

Draft Report on Forest Management Research



California Board of Forestry
and Fire Protection

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Executive Summary

Mandate and Preparation Process for this Report

The Board of Forestry and Fire Protection (Board) has prepared this Report on Forest Management Research (Report) in compliance with the requirements of Public Resources Code (PRC) § 4789.6(a):

The board, assisted by the director [of the Department of Forestry and Fire Protection], shall biennially determine state needs for forest management research and recommend the conduct of needed projects to the Governor and the Legislature.

The Board last prepared a Report on Forest Management Research in 2008. Many developments have occurred since that time in the realm of forest management in California, including growing impacts of climate change and related outcomes; massive increases in wildland fire and related impacts; expansion of State programs and funding focused on forests; and greater public concerns and engagement on forestry issues. Also, the pivotal Wildfire and Forest Resilience Action Plan was released in January 2021 by the Governor's Forest Management Task Force.

This current Report was prepared by a team of forestry experts from the Board and the Department of Forestry and Fire Protection (CAL FIRE). Work on the Report began in August 2020, and an Internet-based survey to rank staff-identified research topics of concern was distributed in December 2020 to several hundred California forestry stakeholders identified through contact lists maintained by the Board, with over 350 responses received. Further public input was solicited and received through the Board's regular meeting and public comment processes. Staff also solicited input from the Science Advisory Panel of the Forest Management Task Force, as was called for in the Wildfire and Forest Resilience Action Plan. The Board approved this Report at its **MONTH 2021** meeting.

The Board intends that its findings on research knowledge gaps and prioritized research topics, which the Board will distribute widely, will be given due consideration by the forest management and forest research community in California. This community includes entities and individuals in the private, public, agency, Tribal, and academic sectors. The Board also directs that CAL FIRE consider these findings in the administration of its related programs, including the Fire and Resource Assessment Program, Forest Health Research Grant Program, Forest Practice Program, Climate and Energy Program, Resource Protection and Improvement Program, and Fire Protection Operations and Intelligence. Board committees, including the Effectiveness Monitoring Committee and the Joint Institute for Wood Products Innovation, also are to make use of the findings in this Report.

Priority Research Topics

A key part of this Report was the compilation of a list of important forest management research knowledge gaps and the development of a priority ranking of research topics to guide organizations engaged in forestry research across the State. The process for identifying and ranking these research topics included review of relevant reports, scientific literature, findings from State meetings on forest research, engagement of experts, a survey of forestry stakeholders, and public input received by the Board. Input also was received from the Science Advisory Panel of the Governor’s Forest Management Task Force.

Through this process, the Board identified the following priority-ranked forest management research topics that need greater understanding:

Recommended Priority Research Topics
<p><i>Very High Ranking</i></p> <p>Biophysical, ecological, social, and economic effects and trade-offs associated with different forest management strategies on private, federal, and state lands, and urban areas under climate change, including impacts associated with increased pace, intensity, and location of forest treatments. Includes identifying areas that should not be treated for ecological, social, or economic reasons.</p>
<p><i>Very High Ranking</i></p> <p>Methods and barriers (including workforce limitations) to obtain greater production and utilization of timber and wood products, while not exceeding sustainable harvest levels.</p>
<p><i>Very High Ranking</i></p> <p>Re-establishment of forests and their ecosystem functions after wildfire and other severe disturbances in the context of a changing climate.</p>
<p><i>Very High Ranking</i></p> <p>Improved wildfire modeling and prediction, including in the wildland urban interface (WUI).</p>
<p><i>Very High Ranking</i></p> <p>Forest Practice Rule effectiveness and management impacts on watershed, plant, and wildlife resources and other ecosystem services.</p>
<p><i>Very High Ranking</i></p> <p>Determining the optimal mix of wildfire prevention and suppression mechanisms, including use of managed fire, where feasible, to reduce losses to life, property, and natural resources, while minimizing costs.</p>
<p><i>Very High Ranking</i></p> <p>Human health impacts of smoke from prescribed and wildfires.</p>

Recommended Priority Research Topics
<p><i>Very High Ranking</i></p> <p>Social sciences related to forest management (including recreational and cultural uses) and wood products, including environmental justice.</p>
<p><i>Very High Ranking</i></p> <p>Climate change mitigation strategies for wildland and urban forests, including carbon storage and emissions after wildfire and other disturbances, and under varying forest management actions.</p>
<p><i>High Ranking</i></p> <p>Utilization of traditional ecological knowledge in conjunction with Western science.</p>
<p><i>High Ranking</i></p> <p>Climate-induced floral and faunal range-shifts.</p>
<p><i>High Ranking</i></p> <p>Early detection and control of invasive species.</p>
<p><i>High Ranking</i></p> <p>Development of enhanced methods for and systematic collection of forest monitoring data.</p>

In addition to these priority research topics, the Report also emphasizes the importance of science synthesis products that bring together relevant research findings in a fashion that integrates sometimes narrowly-drawn, complex findings, and makes this information accessible and practicable for a non-academic audience. These kind of products—such as certain General Technical Reports prepared by the U.S. Forest Service Pacific Southwest Research Station—have greatly assisted stakeholder processes intended to find areas of agreement regarding management of National Forests in the Sierra Nevada, for example.

Recommendations on Future Cycles of Forest Management Research Report Preparation

While preparing this Report, the Board also considered the timing and process required by the legislative mandate. Given the observed rate of change in forest research needs, the Board believes that a five-year cycle is more congruent to that need than a two-year cycle. The Board found that future approaches should link the preparation of the Report on Forest Management Research with the process and timing of the semi-decadal preparation of the required Forest and Rangeland Resources Assessment (Assessment) by CAL FIRE per PRC § 4789.3. Following completion of each Assessment, the Board is mandated to in turn prepare a forest resource policy statement (Policy Statement) (PRC § 4789.4); preparation of the Report on Forest Management Research could be completed concurrently or immediately thereafter. Further, the Board believes that the Assessment and Policy Statement will provide valuable and timely input to the preparation of the Report. Hence, the Board will utilize the Administration's

legislation development processes to investigate the potential for a change to the current requirement to a five-year cycle.

As an additional task in the preparation of this Report, the Board and Board staff reviewed the current Board Policies regarding forestry research contained in Chapter 0330, Section 0333, and elsewhere in the Board Policies. As the result of this review, which found the policies to be out of date, the Board is directing staff to examine the need to maintain policies in these areas, and if needed, to draft revisions for the Board’s consideration prior to the end of the calendar year.

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1. Introduction

The Board of Forestry and Fire Protection (Board) has a broad mandate, which includes establishing forest and range policy in the state of California:

The board shall represent the state's interest in the acquisition and management of state forests as provided by law and in federal land matters pertaining to forestry, and the protection of the state's interests in forest resources on private lands, and shall determine, establish, and maintain an adequate forest policy. General policies for guidance of the department shall be determined by the board. [Public Resources Code (PRC) § 740]

Under PRC § 4789.6, the Board is mandated to periodically prepare recommendations on forest management research needs:

The board, assisted by the [CAL FIRE] director, shall biennially determine state needs for forest management research and recommend the conduct of needed projects to the Governor and the Legislature. [PRC § 4789.6(a)]

The results and recommendations of this required assessment are provided in this research report (Report). The most recent previous Report on Forest Management Research was prepared in 2008. In light of the increasingly catastrophic impacts of wildland fires of greater size, intensity, and destruction, combined with the driving dynamics and uncertainties of climate change, now is an important time for the preparation of a new Report.

In addition to providing the required input to the Legislature, the Board intends that this Report will be used to guide forest management research efforts within the programs under the purview of the Board (e.g., the Joint Institute on Wood Products Innovation and the Effectiveness Monitoring Committee) and CAL FIRE [e.g., Forest Health Research Program, Fire and Resource Assessment Program (FRAP), Demonstration State Forests, Forest Practices, Fire Protection, and Fire Prevention]. It also intends that the Report will provide input on Board priorities to public interagency efforts such as the Timber Regulation and Forest Restoration Program and the Forest Management Task Force (FMTF), as well as research efforts of collaborating entities, including the California Natural Resources Agency (CNRA), California Energy Commission, California Department of Fish and Wildlife (CDFW), California Department of Conservation, California Air Resources Board (CARB), Office of Ecological Health Hazard Assessment (part of the California Environmental Protection Agency), Strategic Growth Council, California Public Utilities Commission (CPUC), and USFS (including both Region 5 and the Pacific Southwest Research Station). The Board's research priorities also can inform academically based research programs through the state's many public and private universities and colleges. Finally, the Board anticipates that nongovernmental organizations conducting or supporting research on forests also may consider the research priorities identified in this Report.

Relationship to Board Policy

The overarching goal of this Report is to meet the legislative mandate [PRC § 4789.6(a)] for the Board to report on State priorities for forest management research to the Governor and the Legislature. Formal [Board Policies](#) further detail the Board's responsibilities for addressing forestry research¹ and helped frame the objectives for this Report. Chapter 0330, General Board Policies explicitly addresses the research directives for the Board, and sections relevant to the legislative mandate are included below. Policy objectives of the Board as they relate to forestry research are based on the following needs (Section 0331.1: Parts C and D, respectively):

Research and Information - The State must enlarge and sustain forestry research and information programs, focused on high priority needs, so that a factual basis for resource policy and management decision making can be provided for;

Public Understanding - The State must provide members of the several key audiences that ultimately influence forest use and management with sufficient information about the forest resource problems. This will ensure that they act in the light of accurate broadly based information.

The Board's requirement to produce a report of forestry research needs in the State is iterated in Board Policy (Section 0333.1: Part D):

The Board is required by law to determine and report on the State's need for forest management research and to suggest needed projects. The Board is also required to conduct or provide for a program of research in specific areas set forth in law. These include forest management, soil characteristics and erosion rates, costs and feasible methods of reforestation, range improvement, and utilization of wood wastes for energy production.

The Board further defines the scope of the research mandate as it applies to forest management (Section 0333.2: Definitions):

"Forestry research" means the development of knowledge about forest resource systems and about man's interrelationship to these systems. It refers to programs to obtain and apply technical knowledge about forest resources systems and ways in which they may serve man's needs. It also includes the development of methods to apply technical knowledge to the

¹ Research on range management, while within the scope of the Board's purview, is not addressed directly in this Report. The Board's Range Management Advisory Committee addresses range management research needs, in part, through its 2020 [Strategic Plan](#) and its 2020 [Objectives](#).

framing and resolving [of] questions about public policy relative to forest resources.

The Board establishes the goals of the forestry research program in Board Policy (Section 0333.3: Forestry Research Program):

In order to promote a vigorous program of forestry research, the Board has found that in the public interest, it should, in conjunction with the Department, forest user groups, other State and Federal agencies, the University of California and other institutions of higher education, and the general public:

- A. Inventory and assess needed forestry research at timely intervals;
- B. Develop a master research plan that specifies and establishes priorities among needs and programs;
- C. Develop legislation needed to maintain a continuing and vigorous program of forestry research;
- D. Foster and participate in mechanisms for ensuring cooperation and coordination in the development and implementation of research programs.

Board Policy describes how information gained from these efforts will be disseminated to relevant audiences for application to forest management (Section 0333.4: Dissemination of New Knowledge):

- A. The Board, through its licensing programs and other mechanisms, will attempt to keep all Registered Professional Foresters, timber operators, nonindustrial, private forest landowners and the general public advised of new technology as it becomes available.
- B. The Board will promote programs for dissemination of new knowledge from research activities.

Given the broad range of the above policy directives and the nature of the Board's overall responsibilities and composition—as well as the mandate provided by the Legislature—this Report takes a general approach to determining forest-based research needs.

Research Report Development Process

A combination of expert opinion, Board member and stakeholder input, and review of existing literature and reports shaped the development of this Report. Assigned staff from the Board and CAL FIRE formed the technical team (Report Team) that prepared this Report. The FMTF Science Advisory Panel's input, as well as Board member discussion and agency and public comment, were critical to the preparation of this Report. A schematic of the process followed in the development of the priority research topics identified in this Report is provided in Figure 1.

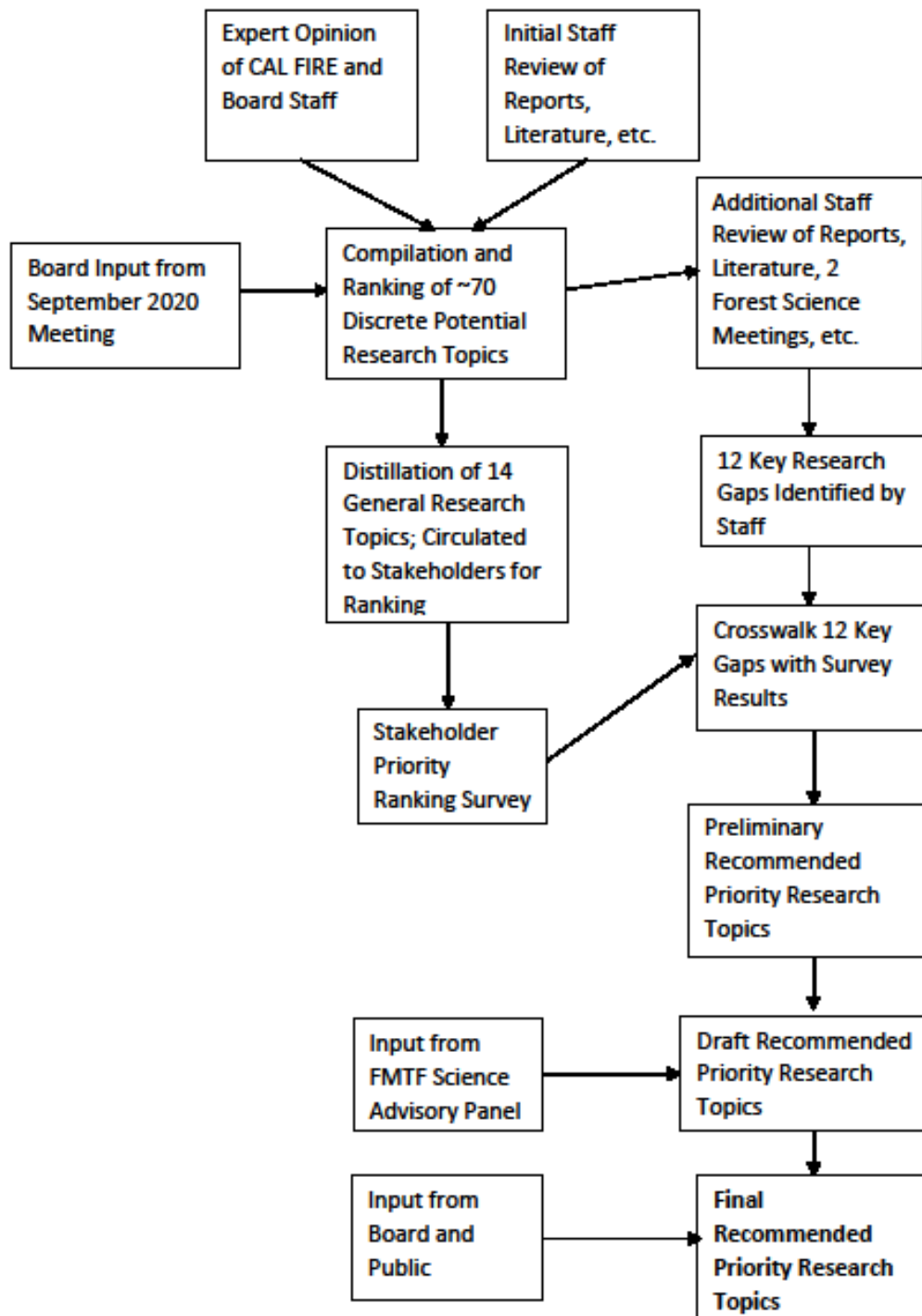


Figure 1. Process for forming recommended priority research topics.

Collaborative Effort of Board and CAL FIRE Staff

In August 2020, the Executive Officer of the Board convened a planning meeting composed of Board and CAL FIRE staff, from the Forest Practice, Environmental Protection, and FRAP programs, with experience in research issues related to forest and fire management, forest health, watershed protection, climate change, and forestry regulations. That group formed the team (Report Team) charged with developing this plan. Process management—including how to solicit public comment, conduct the Board review process, work with the Science Advisory Panel, and address Board Staff concerns—was fostered through collaboration between the Report Team and the Executive Officer. Any significant decisions regarding process or plan components were vetted and approved via consensus between Board and CAL FIRE staff. The review process and report components were collectively developed, with all Report Team members collaborating to develop, review, and revise the Report.

Responding to the Forest Management Task Force’s Wildfire and Forest Resilience Action Plan

In January 2021, the [Governor’s Forest Management Task Force](#) (Task Force) released [California’s Wildfire and Forest Resilience Action Plan](#) (Resilience Action Plan). The Resilience Action Plan guides the State to utilize the best available science to accelerate applied research and identified several key applied research topics. The Resilience Action Plan also recommends that:

In coordination with the Science Advisory Panel of the Task Force and other leading scientists, BOF and CAL FIRE’s Forest [sic] and Resource Assessment Program (FRAP) will develop and issue an applied research plan by June 2021.

It further recommends:

Based on the applied research plan results, CAL FIRE will expand its forest research grant program to address key management questions and priorities.

Therefore, as called for in the Resilience Action Plan, the Board and CAL FIRE worked with the Task Force’s Science Advisory Panel (Science Panel) to be responsive to the Task Force recommendations in the preparation of this Report. The Science Panel is made up of state, local, tribal, and federal governmental agencies, and academics, universities, forest researchers, and other interested stakeholders. One of the key goals of the Science Panel is the identification of research gaps to inform future forest health projects in support of achieving the outcomes of the Forest Carbon Plan.

Public Engagement

Board member discussion and public comment at Board meetings are an important part of public input, and contribute to most Board efforts, including the preparation of this Report. Public comments were carefully considered and are documented in Board meeting minutes and written comments that have been submitted to the Board.

Board staff began providing regular updates regarding Report progress to the Board beginning with the Board's August 2020 meeting. All Board discussions and actions on the Report were publicly noticed via the Board's meeting agendas. The initial plan outline, list of plan references, and potential research topics for prioritization were submitted to the Board's Executive Officer on August 31, 2020. The Board discussed the initial draft outline of this Report at its September 2020 meeting, and Board members suggested that input on research topic prioritization should come from a broad group of stakeholders outside of the committee developing the Report.

To further facilitate public input on the development of this Report, the Report Team utilized public surveys to gauge the relative importance of forestry research topics. First, internal surveys were circulated to identify 14 potential research categories of significant and timely importance to forest management in California. The Report Team then developed and launched an online public survey instrument using numerical rankings to prioritize these research categories. Respondents also were asked to identify other priority research categories that were not identified in the survey. Members of the forestry community were solicited to participate in this survey via emails sent to Board stakeholder email lists, which also included Registered Professional Foresters and members of the CAL FIRE Native American Tribal Council.

In total, the Board received 358 responses to the online survey. The public input received through the survey was crucial to the process of establishing research priorities in this Report. Detailed methods and results are discussed below in **Chapter 3, Stakeholder Prioritization of Potential Research Topics**.

Board Approval of the Research Report

The Board of Forestry and Fire Protection approved this Report at its meeting of MONTH DAY, 2021.

Organization of this Report

The body of this Report continues with **Chapter 2, Background Information**, provides an update on relevant issues since the last Board Report on Forest Management Research in 2008. This material includes short summaries of selected documents, information on research gaps from peer-reviewed literature, findings from interagency meetings on forest research, and brief discussions of related issues such as the Tribal forest research needs, the role of science synthesis reports, and the importance of systematic forest monitoring data to support research as well as management.

Chapter 3, Stakeholder Prioritization of Potential Research Topics, describes the process for the development of and results from an Internet-based survey of forest management stakeholders.

