Table 1). Responding to the survey required tool developers to critique their own products and this may introduce some bias in the feedback.

Spatial scale and geographic domain

Survey respondents indicated which spatial scale(s) and geographic domain(s) are appropriate for the tool's application.

- All tools, except two (LANDIS and Climate-wise Reforestation Toolkit), are suitable for use at a project scale. More than half of the tools are also suitable for use at a tree stand scale.
- A majority (18) of the tools are appropriate for applying anywhere in California. A few tools are currently specific to the Sierra-Cascade-Inyo multi-region (including the Climate-wise Reforestation Toolkit, PReSET Reforestation Tool, and Promote), and the Post-fire Restoration Prioritization Tool is specific to the Southern California Area.

Management applications

Survey respondents indicated which categories of management applications are suitable for their tool (Table 2).

- A majority of the surveyed tools can be used to assess current conditions (16 tools), forecast future conditions (16 tools), evaluate current vs. desired conditions (15 tools), and develop management scenarios (17 tools) at the regional and or project scale.
- Only 8 of the surveyed tools can be used to monitor outcomes of treatments and collect and analyze post-treatment data.

Pillars of resilience

Survey respondents indicated which pillars of resilience are suitable for their tool (Table 3).

- 5 of the responses indicated their tool was applicable to at least eight of the ten pillars of resilience.
- 12 of the responses indicated their tool was applicable to four or fewer of the ten pillars of resilience.
- Forest resilience, fire dynamics, biodiversity conservation, carbon sequestration, and fire adapted communities were the most common pillars, as they fit the application of 14 or more tools.

- Economic diversity, social and cultural well-being, and wetland integrity were the least commonly applicable pillars.

Strengths and limitations

Survey respondents were asked to briefly describe one key strength and limitation of the tool in question. Many of the strength responses referenced the ability of the tool to address information gaps that are crucial to selecting where and how to take management action; others noted the wide variety of questions their tool can address, its ease of use, or open-source format.

Limitations of the surveyed tools reflect the difficulty in balancing the ease of use of a tool (e.g., required expertise, computation time) against accounting for the complexity of the underlying questions. Some tools maintain ease-of-use by simplifying the complex and dynamic ecological processes being modeled. Many responses acknowledged their tool can not answer all of the questions a user might have or account for all of the factors influencing the outcome of a treatment. In some cases, the accuracy and applicability of tools are limited by the resolution and availability of the data required for the underlying models.

As previously stated, all of these tools necessarily depend on high quality input data in order to produce useful outputs. Thus, the strengths and limitations of any tool depend on the user supplying reliable data.

Ease of use

Respondents were asked what type of expertise is required to run the tool:

- The majority of the surveyed tools require the user to have at least a basic understanding of GIS, forest and or fire ecology, and or simulation modeling.
- Only five tools do not require specialized expertise and or only require basic web navigation knowledge.
- A few responses acknowledged users also need familiarity with spatial planning and operations to effectively execute the tool.

Respondents were asked how quickly an analyst could be trained to use their tool:

- A majority of responses (14) indicated an analyst could be trained within a week.
- Three responses indicated their tool would require more than a month of training (BioSum, Landis, RHESSys-SERI-Fire Modeling).
- Some assessments of required training could be underestimated if they assumed what expertise the trainee already possessed. Full functionality of many tools will likely require additional skills and/or training.

The financial cost of a tool may affect its accessibility and ease of use for users:

- Two tools require an upfront purchase and or subscription fee (Land Tender and OpenNRM)
- 22 tools are either free to use or the only potential costs are indirect, such as website hosting fees, cost of computing infrastructure, or qualified personnel time.

Conclusions and Recommendations

An impressive suite of decision-support tools exist for California's land managers and decision-makers; moreover, new tools are being developed and many existing tools continue to evolve and improve. The findings of this report emphasize the importance of appropriately matching a specific application to the right tool and recognizing that tool performance is contingent on the quality of the data.

Generally, most of the tools included in this survey address several of the steps in the management process and are suited to targeting broad outcomes. However, few tools provide support for monitoring the outcome of a management action and few tools target outcomes related to economic diversity, sociocultural well being and wetland ecosystems.The only tools considered by their developers to be applicable to all five categories of management applications (including monitoring outcomes), and applicable to all of the outcomes are: the Center for Ecosystem Climate Solutions, Ecosystem Management Decision Support, Land Tender, and the National Insect & Disease Risk and Hazard Mapping.

Identifying the source data for each tool and representing how much preparation is required before the data can be used in the tool was outside the scope of this project; however, these are crucial considerations for assessing suitability of a tool and would be an important next step.

Additionally, to maintain its relevance and usability, the information summarized in this survey should be built into an online, publicly accessible, regularly maintained, dashboard to help managers navigate the many choices of DS tools and determine which ones best meet their particular needs. The findings of this survey will likely change as tools advance and technical capabilities of users improve.

Table 1. The name and lead developer of the 24 decision-support tools included in the survey results.

