FINAL REPORT

Title: **Coproduction of Wildland Fire Science: Models to transform the way fire science is applied**

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List of Abbreviations/ Acronyms

EPA- Environmental Protection Agency
FASMEE- Fire and Smoke Model Evaluation Experiment
FON- Funding Opportunity Notice
FSEN- Fire Science Exchange Network
GRIN- Graduate Research and Innovation Award
JFSP- Joint Fire Science Program
R&D- Research and Development
RxCADRE- Prescribed Fire Combustion-Atmospheric Dynamics Research Experiments
TREE- Travel, Research and Education Experience Grants
TREX- Training Exchange events
USDA- United States Department of Agriculture
USGS- United States Geological Survey

Keywords

Actionable science, coproduction, extension, fire managers, fire science, funding, partnerships, prescribed fire.

Acknowledgements

This project would not have been possible without the leadership of John Hall and the JFSP Board Advisors. This group worked with our team to craft an agenda for the successful workshop. John's embrace of the coproduction concept followed the pattern of JFSP leading in national (and international) fire science and its applications. We appreciate the contributions of David Bruce, Mark Brunson, Linda Chappell, Eamon Engber, Carolyn Enquist, James Furman, Bil Grauel, Sarah Hamman, Sharon M. Hood, Molly Hunter, Leda Kobziar, Terrie Jain, Jim Menakis, Roger Ottmar, Toral Patel-Weynand, Carl Petrick, Bert Plante, Matthew Reilly, Hugh Safford, Doug Shinneman, Nick Skowronski, Andi Thode, Sarah Trainor, Phil van Mantgem, Jeremy Webber. Additional discussions with Matt Rollins, Janean Creighton, Frank Lake, and Carrie Berger were insightful. Diane Williams facilitated the Workshop. We thank Becky Jenison for assisting with travel and arrangements. We thank Nick Skowronski, who followed the workshop with a prescribed fire science event in New Jersey focused on coproduction.

Abstract

"Coproduction" as a transformative model for fire science application is receiving increasing attention as wildland fire managers face increasingly complex contexts for prescribed fire applications and wildfire suppression (Hiers 2017). Among natural resource disciplines, fire management was featured heavily in a recent call for the development of translational ecology as a means to facilitate coproduction and boundary spanning in complex future conservation contexts (Enquist et al. 2017). While increasing examples of the need for coproduction are emerging from local partnerships, organizations, and research (Beier et al. 2017), as yet there is no business model for how research funding agencies can overcome the significant barriers to coproduction embodied in the disparate incentives and reward structures between researchers and managers (Safford et al. 2017). In fire science, the problems between increasingly deep disciplinary research results and a management community skeptical of science built without experience are acute. Recent examples of coproduction that have been funded or tied to projects of JFSP include RxCADRE, the regional Fire Science Exchanges, the Prescribed Fire Science Consortium, and several individual JFSP projects.

To further investigate the coproduction model for wildland fire science, we conducted a focused workshop that assessed organizational models to help funding agencies achieve meaningful coproduction of wildland fire science and technology. We convened key managers and researchers in Salt Lake City, Utah with a series of presentations from organizations and leaders in the field of coproduction. This workshop included representatives from across R&D (US Geological Survey, Pacific Northwest, Pacific Southwest, Rocky Mountain, and Norther Forest Service Research Stations), multiple universities, members of the Fire Science Exchange Network, land managers from federal and state agencies, and funders. Panelists presented alternative business models focused on addressing coproduction needs regarding: 1) identifying barriers for fire manager and research participation; 2) developing funding incentive structures for co-production; 3) translating management needs into actionable science outputs; and 4) practical constraints of scale for co-production efforts.

In addition to the workshop, we held two Prescribed Fire Science Consortium events as case studies in coproduction. One was held in conjunction with the Fire and Smoke Model Evaluation Experiment (FASMEE) in central Utah. The other was a virtual Prescribed Fire Science workshop focused on the New Jersey pine barrens.

Objectives

Our project had three objectives designed to move wildland fire science coproduction implementation forward:

1. Assemble available experts in coproduction, boundary spanning, and collaborations in wildland fire in a facilitated workshop to discuss alternative funding models to enhance science delivery and relevance.
2. Characterize existing funding of coproduction in wildland fire, review successful models across the globe, and distill characteristics of success and business models for replicating successful coproduction in wildland fire through grant funding organizations.
3. Create a synthetic analysis that addresses the framework or business model to overcome barriers, provide incentives, and understand limitations of scale in coproduction of science.