Chapter 4, Synthesis and Recommended Priority Research Topics, discusses the processes and inputs (including from the Science Panel) that led to the recommended priority research topics presented at the end of the chapter.

Chapter 5, Summary and Recommendations, completes the main body of the Report and presents important findings and recommendations to guide forestry research in the State, and follow-up actions for the Board and other related entities.

Finally, the Report provides a substantial **References** section (including weblinks) to document the wide-ranging materials consulted by the Report Team in the Preparation of this Report. The latter section is followed by an **Appendix** that presents more highly detailed items or items that were considered ancillary to the main body of the Report.

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2. Background Information

From 2008 to 2021

Board of Forestry and Fire Protection 2008 Forest Management Research Report

The last Board Report on Forest Management Research (Board of Forestry and Fire Protection 2008), produced in 2008, was based on the 2003 Forest and Range Assessment (FRAP Assessment; FRAP 2003) and the 2007 Board of Forestry and Fire Protection Policy Statement and Policy Program. The 2003 FRAP assessment followed the Montréal Process framework, using a set of criteria and indicators to measure the sustainability of forest management in California's forests. The framework utilized for the Board's Policy Statement also followed the Montréal Process. The FRAP Assessment was subsequently updated in 2010 and 2017, with the 2010 FRAP Assessment dropping the Montréal Process framework and the 2017 FRAP Assessment returning to it.

The 2008 Board Report on Forest Management Research provided seven potential broad research topics requiring additional development. Each topic was defined by its Montréal Process policy program criterion and included multiple subtopics:

1. Biological Diversity;
2. Productive Capacity;
3. Forest and Range Ecosystem Health;
4. Soil Conservation and Water Quality;
5. Forests and Climate;
6. Socio-Economic Well-Being;
7. Governance.

The Board's Research and Science Committee (RSC) was intended to develop these topics, consistent with the Board's Strategic Policy Program and dependent upon sufficient funding and staffing. The RSC Charter was approved in May 2008, and eight members were confirmed by the Board in June 2010. The RSC had a demanding list of key objectives, including:

- Review ongoing research programs;
- Advise the Board on research needs, priorities, policy, and such other matters as the Board directs (PRC § 4789.6);
- Provide science-based recommendations and technical information to advise and assist the Board in making its determinations on Forest Practice Rules and fire regulations;
- Coordinate reviews of existing science and produce unbiased technical information for consideration by the Board;
- Provide oversight and coordinate the efforts of the Board's technical committees;

- When funding is available, coordinate research projects at the request of the Board;
- Take the lead role to improve coordination and cooperation of the various industrial, educational, State and Federal agencies involved in research; and
- Recommend a system through which information can be collected, maintained, and disseminated on all completed forestry research projects.

The RSC met from August 2010 to November 2012, then disbanded for several reasons, including (1) difficulties in getting members to travel long distances to attend meetings held in Davis (prior to the use of web-based meetings), (2) insufficient Board staffing at that time, (3) changing membership and difficulty finding replacements, and (4) overly broad and ambitious objectives for the RSC. Therefore, many of the goals assigned to the RSC to further the concepts in the 2008 Research Report did not come to fruition. However, many of the research areas prioritized in that report remain relevant today, as indicated in the discussion below of more recent reports, journal articles, and other sources.

Based on learning from the 2008 report, the lack of sufficient progress made by the RSC, and further experience in preparing this current Report, the Board makes recommendations regarding future iterations of the Report on Forest Management Research in **Chapter 5, Synthesis and Recommendations**.

Major Plans, Reports, Initiatives, and Programs in California Since 2008

In the past 13 years numerous documents have identified forestry research needs and contributed to a better understanding of current research activities in forest management in California. The Report Team reviewed these plans, reports, initiatives, and programs (a complete list of references reviewed for this plan with hyperlinks is provided at the end of this Report). The review included, but was not limited to, the following sources:

- California's Wildfire and Forest Resilience Action Plan (Governor's Forest Management Task Force, 2021);
- CAL FIRE Forest Health Research Program (FRHP);
- CAL FIRE Fire and Resource Assessment Program (FRAP);
- California Initiative for Research on Fire and Forests (CIRFF);
- Agreement for Shared Stewardship of California's Forest and Rangelands (State of CA and USDA Forest Service);
- Memorandum of Understanding—Pacific Coast Temperate Forests (California, Oregon, Washington, and British Columbia, 2019);
- State Wildlife Action Plan (Department of Fish and Wildlife, 2015);
- Effectiveness Monitoring Committee 2018 Strategic Plan (Board of Forestry and Fire Protection);
- California Forest Carbon Plan (State of California, 2018);
- U.S. Department of Agriculture (USDA) California Climate Hub;

- Joint Institute Recommendations to Expand Wood and Biomass Utilization in California (Joint Institute for Wood Products Innovation, 2020);
- Literature Review and Evaluation of Research Gaps to Support Wood Products Innovation (Joint Institute for Wood Products Innovation, 2020);
- Electric Program Investment Charge Program (EPIC, California Energy Commission);
- California Environmental Protection Agency (CalEPA):
 - Office of Ecological Health Hazard Assessment (OEHHA);
 - California Air Resources Board (CARB);
 - State Water Resources Control Board;
- California Public Utilities Commission (CPUC);
- Strategic Growth Council Climate Change Research Program;
- USDA Forest Service:
 - Pacific Southwest Research Station;
 - Pacific Northwest Research Station;
 - Forest Products Laboratory.

Brief summaries of key documents reviewed follow:

Board of Forestry and Fire Protection. 2018. **Effectiveness Monitoring Committee Strategic Plan**. Sacramento, CA. 52 p.

A suite of critical monitoring questions developed based on input from a variety of stakeholders was organized into groups of 11 themes. They are used as guidance to solicit and evaluate specific monitoring projects, with a goal of developing a process-based understanding of the effectiveness of Forest Practice Rules (FPRs) and associated regulations in maintaining and enhancing water quality, protecting and restoring aquatic and wildlife habitats, and addressing wildfire hazards. Detailed research priorities for the Board, CNRA, CAL FIRE, California Geological Survey (CGS), CDFW, Regional Water Boards, USFS, National Marine Fisheries Service, and public stakeholders are listed in an Appendix to the Committee's plan.

Butsic, V., H. McCann, J. Axelson, B. Gray, Y. Jin, J. Mount, S. Stephens, and W. Stewart. 2017. **Improving the health of California's headwater forests**. Public Policy Institute of California. San Francisco, CA. 33 p.

This report concludes that California must increase the pace and scale of efforts to improve the health of its headwater forests—the source of two-thirds of the state's surface water supply. This will require changes in the regulation, administration, and management of forests, and implementing these changes will require vision, leadership by state and federal officials, and the backing of an informed public. Management practices including prescribed fire, managed wildfire, and mechanical thinning are needed to

help rebuild resilience in these forests. The document states that a key unknown for forest management budgeting is the large variability in costs for these treatment types.

California Economic Summit. 2019. **California's wildfire crisis: a call to action**. Sacramento, CA. 28 p.

Documentation is provided on the toll that recent wildfires have taken on both rural and urban communities. These consequences will grow without a swift and massive response. Expanding forest thinning and resiliency work, developing wood products industries, and creating stronger rural economies are found essential to mitigating the wildfire crisis. Brief summaries of research studies and initiatives conducted from 2015 through 2019 are provided.

CARB. 2018. **Triennial strategic research plan-fiscal years 2018–2021**. California Environmental Protection Agency. Sacramento, CA. 89 p.

The areas of CARB's highest priority research needs are identified for the next three years. Research is needed to guide the use of the Greenhouse Gas Reduction Fund (GGRF), which is funded by Cap-and-Trade auction proceeds. Critical research is needed to develop a greater understanding of the impacts of wildfire emissions on human health and air quality at local to regional scales, which will inform the selection of forest management practices that will minimize impacts on health, climate, and air quality. For the State to achieve its climate and air quality goals, there is an urgent need to reduce fuel loading that contributes to catastrophic wildfire.

Christensen, G.A., A.N. Gray, O. Kuegler, N.A. Tase, M. Rosenberg, D. Loeffler, N. Anderson, K. Stockmann, and T.A. Morgan. 2018. **AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2017 Reporting Period**. Final Report. U.S. Forest Service agreement no. 18-CO-11052021-214, 17-CO-11261979-086, California Department of Forestry and Fire Protection Agreement No. 8CA04056 and 8CA03714 and the University of Montana. California Department of Forestry and Fire Protection and California Board of Forestry and Fire Protection. Sacramento, CA. 539 p.

These data inform several elements of the state's effort to meet greenhouse gas (GHG) emissions reduction targets by compiling best-available data on GHG emissions and carbon stocks and flux from California's forest sector, identifying critical gaps in data, and suggesting strategies to reduce uncertainty in estimating the magnitude of stocks and flux within the forest sector. The document suggests further research for increasing biomass utilization and for quantifying uncertainty to provide greater confidence in carbon storage and flux estimates. While the most recent version of this

report does not provide recommendations regarding research, it does document methods and provides updated information on carbon sequestration in the State, demonstrating that overall California forests are exceeding the 5 million metric tons carbon dioxide equivalent (MMT CO₂e) target rate of annual sequestration established by Assembly Bill (AB) 1504, sequestering 25.2 MMT CO₂e per year (Christensen et al. 2021).

Forest Climate Action Team (FCAT). 2018. **California forest carbon plan: managing our forest landscapes in a changing climate**. Sacramento, CA. 178 p.

The FCAT plan summarizes current and projected forest conditions in California and directs actions to achieve healthy and resilient wildland and urban forests, with the goal of protecting and enhancing forest carbon and the broader range of public benefits from forests in this state. The plan states that key research priorities must be identified, developed, and funded to ensure that science-based, cost-effective strategies continue to move the state of practice forward. Several research needs are listed, including those addressing monitoring and modeling, forest restoration and protection, forest management and markets, forest carbon emissions, education, and urban forestry. For example, a research need for forest restoration and protection is to “Initiate and continue research relating to appropriate restoration efforts in areas affected by uncharacteristic wildfire or tree mortality or both, including incorporation of climate change modeling.”

FMTF. 2021. **California’s Wildfire and Forest Resilience Action Plan**. Sacramento, CA. 45 p.

This comprehensive action plan was developed to reduce wildfire risk for vulnerable communities, improve the health of forests and wildlands, and accelerate action to mitigate climate change. The Forest Management Task Force and the State’s efforts going forward will be guided by this plan, with an overall goal to increase the pace and scale of forest management and wildfire resilience efforts by 2025. One of the goals is to utilize the best available science and accelerate applied research in eight key applied research areas. Topics include factors that affect fire spread and behavior in the wildland-urban interface (WUI), factors that influence post-fire regeneration, the influence of extreme weather conditions on fire behavior, effectiveness and trade-offs between alternative management strategies, and human health impacts of smoke from prescribed and uncontrolled fires.

FRAP. 2018. **California’s forests and rangelands: 2017 assessment**. California Department of Forestry and Fire Protection. Retrieved from Sacramento, CA. 304 p.

This update of the FRAP assessment uses a set of more than 40 indicators that describe the status and trends of forest and rangelands across

environmental and socio-economic dimensions to evaluate California's forest and rangeland resources and measure progress towards sustainability. FRAP developed and evaluated a set of Montréal-Process-based sustainability indicators specific to California and expanded the focus of each criterion to include rangelands. The role of research and education is stated as being increasingly important for monitoring changing conditions on forest and rangelands, as is the process of adjusting policies and practices accordingly. As an example, for sustainable working forests the assessment suggests expanding research and support to select appropriate genetic sources for adapting new planting for climate change.

Joint Institute for Wood Products Innovation. 2020. **Literature review and evaluation of research gaps to support wood products innovation**. Final report submitted to the California Board of Forestry and Fire Protection under Agreement #9CA04450. Sacramento, CA. 115 p.

This review of forest product innovation literature identified gaps in forest product innovation research and potential strategic partnerships, and developed recommendations for near-term priorities to support the expansion of the innovative wood products sector in California. The most promising classes of wood products are listed as mass timber, liquid and gaseous transportation fuels, and chemically and thermally treated wood. Recommendations include funding research to further innovation in wood products, such as (1) development of product layups for mass timber panels from California feedstock, (2) identification of scalable structural wood products from small diameter and non-merchantable biomass, and (3) investigation of subsidy design for mobilization of nonmerchantable biomass to address California's climate change goals.

Legislative Analyst's Office (LAO). 2019. **Improving California's forest and watershed management**. Sacramento, CA. 7 p.

An overview of current forest conditions in California is provided, as well as the implications associated with unhealthy forest conditions. Recommendations for improving forest and watershed conditions are listed, including increased funding and coordination, revised state policies and practices for forest health activities, and expanded options for utilizing woody biomass.

Little Hoover Commission (LHC). 2018. **Fire on the mountain: rethinking forest management in the Sierra Nevada**. Report #242. Sacramento, CA. 81 p.

The Little Hoover Commission found that California's forests suffer from neglect and mismanagement, resulting in overly dense stands that are susceptible to disease, insects, and wildfire. Recommendations include

having the State take a greater leadership role in collaborative forest management planning at the watershed level, greater use of prescribed fire, and implementing a statewide public education campaign to explain why healthy forests are important and elicit public buy-in for forest treatments. Research recommendations include studying the potential to convert biomass into transportation fuels, the public benefits provided by biomass energy, and appropriate public outreach messaging.

OPR (Governor's Office of Planning and Research). 2018. **Defining vulnerable communities in the context of climate adaptation**. Sacramento, CA. 13 p.

This document includes a definition of climate-vulnerable communities, a summary of assessment tools that can be used to identify vulnerable communities in a climate adaptation context, and a description of indicators that can be used to assess underlying vulnerability on a case-by-case basis.

Taylor, M. 2018. **Improving California's forest and watershed management**. LAO. Sacramento, CA. 42 p.

The poor condition of California's forests is described, along with several recommendations to improve the health of the state's forested watersheds. These include increased funding and coordination, revised state policies and practices to facilitate forest health activities, improved landowner assistance programs, and expanded options for utilizing woody biomass. For example, the report recommends funding for wildfire cost-avoidance and benefit-cost studies by local water and hydropower agencies to show the value of investing in treatments to maintain watershed health.

USDA Forest Service. 2021. **Draft charter: Science to enhance sustainable ecosystem stewardship—Pacific Southwest Research Station's dynamic approach for the coming decade**. April 19. Pacific Southwest Research Station, Albany, CA. 8 p.

This draft charter, currently out for public review and comment, would commit the Station to focus on three priority research areas. The first—Biodiversity and Ecosystems—focuses on biophysical factors of ecosystems and supply of ecosystem services, ecosystem response and adaptation to stressors and disturbances, and strategies to conserve biodiversity and ecosystem structure, function, and dynamics. The second—Wildland Fire Stewardship and Ecology—emphasizes understanding novel and future climate conditions, the effects of wildland fire or its absence, and how ecosystem stewardship can influence fire ecology and fire effects on ecosystems and human communities. The third—Humans and Nature—focuses on elements such as sustainable recreation, cultural and community-based resource stewardship, socio-ecological processes across wildland-

urban gradients, and social, cultural, and economic dynamics and dimensions of stewardship.

Recent Statewide Forest Science Coordination Meetings: Major Areas Needing Additional Research

The CNRA and the Strategic Growth Council convened the first Statewide Forest Science Coordination Meeting in November 2019 to support improved understanding of major statewide forest science research underway. It included state and federal scientists as well as research partners, and it focused on four recently funded, major statewide forest science research projects that commenced in 2019:

- The next generation of wildfire models for grid resiliency (Spatial Informatics Group-lead);
- The future of California drought, fire, and forest dieback (UCLA-lead);
- Wildfire risk mapping and early detection (Salo Sciences-lead);
- Advancing ecosystem climate solutions (UC Irvine-lead).

One of the goals of this meeting was to develop a common awareness of the extensive forest science work underway, and the outcomes provided valuable information for the Board's Report. A key goal was to identify possible data or knowledge gaps. Those gaps identified at the meeting for carbon, water, wildlife, and fire included:

- Real time dynamic monitoring of forest change;
- Improved information on impacts from increased pace, intensity, and location of forest treatments (differing intensity and frequency of treatments);
- Real time dynamic monitoring of water change, including effects of disturbance on snow, water supply, and water quality;
- Flooding—disturbance connection;
- Improved meteorology data;
- Climate resilience maps;
- Wildlife habitat connectivity;
- Wildlife habitat impacts from large-scale high severity events;
- Sensitive wildlife habitat in modeling projects (include wildlife and biodiversity as an element of forest health);
- Future fire ignition scenarios;
- WUI fuel models;
- Improved fire behavior fuel models;
- Wind data;
- Post-fire conditions/recovery;
- Improved wildfire spread models;
- Annualized high intensity burn probabilities;

- Fire response function vs. fire intensity.

The second CNRA Statewide Forest Science Research Coordination Meeting was held in January 2021, this time remotely convening scientists from state, federal, university, and private sectors to review major ongoing research projects and identify knowledge gaps related to forestry and wildland science in California. Research updates were presented for the following large-scale, well-funded collaborative forestry and wildland-related research efforts that are currently underway in California (four of which were summarized in the first meeting):

- Assessment and mitigation of wildfire induced air pollution (UC Davis-lead);
- Transforming prescribed fire practices for California (UC Irvine-lead);
- Mitigating and managing extreme wildfire risk in California (UC Santa Barbara-lead);
- Climate-informed spatial analysis and restoration priority (UCANR-lead);
- The future of California drought, fire, and forest dieback (UCLA-lead);
- The next generation of wildfire models for grid resiliency (Spatial Informatics Group-lead);
- High-resolution, dynamic mapping of forest fuels and wildfire hazard (Salo Sciences-lead);
- Innovative center for advancing California ecosystem climate solutions (CECS) (UC Irvine-lead).

Questions remain on the long-term sustainability of these existing research efforts, and whether the products produced will be relatively easy to update in the future. Therefore, knowledge gaps of varying degrees were again identified at the meeting for various topics in forest management, prescribed fire, climate change, wildlife/habitat, monitoring, reforestation and restoration, economics, wildfire, and novel data development. Examples of forestry and wildland-related research gaps identified during the second annual meeting included:

- What are soil carbon impacts from forest management disaggregated by forest types?
- How will climate change shift prescribed burning windows?
- What are effective mitigation strategies for smoke exposure?
- What is the fate and life cycle of carbon under various forest management actions?
- How long does carbon storage take to recover from major disturbances?
- What are WUI management strategies that effectively mitigate wildfires across diverse ownerships?
- What are fuels and other burning materials and/or emission factors from WUI-specific fuels and fire characteristics?
- What are the most effective strategies for restoration of all aspects of heterogeneity across spatiotemporal scales?
- What vegetation types/habitats are most vulnerable to type conversions after major disturbances?

- Research on the dynamics involved in California’s shrublands.
- How do species respond to landscape restoration?

Assuming that these annual forest science research coordination meetings continue going forward, their outputs will continue to be an important information resource for the Board’s periodic Reports on Forest Management Research.

Tribal Forest Research Needs

Many California State agencies² are increasingly looking to support tribal land management programs and to foster opportunities for the broader forestry community to learn about traditional ecological knowledge for management of wildlands. To better understand the research needs, priorities, and interests of Native American tribal forest resource managers and decision-makers, in 2011 the Intertribal Timber Council (ITC) conducted a survey of representatives from 31 tribes, as well as relevant federal agencies and research or educational institutions. The survey was developed by a [research subcommittee](#) newly created by the ITC. The [Charter](#) for the ITC Research Subcommittee states that, “Research activities involving forest and fire management, traditional ecological knowledge, and social/economic factors are vital to improving natural resource management in Indian country.” The top five ranked areas of research needs identified in the ITC survey (Beatty and Leighton 2012) were:

1. Water quality;
2. Fish and wildlife management;
3. Integration of traditional knowledge with Western science;
4. Mechanisms to improve knowledge sharing; and
5. Invasive species.