Decision Support Tool Name	**Lead developer**
Bioregional Inventory Originated Simulation Under Management	USFS
Cal-Adapt	UC Berkeley Geospatial Innovation Facility
Center for Ecosystem Climate Solutions	UC Irvine
Climate-Adapted Seed Tool	UC Davis
Climate-wise Reforestation Toolkit	USDA California Climate Hub
Ecosystem Management Decision Support	EMDS Consortium (includes USFS)
eDaRT	UC Davis & USFS R5 Remote Sensing Lab
First Order Fire Effects Model	USFS RMRS
ForSys	USFS RMRS
Interagency Fuel Treatment Decision Support System	Office of Wildland Fire
LANDIS	North Carolina State University
Land Tender	Vibrant Planet

LicoSim and RxGaming	University of Washington
National Insect & Disease Risk and Hazard Mapping	USFS
OpenNRM	34 North
POSCRPT: Postfire Spatial Conifer Restoration Planning Tool	UC Davis
Post-fire Restoration Prioritization Tool	UC Davis & USFS
PReSET Reforestation Tool	UC Davis
Promote	USFS PSW
Pyregence Fire Forecast Tool	Spatial Informatics Group
RHESSys-SERI-Fire modeling	UC Santa Barbara
TRM Seed Zone map	USFS WWETAC
WIFIRE Firemap	UC San Diego
Wildfire Interdisciplinary Research Center's WRF-SFIRE	San Jose State University

Table 2. The project team grouped possible applications of the tools during the typical management process into five categories. The categorization was developed iteratively with a stakeholder group of end users. Each survey respondent indicated to which categories of management application the tool they developed was suited.

	Categories of management applications					
Decision Support Tool	**Assessing current conditions (assemble and display current data)**	**Forecasting future conditions**	**Evaluating current vs. desired conditions**	**Develop management scenarios and compare alternatives**	**Monitoring outcomes; collect and analyze post-treatment data**	**None of the above**
Bioregional Inventory Originated Simulation Under Management	X	X	X	X	X	
Cal-Adapt						X
Center for Ecosystem Climate Solutions	X			X	X	
Climate-Adapted Seed Tool	X	X	X	X		
Climate-wise Reforestation Toolkit	X					
Ecosystem Management Decision Support	X	X	X	X	X	
eDaRT	X	X	X	X	X	
First Order Fire Effects Model		X	X	X		
ForSys			X	X		
Interagency Fuel Treatment Decision Support System	X	X	X	X	X	
LANDIS		X		X		
Land Tender	X	X	X	X	X	
LicoSim and RxGaming	X		X	X		

	Categories of management applications					
Decision Support Tool	**Assessing current conditions (assemble and display current data)**	**Forecasting future conditions**	**Evaluating current vs. desired conditions**	**Develop management scenarios and compare alternatives**	**Monitoring outcomes; collect and analyze post-treatment data**	**None of the above**
National Insect & Disease Risk and Hazard Mapping	X	X	X	X	X	
OpenNRM	X		X	X	X	
POSCRPT: Postfire Spatial Conifer Restoration Planning Tool	X	X				
Post-fire Restoration Prioritization Tool	X	X	X	X		
PReSET Reforestation Tool		X		X		
Promote	X	X	X			
Pyregence Fire Forecast Tool	X	X				
RHESSys-SERI-Fire modeling		X	X	X		
TRM Seed Zone map						X
WIFIRE Firemap						X
Wildfire Interdisciplinary Research Center's WRF-SFIRE	X	X	X	X		
TOTAL COUNT	16	16	15	17	8	3

Table 3. The project team used the Framework for Resilience's Pillars of Resilience to define categories of major management outcomes. Each respondent indicated to which pillars of resilience the tool they developed was applicable.

	Applicable "pillars of resilience" (major mgmt. outcomes)										
Decision-support system or tool name	Air quality	Biodiversity conservation	Carbon sequestration	Economic diversity	Fire adapted communities	Fire dynamics	Forest resilience	Social & cultural well-being	Water security	Wetland integrity	Other
Bioregional Inventory Originated Simulation Under Management	X		X	X		X	X				
Cal-Adapt											X
Center for Ecosystem Climate Solutions	X	X	X		X	X	X		X	X	
Climate-Adapted Seed Tool	X	X	X		X	X	X	X	X		
Climate-wise Reforestation Toolkit		X					X				
Ecosystem Management Decision Support	X	X	X	X	X	X	X	X	X	X	
eDaRT			X		X	X	X				
First Order Fire Effects Model	X	X	X				X				
ForSys		X	X	X	X		X		X		
Interagency Fuel Treatment Decision Support System	X				X	X	X			X	
LANDIS		X	X		X	X	X				
Land Tender	X	X	X	X	X	X	X	X	X	X	
LicoSim and RxGaming							X				
National Insect & Disease Risk and Hazard Mapping	X	X	X	X	X	X	X	X	X	X	
OpenNRM		X		X	X	X	X		X		