Background

Fire science is an inherently applied amalgamation of disciplines which is increasingly developing exceptional disciplinary depth. There is a definitive need for managers and researchers to leverage experiential and theoretical knowledge to address the complex problems facing fire managers today. Management relevance is increasingly used as criteria for funding and publishing research, but fire management is based on experience in balancing competing resources and human safety, often in politically charged situations or emergency response crises. Applications of research results are as much constrained by the processes of fire management as the information itself. Generating an understanding for how information can be used is a critical benefit to coproduction in the context of fire science. The potential benefits of coproduced fire science are tremendous for both parties: for managers, coproduction empowers them to help solve on-the-ground problems and for scientists, coproduction offers relevance and application of research findings and tools. Simply put, coproduction offers a transformative pathway for wildland fire science and management.

Materials and Methods

Workshop on Wildland Fire Co-production

Using our existing networks of fire scientists and managers (PIs have worked in federal agencies as managers and in R&D, in universities, non-governmental organizations across the South and West) and others recognized in the broader fields of coproduction and wildland fire, we convened a workshop in conjunction with the JFSP Board Meeting in October 2019. The workshop focused on key hurdles to coproduction: what are potential business models for JFSP and other competitive research programs to support coproduction? What are the impediments for scientists to coproduce? what are the impediments for managers to coproduce? Are there successes (and failures) that we might learn from along the path to a research-management agenda focused on coproduction? The workshop tackled each of these issues with participants from key relevant management (federal agencies, NGOs, state, and private) and science R&D (federal, university, NGO, and private) entities represented (Table 1). We focused our 2-day workshop on key hurdles in mechanisms of funding, lessons learned, and best practices.

The Workshop was organized as a three-phase process: introductions to formal coproduction; the diversity of successful intramural and extramural coproduction in natural resources and fire, internationally to local; and how to facilitate JFSP's leadership in coproduction. Workshop participants iteratively categorized potential changes to JFSP funding into those that would require slight modifications to existing announcements or program policies, those that would require moderate changes, and those that would require somewhat major changes. Some topics are listed in multiple categories based on the level of investment required. Rather than rank these, the participants agreed that these ideas should be presented to the JFSP staff and Board for their reflection.

Table 1. Participants in the 2019 Salt Lake City Coproduction Workshop. In addition, JFSP Staff John Hall, Ed Brunson, Becky Jenison, Molly Hunter, and Diane Williams participated along with Tall Timbers Staff Morgan Varner and Kevin Hiers.

1. David Bruce, Bushfire and Natural Hazards CRC (Melbourne, Australia)
2. Mark Brunson, Great Basin Fire Science Exchange & Utah State Univ. (Logan, UT)
3. Linda Chappell, USDA Forest Service, Region 4 (Ogden, UT)
4. Eamon Engber, National Park Service (Orick, CA)
5. Carolyn Enquist, US Geological Survey (Tucson, AZ)
6. James Furman, USDA Forest Service, State & Private (Milton, FL)
7. David Godwin, Southern Fire Exchange & Univ. of Florida (Tallahassee, FL)
8. Bil Grauel, Bureau of Indian Affairs & JFSP Board (Boise, ID)
9. Sarah Hamman, Center for Natural Lands Management & Northwest Fire Science Exchange (Olympia, WA)
10. Sharon Hood, USDA Forest Service Rocky Mtn Research Station (Missoula, MT)
11. Leda Kobziar, Univ. of Idaho (Coeur d'Alene, ID)
12. Terrie Jain, USDA Forest Service Rocky Mtn Research Station (Moscow, ID)
13. Jim Menakis, USDA Forest Service Fire & Aviation Management & JFSP Board (Fort Collins, CO)
14. Roger Ottmar, USDA Forest Service Pacific NW Research Station (Seattle, WA)
15. Toral Patel-Weynand, USDA Forest Service R&D & JFSP Board (Washington, D.C.)
16. Carl Petrick, USDA Forest Service, National Forests of Mississippi/ JFSP Board (Jackson, MS)
17. Bert Plante, US Fish & Wildlife Service & JFSP Board (Manteo, NC)
18. Matt Reilly, Humboldt State Univ. & USDA Forest Service PNW Res Station (Arcata)
19. Hugh Safford, USDA Forest Service, Region 5 (Davis, CA)
20. Doug Shinneman, USGS Forest & Rangeland Ecosystem Science Center (Boise, ID)
21. Nick Skowronski, North Atlantic Fire Science Exch. & USDA FS Northern Res
22. Station (Morgantown, WV)
23. Paul Steblein, US Geological Survey- Fire Research & JFSP Board (Reston, VA)
24. Andi Thode, Southwest Fire Science Exch. & Northern Arizona Univ. (Flagstaff, AZ)
25. Sarah Trainor, Alaska Fire Science Exchange & University of Alaska (Fairbanks, AK)
26. Phil van Mantgem, US Geological Survey (Arcata, CA)
27. John Wallace, US Fish & Wildlife Service (St. Marks, FL)
28. Jeremy Webber, New Jersey Fire Service (Pinelands, NJ)