Data and Monitoring to Support Research and Management

Data on forest resources and related social and economic systems are critical to support forest management research and decision-making. This centrality is underscored by the Governor’s recent \$39 million budget request to support scientifically based monitoring. Consistent, long-term monitoring data that improve understanding of changes in forest conditions over time and the drivers of these changes, be they naturogenic or anthropogenic, are particularly important. These data are especially valuable when spatially referenced for use in geographic information systems, as they can then be utilized to support research or decision-making at varying spatial scales. Improvements in these kinds of data are currently widely sought to support collaborative decision-making in forest management at landscape scales. For example, geospatial data can support determinations of the most efficient and effective locations for forest resilience treatments and may contribute to improvements in our understanding of the

² Such as via the [Regional Forest and Fire Capacity Program](#) at the Department of Conservation.

relationships between forest conditions and climate change, from both adaptation and mitigation perspectives. Improved longitudinal data on forest resources conditions, including water resources and wildlife habitat, are also increasingly sought by public agencies to support implementation and evaluation of environmental regulatory programs, such as data to inform forest practices on nonfederal lands, and to support improved water quality, endangered species programs, and regulation of cannabis cultivation.

The State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP) provides a good example of a long-term monitoring program that is delivering critical water quality data that can support management decisions and research. SWAMP conducts biological, chemical, and physical water quality monitoring in both forested and non-forested watersheds in California. This program has developed standardized bioassessment protocols for measuring stream health based on the composition of invertebrate and algal communities, in which conditions at sample stream reaches are compared to reference conditions. CNRA provided funding in 2016 to increase the number of reference sites on private timberlands in California—as they were under-represented—providing a more complete understanding of statewide stream conditions.

Plot-level forest resources data collected systematically across all forestland in the United States by the U.S. Forest Service FIA Program have been the gold standard for monitoring forest conditions from the county or sub-state regional level to the national level, particularly evaluating metrics such as tree species, stocking, volumes, growth rates, forest health, and carbon storage and flux. With funding from the GGFRF, CAL FIRE is working with FIA Program staff at the USFS Pacific Northwest Research Station to work toward intensifying the data cycle frequency in California from ten-year remeasurement intervals to five-year intervals. With the increased rates of disturbance (drought, pests, fire) and other changes in forests in recent years, this shorter remeasurement cycle will increase our understanding of highly dynamic forest conditions to better support research, management decisions, and policymaking.

The rapidly expanding use of Light Detection and Ranging (LiDAR), a remote sensing technology, has greatly increased our ability to generate high resolution 3-D images of the earth's surface and forest stand structure. State funding at times has made an important contribution to the acquisition of LiDAR data. Coupled with other data sources, such as remotely-sensed hyperspectral data or plot-level data (including FIA), LiDAR supports research, assessment, monitoring, and management. However, a downside of LiDAR is the high cost of data collection, which typically requires airplane flights and massive data processing and storage, making it problematic to update data as frequently as necessary to understand current high rates of forest dynamics. New LiDAR platforms coming online, such as satellite-based, ground-based, and unmanned aerial vehicle systems, may help reduce data collection costs, but there remains a need for further research into the effective use of LiDAR as a monitoring tool.

One example of the practical application of LiDAR in policy-making is demonstrated by [Assembly Bill 2551](#) [Wood, 2018 (PRC § 71365 et seq.)], which requires the CNRA and CalEPA to

jointly submit to the Legislature a spatially explicit natural resources assessment and watershed management and restoration plan for the watersheds that deliver water to the major north-state reservoirs. Two key goals of this legislation are to:

- Establish a comprehensive understanding of forest management and restoration needs in the above defined watersheds, across all ownership classes, including priority-setting; and,
- Provide transparent and defensible data and analysis in support of prioritization of investment opportunities to improve watershed function and resilience.

This work is now underway following a competitive request-for-proposal process that awarded the work to a team led by the University of California, and includes collaborators from the University of New Mexico and the USFS Pacific Southwest Research Station. This spatial assessment will link to and integrate with a related effort led by CNRA and CalEPA—the AB 1492 [Committee on Budget, 2012 (PRC § 4629 et seq.)] statewide forest ecosystem monitoring and assessment—which is currently in the early stages of development. This effort under AB 1492 focuses on forested ecosystems throughout California, is compatible with the AB 2551 assessment, and seeks to develop a long-term, consistent, spatially explicit quantification of natural resource conditions at the watershed level. As these programs are further developed, resultant data streams will be useful in addressing a wide range of research and assessment questions.

Finally, multiple entities in the private sector have recently started moving forward with forest monitoring data streams. With appropriate vetting, these, too may prove useful in supporting forest research and management decision-making.

Bringing the Scientific Process and Science Synthesis Products to Stakeholders and Other Users

Over the past decade or so, significant efforts have been made to utilize science to build trust among stakeholders and improve accessibility of scientific findings to end-users. Examples briefly described here, and which may provide a model for similar future efforts, are the Sierra Nevada Adaptive Management Project (SNAMP) and a set of science synthesis reports prepared by the USFS Pacific Southwest Research Station. California is continuing to build on the outcomes from these earlier efforts today, though programs such as the [Tahoe-Central Sierra Initiative](#), the Task Force's [Regional Prioritization Groups](#), and the [Regional Forest and Fire Capacity Program](#).

Running 2005 to 2015, SNAMP was a joint effort by the University of California and other universities, state and federal agencies, and the public to investigate forest fuels management in the Sierra Nevada. Public participation processes were integrated throughout all stages of SNAMP, including in the formulation of research questions, design and implementation of experimental treatments on National Forest lands, and related pre- and post-treatment data collection and analysis. As such, SNAMP was an exercise both in biophysical science and social

science. A key objective was to evaluate the impact of strategically placed land area treatments (SPLATS) on ecosystem health, wildlife, water quality and quantity, and to evaluate the effectiveness of the public participation processes used as an essential part of SNAMP.

Management of the national forests in the Sierra Nevada has often been contentious among stakeholders. While stakeholder differences frequently revolve around values, they also may reflect different interpretations of scientific findings. While values tend to be relatively intractable, the resolution of the latter differences may be achieved where there is at least some level of agreement on accepting the outcomes of the application of the scientific process. However, the typical manner of reporting scientific findings via complex, reductionist journal articles—often locked behind costly paywalls—does not effectively communicate needed information to a large proportion of stakeholders. By producing several science synthesis reports (Meyer et al. 2021; Long et al. 2014; North 2012; North et al. 2009) that brought together highly relevant scientific findings in an integrated, accessible style, the USFS Pacific Southwest Research Station provided critical information that—based on the experience of staff preparing this Report—most stakeholders are willing to use to inform decision-making. Moreover, key scientists directly interacted with stakeholders, furthering improved stakeholder understanding and rapport.

These two cases provide examples of how participatory scientific processes, high quality science synthesis reports, and direct interactions between scientists and stakeholders can significantly increase stakeholder accessibility to and acceptance of scientific findings that are needed to address immediate management concerns.

National Dialogues on Forestry Research Needs

To complement the California focus of this Report, we also investigated one broad, national-level effort to assess forestry research needs. Guldin (2019) conducted seven small-group practitioner dialogues with field-based natural resource professionals across the United States (including one in Sacramento) in 2016–2017, asking them to identify the most difficult problems they foresee over the next 10–15 years. They then compared these findings with those identified since 1996 by panels of experts who had compiled national research reports. The comparison showed that the research priorities identified by the expert panels fell into the same general categories as the priorities identified in the practitioner dialogues. However, there was greater specificity and focus to the emerging problems and science gaps identified by the practitioners.

The practitioner dialogues identified that better understanding of the socioeconomic forces driving ecological changes was the area of greatest need. A key finding from practitioners was that public support for proposed projects was more likely where they communicated with the public about potential local social and economic values as well as the potential ecological benefits. Based on these results, the author recommended support for broad, interdisciplinary

research, bringing together ecology, demographics, sociology, political science, governance, and economics, identified in five themes:

1. Changing and increasingly erratic weather patterns: introduce higher risks and uncertainties into resource management decisions; would affect future water availability; are contributing to wildfire risks and post-fire restoration and recovery problems; and are causing pest outbreaks and declining forest health.
2. Human dimensions of resource management are often not adequately considered in developing and presenting proposals to stakeholders.
3. Fire research:
 - a. Socioeconomic research related to fire is needed to better understand how to build public support for reintroducing fire to ecosystems;
 - b. Monitoring and demonstrating effectiveness of fire as a tool to promote resilient forests and communities;
 - c. Fire models can be confusing;
 - d. Place increased emphasis on transferring science to field practitioners.
4. Expanded investments in science synthesis are needed.
5. Halting the decline in the forest sector's research capacity.

Relationship of the Board Research Report to Other Research Efforts

This Report may be utilized by other state agencies, universities and colleges, and nongovernmental organizations to guide forest management research efforts across the State. Information on the research commitments engaged in by forestry and wildland-related research entities over the past decade are detailed in Appendix A in a table that is organized into five programmatic categories: Interagency/Intergovernmental Agreements, Government Programs, Private Forest Industry Research and Monitoring Programs, University Programs, and Nongovernmental Organizations. This Report is directly applicable to Board and CAL FIRE funded research efforts. However, the Board invites all forestry research entities to consider the research priorities recommended by this Report. A database of proposed, approved or current, and completed CAL FIRE and Board-funded research projects is in development by FRAP.

The main organizations conducting or funding research in California include: State Board of Forestry and Fire Protection, CNRA, CAL FIRE, other State agencies (Air Resources Board, Department of Fish and Wildlife, Environmental Protection Agency, etc.), California universities (Universities of California, California State Universities, etc.), out-of-state universities (e.g., Oregon State University, Colorado State University), private forest industry (e.g., Sierra Pacific Industries, Humboldt and Mendocino Redwood Companies, Green Diamond Resource Company, etc.), USDA Forest Service (Pacific Southwest and Pacific Northwest Research Stations, Forest Products Laboratory, Pacific Southwest Region), U.S. Geological Survey, and National Park Service. The primary topic areas addressed for each entity conducting or funding research, as well as examples of major projects undertaken in the past decade, are also

provided in Appendix A. Typical funding mechanisms for forest research are presented in Appendix B, and includes examples from state, federal, private, and non-profit sectors.

Board-funded research currently occurs through several of the Board's committees or programs: the Effectiveness Monitoring Committee, Joint Institute for Wood Products Innovation, and the Forest Carbon Accounting Program. CAL FIRE has funded research through its (1) Forest Practice Watershed Protection Program, (2) Demonstration State Forests Research Program, (3) Nursery Program, and (4) Prescribed Fire Monitoring and Research Program at FRAP. Additionally, CAL FIRE funds forestry-related research through its FRAP California Climate Investments (CCI) Forest Health Research Program, and via research on pest management and urban forestry. CAL FIRE CCI funds have recently been applied to the USFS Forest Inventory and Analysis (FIA) program in California to increase frequency of the remeasurement cycle from 10-years to 5-years. Many of the other research entities listed in Appendix A have received state funding for forestry or wildland-related research in the past decade, but their primary funding comes from other sources.

CAL FIRE Forest Health Research Program

A major, relatively recent effort at CAL FIRE is the Forest Health Research Program (FHRP) (Research Program), which supports scientific studies that provide critical information and tools to forest landowners, resource agencies, fire management organizations, and policy makers across California on a variety of topics related to forest health and management. The Research Program offers grants to eligible applicants primarily through an annual competitive proposal and selection process, as well as through discretionary awards and contracts for specific topics of interest to the Department. Priority topics for study are identified for each round of grant funding. Currently, funded projects are focused on:

- Implementation, effectiveness and impacts of significantly increased pace and scale of fuel reduction and forest health treatments, including prescribed fire;
- Wildfire impacts, recovery and resilience in an altered future climate;
- Improved prediction of wildland fire behavior, weather, near-term fire danger, and long-term probability of fire occurrence;
- Utilization of forest residues and forest products related to fuel reduction and forest health treatments;
- Co-benefits of managing for stable forest carbon;
- Natural, historical and contemporary range of variation in fire regimes and wildfire-related GHG emissions in California ecosystems;
- Wildfire mechanics, spread and associated impacts in WUI landscapes.

The Research Program budget allocates grant funding to four different project types:

- Projects on a general range of California wildlands (details below);
- Projects on CAL FIRE Demonstration State Forests;

- Graduate student research;
- Scientific synthesis and tool development.

The Research Program is managed by CAL FIRE's FRAP and is funded through the CCI program. As such, the selection process places some importance on projects that can demonstrate a clear justification for how the knowledge gained will ultimately result in healthy forests with reduced GHG emissions and other climate benefits.

To date, the Research Program has funded over \$5.4 million in research grants and has provisionally agreed to fund an additional \$2.0 million for the second phase of multi-phase projects. Tables 1 and 2 summarize program funding to date, by the principal priority topic which they address, and by project type. Note that many funded projects address more than one priority topic.

Table 1. Summary of Forest Health Research Projects funded through 2020 by priority topic.

Priority Topic	Number of Awards	Awarded 2018–2020
Implementation, effectiveness and impacts of significantly increased pace and scale of fuel reduction and forest health treatments, including prescribed fire	9	\$2,097,809
Wildfire impacts, recovery, and resilience in an altered future climate	8	\$1,653,318
Improved prediction of wildland fire behavior, weather, near-term fire danger, and long-term probability of fire occurrence	2	\$693,195
Utilization of forest residues and forest products related to fuel reduction and forest health treatments	1	\$353,876
Co-benefits of managing for stable forest carbon	2	\$317,005
Natural, historical and contemporary range of variation in fire regimes and wildfire-related greenhouse gas emissions in California ecosystems	2	\$270,537
Wildfire mechanics, spread and associated impacts in wildland-urban interface landscapes	1	\$50,000
Total (2018–2020)	25	\$5,435,740

Table 2. Summary of Forest Health Research Projects funded through 2020 by project type.

Project Type	Number of Awards	Awarded 2018–2020
General: Projects must include original research and may occur or focus on any land in California that is relevant to the California Forest Carbon Plan, California Strategic Fire Plan, or other large scale forest, fire or ecosystem management planning documents.	12	\$3,281,742
Graduate Student: Research proposal must be written by a graduate student, and project must include original research which will be led by the student and contribute both to their program of graduate study and to the goals of the Research Program.	5	\$330,743
State Forests: Projects must include original research and must include at least one study site on a Demonstration State Forest or other CAL FIRE-managed land.	6	\$1,718,885
Synthesis and Tool Development: Project should be solely or primarily focused on the synthesis of current scientific information and literature, and/or distribution of current scientific data and information for landowners, managers, and the public.	2	\$104,369
Total (2018–2020)	25	\$5,435,740

A full listing of projects funded to date is provided in Appendix C.

It would be useful for the Board to receive annual reports from the Research Program on the program's funded projects, outcomes, and findings; and this information could be valuable in development of future Board research reports. Also, it may be useful for the Research Program to consult with the Board annually when revising the program's priority topics for funding.

Chapter Summary and Conclusions

In summary, limitations to achieving research goals listed in the 2008 Board Report on Forest Management Research were primarily attributed to the inability of the Board's Research and Science Committee to meet the numerous objectives established for the RSC. Numerous reports written in the past 13 years have investigated key issues facing California forests and identified research needs. Brief summaries of key documents that were reviewed are provided, as are research commitments by the primary entities engaged in forestry and wildland-related

research over the past decade, along with their main topic area(s) and examples of major projects or goals.

Recently held Statewide Forest Science Coordination Meetings have also identified key forest science research gaps relating to forest management, reforestation, wildfire, prescribed fire, carbon storage, climate change, watershed and wildlife resources, and invasive species. Major collaborative research projects are currently underway to help address these topics, but much remains to be learned in a rapidly changing environment. Identified science gaps vary in breadth, from those taking a narrow, limited focus on research problems or issues, to those taking a broader view of resource management problems.

As California tribes increase their forest management activities and capacity, there is a clear need for the larger forestry community to increase attention to specific tribal needs for forestry research information. The State is increasingly investing in forest management activities on tribal lands and supporting information exchanges in both directions.

This chapter discussed how extensive data collection and monitoring efforts are growing and have the potential to provide data streams that will support scientific investigations as well as management decisions. While progress has been made, more work remains to be done to improve mapping and monitoring technologies and systems.

This chapter also showed that increasing stakeholder involvement in research processes and providing accessible science synthesis products helps to increase the acceptance of scientific findings by widely-ranging stakeholders and establishes a common basis of accepted factual information. These areas of development (social-process-wise and technical-content-wise) are proving to be supportive of individual, group, and agency decision-making processes for management of forestlands in the state.

Key areas requiring greater scientific understanding, as identified in the multiple reports and journal articles reviewed here, and the two Forest Science Coordination Meetings, include the following twelve items, in unranked order:

- Sustaining existing forests and their ecosystem functions, and re-establishing forests after wildfire and other severe disturbances with climate change;
- Improved wildfire modeling, including fire spread and behavior in the WUI;
- Carbon storage and emissions after wildfire and under varying forest management actions;
- Effects and trade-offs from increased pace, intensity, and location of forest treatments;
- Methods and barriers to obtain greater utilization of wood products;
- Changing forest conditions and their impacts on watershed and wildlife resources and other ecosystem services;
- Human health impacts of smoke from prescribed and wildfires;

- Utilization of traditional ecological knowledge in conjunction with Western science;
- Social sciences (including sociology, demographics, political science, governance, and economics) related to forest management and wood products;
- Early detection and control of invasive species;
- Determining the optimal mix of wildfire prevention (e.g., fuels management, defensible space requirements, land use planning, building codes, ingress and egress standards) and suppression mechanisms to reduce losses to life, property, and natural resources, while minimizing costs; and;
- Developing enhanced methods for and systematic collection of forest monitoring data.

DRAFT

3. Stakeholder Prioritization of Potential Research Topics

A primary objective of this Report, and a requirement of PRC § 4789.6 is to identify “state needs for forest management research.” Research needs are considered here in two ways: (1) topics for which sound scientific information is insufficient to provide a foundation for management or policy decisions (“gaps”), and (2) the importance and relevance of a given topic to current issues and decision points in forest management. This Report first identified, examined, and described known or potential research gaps through document review and expert opinion, and then stakeholders—including laypersons and experts in the field—rank-ordered the list of research topics and provided additional input on these topics. The process of developing these research topic rankings, which is illustrated above in Figure 1, is described in more detail below.

Research Topic Development and Prioritization

To develop an initial set of potential research topics, CAL FIRE scientific staff first reviewed a variety of documents and plans from the Board and other entities involved in forest management and research, including the 2008 Research Report and others as described in the chapter above. Additionally, CAL FIRE staff involved in this process—representing multiple disciplines within forest management—applied expert opinion and understanding of current issues to develop an initial list of approximately 70 potential research topics. Similar or overlapping topics from the initial list were combined to create a refined list of 14 general research topics that could be presented to stakeholders via an online survey. Themes from many topics were necessarily overlapping or could be considered sub-topics of others in the list. This overlap was recognized, but the Report Team believed that some specific sub-topics warranted their own evaluation. This circumstance was explained in the survey instructions.

The online survey was designed to allow respondents to rank the proposed topics in order of importance to them or to the entity they were representing. It also allowed respondents to suggest additional research topics they believed were not addressed in the pre-defined list. Finally, the survey collected limited information about the respondents, including organizational affiliation and areas of expertise, although respondents could remain anonymous if desired. The survey request was sent via email to multiple stakeholder mailing lists maintained by the Board, including Registered Professional Foresters, the Tribal Timber Council, general Board interest, and others. The survey was open for response between December 10, 2020 and January 18, 2021. The full survey as provided to the public is included in Appendix D of this Report.