	Applicable "pillars of resilience" (major mgmt. outcomes)										
Decision-support system or tool name	Air quality	Biodiversity conservation	Carbon sequestration	Economic diversity	Fire adapted communities	Fire dynamics	Forest resilience	Social & cultural well-being	Water security	Wetland integrity	Other
POSCRPT: Postfire Spatial Conifer Restoration Planning Tool		X	X				X				
Post-fire Restoration Prioritization Tool		X	X		X	X					
PReSET Reforestation Tool		X	X				X				
Promote		X	X		X	X	X		X		
Pyregence Fire Forecast Tool	X				X	X					
RHESSys-SERI-Fire modelling			X			X	X		X	X	
TRM Seed Zone map		X						X	X	X	
WIFIRE Firemap	X				X	X		X			
Wildfire Interdisciplinary Research Center's WRF-SFIRE	X					X		X			
TOTAL COUNT	11	15	15	6	14	16	18	7	10	7	1

Appendix 1: *Survey questions*

1. **2021 California Forest and Shrubland Decision Support Tools - Why is this survey being conducted?** At the request of the California Wildfire and Forest Resilience Task Force, the Science Advisory Panel is developing an overview of the decision support (DS) tools and systems available to inform natural resource management decisions. The sheer number and varying purposes of DS tools, as well as the required technical sophistication of end users, makes it challenging for land managers to understand, track, and select the most appropriate tool for their situation and need. With the help of the USFS Pacific Southwest Research Station, the Science Advisory Panel is working to curate, characterize, and summarize information on a suite of relevant DS tools. Our intention is two fold: 1) to help managers navigate the many choices of DS tools and determine which best meet their particular needs and 2) to inform state and federal agency leadership of existing DS resources and relevant gaps. **Why have we invited your participation?** Our team has identified a tool that you have either developed or supported that we believe is suitable for use in California forest and shrubland management and is currently or soon to be available for use (before July 2022). If you believe your tool was erroneously included in this curation, please answer "No" on Q2 to skip to the end of the survey and submit your response. **How will the findings from this survey be used?** Survey findings will be summarized for state and federal agency leadership and compiled information for the curated list of DS tools will be accessible online in a user-friendly dashboard.
2. Based on the information provided above, do you agree your tool should be included in this survey?
3. Please select the name of your decision-support system or tool from the list below. If you do not see your product listed, please contact Jennifer Smith.
4. Please provide a brief description of the DS Tool that includes the following: *(1000 character limit): a single, non-technical, sentence describing the purpose and function of the tool, the problem(s) or issue(s) the tool can help resolve, the nature and potential application of the output the intended audience
5. For which of the following categories of forest or shrubland management applications is the DS Tool best suited? Select all that apply.
6. For which spatial domain is the DS Tool appropriate? Select all that apply.
7. For which geographical area(s) is the DS Tool appropriate? Select all that apply.
8. For which pillar(s) is the DS Tool applicable? Select all that apply.
9. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Air Quality does the DS Tool provide information? Select all that apply.
10. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Biodiversity Conservation does the DS Tool provide information?
11. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Carbon Sequestration does the DS Tool provide information?
12. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Economic Diversity does the DS Tool provide information?

13. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Fire Adapted Communities does the DS Tool provide information?
14. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Fire Dynamics does the DS Tool provide information? Select all that apply.
15. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar.For which element(s) of Forest Resilience does the DS Tool provide information? Select all that apply.
16. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Social and Cultural Well-being does the DS Tool provide information? Select all that apply.
17. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Water Security does the DS Tool provide information? Select all that apply.
18. Elements of the pillars of resilience represent the primary processes and functions that collectively make up a pillar. For which element(s) of Wetland Integrity does the DS Tool provide information? Select all that apply.
19. Which specific metrics does the DS Tool use to quantitatively or qualitatively describe the elements selected in the previous question?
20. What format of data input does the DS Tool require or allow? For example: raster, CSV, shapefiles, etc.
21. What is the format of the main output of the DS Tool? Please select all that apply.
22. Please briefly describe the main output of the DS Tool:
23. Please briefly describe a key strength of the DS Tool *(500 character limit)*:
24. Please briefly describe a key limitation of the DS Tool *(500 character limit)*:
25. What type of expertise or knowledge is needed to run the DS Tool?
26. How much time, on average, is required to train an analyst to use the DS Tool to produce meaningful results?
27. Have the models underlying the DS Tool been validated, published, or ground truthed?
28. Please briefly describe the results of the model validation OR provide a link to the relevant publication:
29. Are the following sustainment, maintenance, or support features included in the tool? (Regular updates to the tool (e.g., software, data); At least 3 years of planned support and maintenance for the tool; An active Help Desk; Recorded webinars demonstrating tool; Technical documentation (e.g., user guide); Other)
30. What, if any, financial costs are associated with using the DS Tool?
31. Is there a documented application of the DS Tool? For example, a tool may have been used to support justification for forest treatments during CEQA or NEPA review.
32. Thank you for providing this information. Is there anything else you would like to share about the DS Tool?
33. Are there any other DS Tools specific to California forest and shrubland management you believe should be included in this survey that are <u>not</u> listed below?