Case Studies: Prescribed Fire Science Consortium as a Model

Using findings and recommendations from our workshop, we applied these in two Prescribed Fire Science Consortium events in October 2019 and September 2020. The Prescribed Fire Science Consortium is a "pyro-blitz" week of integrated prescribed fire measurements, focused discussion on actionable fire science, all done with co-production as the overarching approach (Skowronski et al. *In press*). We shared and presented findings from our workshop, invited key workshop representatives, and included lessons learned in the weeks' events. As coproduction is an iterative process, we saw these case studies as opportunities to evaluate practices *in situ* to inform the practice of coproduction.

The two events focused on different aspects that are somewhat representative of national fire management challenges. The first was co-held with the FASMEE Annabella burn in the Fishlake National Forest in central Utah. Tall Timbers staff along with Southern Research Station personnel coordinated manager-scientist dialogues in Richfield, Utah. The manager group discussed issues they faced on their home units (primarily central Utah) and how scientists had assisted in the past. Scientists discussed how their work regionally fit the needs identified. In the second event, we co-hosted (with the North Atlantic Fire Science Exchange) a virtual event (during COVID-19) based on work in the New Jersey pine barrens. This workshop consisted of managers working with modelers of the fire behavior model, QUIC-Fire (Linn et al. 2020), with modeling runs on a local pine barrens wildfire and prescribed fire. The coproduction team worked to assess manager needs and resulting model output adjustments.

Results and Discussion

The categories below reflect several major themes of the Salt Lake City Workshop. First, many participants observed that minor "tweaks" to current JFSP Funding Opportunity Notices (FONs) and activities of JFSP's Fire Science Exchange Network (FSENs) would result in measurable change. Second, participants emphasized investments in young scientists and managers, as JFSP has with its GRIN and TREE programs- there was agreement that investments today would increase the capacity for coproduction across their careers. Lastly, many ideas related to "local needs" that are key to the rationale for the regional FSENs and were foundational to JFSP's early program success. The findings are provided below, with notes added post-workshop by the PIs.

Table 2. Suggested changes to the Joint Fire Science Program to increase wildland fire scientist-manager coproduction.

Category 1: Slight Changes (11)

1. A major theme of participant responses suggested adding criteria to JFSP FONs:
    a. Calling for explicit involvement with managers through the life cycle of the project (idea conception, design, implementation, interpreting results, designing applications for management, and technology transfer and outreach to other managers).
    b. Identifying scientists' and managers' objectives and their tasks explicitly in each proposal (i.e. as stand-alone subsections in the body of the proposal).
    c. Identifying scope and scale to management as a stand-alone section with a manager cadre or staff manager identified.
2. To garner more pre-proposal collaboration between managers and scientists in the early stages of idea conception and proposal preparation, JFSP could offer a pre-proposal stage (e.g., Letter of Intent, Interest).
3. To enable manager-scientist collaborations, increasing the period between FON announcement and proposal submission due dates.
4. To encourage investment by PIs into coproduction activities, the Fire Science Exchange Network (FSENs) or JFSP office could host a webinar(s) on coproduction topics: what is coproduction, how can coproduction be successful, steps in coproduction process, and the role(s) of exchanges in JFSP project coproduction.
5. Using the existing GRIN (and proposed programs), JFSP could add an experiential aspect that promoted the culture of coproduction. Examples of these efforts might include requiring experience in a training exchange (like the successful TREX programs or similar), involvement with the National Interagency Prescribed Fire Training Center, or as an internship with a public land management agency.
6. Using the Needs Assessments conducted by the regional FSENs, providing a section within the FON that showed evidence that proposals meet regional needs of managers in addition to falling within the broader FON Task Statements.
7. Following the success of the USGS-led Climate Adaptation Science Centers' funding program, JFSP could have funds distributed to regional FSENs for disbursement to

regional or local needs that fit that region, but perhaps never rise to a formal FON Task Statement.