Survey Results

In total, 358 people responded to the survey, with 322 providing rankings for the list of 14 topics presented. Respondents self-identified by organizational affiliation, with the majority representing either governmental agencies (25.1%), private landowners (20.9%) or forest industry professionals (15.4%) (Table 3).

Table 3. Affiliation of survey respondents.

Primary Affiliation	Percentage of Respondents
Government Agency—Federal, State or Local Resource Management	25.1%
Private Landowner (Non-Industrial) or Representative	20.9%
Forest Industry	15.4%
Other	14.6%
Non-Governmental Organization (NGO)	8.0%
General Public	6.0%
Academic Institution/University	5.1%
Private Landowner (Industrial) or Representative	4.6%
Tribal Representative	0.3%

Respondents also self-identified by professional expertise and could choose more than one area from the list provided. Forestry (71.4%), fire management (27.4%), and environmental protection (23.4%) were the most commonly selection options (Table 4).

Table 4. Survey respondent areas of expertise.

Area of Professional Expertise	Percentage of Respondents
Forestry	71.4%
Fire Management	27.4%
Environmental Protection	23.4%
Ecosystem Science	18.6%
Wood Products and Utilization	18.3%
Water Resources	17.1%
Resource Policy	17.1%
Other (please specify)	15.1%

Area of Professional Expertise	Percentage of Respondents
Wildlife	14.0%
GIS and Remote Sensing	10.9%
Conservation Biology	10.6%
General Public	9.4%
Botany	8.0%
Archaeology and Cultural Resources	8.0%
Rangeland Management	7.7%
Urban Forestry	5.4%
Climate Science	5.4%
Social Sciences	5.1%

Respondents ranked the 14 proposed topics in order of importance or priority, with 1 being the highest rank and 14 being the lowest rank. For each topic, a composite score was compiled as follows:

$$\text{Composite Score} = \frac{14 * X_1 + 13 * X_2 + 12 * X_3 + \dots + 1 * X_{14}}{\text{Total Count of Responses}}$$

Where: X_n = Number of responses of rank n

Thus, the highest composite score represents the topic of highest importance to the respondents. Composite scores were classified by the Report Team into simplified priority classes (“very high” to “moderate”) which were assigned as follows:

- “Very High” (composite score > 8.0);
- “High” (composite score > 7.0 and ≤ 8.0); and
- “Moderate” (composite score ≤ 7.0).

There is no “Low” priority class. Additional qualifiers were assigned to each research topic to characterize the scope of the research topic:

- “Overarching” describes topics that are integrative of many other topic areas (e.g., strategy development);
- “Specialized” describes topics that are more narrow in scope, or which could be considered a specific sub-topic of one of the other categories; and,
- “Midscale” is a qualifier describing topics that are at an intermediate scale falling between Specialized and Overarching.

The list of topics, composite scores, and priority classes is presented below (Table 5). The discussion that follows represents a synthesis of the survey results and interpretation by the Report Team.

Table 5. Research topic rankings.

Topic	Rank	Composite Score	Priority	Qualifier
Forest Management Strategies	1	10.4	Very High	Overarching
Private Forests Management	2	9.3	Very High	Overarching
Wood Utilization	3	9.0	Very High	Midscale
Reforestation Strategies	4	8.9	Very High	Midscale
Wildfire Prediction	5	8.9	Very High	Midscale
Forest Practice Rules Effectiveness and Harvest Operations	6	8.2	Very High	Midscale
Watershed, Wildlife, and Botanical Resources	7	8.1	Very High	Midscale
Climate Change Mitigation	8	7.5	High	Midscale
Long-Term Forest Monitoring	9	7.3	High	Midscale
Quantitative Risk Assessment	10	7.1	High	Midscale
Forest Carbon Inventory and Change	11	5.9	Moderate	Midscale
Climate-Induced Range Shifts	12	5.9	Moderate	Specialized
Human Dimensions	13	5.7	Moderate	Overarching
Urban Forests	14	4.2	Moderate	Specialized

Each of the 14 research topics are grouped into the three priority rankings in Tables 6–8, where they are also sub-categorized by qualifier, and each topic is briefly described.

Table 6. Very high priority research topics.

Qualifier Topic	Description
Overarching	
Forest Management Strategies	Tradeoffs and long-term impacts of forest management strategies to produce forest conditions resilient to disturbance, drought, and climate change (e.g., different thinning regimes, silvicultural activities, pest management activities, increased pace and scale of vegetation fuel management and forest health treatments).
Private Forests Management	Inform development of strategies on privately owned forestlands that promote resilience, carbon sequestration and storage, and mitigation of wildfire risks, while meeting other landowner objectives. Identify landowner behavior, barriers, and incentives to adopting forest management strategies.
Midscale	
Wood Utilization	Facilitating increased utilization of forest products and residues related to fuel reduction, forest health treatments, and forest management; removing barriers and incentivizing use of wood products that enhance carbon storage and reduce GHG emissions, including facility siting; wood products market development.
Reforestation Strategies	Appropriate reforestation approaches in areas affected by high severity disturbances (e.g., wildfire, pest, and disease-induced tree mortality), accounting for future climate conditions, including selection of appropriate species and genetic seed sources, and use of appropriate planting patterns.
Wildfire Prediction	Improved prediction of wildfire hazard, including wildland fire behavior, weather and climate, near-term fire danger and potential, fire spread in the wildland-urban interface, fire behavior and spread following high severity disturbance, and long-term probability of fire occurrence under climate change and different global emissions scenarios.
Forest Practice Rules Effectiveness and Harvest Operations	Effectiveness of California Forest Practice Rules related to management in Watercourse and Lake Protection Zones (WLPZs) and riparian areas, sediment delivery, wildfire hazard reduction, powerline vegetation management, wildlife habitat, and road systems. Innovations in harvest operations on sensitive landscapes, e.g., tethered yarding on steep slopes.

Qualifier Topic	Description
Watershed, Wildlife, and Botanical Resources	Forest management and treatment effects on water quality, quantity, and timing with climate change. Improved prediction of post-fire responses related to watershed hazards. Vegetative and aquatic responses with varying riparian zone management approaches. Development of strategies for key threatened or endangered plant and animal species (e.g., northern spotted owl), including documentation of how species respond to different forest management activities. Identification of approaches for protecting critical habitat and biodiversity.

The two highest ranking topics—Forest Management Strategies and Private Forests Management—are overarching categories representing development of management strategies on private and public lands. These topics could be considered inclusive of more specific research needs identified in the survey process, but their high ranking by stakeholders speaks to the challenges faced in decision- and policy-making in an environment of multiple, often competing land management objectives and changing disturbance regimes.

The highest-ranking topics qualified as midscale in nature are often at the forefront of management and policy questions today. Developing technologies, infrastructure, and economies for effective wood product utilization is a key barrier to achieving contemporary forest management objectives on both public and private land. Increasing incidence of high-severity fire has highlighted the need for effective strategies for reforestation to maintain resilient forests under a changing climate and increased disturbances. Development of wood product markets and reforestation efforts can contribute to local employment and economic activity in disadvantaged rural areas. Challenges in predicting wildfire hazard and risk has highlighted weaknesses in current models, presenting numerous difficulties for public health and safety, and resource protection. Better understanding of how to monitor and assess the effects and effectiveness of current FPRs, as well as improved protection of water, botanical, and wildlife resources will continue to be critical as climate, disturbance, and proposed increases in active management interact to affect forest resources across the landscape.

Table 7. High priority research topics.

Qualifier Topic	Description
Midscale	
Climate Change Mitigation	Identification of forest management and wood utilization opportunities for climate mitigation through emissions reductions, avoided emissions, wood products, afforestation/reforestation, avoided forestland conversion, and/or improved carbon sequestration with consideration for timing of benefits, different global emissions scenarios, and future climate.
Long-Term Forest Monitoring	Long-term monitoring of disturbance regimes, individual pest species, and conditions such as forest extent, structure, composition, productivity, and carbon to better understand how forests are responding to changes in climatic conditions.
Quantitative Risk Assessment	Development and application of landscape level, multi-hazard risk assessments, decision support tools, and prioritization frameworks that address ecological, wildfire, and community risks, as well as impacts to vulnerable populations under future climate.

Research into the high priority topics identified here—all qualified as midscale in nature—would address long-term and/or broad scale assessments and strategy development. Assessment and monitoring of forest resources for climate- and disturbance-induced changes will be critical to understanding effects from management, stressors, and disturbance, and adapting management strategies and approaches in an uncertain future. Forests are a core element of the State’s natural and working land approaches to climate change mitigation, but many key questions remain and tradeoffs of some strategies remain uncertain. Comprehensive, multi-asset, multi-hazard risk assessment and related economic evaluation is needed to effectively prioritize investments by the State.

Table 8. Moderate priority research topics.

Qualifier Topic	Description
Overarching	
Human Dimensions	Examining socio-economic considerations related to forest health and management, including equity issues, vulnerable communities, ecosystem services, and public health; understanding public perceptions and support for forest management strategies; indigenous perspectives on forest health and best management practices.
Midscale	
Forest Carbon Inventory and Change	Inventory and quantification of above- and below-ground forest ecosystem and harvested wood product carbon pools and flux, and of impacts to forest carbon from management activities and disturbance (e.g., prescribed and wildfire, site preparation activities, silvicultural systems, etc.).
Specialized	
Climate-Induced Species Range Shifts	Identification of potential climate-induced shifts in the ranges of forest plant and animal species, and identification of potential areas of refugia for protecting forest health, habitat, biodiversity, and carbon storage.
Urban Forests	Development of a comprehensive needs assessment for urban forests. Examination of the costs, benefits, feasibility, and acceptability of expanding and enhancing urban forests using field-based and remote sensing data. Documentation of the effects from climate change on urban forests, and development of strategies to keep them resilient with a changing climate.

While ranking lower in this stakeholder survey, understanding the human dimensions of forest management—including public perceptions and socio-economic implications of forest management actions—is an overarching category that is critical to decision-making frameworks and strategies for managing public and private forests. Development of tools and analyses that can inform trade-offs incurred when balancing landowner objectives, benefits, impacts, and constraints is of critical importance.

Forest carbon inventory and quantification, as well as identification of climate-change-induced species range shifts—while ranking lower in the stakeholder survey—are more specialized topics that could be considered either foundational or closely related to climate change mitigation (which ranks higher) or the umbrella strategies that require robust data and projections of future conditions. Funding research in these areas may be necessary to support

higher-priority topics. Urban forests, while ranking lower in the stakeholder survey, should remain a research priority for their direct impact to 95 percent of the state's residents.

Additional Topics Identified by Stakeholders

A total of 127 survey respondents provided additional suggestions or comments on research topics (see Appendix E for a complete list of these responses). An additional comment, received separately from the survey via a memo to the Board, stated that, "a key component should be to provide a more transparent and empirically based assessment of the role of all forests in providing climate benefits." Taken together, the suggested topics were wide ranging, but several common themes emerged. They are summarized and presented below without ranking.

1. Understanding whether current forest policies and regulations are creating barriers and disincentives to forest management.
2. Current state of the forest products' industry, and overcoming economic barriers to achieving forest management goals and objectives.
3. Effectiveness of the Forest Practice Rules in addressing sustainable forestry (e.g., Maximum Sustained Yield, cumulative impacts), and wildfire hazard (e.g., stocking standards and fuel loading).
4. Workforce development, including building resources needed for increasing active management statewide, and in the forestry profession itself (i.e., Registered Professional Forester attrition).

The Report Team believes that these four areas are largely addressed by the research topics used in the survey, though perhaps not always as directly or in the same way. The fourth item, workforce development, is included as a part of final research topic recommendations provided in this Report.

Additional topics and suggestions provided by multiple respondents included invasive species' management, the use of grazing as an effective method for fuel reduction, oak woodland restoration and conservation, prescribed fire (particularly smoke impacts vs. wildfire), defining "resilience" and "health" in forests, post-wildfire recovery, impacts of federal forest management on private forestlands, forest and fuel management strategies at large scales (e.g. regional or "landscape"), and effective wildfire risk reduction (especially in the WUI). Again, most of the suggested topics appear to be already recognized to some degree, directly or indirectly, by the 14 topics developed by Board and CAL FIRE staff for stakeholder ranking. Invasive species are now more directly called out as a part of final research topic recommendations provided in this Report.

Chapter Summary and Recommendations

Tables 6–8, organized by priority rankings, describe each of the 14 research topics and provide a brief discussion for each priority category. Half of the research categories fell into the very

high priority ranking category, with two of the seven considered overarching in scope, and the remaining five of a midscale nature. Overarching, very-high-ranking research priorities focused on the implications and tradeoffs of forest resource management in general—including in private forests—and on more specific areas of research related to wildfire prediction, restoration, harvest operations and wood products, and biological and physical resources, with consideration of impacts to local economies and the interactive effects of climate change. Additional areas of research identified by stakeholders included the intended and expected outcomes of the FPRs. Midscale research topics of high-ranking priority comprised climate change mitigation, long-term monitoring, and decision-making frameworks, all of which revolve around management of large-scale dynamic forested ecosystems over longer timescales, during which a variety of social, economic, and biological characteristics interact in complex, often unpredictable ways.

While ranked as a moderate research priority, the overarching aspect of human dimensions in forest management often strongly influences physical and biological outcomes, and consideration of socio-economic drivers is a critical component in decision-making and practical, on-the-ground management. Additional areas of research identified by stakeholders included aspects of socio-economic challenges in the forest management and timber industry, such as political, legislative, and logistical barriers to improved forest management practices, and the ability of the current workforce structure and organization to meet the needs and demands of these highly dynamic, complex systems. Midscale research topics of moderate ranking priority included carbon- and climate-related aspects of forest resource fluctuations over time, including carbon stocks and temporal and spatial shifts in floral and faunal species' ranges.

4. Synthesis and Recommended Priority Research Topics

The process for the development of the Board's recommended priority research topics is visualized in Figure 1 (see **Chapter 1, Introduction**). In this fourth chapter, we first synthesize (1) the 12 key research gaps identified in **Chapter 2, Background Information**, and (2) the 14 research topic areas ranked by stakeholders in the survey process described in **Chapter 3, Stakeholder Prioritization of Potential Research Topics**, to produce (3) a set of 13 preliminary recommended priority research topics; this process is described in further detail below. This synthesis was done to address minor discrepancies in the research gaps identified in Chapter 2 and the stakeholder survey described in Chapter 3. The resulting set of preliminary ranked topics was provided to the Forest Management Task Force Science Advisory Panel, whose input is summarized here. Finally, the Report Team utilized the Science Panel's input to develop a set of recommended priority research topics. A draft version of this Report was reviewed by the Board at its public meeting on May 5, 2021, and an additional two-week public comment period was provided at that time. The Report Team synthesized and incorporated Board input and public comments to develop a final set of recommended priority research topics to guide forestry research in the State.

Synthesizing Staff's Twelve Key Research Gaps with the Fourteen Research Topics Ranked by Stakeholders into Recommended Priority Research Topics

As a first step in the synthesis of the 12 key research gaps with the 14 research topics ranked by stakeholders, a crosswalk table was used to compare the two sets of research areas (Table 9). The more generalized topics in the first column from the left were reviewed with respect to how well they related to topics in the second column, then modified to produce a revised, integrated prioritized research topic list in the third, right-hand column. Finally, along with Report Team expertise, information gathered in the preparation of this Report, and consideration of the stakeholder rankings, the Report Team ranked the topics in the right-hand column, at times adjusting the rankings from the results from the stakeholder survey to account for more current knowledge regarding relevant knowledge gaps and critical research areas. For example, staff ranked Human Dimensions as "very high", while stakeholders ranked this as "moderate".

Table 9. Crosswalk Table for Development of Preliminary Recommended Priority Research Topics.

Key Research Gaps (Chapter 2)	Stakeholder Survey Ranking of 14 Research Topics (Chapter 3)	Preliminary Recommended Priority Forestry Research Topic
<p>Effects and trade-offs from increased pace, intensity, and location of wildland and urban forest treatments.</p>	<p><i>Very High Ranking</i></p> <ol style="list-style-type: none"> 1. Forest Management Strategies. Tradeoffs and long-term impacts of forest management strategies to produce forest conditions resilient to disturbance, drought, and climate change (e.g., different thinning regimes, silvicultural activities, pest management activities, increased pace and scale of vegetation fuel management and forest health treatments). (Overarching scope) 2. Private Forests Management. Inform development of strategies on privately owned forestlands that promote resilience, carbon sequestration and storage, and mitigation of wildfire risks, while meeting other landowner objectives. Identify landowner behavior, barriers, and incentives to adopting forest management strategies. (Overarching) <p><i>Moderate Ranking</i></p> <ol style="list-style-type: none"> 14. Urban Forests. Development of a comprehensive needs assessment for urban forests. Examination of the costs, benefits, feasibility, and acceptability of expanding and enhancing urban forests using field-based and remote sensing data. Documentation of the effects from climate change on urban forests, and development of strategies to keep them resilient with a changing climate. (Specialized) 	<p><i>Very High Ranking</i></p> <p>Effects and trade-offs associated with different forest management strategies on private, federal, and state lands, and urban areas, including impacts associated with increased pace, intensity, and location of forest treatments.</p>

Key Research Gaps (Chapter 2)	Stakeholder Survey Ranking of 14 Research Topics (Chapter 3)	Preliminary Recommended Priority Forestry Research Topic
Methods and barriers to obtain greater production and utilization of timber and wood products.	<p><i>Very High Ranking</i></p> <p>3. Wood Utilization. Facilitating increased utilization of forest products and residues related to fuel reduction, forest health treatments, and forest management; removing barriers and incentivizing use of wood products that enhance carbon storage and reduce GHG emissions, including facility siting; wood products market development. (Midscale)</p>	<p><i>Very High Ranking</i></p> <p>Methods and barriers to obtain greater production and utilization of timber and wood products.</p>
Sustaining existing forests and their ecosystem functions, and re-establishing forests after wildfire and other severe disturbances with climate change.	<p><i>Very High Ranking</i></p> <p>4. Reforestation Strategies. Appropriate reforestation approaches in areas affected by high severity disturbances (e.g., wildfire, pest, and disease-induced tree mortality), accounting for future climate conditions, including selection of appropriate species and genetic seed sources, and use of appropriate planting patterns. (Midscale)</p>	<p><i>Very High Ranking</i></p> <p>Re-establishment of forests and their ecosystem functions after wildfire and other severe disturbances in the context of a changing climate.</p>
Improved wildfire modeling, including fire spread and behavior in the WUI.	<p><i>Very High Ranking</i></p> <p>5. Wildfire Prediction. Improved prediction of wildfire hazard, including wildland fire behavior, weather and climate, near-term fire danger and potential, fire spread in the wildland-urban interface, fire behavior and spread following high severity disturbance, and long-term probability of fire occurrence under climate change and different global emissions scenarios. (Midscale)</p>	<p><i>Very High Ranking</i></p> <p>Improved wildfire modeling and prediction, including in the WUI.</p>

Key Research Gaps (Chapter 2)	Stakeholder Survey Ranking of 14 Research Topics (Chapter 3)	Preliminary Recommended Priority Forestry Research Topic
<p>Changing forest conditions and their impacts on watershed and wildlife resources and other ecosystem services.</p>	<p><i>Very High Ranking</i></p> <p>6. Forest Practice Rules Effectiveness and Harvest Operations. Effectiveness of California Forest Practice Rules related to management in Watercourse and Lake Protection Zones (WLPZs) and riparian areas, sediment delivery, wildfire hazard reduction, powerline vegetation management, wildlife habitat, and road systems. Innovations in harvest operations on sensitive landscapes, e.g., tethered yarding on steep slopes. (Midscale)</p> <p>7. Watershed, Wildlife, and Botanical Resources. Forest management and treatment effects on water quality, quantity, and timing with climate change. Improved prediction of post-fire responses related to watershed hazards. Vegetative and aquatic responses with varying riparian zone management approaches. Development of strategies for key threatened or endangered plant and animal species (e.g., northern spotted owl), including documentation of how species respond to different forest management activities. Identification of approaches for protecting critical habitat and biodiversity. (Midscale)</p>	<p><i>Very High Ranking</i></p> <p>Forest Practice Rule effectiveness and management impacts on watershed, plant, and wildlife resources and other ecosystem services.</p>

Key Research Gaps (Chapter 2)	Stakeholder Survey Ranking of 14 Research Topics (Chapter 3)	Preliminary Recommended Priority Forestry Research Topic
<p>Determining the optimal mix of wildfire prevention and suppression mechanisms to reduce losses to life, property, and natural resources, while minimizing costs.</p>	<p><i>High Ranking</i></p> <p>10. Quantitative Risk Assessment. Development and application of landscape level, multi-hazard risk assessments, decision support tools, and prioritization frameworks that address ecological, wildfire, and community risks, as well as impacts to vulnerable populations under future climate. (Midscale)</p>	<p><i>Very High Ranking</i></p> <p>Determining the optimal mix of wildfire prevention and suppression mechanisms to reduce losses to life, property, and natural resources, while minimizing costs.</p>
<p>Human health impacts of smoke from prescribed and wildfires.</p> <p>Utilization of traditional ecological knowledge in conjunction with Western science.</p> <p>Social sciences related to forest management and wood products.</p>	<p><i>Moderate Ranking</i></p> <p>13. Human Dimensions. Examining socio-economic considerations related to forest health and management, including equity issues, vulnerable communities, ecosystem services, and public health; understanding public perceptions and support for forest management strategies; indigenous perspectives on forest health and best management practices. (Overarching)</p>	<p><i>Very High Ranking</i></p> <p>Human health impacts of smoke from prescribed and wildfires.</p> <p>Utilization of traditional ecological knowledge in conjunction with Western science.</p> <p>Social sciences related to forest management (including recreational and cultural uses) and wood products.</p>

Key Research Gaps (Chapter 2)	Stakeholder Survey Ranking of 14 Research Topics (Chapter 3)	Preliminary Recommended Priority Forestry Research Topic
Carbon storage and emissions after wildfire and under varying forest management actions.	<p><i>High Ranking</i></p> <p>8. Climate Change Mitigation. Identification of forest management and wood utilization opportunities for climate mitigation through emissions reductions, avoided emissions, wood products, afforestation/reforestation, avoided forestland conversion, and/or improved carbon sequestration with consideration for timing of benefits, different global emissions scenarios, and future climate. (Midscale)</p> <p><i>Moderate Ranking</i></p> <p>11. Forest Carbon Inventory and Change. Inventory and quantification of above- and below-ground forest ecosystem and harvested wood product carbon pools and flux, and of impacts to forest carbon from management activities and disturbance (e.g., prescribed and wildfire, site preparation activities, silvicultural systems, etc.). (Midscale)</p> <p>12. Climate-Induced Range Shifts. Identification of potential climate-induced shifts in the ranges of forest plant and animal species, and identification of potential areas of refugia for protecting forest health, habitat, biodiversity, and carbon storage. (Specialized)</p> <p>14. Urban Forests. <i>See above for detail.</i></p>	<p><i>High Ranking</i></p> <p>Climate change mitigation strategies for wildland and urban forests, including carbon storage and emissions after wildfire and other disturbances, and under varying forest management actions.</p> <p>Climate-induced floral and faunal range-shifts.</p>
Early detection and control of invasive species.	<p><i>[Not explicitly included in survey list of research topics.]</i></p>	<p><i>High Ranking</i></p> <p>Early detection and control of invasive species.</p>

Key Research Gaps (Chapter 2)	Stakeholder Survey Ranking of 14 Research Topics (Chapter 3)	Preliminary Recommended Priority Forestry Research Topic
Development of enhanced methods for and systematic collection of forest monitoring data.	<p><i>Moderate Ranking</i></p> <p>9. Long-Term Forest Monitoring. Long-term monitoring of disturbance regimes, individual pest species, and conditions such as forest extent, structure, composition, productivity, and carbon to better understand how forests are responding to changes in climatic conditions. (Midscale)</p>	<p><i>Moderate Ranking</i></p> <p>Development of enhanced methods for and systematic collection of forest monitoring data.</p>

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Input Received from the Science Advisory Panel

As described earlier, in response to the direction from the Resilience Action Plan, an initial consultation was held with the Science Advisory Panel leadership and staff on March 12, 2021. This was followed by a meeting of CAL FIRE staff with the full Science Advisory Panel during its regular meeting on April 6, 2021, where a draft of Table 9 (above) was presented for discussion. Some preliminary comments were provided by individual Panel members on the preliminary list of recommended priority research topics, including (paraphrased from meeting notes and meeting chat log):

- Include climate mitigation as an explicit part of the topic regarding tradeoffs among different forest management strategies.
- Increase the priority of long-term forest monitoring.
- Increase specificity in regards to needs and constraints in the wood utilization industry (i.e., regulatory constraints on harvest are less of a constraint than wood products innovation, marketing, workforce development, and capital investment, for example).
- Increase and build on synthesis of scientific research.³
- Emphasize importance of matching the sizing of consumer products to the scale of sustainable harvest, such that industry raw material demand does not exceed the regional, sustainable supply, particularly under our evolving fire and climate regimes.
- Human Dimensions and aspects of social science are critical to success in tackling forest management challenges.
- Urban forestry also should be recognized as a priority.
- Important to incorporate traditional ecological knowledge.
- Watersheds should be emphasized as an important scale for which to consider biophysical processes.
- Identification and clarification of the evolving definition of an invasive species (e.g., invasive species versus a climate change refugee: e.g., Barred Owls [*Strix varia*] movement with climate change and human tree planting in the Plains States).
- Barriers to reforestation, including seed sourcing and distribution.

At this meeting, a decision was made to use a survey approach to gather input from the Science Panel on the completeness of the preliminary recommended priority research topics, how they should be ranked priority-wise, and what other changes to these topics were warranted. It was decided that Panel staff would compile the responses from Panel members before providing

³ While this topic does not appear in the preliminary recommended priority research topics, it is addressed explicitly in **Chapter 2**, with strong support for its value.

them to the Report Team. The Science Panel's compiled responses (based on 14 individual member responses) were received on April 20, 2020. The comments provided as a part of the survey that add new points to the Panel's above preliminary comments, are summarized below:

Comments on Additional Research Topic Areas to Include

- Prioritizing where not to treat; for example, determining which areas in forested regions were likely chaparral prior to fire suppression and which areas are least likely to persist under climate change. Treating these areas may be a waste of resources.
- Examining the risks and opportunities for expanded use of wildland fire ("let burn" policies). This would require social science on the acceptance of managed wildfire as well as ecological, vegetation, fire, and climate science.
- Greater emphasis on environmental justice. One option would be to include environmental justice implications as a component of every research priority.
- Research in non-forested ecosystems such as mixed woodland/shrubs near communities – e.g., in wine country.⁴
- How to increase fire resistance of chaparral near the WUI. This research will require social, ecological, and land use planning expertise. Example topics include partnerships, communication, structure hardening, urban planning, and ecological management.
- Water quality, sediment/erosion losses associated with wildfire, and the potential for forest treatments to reduce these effects.
- Current and future population dynamics for key tree and wildlife species.

Additional Comments from Science Panel

- A significant investment in social sciences is needed. This sentiment was repeated by several panel members. Social science research may be best led by groups like local governments, the Air Resources Board, Water Board, and others rather than USFS, CAL FIRE, and timber groups.
- Consider rephrasing the topic, "Determining the optimal mix of wildfire prevention and suppression mechanisms..." to include managed wildfire in addition to prevention and suppression. Avoiding and excluding fire is not sustainable in the long term. This was repeated by multiple panel members.

⁴ As noted earlier, the focus of this report is forestlands; shrublands are not addressed here, but they are addressed by Range Management Advisory Committee plans and objectives.

- Some of the research priorities are so broad that some panel members ranked them lower than more concrete, short-term topics.
- The “early detection and control of invasive species” item may be more of an implementation challenge than a science challenge.
- Watershed impacts were listed under Forest Practice Rules but warrant a separate topic, which made ranking more difficult.
- Separate topics for economics and communication/managing public perceptions may be warranted.

Science Panel’s Priority Rankings

Table 10 presents the priority rankings from the fourteen responses received from the Science Panel.

Table 10. Priority rankings of research topics from the Science Advisory Panel.

Preliminary Recommended Priority Forestry Research Topic	Number of Responses in Each Rank (n=14)		
	Medium	High	Very High
Effects and trade-offs associated with different forest management strategies on private, federal, and state lands, and urban areas, including impacts associated with increased pace, intensity, and location of forest treatments.	2	3	9
Methods and barriers to obtain greater production and utilization of timber and wood products.	5	4	5
Re-establishment of forests and their ecosystem functions after wildfire and other severe disturbances in the context of a changing climate.	1	4	9
Improved wildfire modeling and prediction, including in the WUI.	6	7	1
Forest Practice Rule effectiveness and management impacts on watershed, plant, and wildlife resources and other ecosystem services.	4	7	3
Determining the optimal mix of wildfire prevention and suppression mechanisms to reduce losses to life, property, and natural resources, while minimizing costs.	1	5	8
Human health impacts of smoke from prescribed and wildfires.	1	7	6

Preliminary Recommended Priority Forestry Research Topic	Number of Responses in Each Rank (n=14)		
	Medium	High	Very High
Utilization of traditional ecological knowledge in conjunction with Western science.	2	6	6
Social sciences related to forest management (including recreational and cultural uses) and wood products.	2	5	7
Climate change mitigation strategies for wildland and urban forests, including carbon storage and emissions after wildfire and other disturbances, and under varying forest management actions.	2	3	9
Climate-induced floral and faunal range-shifts.	5	7	2
Early detection and control of invasive species.	8	5	1
Development of enhanced methods for and systematic collection of forest monitoring data.	4	7	3

Recommended Priority Research Topics

Utilizing the Science Advisory Panel’s input on the above-described preliminary recommended priority research topics, the Report Team developed the following recommended priority research topics for the Board’s consideration (Table 11). The underlined text represents additions made in response to the Science Panel’s comments.

NOTE to the reviewing Board and public:
The recommended priority ranking of these research topics in this draft is the result of the process and input described above. Since this process was inherently subjective, the Board and public should review them and provide further input to staff. An option for the Board to consider is to provide a listing of priority topics without ranking.

Table 11. Recommended priority research topics.

Recommended Priority Research Topics
<p><i>Very High Ranking</i></p> <p><u>Biophysical, ecological, social, and economic</u> effects and trade-offs associated with different forest management strategies on private, federal, and state lands, and urban areas <u>under climate change</u>, including impacts associated with increased pace, intensity, and location of</p>

Recommended Priority Research Topics
forest treatments. <u>Includes identifying areas that should not be treated for ecological, social, or economic reasons.</u>
<i>Very High Ranking</i> Methods and barriers <u>(including workforce limitations)</u> to obtain greater production and utilization of timber and wood products, <u>while not exceeding sustainable harvest levels.</u>
<i>Very High Ranking</i> Re-establishment of forests and their ecosystem functions after wildfire and other severe disturbances in the context of a changing climate.
<i>Very High Ranking</i> Improved wildfire modeling and prediction, including in the WUI.
<i>Very High Ranking</i> Forest Practice Rule effectiveness and management impacts on watershed, plant, and wildlife resources and other ecosystem services.
<i>Very High Ranking</i> Determining the optimal mix of wildfire prevention and suppression mechanisms, <u>including use of managed fire, where feasible</u> , to reduce losses to life, property, and natural resources, while minimizing costs.
<i>Very High Ranking</i> Human health impacts of smoke from prescribed and wildfires.
<i>Very High Ranking</i> Social sciences related to forest management (including recreational and cultural uses) and wood products, including environmental justice.
<i>Very High Ranking</i> Climate change mitigation strategies for wildland and urban forests, including carbon storage and emissions after wildfire and other disturbances, and under varying forest management actions.
<i>High Ranking</i> Utilization of traditional ecological knowledge in conjunction with Western science.
<i>High Ranking</i> Climate-induced floral and faunal range-shifts.
<i>High Ranking</i> Early detection and control of invasive species.

Recommended Priority Research Topics

High Ranking

Development of enhanced methods for and systematic collection of forest monitoring data.

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5. Summary and Recommendations

This Report was developed to be responsive to the directives of the Public Resources Code and the Wildfire and Forest Resilience Action Plan regarding the preparation of a coordinated list of forest management research priorities by the Board. Its main findings include the list of recommended priority research topics to address gaps and support more intensive research on the forest management topics detailed in Table 11, above.

This Report also emphasized the value of high-quality science synthesis reports for summarizing scientific findings and research-based forest management recommendations in a fashion that is understandable for a wide range of audiences. Moreover, this Report recognized the critical importance of the collection of long-term, high-quality forest monitoring data for its multiple roles in informing forest management decisions, allowing the evaluation of the outcomes of management actions such as projects to enhance forest resilience, and providing data streams for research projects.

While the Research and Science Committee established per the Board's 2008 Research Report was not fully successful in meeting all the goals assigned to it by the Board, the Board now has more staff and resources than it did in 2008 to support the recommendations in this 2021 Report. Additional recommendations to facilitate and support forestry research in the State include the following:

- Develop an outreach effort to encourage the distribution and promotion of this Report to better ensure that its findings on research knowledge gaps, prioritized research topics, and other findings will be given due consideration by the forest management and forest research community in California.
- CAL FIRE should consider the Report findings in the administration of its related programs, including the Fire and Resource Assessment Program, Forest Health Research Program, Forest Practice Program, Climate and Energy Program, Resource Protection and Improvement Program, and Fire Protection Operations and Intelligence.
- The Forest Health Research Program should report annually to the Board on funded projects, outcomes, and findings. These reports will be considered in development of future Board research reports. The FHRP should also consult with the Board annually when revising priority topics for funding.
- Standing Board Committees, including the Effectiveness Monitoring Committee and the Joint Institute for Wood Products Innovation, should make use of the findings in this Report.
- To more directly coordinate preparation of the Board's Report on Forest Management Research with other Board and Department responsibilities, future

iterations should link the preparation of the report with the process and timing of the semi-decadal preparation of the Forest and Rangeland Resources Assessment by CAL FIRE (required by PRC § 4789.3). Following completion of that Assessment, and the Board's subsequent preparation of a forest resource policy statement (PRC § 4789.4), preparation of this Report could be completed immediately thereafter. A five-year refreshment cycle (versus the current two-year cycle) for the Research Report seems frequent enough to address the need for Board input on research priorities, and linking the Research Report with other reporting responsibilities will allow for better work efficiencies.

- Cross-sector collaboration on forest management research, including private sector, academic, State, and federal entities, as well as the interested public, is essential to the development and maintenance of a rigorous forestry research program. The Board could consider positioning itself to take an expanded role to improve coordination and cooperation among these parties. To do so, the Board would need to clearly define this role and identify and secure the additional staff and funding needed.
- The Board should revisit the current Board Policies regarding forestry research and examine the need to update or maintain policies in these areas. If needed, Board staff should draft revisions for the Board's consideration by the end of 2021.

The Board greatly appreciates the diligent work of Board and CAL FIRE staff to prepare this Report. The Board also appreciates the willing engagement of the Forest Management Task Force Science Advisory Panel to provide valuable input on this Report.

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Appendices

Appendix A Research or Monitoring Entities for California Forest Management.

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
<i>Interagency/Intergovernmental Agreements</i>		
Agreement for Shared Stewardship of California's Forest and Rangelands [State of California (CA) and United States Department of Agriculture (USDA) Forest Service (FS) Pacific Southwest Research Station]	Forest health, wildfire, climate change, forest restoration, collaboration on research and data sharing	Goal is to support long-term research and monitoring efforts (signed in August 2020)
Memorandum of Understanding (MOU)- Pacific Coast Temperate Forests (CA, Oregon, Washington, and British Columbia)	Fuel management, reforestation, forest carbon, climate change, innovative wood products	Pacific Coast Temperate Forest Regional Carbon report, Pacific Coast Carbon Initiative
CAL FIRE-UC Berkeley Center for Fire Research and Outreach MOU for CA Initiative for Research on Fires and Forests (CIRFF)	Forest health and resiliency, wildfire impacts to ecological communities, and improving land management practices that benefit the people of California	Five-year Statement of Work covering four research focus areas: Drivers of Emergent Large Fires in North Coastal California; Fire Effects on Old Growth Giant Sequoia; Mitigating Adverse Climate Impacts on Mixed Conifer Forests through innovation Management; Active Management Strategies for Young Forest Resiliency

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
Tahoe Science Advisory Council (CA and Nevada)	Upland ecosystems	The Upland Ecosystem Science to Action Plan establishes a vision for near- and long-term research that improves future outcomes, promotes resilience, protects resources, adapts to change, and enhances ecological and community sustainability.
Governmental Programs		
Board of Forestry and Fire Protection Effectiveness Monitoring Committee (EMC)	Effectiveness of CA Forest Practice Rules (FPR) (e.g., related to watersheds, wildlife, wildfire hazards)	Class II Large watercourse Forest Practice Rule effectiveness, Boggs Mountain Demonstration State Forest post-fire studies
Board of Forestry and Fire Protection Joint Institute for Wood Products Innovation	Wood products utilization	Biomass utilization studies
Board of Forestry and Fire Protection-Department of Forestry and Fire Protection (CAL FIRE) Forest Carbon Accounting Program	Forest and wood products carbon accounting, per AB 1504 [Skinner, 2010 (PRC § 4512 et seq.)] requirements.	Annual forest ecosystem and harvested wood product carbon inventory
CAL FIRE Forest Practice Watershed Protection Program	Effectiveness of CA FPRs for watershed resources	Caspar Creek Watershed Study, Railroad Gulch Best Management Practice Effectiveness Study
CAL FIRE Forest Resource Assessment Program (FRAP) Fire Hazard Mapping Program	High hazard fire zones	Updated CA fire hazard maps
CAL FIRE California Climate Investments (CCI) Forest Health Research Grant Program	Forest health and wildfire science	Grant-funded studies on prescribed fire and fuel treatment effects on carbon, biodiversity, public health; post-fire forest recovery and management including salvage and

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
		reforestation; biomass utilization approaches; fire modeling and prediction; others.
CAL FIRE FRAP Prescribed Fire Monitoring Program	Prescribed fire	Prescribed fire monitoring and research studies
CAL FIRE Demonstration State Forest Research Program	Silviculture, watershed, wildlife	Caspar Creek Watershed Studies, Whiskey Springs Thinning Studies, Boggs Mountain Demonstration State Forest post-fire reforestation study, Land Degradation Surveillance Framework (LDSF) plantation restoration study, Climate-adaptive silviculture study
CAL FIRE Pest Management	Forest entomology and pathology	Forest entomology and pathology studies
CAL FIRE Urban and Community Forestry Grant Program	Urban forestry	Urban forestry-related research studies
CA Department of Fish and Wildlife Habitat Conservation Planning Branch	Terrestrial vegetation, wildlife, and fisheries	Terrestrial vegetation, wildlife, and fisheries studies
California Natural Resources Agency/California Environmental Protection Agency (CalEPA) Timber Regulation and Forest Restoration Program Ecological Performance Measures	Effectiveness of CA FPRs in protecting or enhancing forest resources on nonfederal timberlands	Climate-informed spatial analysis and restoration priority project