8. A simple solution suggested was to add a coproduction sentence or two to FONs that state something to the effect that "proposals are encouraged that show evidence of scientist-manager engagement in formal coproduction."
9. To remind reviewers of the importance of coproduction to meeting the goals of JFSP, adding an evaluation question/box for proposal reviewers on how responsive the proposal is to coproduction of actionable science.
10. To make the FONs more accessible, re-crafting the language of FONs for both scientists and managers.
11. On the theme of learning from what JFSP has already done, participants were interested in analyses of past successful coproduction projects. The work that Molly Hunter completed on past work was the seed here. Participants were interested in meta-analyses for lessons learned- successes and failure.

Category 2: Moderate Changes (13)

1. To encourage "year-round" collaborations that result in successful proposals and projects, JFSP could create a category of FON or specific Task Statements for scientist-manager coproduction that have rolling due dates (i.e. open for submissions at all times).
2. To encourage collaboration to build year-round, FON Task Statements could be broadened (i.e. less specific within the overarching goals of JFSP).
3. To link to managers and science users, JFSP could require involvement with FSENs over the project's life cycle. This might take the form of working with the FSENs to have end-users chime in early on project design, piloting of results to end-users, and assistance with delivery of findings to managers.
4. JFSP could support long-term and adaptive management projects (learning from on-the-ground work) by providing funding for data analysis and science delivery beyond the partners that implemented the projects.
5. JFSP could magnify its impact by following past funding that resulted in projects with a next-generation potential for added impact. This might take the form of added funds post-

delivery for additional outreach or funds to develop a decision support tool that is born from the original JFSP-funded work.

6. A general idea was to invest in or redirect funds already allocated to the FSENs explicitly to build FSEN capacity to facilitate and support coproduction and collaboration between scientists and managers.
7. FON Task Statements could have more explicit links to identified management needs collected by FSENs. This idea is related to Slight Change #6, but participants argued that this meant using an improved needs assessment (i.e. going beyond the disparate assessments that are currently used across FSENs) and a further refining of these topics post-survey or across FSENs was weighted to needs in a prioritized fashion. Some discussion on this was the perception (by several) that the Needs Assessments are ad hoc, differ in quality by region, and lack a weighting by regional managers for the priorities they have for each.
8. To invigorate coproduction in wildland fire science broadly, FSENs could provide training on how coproduction works (as above in Slight #4), but also to collaborate with partners who have been successful with coproduction as a working model. These could be made more accessible at conferences, regional meetings, etc. outside of the webinar crowd.
9. A suggestion was made to lean on two JFSP programs (GRIN and the proposed programs) to better prioritize the "laundry lists" of research topics that JFSP funds for manager application.
10. A suggestion was made that each JFSP project engage an Evaluator (as the National Science Foundation does) and develop comparable and objective metrics that could be used to evaluate coproduction projects and improve future investments.
11. To more formally engage managers, suggestions were made to formally list managers as Co-PIs (as many already do) or perhaps as a Manager PI or similar parallel role to the scientist. This would elevate their role (and presumably their institutional investment), but may also bring in resources such as project management or access to different funding streams to support project activities.
12. To encourage the next generation of coproduction, suggestions were made re: mentoring as a criterion for proposal evaluation. This category might factor into selection because

the proposal identified a junior scientist (i.e. pre-tenure or pre-promotion or within 5 years of terminal degree) and/or a junior manager (i.e. within 5 years of service in organization or as a decision maker in their organization).

13. General comments in this section related to highlighting results of coproduction for agency leaders in Washington DC. Ideas mentioned included poster sessions or DC-located meetings to showcase these results.