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
Sierra Nevada Conservancy, working in collaboration with CAL FIRE, CA Dept of Conservation, University of Washington, Forest Service, and others.	Use of Light Detection and Ranging (LiDAR), other remotely-sensed data, and ground-based data to characterize forest conditions at stand and landscape scales; develop data-driven decision tools for collaborative prioritization of forest resilience projects; foster biomass utilization; and assess wildfire impacts on economics, society, and ecosystem services.	Tahoe-Central Sierra Initiative; trends of high severity fire events; characterizing trajectory of forest stands experiencing “healthy” fire events over time; identification of CA Spotted Owl nesting habitat across an entire National Forest via LiDAR methods.
Strategic Growth Council Climate Change Research Grant Program	The Climate Change Research Program supports science to action, engaging both researchers and community partners in all stages of the research process to advance California’s climate change goals.	CO ₂ capture and greenhouse gas (GHG) emissions reductions via soil amendment; integrated land use planning to support climate resilient ecosystems and local communities: fire risk, water sustainability, and biodiversity
California Multi-Agency Information and Analysis Network (CalMAIN)	Shared natural resources-related data	Still in development
CA Air Resources Board Research Screening Committee	Air pollution, forest carbon, greenhouse gas emissions	Air pollution studies
California Geological Survey Post-Fire Monitoring and Research	Post-fire debris flows and flooding	Post-fire debris flow monitoring
California Department of	Terrestrial vegetation,	Biogeographic Information and

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
Fish and Wildlife (CDFW)	wildlife, and fisheries	Observation System (BIOS), California Wildlife Habitat Relationship System (CWHR), California Natural Diversity Database (CNDDDB)
California Energy Commission Electric Program Investment Charge (EPIC)	Renewable energy research	Biomass-to-energy conversion systems
CalEPA Office of Environmental Health Hazard Assessment, Division of Scientific Programs: Air and Site Assessment and Climate Indicators	Air pollution	Air pollution research studies
California Water Boards	Water quality	Surface Water Ambient Monitoring Program (SWAMP)
National Parks (U.S. Department of Interior):		
Redwood National and State Parks	Watershed, wildlife, silvicultural strategies	Second growth thinning studies; road decommissioning studies
Yosemite National Park	Prescribed fire, managed wildfire	Prescribed fire and managed wildfire study-Illilouette Basin
Kings Canyon/Sequoia National Park	Prescribed fire, managed wildfire	Prescribed fire and managed wildfire studies on fuels, wildlife
U.S. Geological Survey (USGS) Western Ecological Research Center	Ecological impacts of wildfire	Effects of wildfire on plant ecology
USGS Landslide Hazards Program Post-Fire Monitoring and Research	Post-fire debris flows and flooding	Debris flow prediction models for southern California
USDA Forest Service Pacific Southwest Region	Watershed, wildlife, forest health, forest	Sierra Nevada Adaptive Management Project (SNAMP),

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
	ecology, forest mgt strategies, remote sensing	Tahoe-Central Sierra Initiative
USDA Forest Service Pacific Northwest Research Station, Forest Inventory and Analysis (FIA) Program	Forest inventory, carbon storage, and modeling	FIA Inventory data for California, annual forest carbon reporting
USDA Forest Service Pacific Southwest Research Station programs:		
Ecosystem Function and Health Program	Watershed, wildlife, air pollution, silviculture,	Caspar Creek, Kings River Experimental Watersheds, growth and yield of mixed conifer forests
	forest pathology, forest entomology, urban forestry	2012–2016 bark beetle epidemic documentation, urban forestry studies
Conservation of Biodiversity Program	Forest genetics, wildlife, fisheries, forest ecology	Fisheries studies in Caspar Creek and NW California
Fire and Fuels Program	Forest ecology, forest and fuels management, prescribed fire	Forest fuels reduction studies, Stanislaus-Tuolumne Experimental Forest
Other USDA programs:		
USDA Forest Service Forest Products Laboratory	Innovative wood and fiber utilization research	Environmental impacts of redwood lumber
USDA California Climate Hub	Climate-related topics	Climate-wise reforestation toolkit
USDA Forestry Research Advisory Council	Provides advice to the Secretary on supporting states in carrying out forestry research through land-grant colleges, agricultural experiment stations, and other state-supported colleges and universities; also,	Most recent annual reports have targeted research on social science and economics to better understand how forests address human needs and values; forest products and technology that enhance energy efficiency, carbon sequestration, and community vitality; destructive forest agents

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
	provides advice related to the Forest Service research program.	such as wildfire, invasive pests, and diseases; and responding to climate change through assessment and innovation.
<i>Private Forest Industry Research and Monitoring Programs</i>		
Sierra Pacific Industries	Watershed and wildlife	Judd Creek Experimental Watershed; Battle Creek watershed studies
Humboldt/Mendocino Redwood Companies	Watershed, fisheries, wildlife	Railroad Gulch best management practice Evaluation study, ownership wide studies
Green Diamond Resource Company	Watershed, fisheries, wildlife	Class II Large watercourse FPR effectiveness study, ownership wide studies
<i>University Programs</i>		
University of California (UC) Berkeley	Silviculture, watershed, wildlife, prescribed and managed wildfire	Sierra Nevada Adaptive Management Program (SNAMP), Blodgett Forest Research Station studies, Yosemite National Park studies
UC Merced	Watershed, climate change impacts	SNAMP, central and southern Sierra Nevada studies
UC Davis	Silviculture, forest management strategies, climate change impacts, air pollution	Central and southern Sierra Nevada studies
UC Santa Cruz	Forest ecology	UCSC Forest Ecology Research Plot
UC Riverside	Post-fire debris flows and flooding; air pollution from wildfires	Riverside and Orange County post-fire studies
UC Santa Barbara	Post-fire debris flows and flooding, modeling wildfire risk	Santa Barbara County post-fire studies, Modeling Extreme Wildfire Risk

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
UC Irvine	Prescribed burning, terrestrial ecosystem changes over time	Transforming prescribed fire practices for CA, Center for Ecosystem Climate Solutions (CESC)
UC Los Angeles	Forest ecology, climate change impacts, wildfire modeling	Future of California Drought, Fire, and Forest Dieback Project
Humboldt State University	Watershed, wildlife, fisheries, wildfire hazard	Northwest CA studies
California Polytechnic State University, San Luis Obispo	Watershed, silviculture, wildlife, wildfire hazard	Little Creek, Swanton Pacific Ranch
San Diego State University	Post-fire flooding	Southern CA watersheds studied
Oregon State University	Riparian management impacts, post-fire impacts	Boggs Mountain Demonstration State Forest, Class II Large watercourse studies
Colorado State University	Post-fire impacts, cumulative watershed effects	Kings River Experimental Watersheds, Little River Watershed Study
Stanford University	Aerial detection/remote sensing, wildfire research	Sierra Nevada bark beetle epidemic documentation
Michigan State University	Forests and climate mitigation	Effects on forest management and wood utilization of carbon sequestration and storage in California and the Pacific Coast temperate forests
University of Montana – Bureau of Business and Economic Research	Timber products output	Mill surveys, sawmill energy-use studies, harvested wood product carbon, timber flow analyses
<i>Nongovernmental Organizations</i>		
Blue Forest	Evaluation, and monitoring of the many distinct benefits provided by healthy ecosystems.	Develop, test, and deploy emerging tools and methodologies for quantifying and monitoring the multiple benefits of ecosystem

Research/Monitoring Entity or Agreement	Forestry/Wildland Topic Areas	Examples of Major Projects/Goals
		restoration. Maintain a portfolio of independent research projects to gain new insights into the benefits of well-managed landscapes and environmental finance.
The Nature Conservancy	Forests and climate change.	Wildfires and Forest Resilience: The Case for Ecological Forestry in the Sierra Nevada
Save the Redwoods League	Biology and ecology of coast redwood and giant sequoia forest ecosystems	Investigate the interacting effects of wildfire, drought, and insect outbreak in giant sequoia groves (UC Davis).
American Forests, Northern Institute for Applied Climate Science	Forests and climate mitigation	Effects on forest management and wood utilization of carbon sequestration and storage in California and the Pacific Coast temperate forests.

Appendix B. Typical Funding Mechanisms for Forest Research in California by Sector.

Sector Entity	Example Funding Mechanisms
State	
CAL FIRE	<p>State forests provide research and demonstration opportunities. Common activities on State forests include experimental timber harvesting techniques and a variety of university research projects. Examples of ongoing research projects on State forests include Class II large watercourse monitoring in coastal and Sierran forest systems under active forest management; assessment of hydrologic and sedimentation response following stand-replacement fire; post-fire forest regeneration strategies on forest recovery, fuel hazards and carbon dynamics; and improved growth and resiliency of mid-seral plantations established after stand-replacing fire, and novel silvicultural techniques designed to improve forest persistence in the face of long-term climate change. Board policy indicates that State forests shall be used for experimentation to determine the economic feasibility of artificial reforestation, and to demonstrate the productive and economic possibilities of good forest practices toward maintaining forest crop land in a productive condition. Funding is from the Forest Resource Improvement Fund (FRIF), which derives revenues from State forest timber harvests.</p> <p>CAL FIRE's Forest Health Grant Program awards Greenhouse Gas Reduction Funds (GGRF) for California Climate Investments (CCI) projects in conservation, water supply and carbon storage.</p> <p>Fire and Resource Assessment Program (FRAP) studies alternative management and policy guidelines.</p> <p>CAL FIRE's Forest Practice Program helps fund research on the effectiveness of CA FPRs for protecting watershed resources.</p>
Board of Forestry and Fire Protection	<p>The Board can direct the Executive Officer to prepare Budget Change Proposals (BCP) to fund specific resource topics.</p> <p>The Joint Institute for Wood Products relies on general funds, with a portion allocated to research in wood products development.</p>
California Air Resources Board (CARB)	<p>CARB manages CCI, which is funded through cap-and-trade auction revenues housed in the GGRF.</p>
The California Energy	<p>The CEC's Electric Program Investment Charge (EPIC) program invests in scientific and technological research, including the expansion of bioenergy.</p>

Sector Entity	Example Funding Mechanisms
Commission (CEC)	
State Academic Institutions	U.C. Berkeley's Blodgett Forest funds research through timber revenues and research grants. Humboldt State University and California Polytechnic State University, San Luis Obispo also have research forests that may periodically generate harvest revenues.
Federal	
USDA Forest Service	<p>The Pacific Southwest Research Station develops and communicates science needed to sustain forest ecosystems and their related societal benefits.</p> <p>Forest Inventory and Analysis (FIA) reports on status and trends in: forest area and location; species, size, and health of trees; total tree growth, mortality, and removals by harvest; wood production and utilization rates by various products; and forest land ownership.</p> <p>McIntire-Stennis Capacity Grants managed by the USDA provide states grants to fund forestry research.</p> <p>The Forest Service awards direct grants in areas such as wood products innovation, hazardous fuels reduction, forest management, and community health.</p>
Research Cooperatives	Currently research cooperatives are focused on tree improvement programs, but are also utilized to include growth and yield cooperatives. Nationally, there has been a substantial decrease in forest research cooperatives, and fragmentation of forest products industries and lands has continued to contribute to decreased cooperative research.
Private and Non-Profit Organizations	
Private industry	Private industry funds research, such as research in applied wood products which is funded by large operators in the State to improve operations. The Board can encourage collaborative research to maintain and protect the natural resources that have supported California's robust economy, particularly in light of the elevated or extreme level of fire danger and interactive effects of climate change. One mechanism to do this is via Board designation of "experimental forestland" status (see PRC 4526) to an area to permit increased flexibility in the management practices that may be applied. In particular, resilience projects are essential for California businesses to remain competitive.

Sector Entity	Example Funding Mechanisms
Non-Profit Organizations	Non-profit organizations—such as The Nature Conservancy—may fund research through a combination of approaches, including research conducted by staff, contracted research, and competitive or targeted grants to support research by external entities.

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Appendix C. Forest Health Research Program - Projects Funded Through 2020.

The following table lists all research grants awarded to date (FY 2018–2019 and 2019–2020). Research grants are awarded in two phases, each up to two-years long. The first phase is awarded upon project selection. The second phase is provisionally awarded, contingent upon project performance and funding availability in future fiscal years. Total Funding listed below includes both current and provisional awards.

Award Type*	Organization	Project Title	Principal Investigator	Total Funding
Fiscal Year 2018–2019 Awards				
General	University of California, Berkeley	Keeping fire on the landscape: Consequences for carbon balance and forest resilience	John Battles, Ph.D.	\$454,772
General	University of New Mexico	The Carbon Consequences of Catchment-Scale Prescribed Burning	Matthew Hurteau, Ph.D.	\$396,089
General	University of California, Davis	Impacts of Wildfire and Climate on Ecosystem Services in Southern California: Tool Development and Data Needs	Emma Underwood, Ph.D.	\$285,599
State Forests	University of California, Davis	Effects of salvage logging on the resilience and successional trajectory of high-mortality forests	Rebecca Wayman	\$457,596
State Forests	University of California, Davis	Using UAV's and Big Data to Map Live Trees and Predict Postfire Regeneration	Derek Young, Ph.D.	\$222,165
State Forests	Sonoma State University	Evaluating plot-level remote sensing tools to increase accuracy and efficiency of fuels management approaches	Lisa Bentley, Ph.D.	\$448,552
State Forests	University of California, ANR	Decentralized biomass torrefaction to reduce cost and improve utilization of woody biomass	Daniel Sanchez, Ph.D.	\$353,876

Award Type*	Organization	Project Title	Principal Investigator	Total Funding
Graduate Student	University of California, Berkeley	What's the baseline? Carbon storage in a northern California mixed-conifer forest before fire suppression policies	Clarke Knight (Graduate Student)	\$60,528
Graduate Student	University of California, Davis	Threats for Carbon Storage in High Montane Forests in the Sierra Nevada	Sara Winsemius (Graduate Student)	\$66,892
Graduate Student	University of California, Davis	Tree recruitment and forest expansion following reforestation	Tara Ursell (Graduate Student)	\$61,250
Fiscal Year 2019–2020 Awards				
General	University of California, Berkeley	Implications of increasing the scale of managed wildfire on forest carbon stocks and pyrodiversity	Scott Stephens, Ph.D.	\$422,391
General	University of New Mexico	The carbon consequences of catchment-scale prescribed burning, post-treatment	Matthew Hurteau, Ph.D.	\$499,934
General	University of Nevada, Reno	Assessing smoke-plume injection height as a function of sub-canopy wind convergence of prescribed burns in the Central Sierra Nevada	Stephen Drake, Ph.D.	\$171,145
General	Sequoia Foundation	Public health effects of increased prescribed burns for wildfire management	Sumi Hoshiko, MPH	\$504,496
General	Michigan State University	Evaluating forest resilience and carbon recovery using a chronosequence of co-located pre-, active-, and post-wildfire measurements in California mixed-conifer forests	Jessica Miesel, Ph.D.	\$453,078
General	San Jose State University	Effectiveness and optimization of forest fuels reductions for	M. Zachariah Peery, Ph.D.	\$499,825

Award Type*	Organization	Project Title	Principal Investigator	Total Funding
		biodiversity conservation in a changing Sierra Nevada ecosystem		
State Forests	University of California, Berkeley	Simulating the heterogeneous consequences of widespread forest health treatments for California mixed conifer forest resilience to climate change and wildfire	Lara Kueppers, Ph.D.	\$499,660
State Forests	University of Nevada, Reno	Sierra Nevada-wide provenance trials to support climate-based seed zones and reforestation efforts	Sarah Bisbing, Ph.D.	\$499,745
Grad Student	University of California, Santa Cruz	A physiological approach to assess the resilience of Sierra Nevada forest communities following prescribed burns	Ryan Salladay (Grad Student)	\$88,238
Grad Student	University of California, Davis	Vulnerability in California's carbon stocks: understanding post-fire regeneration in the state's high elevation forests	Emily Brodie (Grad Student)	\$53,836
Synthesis & Tool Dev.	Lawrence Berkeley National Lab	Development of rapid-response post-wildfire water quality sampling guidelines to determine watershed and natural resource asset conditions and priorities for future recovery	Michelle Newcomer, Ph.D.	\$50,000
Synthesis & Tool Dev.	University of Washington	Addressing common misconceptions about dry forest restoration and fuel treatments	Susan Prichard, Ph.D.	\$54,369
General	University of California – Division of Agriculture and Natural Resources	California Fire Probability	Max Moritz, Ph.D.	\$244,643

Award Type*	Organization	Project Title	Principal Investigator	Total Funding
General	Pepperwood Foundation	Vegetation Trends and Cycles in the Fire-Prone Landscapes of Lake, Napa, and Sonoma Counties	Tosha Comendant	\$210,009
General	University of California, Davis	Measuring wildfire impacts and post-fire recovery of shrubland biomass under different climate conditions	Emma Underwood, Ph.D.	\$333,869
Total (2018–2020)				\$7,392,559

*Award Project Types

<p>General: Projects must include original research, and may occur or focus on any land in California that is relevant to the California Forest Carbon Plan, California Strategic Fire Plan, or other large scale forest, fire or ecosystem management planning documents.</p>
<p>Graduate Student: Research proposal must be written by a graduate student, and project must include original research which will be led by the student and contribute both to their program of graduate study and to the goals of the Research Program.</p>
<p>State Forests: Projects must include original research, and must include at least one study site on a Demonstration State Forest or other CAL FIRE-managed land.</p>
<p>Synthesis and Tool Development: Project should be solely or primarily focused on the synthesis of current scientific information and literature, and/or distribution of current scientific data and information for land owners, managers, and the public.</p>

Appendix D Stakeholder Survey Questions

The stakeholder survey of research priorities was conducted between December, 2020 and January, 2021 using the SurveyMonkey online service (<https://www.surveymonkey.com/>). The following are the survey questions and instructions as they were presented to stakeholders.

Section 1: Research Priorities

Introduction: The California Board of Forestry and Fire Protection is required to periodically inventory, assess and report on the State's priorities for forest management research and to suggest needed projects. We would appreciate your input on topics and issues the Board should prioritize moving forward.

Please answer the following questions. Your responses will help guide the development of the Board of Forestry and Fire Protection's updated Research Plan.

Question 1: Please rank the following research topics in order of priority. Topics are presented initially in random order. You can click and drag to prioritize topics, or number each topic in order of priority. Top position (or 1) = highest priority; Bottom position (or 14) = lowest priority.

☰ 3	WOOD UTILIZATION: Facilitating increased utilization of forest products and residues related to fuel reduction, forest health treatments, and forest management; removing barriers and incentivizing use of wood products that enhance carbon storage and reduce GHG emissions, including facility siting; wood products market development.
☰ 8	CLIMATE CHANGE MITIGATION: Identification of forest management and wood utilization opportunities for climate mitigation through emissions reductions, avoided emissions, wood products, afforestation/reforestation, avoided forestland conversion, and/or improved sequestration with consideration for timing of benefits, different global emissions scenarios, and future climate.
☰ 13	HUMAN DIMENSIONS: Examining socio-economic considerations related to forest health and management, including equity issues, vulnerable communities, ecosystem services, and public health; understanding public perceptions and support for forest management strategies; indigenous perspectives on forest health and best management practices in forest management.
☰ 9	LONG-TERM FOREST MONITORING: Long-term monitoring of disturbance regimes, individual pest species, and conditions such as forest extent, structure, composition, productivity and carbon to better understand how forests are responding to changes in climatic conditions.
☰ 1	FOREST MANAGEMENT STRATEGIES: Tradeoffs and long-term impacts of forest management strategies to produce forest conditions resilient to disturbance, drought, and climate change (e.g., different thinning regimes, silvicultural activities, pest management activities, increased pace and scale of vegetation fuel management and forest health treatments).
☰ 10	QUANTITATIVE RISK ASSESSMENT: Development and application of landscape level, multi-hazard risk assessments, decision support tools, and prioritization frameworks that address ecological, wildfire and community risks, as well as risks to vulnerable populations under future climate.
☰ 7	WATERSHED, WILDLIFE, AND BOTANICAL RESOURCES: Forest management and treatment effects on water quality and quantity with climate change. Improved prediction of post-fire responses related to watershed hazards. Vegetative and aquatic responses with varying riparian zone management approaches. Development of strategies for key threatened or endangered plant and animal species (e.g., northern spotted owls), including documentation of how they respond to different forest management activities. Identification of approaches for protecting critical habitat and biodiversity.

(continued on next page)

14	URBAN FORESTS: Development of a comprehensive needs assessment for urban forests. Examination of the costs, benefits, feasibility, and acceptability of expanding and enhancing urban forests using field-based and remote sensing data. Documentation of the effects from climate change on urban forests, and strategies to keep them resilient with a changing climate.
6	FOREST PRACTICE RULES EFFECTIVENESS AND HARVEST OPERATIONS: Effectiveness of California Forest Practice Rules related to management in Watercourse and Lake Protection Zones (WLPZ's) and riparian areas, sediment delivery, wildfire hazard reduction, powerline vegetation management, wildlife habitat, and road systems. Innovations in harvest operations on sensitive landscapes, e.g. tethered logging.
5	WILDFIRE PREDICTION: Improved prediction of wildfire hazard, including wildland fire behavior, weather and climate, near-term fire danger and potential, fire spread in the wildland-urban interface, fire behavior and spread following high severity disturbance, and long-term probability of fire occurrence under climate change and different global emissions scenarios.
12	CLIMATE-INDUCED RANGE SHIFTS: Identification of potential climate-induced shifts in the ranges of forest plant and animal species and identify potential areas of refugia for protecting forest health, habitat, biodiversity, and carbon storage.
4	REFORESTATION STRATEGIES: Appropriate reforestation approaches in areas affected by high severity disturbances (e.g., wildfire, pest and disease induced tree mortality), accounting for future climate conditions, including selection of appropriate genetic seed sources and use of appropriate planting patterns.
2	PRIVATE FORESTS MANAGEMENT: Inform development of strategies on small and large privately owned forestlands that promote resilience, carbon sequestration and storage, and mitigation of wildfire risks, while meeting other landowner objectives. Identifying landowner behavior, barriers, and incentives to adopting forest management strategies.
11	FOREST CARBON: Inventory and quantification of above- and belowground forest ecosystem and harvested wood product carbon pools and flux, and impacts to forest carbon from management activities and disturbance (i.e., prescribed and wildfire, site preparation activities, silvicultural systems, etc.).

We recognize that there is inherent overlap between many of these categories, but feel that certain specific topics warrant their own assessment in this survey. Specific research approaches (e.g., field-based, modeled, etc.) or use and development of specific technologies (e.g., remote sensing, UAV's, etc.) are not identified as these are intended to be broad topic areas.

You will have an opportunity in the next question to suggest different or additional topics.

Question 2: Are there additional research topics that the Board should consider? Please describe below.

Section 2: Affiliation and Expertise

Please answer the following questions about your affiliation and expertise. Your responses will help guide the development of the Board of Forestry and Fire Protection's updated Research Plan. Your name and contact information are optional.

Question 3: What is your primary affiliation?

- Government Agency - Federal, State or Local Resource Management
- Non-Governmental Organization (NGO)
- Academic Institution / University
- Tribal Representative
- Private Landowner (non-industrial) or Representative
- Private Landowner (industrial) or Representative
- Forest Industry
- General Public
- Other (please specify)

Question 4: What is your area of professional expertise? (Choose all that apply)

- Fire Management
- Forestry
- Wood Products and Utilization
- Ecosystem Science
- Conservation Biology
- Water Resources
- Wildlife
- Botany
- Urban Forestry
- Social Sciences
- Resource Policy
- Environmental Protection
- Climate Science
- Rangeland Management
- Archaeology and Cultural Resources
- GIS and Remote Sensing
- General Public
- Other (please specify)

Question 5: Contact Information (OPTIONAL)

Name	<input type="text"/>
Company	<input type="text"/>
Email Address	<input type="text"/>
Phone Number	<input type="text"/>

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Appendix E. Additional Research Topics Identified by Stakeholders

As a part of the online stakeholder survey conducted between December 2020 and January 2021, respondents were allowed suggest additional research topics they felt were not otherwise addressed in the 14 topics presented for ranking. The following table (numbering is only for reference; nor ranking intended or implied) is a complete, unedited, anonymized listing of all stakeholder responses to the following question:

Are there additional research topics that the Board should consider? Please describe below.

1.	Several of these topics already have a lot of research directed their way and finance. BOF and others should consider bolstering finance around ground-based data collection (e.g. soil carbon, stream gauge data) to improve how we assess/analyze landscapes. Lacking ground based data is our biggest limitation.
2.	There really are enough here: they are all vitally important if we are to survive. i didn't answer the wood utilization one, although I believe in an industry of value-added products. I'm very skeptical of wood pellet production: too tempting for producers to use trees that should be allowed to grow up.
3.	Academic and vocational opportunities for the next generation of foresters; health of the forestry profession in this state
4.	WHY IT IS TIME FOR A "CALFIRE DIVORCE": THE CASE FOR ESTABLISHING AN INDEPENDENT FOREST AND RESOURCE MANAGEMENT AGENCY TO SECURE HEALTHY FORESTS IN CALIFORNIA Richard A. Wilson Why Forests Matter Sharon E. Duggan Why Forests Matter
5.	Integration of regional levels plans for hazard reduction with local and state governments
6.	Indigenous ecological knowledge
7.	Along the lines of the human dimensions I am interested to see more research into the economic and workforce dimensions of forest management. How many forest workers and how many foresters and other professionals do we need to accomplish the goals we have set out for the state in our existing goals and plans for forest management? How do we get the right people in the right places to address all the issues listed above? Where are the gaps and how do we get them filled with those who have the right skills and knowledge? How do we actually get work done on the ground and keep from bloating the bureaucracy even more?

8.	Wildland Urban Interface hazard fuel mitigation methodologies; How to empower private landowners and fire managers with the knowledge and tools to go beyond defensible space for hazard fuel reduction at neighborhood and community level. Structural retrofit in WUI: Methods, materials, technology, and outreach to increase the retrofit of existing buildings to increase ignition resistance and survivability. Use of Unmanned Aerial Systems (UAS) in hazard fuel reduction and fire management: Investigate the expanded use of UAS in planning, intelligence gathering, monitoring, and management of wildfires and fuel reduction projects
9.	There is no scientific evidence supporting wood utilization as a climate mitigation practice. The State of California needs to embark upon an independent third party scientific evaluation of the the validity of documents like the California Forest Carbon Plan. The framing of these research questions is based upon erroneous assumptions and flawed science. It is long past time for state agencies to provide the concerned public the tools and the political power to address the capture of state agencies by extractive industry.
10.	Enforcement of FPA with accountability (license suspension) when RPF or Licensed Geologists claim no cumulative impacts and then are proven wrong by landslides, lack of regrowth and the like
11.	Yes. The BOF should closely examine recent California legislative changes which grant utilities far too broad permission to access lands and remove vegetation, including trees, while giving property owners very little right of protest or access to a hearing. While the protection of power infrastructure is necessary, the current approach emphasizing tree cutting over equipment upgrades is deeply flawed and leaves forested lands vulnerable not only to fire but to human-caused environmental degradation as well. These policies will not in the end provide sufficient safe guarding for utilities, but they will hasten the destruction of irreplaceable habitat for utterly misguided reasons.
12.	Maximizing long residence time carbon sequestration while improving site productivity and eliminating emissions from management activity and fires
13.	** Optimum standards for sustained yield compliance for all acreages with an emphasis on reaching exceeding culmination of mean annual increment for large portions of forested areas ** Optimum formats for information regarding forest and watershed conditions, and effective implementation and standards for recovery measures ** Optimum and effective public transparency, participation, and multi-generational engagement in forest and watershed management

14.	<p>LOG IT TO SAVE IT. Commercial logging or the combination of logging green trees after wildfires or natural die-off of a substantial amount of forest canopy could have a devastating effect on owls and fishers and the forest ecosystem and would exacerbate climate change. Rather than adapting to climate change, the Board of Forestry must stop enabling climate change to occur by prohibiting the use of fossil fuels to implement forest management practice and stop enabling forest management practices that pollute the air and water and reduce the ability of the forest to sequester carbon. The Board of Forestry must consider all the climate impacts of all of its forest management practices and consider the science that indicates these forest management practices are not beneficial to the forests, the hydrologic function of the watersheds, and the above-ground and below-ground species that inhabit these ecosystems, are not beneficial to drinking water quantity or quality, the air we breathe, or the global climate. But there are other reasons to research for science that questions forest management practices and the entire fuels reduction program. LOGGING WOULD DECIMATE THE AREA AND REDUCE THE HABITAT FOR ALL SPECIES. Logging causes the sun to shine on the forest floor, causes the forest to become hot and dry, causes brush to grow where the trees once stood, and causes winds to increase, which all increase, not decrease, fire risk. https://training.nwcg.gov/pre-courses/s290/Fire_Weather_Handbook_pms_425.pdf LOGGING IS NOT HARMLESS. Most thinning/logging operations, including the equipment being used and the transport of equipment, personnel, and biomass materials, cause other damage like, soil compaction, disturbance of wildlife, the spread of weeds, road construction that fragments forests, causes sedimentation of streams, causes damage to roads outside the forest, and releases more carbon and methane into the air we breathe. Science indicates that fuel reduction benefits are usually negated in 3-10 years by new growth of fine fuels — fallen needles, shrubs, small trees and so forth. And while there's money for logging/thinning, there is less funding available to do the required maintenance. So even if effective immediately after treatment, effectiveness declines rapidly. CENTURY-LONG FIRE CYCLES ARE COMMON IN WESTERN FORESTS. Most forest types, which are most of the annual acreage of forest burned, have long fire intervals — often a hundred years or more — between blazes. So the probability that any fire will actually encounter a fuel reduction treatment in the time when it's effective is exceedingly small. However, all fuel treatments, while they may occasionally slow or control blazes under moderate "fire weather" conditions, usually won't stop the large fires burning under severe "fire weather" that are the real threat to western communities. Severe fire weather conditions include drought, high temperatures, low humidity, and most importantly high winds. If you have high winds, you cannot effectively control a blaze. Most fires burning under low-to-moderate fire weather conditions will self-extinguish or are easily controlled. However, under severe fire weather, nothing works. Thinning and prescribed burning usually fail to alter the</p>
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	<p>outcome for the largest fires burning under severe fire weather. LARGE, INTENSE FIRES ARE IMPORTANT FOR ECOSYSTEMS. Plus, large high-severity fires are critical to healthy forest ecosystems. Severe fires provide woody debris that maintains soil nutrients and habitat for species like insects and salamanders. High-severity fires provide snags that are valuable for birds and mammals for feeding and homes (cavities). Burned forests also store carbon and nutrients. Ecologically speaking, thinning impoverishes our forest ecosystems, while large wildfires enrich them. "Timber harvest, through its effects on forest structure, local microclimate, and fuels accumulation, has increased fire severity more than any other recent human activity." (Sierra Nevada Ecosystem Project, 1996. Final Report to Congress https://www.loc.gov/item/97116669/) HOME PROTECTION MUST BE THE CONCERN OF AND COULD BE FUNDED BY THE BOARD OF FORESTRY. No one wants to see a home threatened by wildfire, but we can protect homes without destroying our forest ecosystems by logging and hazard tree removal beyond 200-feet from homes, structures, and access/escape routes. For homes already constructed in the wrong places, reducing the flammability of homes is proven highly effective. Metal roofs, cement siding panels, cement decking, screened roof vents and under decking, removal of flammable materials from eaves and around the base of the house, and building a modest masonry wall that can keep surface fires from burning at the base of a home are only a few of the proven methods that can save a home from wildfire. Some spacing of decorative vegetation in the 200 feet immediately surrounding and adjacent to the home and prescribed surface burning on the edge of the community can help, only if regularly maintained and strategically done to disconnect fuel from the home and structures. For homes already constructed in the wrong places, reducing the flammability of homes is proven highly effective. Metal roofs, cement siding panels, cement decking, screened roof vents and under decking, removal of flammable materials from eaves and around the base of the house, and building a modest masonry wall that can keep surface fires from burning at the base of a home are only a few of the proven methods that can save a home from wildfire. Some spacing of decorative vegetation in the 200 feet immediately surrounding and adjacent to the home and prescribed surface burning on the edge of the community can help, only if regularly maintained and strategically done to disconnect fuel from the home and structures.</p>
15.	<p>Proforestation science that is now circulating as to the best way to utilize forest management to combat the existential threat of global warming. Also an overhaul of the FPR's. Especially the cumulative effects section of THP applications. A whole watershed approach is needed, not using the flawed planning watershed technique now employed. Post harvest monitoring is lax to non-existent. Especially with NTMPs. Multiple landowners on one NTMP is a bad policy to allow. It is like having multiple people on one driver's license. Accountability is next to impossible to enforce.</p>

16.	County mitigations which do not conform with fire regs on development
17.	Undergrounding utility lines through forests where possible. Where not possible, upgrading all lines with triple-insulated steel reinforced aluminum cables with updated breakers that shut down voltage when something lands on the lines.
18.	While not necessarily new topics, other issues that could be incorporated into the above topics are extent and impacts of herbicide use to control vegetation growth in forests and also extent and impacts of recreation in forests.
19.	The Board of Forestry and Fire Protection should take the lead on a RPF-led approach to use empirical data to document what sustainable forest management in an era of changing climates should look like. Many other state agencies and sponsored task forces seem to be taking random ideas , ignoring all empirical data, and essentially practicing forestry without a license to the detriment of our forests, the global climate, and our residents. An RPF-led scenario will align much better with current IPCC guidance on forestry and avoid the trickery that has been unfortunately documented in some forest offset schemes.
20.	effects on watersheds from the arborist work post-fire. How do post-fire activities that are not regulated by CAL-FIRE effect watersheds as they do not follow California Forest Practice Rules but by defiinition fall within the jurisdiction of them while timber companies and timberland owners cannot sell their wood due to no legitimate competition in the market and a flooded market from Arborist cut wood (they're already making \$2,000/tree plus or minus.) How would biomass facilities effect a landscapes ability to become and stay fire resilient? Develop that market so communities can reduce fuel without so much reliance on grant funding and the such.
21.	Look into the success of “Collaborative Groups “ ie; Yosemite Stanislaus Solutions, a group formed after the Rim Fire (2013) and the Master Stewardship grants to guide forest management. Emphasize the natural processes of lightning fires and indigenous peoples and early ranching.
22.	1. Adaptive pre and post fire maintenance practices to mimic fires role in landscape to reduce extreme fire behavior. 2. Optimization of risk reduction benefits associated with mandates of PRC 4291-4293
23.	creating jobs in poor, rural areas through Forestry, the effects of prescribed fire on reducing wildfire intensity
24.	Wildfire Protection of citizens and property

25.	Wildfire prevention not simply prediction seems to be missing. Also, there is not mention of cumulative effects which seems to be huge omission and may need to be specifically addressed in each research project area. Long term monitoring should be required for each topic area, as well. Human dimensions should also be integrated into each research topic. I had a tough time ranking these as they are not mutually exclusive and interdependent. Perhaps seeking integrated research projects addressing the highest priority issues, such as wildfires, and cumulative watershed impacts need to be the highest priority.
26.	The future recruitment of RPF's and how to make the industry a desired profession for years to come. There are less and less foresters helping and wanting to help non industrial private landowners because of the difficult procedures and regulations in this state. How do we make this more desirable?
27.	Construction of homes, cabins and other structures in a wildland setting.
28.	Prescribed burning smoke affects and regulations vs wildfire smoke. Weighing risks promoting treatment of ground fuels
29.	Valuation of ecosystem assets to enable forest managers to achieve economic goals and all those other wonderful management attributes outlined in the Zberg Nejedly Act
30.	Use of targeted livestock grazing to better manage fine-fuels and fire spread
31.	Consequences of continuing to do nothing. Forest management is often challenged via CEQA, often ignored is the do nothing approach. The lack of management on federal lands is coming back to bite us. Excessive build up of fuels and over dense forests leading to extreme drought mortality and insect and disease problems along with increasingly catastrophic fires. Sustainability is an issue often raised to challenge harvesting. Is the current rate of fires sustainable?
32.	Focus on rebuilding and promoting forest product utilization (mills, biomass facilities, new product development) to allow increased forest management. Without forest product utilization infrastructure, any expansion in California forest management will be prohibitive.
33.	Alternatives to pesticides for vegetation management.
34.	the Board should focus on removing cumbersome regulation the at is not beneficial to resource utilization and protection.
35.	Effects of National Forest mis management on non federal ownership. Creating an avenue where national forest managers are held accountable for non- stewardship and causing damage and devastation to private ownerships. This is not in the name of

	seeking financial repercussions but to have a say in the management of federal lands in order to protect private lands.
36.	Widespread tree mortality in the East Bay (SF Bay Area). Primarily in acacia, eucalyptus, bay laurel, coyote brush and others.
37.	Efficacy of conservation easements to protect related watershed, wildlife. Oak woodland protection.
38.	Stocking standards for MSR (Maximum Sustained Resilience)
39.	Grazing should be incorporated into several of these areas explicitly. Fire is the most important issue; all tools should be brought to bear. Grazing take place on 25 million acres and removes about 12 million tons of fuel from woodlands, grasslands and forests in CA each year, but we need to learn how to do it specifically for fire hazard reduction and to maintain prescribed burns. We are also going to lose animals if we don't incentivize grazing so that people can stay in business. We already don't have enough. How does 25 million acres compare to what is being done with thinning and prescribed burning? It is not smart to ignore this.
40.	Potential barriers to forest practice rules inhibiting ecological restoration opportunities in historical rangelands that have experienced conversion due to fire exclusion.
41.	Expand State Seed Bank Inventories and Develop an Improved Seed Program for Statewide Reforestation Needs.
42.	I would like to see some research in fuels management alternatives and actual firefighting techniques. Maybe the whole methodology of wildland fire fighting needs to be reassessed.
43.	Effects of smoke (from prescribed fire and wildfire) on human health. Effects of regulation (state & federal) on private forestland ownership & land use patterns by region.
44.	Cost/benefit of augmenting firefighting budget VS augmenting home ignition zone budget and/or wild land fuels mgmt. budget
45.	Corrections or tweaking of FPR's to truly deal with fuel loading. For example Forest Fire Prevention "Exemption" has too high of basal area retention in some instances to get crown separation of trees for real fuel reduction.
46.	We need to simplify and encourage reduction of woody biomass to alleviate wildfire severity
47.	Specifically, reforestation strategies that focus on short term and long term fire resilience.

48.	As landowner of a non industrial forest, we would like to see a simplification of government regulations and monitoring. We do support the state rebuilding the timber industry and its infrastructure.
49.	Almost all of the research on forest health is conducted west of the crest of the Sierra, but there are forests on the east side of the crest as well. This area needs more study, at the very least to confirm what conclusions about the west side apply to the east side.
50.	stump sprouting of redwood trees
51.	Workforce development; economic impacts to counties by owners of TPZ lands that have NOT logged in last 30 years and whether those owners should be required to log by a certain date; effectiveness of various fuel treatment regimes in reducing adverse fire effects.
52.	Wildfire reburn survey across CA. Where, extent, periodicity. This was a recognized curse in the early 1900s. Also, why USFS has largely abandoned going direct in fire suppression and extended attack? Comprehensive survey via literature review of what is already known and when. I submit we know who to do given more than 150 years of forestry efforts, formal education, and research in CA. Nothing matters until we reign in the CA wildfire pandemic - the natural resource issue of our time, ramp up Rx burn, more commercial thin and biomass, and resurrect wood processing including biomass. Ultimately this depends upon the USFS which CA can interact. Respectfully, Scott Warner CA RPF 1955
53.	Grouped with wildfire prediction: fuel mapping/monitoring
54.	Biofuels: harvesting, transporting, and utilizing. Benefits of use of biofuels in carbon offset and fire hazard reduction.
55.	implementation of forest thinning and burning at the landscape scale to reduce wildfires
56.	How to stop duplicate regulation. There are too many agencies for each permit required. Decide which agency is going to handle culverts or other stream crossings etc. Too many costs without having a benefit. Too many environmental regulations can be counterproductive. Building a Farm Employee dwelling and placement is being dictated by road construction costs. We cannot afford to place the house where it would be best sited for fire danger as it would be required to be paved. Paving would cost more than house construction. The survey is very unclear on what course of action is being favored based on number given. When I get surveys from politicians to rank how important something is to me gun control is sometimes on the list. I am a Second Amendment supporter so this issue is high in importance to me but I am against any more gun control laws. You need to study how many beneficial practices

	landowners are stopped from doing due to total permit costs, as the engineering and biological studies etc. often far exceed to stated permit cost.
57.	Total interaction between Forest Practice Rules, Endangered Species Act, Fish and Game Code, and Porter Cologne Water Quality Control Act (Basin Plans). I feel the Board of Forestry has done a great job at reducing the barriers for active forest management but the other agencies are expanding the interpretations of their authorities to counteract that positive momentum. The sum total of applying all these laws on forest management projects produces a chilling effect on management that is beyond what any of the laws intended, in my opinion.
58.	Cost share programs for small forest owners and the ability to attract those owners to the programs involving forest management.
59.	Forest management best practices. Fuels reduction. Financial support of non industrial forests. Simplify regs. Support to rebuild timber/biomass industry infrastructure. Discourage excessive monitoring and quantitative measurement.
60.	Understanding the American ethos for camping, and the use of campfires, it may time to ban them in forests. As a wilderness ranger, I have found too many fires left still smoldering. With the advent of small LED camplights, this reason for fires is eliminated. There will be opposition to this idea, but with so many fires started by campfires, the cost is too high to not begin the discussion.
61.	Impacts of double standard created by the USFWS/CDFW "guidance" for northern spotted owl incidental take avoidance as applied to non-industrial timberland when compared to what the USFWS Biological Opinion for the Green Diamond HCP considers are the actions that constitute take under the Incidental Take Permit for NSO. One document is considered "Guidance" by the USFWS, while the other is a biological analysis required by the implementing regulations of the Federal Endangered Species Act. Yet the "Guidance", which contains no analysis whatsoever, is what is applied by CDFW. This is an enormous problem for the non-industrial timberland owner clients of CALFIRE. Please consider reading the Biological Opinion for the current Green Diamond NSO HCP. Thank you.
62.	Increasing funding sources for small landowners that would help with forest health, wildlife enhancements, and use of exemptions such as the oak woodland exemption for timber harvesting.
63.	The economic ecosystem behind achieving these goals. For example - Working with the CUPC and other agencies to identify where Cogen plants could be usefully fit into the grid, and have sufficient wood basins. This would improve fiscal viability of small diameter management, improving long term wildfire resiliency and encourage

	management of small ownerships, while also it could be a place for carbon Monies to be put to use.
64.	I still believe that there is a stronger need for management strategies to address adaptation to climate change, rather than mitigation. Climate change is certain, regardless of the cause.
65.	This might be related to the Human Dimensions topic but if we're serious about managing our forests, creating employment and educational opportunities and serving all Californians then we need to create access to a more ethnically diverse forestry work force.
66.	All of the above subjects should be balanced with input from USFS ,at least in our area of Northern California, since our boundary's are so extensive.
67.	Cumulative effect of added regulation on small or medium sized land owners. Are regulations driving a transfer of acres from small or medium sized landowners to large companies that have the resources to navigate the ever increasing regulatory environment of California forestry?
68.	How does approval of logging, road construction and road reconstruction on landslide terrain, including earthflows., impact the rate of landsliding and sediment delivery to streams? Do the current FPRs adequately protect landslide terrain?
69.	Oak woodland and savanna education of importance and conservation. Every county should have strong oak protection. Just planting a replacement takes too many years to replace what's destroyed. We NEED our oaks preserved for animals, climate change, fire resiliency and more!
70.	Research how to reduce meaningless green tape from regulations so small forest landowners can cost effectively manage their forests. Trying to do a small prescribed burn on a couple of acres. Why do I need environmental documentation to do a small burn??
71.	Cumulative Impacts Assessment process: Among the most pressing of issues to be researched: Establishing baseline measurements and thresholds of significance for all potential cumulative impacts area to assure that findings of significance or non-significance are based on data and not on opinion or conjecture.
72.	Stream line the NTMP regulations including owl calls 2 years in a row to harvest. This plan was designed to be flexible to react to market conditions. If you don't call every year, you can't react to a high log price. I still say dope growers have killed more NSO than logging, and suffered no consequences. Just why don't dope growers have to call NSO. Owl calling should be specific to each NTMP in regard to who your neighbors are, for example State Park, Comercial timber land, dope growers. A 40 acre NTMP

	shouldn't be a stand alone entity when you are surrounded by Humboldt Redwoods State Park on 2 sides and Humboldt Redwood Co. on the other 2 sides.
73.	environmental impact of marijuana growing by neighbors. water pollution, water use from streams and aquifers, soil pollution from use of chemicals, increase traffic on country roads and other negative impacts of marijuana growing such as attraction for criminal activities such as criminal raiding and stealing of ripe plants, violating of laws
74.	reform the evaluation of cumulative impacts
75.	The relationship between the FPR stocking standards and long term fuel loads for wildfire hazard. What role do the stocking standards, if any, play in creating overstocked forests? What are appropriate stocking standards if we are trying to grow and manage forests that are fire resilient and might have a chance of surviving an extreme wildfire? Do the growth and yield requirements for non-industrial landowners prevent the creation and maintenance of fire resilient forests? If we know that we need fewer trees in CA forests, how can we reduce barriers to achieving that?
76.	Compare historic data, company cruise info, GLO notes, photos. Etc to current stocking levels.
77.	Keeping markets for forest product open. If we can't sell our timber, we can't afford to hang onto our land. Do you want private timberland sold and converted to more intensive, less environmentally friendly uses ?
78.	White Pine Blister Rust elimination
79.	Grant opportunities for research surrounding subjects of wildfire prevention. SBA loans for mills.
80.	Simplify and streamline regulations to allow private landowners to manage private land and timber resources...inform landowners do not dictate to them.
81.	Evaluate which cities and counties enforce PRC 4291 or timberland conversions for home building permits and how non enforcement of regulations for these homeowners effect catastrophic wildfire and insurance
82.	This survey is a pain to fill out. I attempted many times to complete as asked, however the ranking criteria continued to auto correct and change my answers. Also, The categories nearly require a translator- or lawyer-to really see what is being assessed.
83.	The impact the cost of a THP is having on forest management.
84.	Government support to rebuild timber mills, biomass facilities, and other forestry-related infrastructure so that timber markets can thrive and pay for active forest management and forest fuel reduction. Small nonindustrial forest landowner funding increases will be key to reducing catastrophic wildfire in future.

85.	Fire detection (satellites, etc.)! Invasive non-native plant & animal removal. Stopping habitat destruction (trail-building, mountain biking, road-building, dam-building, etc.).
86.	Restoration of Salmonid spawning and rearing habitat and flows temperature monitoring.
87.	Enforcement of the rules and discipline of foresters. Enforcement is virtually zero. Forester misconduct is ubiquitous and CalFire is doing much of the work for them at great expense. CalFire refuses to refer them to the Licensing Committee of the Board. The Board and CalFire view the timber industry as their client. Their client should be the general public!
88.	Forest Management: Producing and transporting low value forest products and debris in a cost-effective manner
89.	The Board should really be looking at how and what a public information program looks like which is lead by the state to educate our public who is anti-forest management!
90.	-Use of the 100 year horizon as an outcome target is bogus. That leaves way too much room for fake estimates. None of the people making those estimates will even be alive in 100 years. Use a reasonable time frame, so that foresters who present lies and fake information can be held accountable. -Regional specific definitions of resiliency and potential and intended outcomes need to be developed. Currently there are no standards or sufficient science to support planning.
91.	Focusing forest management for water resource conservation and delivery
92.	Just a comment. Note that I have rated items such as 14, 10, 11 & 12 near the bottom. This is not because they are less important than say items 1-5, but because if we do not address the immediate threat of poor fuels management on a LANDSCAPE BASIS, then there will be no need for study of these other forest factors. The resource will be gone or changed to a lesser state both biologically and economically. We must recognize that without economic vehicles to treat the problem with responsible management then addressing climate change and associated biological/ecosystem problems will be very difficult to say the least.
93.	Within the realm of 'Human Dimensions', please research/investigate the existence of unprofessional activism, masquerading as science, being perpetuated by a small cabal of managers & supervisors within a CNRA department entrusted with what is supposed to be science-based & legally appropriate (i.e., devoid of 'underground regulation') review of timber harvesting plans under the Forest Practice Act.

94.	As acknowledged, these topics are broad and overlapping. Two thoughts: 1. Please consider some additional questions to really explore the subject matter here. I think your RPF community would be willing to spend more survey time providing you more detailed and perhaps focused input. 2. I really didn't see a Policy theme here. I think the BOF should prioritize research on barriers (e.g. regulatory, economic, social) to forest management in the state and policy changes to overcome these barriers. Lastly, thank you for your consideration and your efforts to query this community of professionals.
95.	Regional specific definitions of resiliency and potential and intended outcomes need to be developed. Currently there are no standards or sufficient science to support planning. Science needs to be developed – based on history and experimental applications – to make determinations on how planning and treatments may be applied. Use of the 100 year horizon as an outcome target is not appropriate for managing attainment of short or long term goals. Reporting, and modeling, need a standards upgrade – so the Department can make determinations as to the state of current and potential future inventories and stand conditions. It has been reported that analysis and data supplied to the Department is insufficient or inaccurate (documents from Chris Moranto), and does not allow for accurate determinations. Thus, the Department is running in the dark on this subject.
96.	Mitigation Measures: Defensible space, building materials, and more stringent wildland urban interface building codes.
97.	Impacts of more stringent codes, building construction materials, and effectiveness of defensible space measures.
98.	Pyrosilviculture: Exploring silvicultural strategies for optimizing the incorporation of prescribed fire in the future. Finding tradeoffs between prescribed fire and other values such as timber and carbon. Human dimension research into professional education of foresters in conducting prescribed fires.
99.	Fire ecology. Research that promotes understanding of ecological effects of wildfire and prescribed fire. Use of prescribed fire to manage fuels and manage timberlands.
100.	Post Fire Restoration
101.	Research to assess the consequences of management and risk averse decisions on long-term forest conditions. Research to develop wildfire defensible landscapes. Research to make aquatic systems more productive for salmon and trout.
102.	Update FORSEE to better capture growth models in uneven aged silviculture, make this information publicly available, use this information to inform decisions on forest management for climate resilience and sustained production of wood products.

103.	Not so much a research problem but rather a policy issues that crosses Department and Agency boundaries such as Cal EPA and CPUC. Regarding some of the above categories (wood utilization; Private Forests Management; and Forest Management Strategies) there is the issue of infrastructure to accommodate the addition material that would be generated by better or expanded utilization of small logs and wood fuel biomass. The needed infrastructure will require millions of dollars in investment. However, that investment will not come without some certainty regarding the regulatory environment climate in California. There is a reason California no longer has a plywood lay-up plant; or that over 30 wood fired electric generating plants are closed; or why we do not have an OSB plant.
104.	One big factor in all of this is the cost of transportation. I have yet to hear why trucks in WA and OR carry 30% more per load with longer/more trailers that do not affect road or bridge maintenance (because they have more axles). Changing this one thing would significantly tilt the balance for low-value wood products from the Central/Southern Sierras. I understand it involves Caltrans, but this needs to be a focus. Specifically on the Wood Utilization topic, I think BOF could fund research into masswood products and densification technologies that use the Ponderosa and Juniper pines that currently have low economic value. Another idea could be developing a plug-in developed for CAD programs that converts dimensions of standard/template building designs based on Doug fir into structurally equivalent beams made from Ponderosa/Juniper (basically, all the structural beams and wall framing goes from 4x4s and 2x4s using Doug fir to 6x6s and 2x6s using Ponderosa). A third idea is to demonstrate automated and electrified equipment. A fourth is to look at the beneficial effects of applying biochar back into the forests, simulating the effects of historical low intensity fires.
105.	Post Fire Recovery: Immediate actions to minimize the downside impacts of doing nothing, recovery and restoration Process improvements to speed all positive activity, CEQA / NEPA approvals, Categorical Exemptions post Fire Definition of healthy forests Definition of Success for Task Force
106.	Converting softwoody biomass to higher value, market-based product
107.	Economic Analyses with the first study focused on doing up front forest management to reduce risk of stand replacing fires and threats to local communities as a means to reduce fire suppression costs. We spend some \$500,000,000 (i.e., 1/2 Billion dollars) to put out the fire, what would happen if we spent \$100.000,000 to undertake forest management activities designed to reduce fire suppression costs!!! I wonder... We are so short-sighted
108.	Research is needed on new strategies, methods, and equipment for fire fighting

109.	Expanding geospatial data to support many types of analysis. One meter lidar should be available for all forestland in the state.
110.	Promote all timberland (PRC 4526) owners, either by incentivizing or punitive measures, to conduct fuels reduction operations.
111.	Effect of Land Use Change on Forestlands: Quantify the historic effects of land use change on forestlands from pre-European settlement, approximately 1840, population estimated around 200,000, to today, population estimated around 40 million and the resulting degradation of forest health. Starting with changes in prehistoric fire return intervals pre 1840 from natural ignitions including native American burning practices from: settlement, timber extraction 1850s to early 1900s (often utilizing dysgenic selection leaving poor quality stock to seed cut over area), wild land fire suppression starting early 1900s (reducing natural fire regime with regards to annual acres burned), zoning changes and counties encouraging development in the forestlands to increase property tax revenues, state legislation (California Forest Protection Act 1905), federal legislation (Land Transfer Act 1905, Weeks Act 1911, Clarke McNary Act of 1924 which allowed Federal officials to cooperatively work with State officials for better forest protection, chiefly in fire control and water resources), WWI, the Great Depression (state labor camps for project implementation), WWII and resource needs, post WWII housing boom and movement into forestlands, environmental movement of the 1960-80s and resulting less treated acres, primarily on federal lands. The land use impact of an increase in population from 200,000 to 40 million over 180 years would be more understood and encourage a more relatable approach to developing mitigation measures to overcome our current largely unhealthy forest condition.
112.	Oak woodland restoration effectiveness - what works, what doesn't, and how do you identify restorable oak groves vs ones that are too far gone. Analyze strategies for more cost effective fuels reduction - state subsidized equipment and crews, regulatory bottlenecks, barriers to grant funding? (in other words, we have a lot of uneconomical thinning to do - what will it take to get it done?). Look at ways to harmonize silvicultural prescriptions and harvest layout with follow-up prescribed burning.
113.	Wildfire and post-fire management effects on water quantity and quality. At present, we have limited knowledge about the effectiveness of the various post-fire management approaches.
114.	Are Forest Practice rules cost effective? Costs to prepare environmental documents for small owners are prohibitive. therefore no management on these properties.

115.	Note: I did NOT order these topics, the program did. I strongly suggest that you study/investigate the level of current and projected sustained yield or is projected to be vs a true "maximum" potential. Also, please examine and evaluate the current monopoly situations in both the pine and redwood regions and the resultant impact upon small owners and rural towns. Lastly, look into effective strategies to protect rural towns and neighborhoods from wildfire along with recommendations to CALFIRE and USFS/BLM concerning response time improvements.
116.	Education and Inspection of WUI areas intensified. Grants for Counties to use for Code Enforcement of 100' defensible space.
117.	Staffing and coordination necessary to support a restoration/proactive forest health management program when fire suppression will continue to require so many resources into the future.
118.	Adding additional equipment and resources
119.	Develop and utilize fire behavior information around communities to determine priority wildland firefighting resource allocation based on where a fire is likely to go under normal predictable weather conditions. Current practice seems to focus on proximity of fire starts to communities, not necessarily likelihood of fire reaching communities from further away. Put them out before they become too big to handle as they approach communities.
120.	Forest Carbon measurements should not be required on all timber harvesting plans as this is a huge waste of time and resources. This can be done through a few sample surveys based on the silvicultural system applied.
121.	Additional resource conversion facilities around the state are needed. Without sawmills, wood based power plants, etc., there are fewer options for timber owners to manage properties. Over time, previous facilities have either folded up or moved to a more business conducive state. Especially when federal timber is added to the CA supply- there are not enough facilities to handle the wood volume. We need to research/address why there is a lack of capacity to handle CA's resource needs. Another topic has been the ongoing attrition of practicing RPFs in the profession. There has been an availability problem for awhile, and we need to get serious about why this is occurring and how to correct the problem. The USFS has been requiring RPFs to oversee their projects for a few years now, and with the ongoing private sector needs, there are not enough RPFs to effectively handle CA needs. The BOF has recognized this for some time and has been working towards recruiting, but the current number of practicing RPFs is still deficient. This would be a research project of value.

122.	Methods/treatments to increase forest soil health and productivity (ex. AWC, mineral content, infiltration and water holding capacity) and to provide incentives to forest landowners to adopt these methods/treatments. Especially investigate use of fuel reduction slash and dead trees killed by wildfires.
123.	Potential State cost savings of funding a Douglas-fir mill in remote areas with subsidized logging targeted at climate and fire resilient stand outcomes.
124.	Benefits of Grazing grasslands to slow the spread of wildfire, also the benefits livestock have in forestlands. Not one research topic includes grazing.
125.	Efficient cooperation and communication between review team agencies (Cal Fire, CDFW, CGS, Water Boards, etc.), multiagency oversight of EM/EX and conversion projects
126.	Get rid of the cumbersome Forest Practice Rules and start over. Keep the rule sections of 912, 913, 914, etc. and let the forester decide and prove how to meet the intent of those rule sections. Less writing. More proof on-the-ground!
127.	How the lack of forest management on Federal Lands has significantly impacted the private landowners of California.
128.	1. Wildland fuel models for current California wildland fuel complexes that are specific for the Fuel complexes present within California geographic regions for the predictive modeling necessary for successful prescribed burning project planning.
129.	1) State of Emergency Action wherein until overall California State Forest Health restored - Federal Public Lands subject to CEQA rather than NEPA 2) Develop Federal Public Lands commitments of forest fuels materials to long-term (10-year+) contracts wherein power producing biomass plants would be constructed and operated - Reducing fire intensity & spread - Increasing available electric power to the grid
130.	PG&E. North Review Team accepts exemptions from PG&E stating PG&E is the timber owner. PG&E subcontractors can use this to bully small landowners into the loss of their timber. PG&E and timber is just bad - all around. Regular maintenance inspections continue to trim trees, as opposed to removing them for sustained work, while the arborist technician completely misses the true hazard trees
131.	This list is so long and overlapping the ranking is probably not a very useful measure of the priorities
132.	Non-native, invasive species, including plants, insects, and pathogens--(1) policy options to prevent introduction, (2) optimal management for containment, (3) education and outreach strategies for public awareness