Category 3: Major Changes (9)

1. Consider a model for Task Statement where ideas are developed by managers, solicited and selected by JFSP (or a regional FSEN where more realistic), and managers play a PI or Project Director role. The term for this idea was "match-making" to hint at the concept that the need is present already, the missing part is the science team to do the work in a thoughtful way. This proposed approach would come with substantial funding from the proposer's agency rather than relying on JFSP.
2. To encourage collaborative interactions between scientists and managers, JFSP could develop a small-grants program for project development or travel grants (as they do for students with the JFSP TREE grants) to connect scientists and managers. JFSP could consider seed grants to build partnerships between scientists and managers in a working group setting for a period pre-proposal. This arrangement would allow for substantial understanding of each partner's needs prior to initiating a funded project and would serve to build institutional relationships beyond the PI and project manager.
3. JFSP could consider something like a management innovation grant program focused on emerging technology and tools. These could be where end-users work with developers on research investments that JFSP has supported that now could use stimulus to make the next step toward actionable tools. Beyond the idea, participants liked the idea that this could serve as a riskier investment within the general JFSP portfolio that may have transformational value.
4. A consistent theme was investment in future coproduction, or building coproduction capacity (as JFSP built capacity in traditional fire science and delivery). The ideas under this change revolved around supporting early career scientists and managers. Examples included:

    a. experiential interaction in “internships” for scientists and managers at each other’s organizations. Promoting details between management and R&D (as the National Park Service does with its Scientists in the Parks program) could enable this. While this could be done beyond JFSP’s auspices, having JFSP’s voice and experience brought to bear would be a natural extension.
    b. TREX for scientists- where beginner or novice scientists (in graduate school, post-doc, or junior scientist) could work with fire managers to learn their issues, hurdles to implementation, and to break down barriers between the ivory tower and boots-on-the-ground.
5. Engagement with JFSP program office via details or internships that focus on “learning from each other” and how coproduction has happened, could be improved, and developing initiatives that foster a coproduction culture at JFSP and with its partner organizations. Similar activities could be supported at FSENs with an explicit coproduction theme.
6. Adding to existing Wildland Fire Academies to connect managers and scientists elbow-to-elbow. Several opportunities for engagement with the National Interagency Training organization (Tucson, McClellan, and Tallahassee) could be developed.
7. Related to these ideas in this section, considerable interest focused on following up on or extending past funding investments. This follows past JFSP FONs that leveraged previous investment to magnify previous work. The idea that had traction was to focus a FON on implementation hurdles or how coproduction could expand or refine past funded work or continue the good work that continues to occur long after the project “ends”.
8. Beyond the large FON “events”, there were calls for emergent issues and their support. An idea floated was for “Nano-proposals” where, for instance, a prescribed fire specialist connects with a scientist on an emergent issue. FSENs could be matchmakers or help contextualize the issue, as in how big an issue that is regionally (within a single FSEN) or how broadly applicable it might be (across multiple FSENs). The attractiveness beyond the emergent idea was that this might be a small investment for short period but with rapid and potentially important results.

9. Several participants encouraged pooling resources with other funders on research topics where there was shared interest and priority and where combined funds would result in a higher level of work. Example of this included:
    a. A co-solicitation between a climate organization (like the CASC) and JFSP to accelerate fire and climate research in a coproduced approach.
    b. Partnering with the larger national funders such as the USDA National Research Initiative (NRI) or National Science Foundation (NSF) on coproduced fire research, with their expertise and resources in research funding and JFSP's leadership in fire research and manager engagement.
    c. Partnering with an agency to support research-monitoring-implementation projects that have multiple partners but have substantial potential for impact locally and more broadly as a pilot arrangement to produce actionable science.
    d. Participants agreed that JFSP support of workshops that connect scientists and managers were a priority. Examples included:
    a. The Rx Fire Science Consortium, a current FSEN, Forest Service R&D, EPA, USGS, university, Tall Timbers, and public-private land manager project.
    b. Local and regional meetings that are not subject to the same travel scrutiny that large conferences face. FSENs could convene and host these with additional funding, prioritizing the region's needs.

Our manuscript on this topic reflects the ways in which coproduction has and will be fundamental to generating actionable wildland fire science. We contrast efforts across a spectrum of scientist-manager engagement that will be of use.

Conclusions (Key Findings) and Implications for Management/ Policy and Future Research

Coproduction clearly provides an avenue for improving actionable fire science. Our workshop participants and those engaged in our field and virtual workshops all are enthusiastic to change the narrative on how science works to solve problems. As part of our manuscript on this topic, we propose a conceptual model on how partners interact to coproduce (Figure 1).

JFSP's roles in coproduction could take many forms. Our workshop participants crafted categories of change that span "easy fixes" to "tide shift" in the way JFSP and other funders (both intramural and extramural) can help steer these changes. Based on our experiences since the Salt Lake City event and our field and virtual events, we have noted somewhat of a sea shift in how coproduction is becoming part of discussions and how it may help us increase the pace and scale of fire and fuels treatments at the heart of JFSP's mission and its partners.

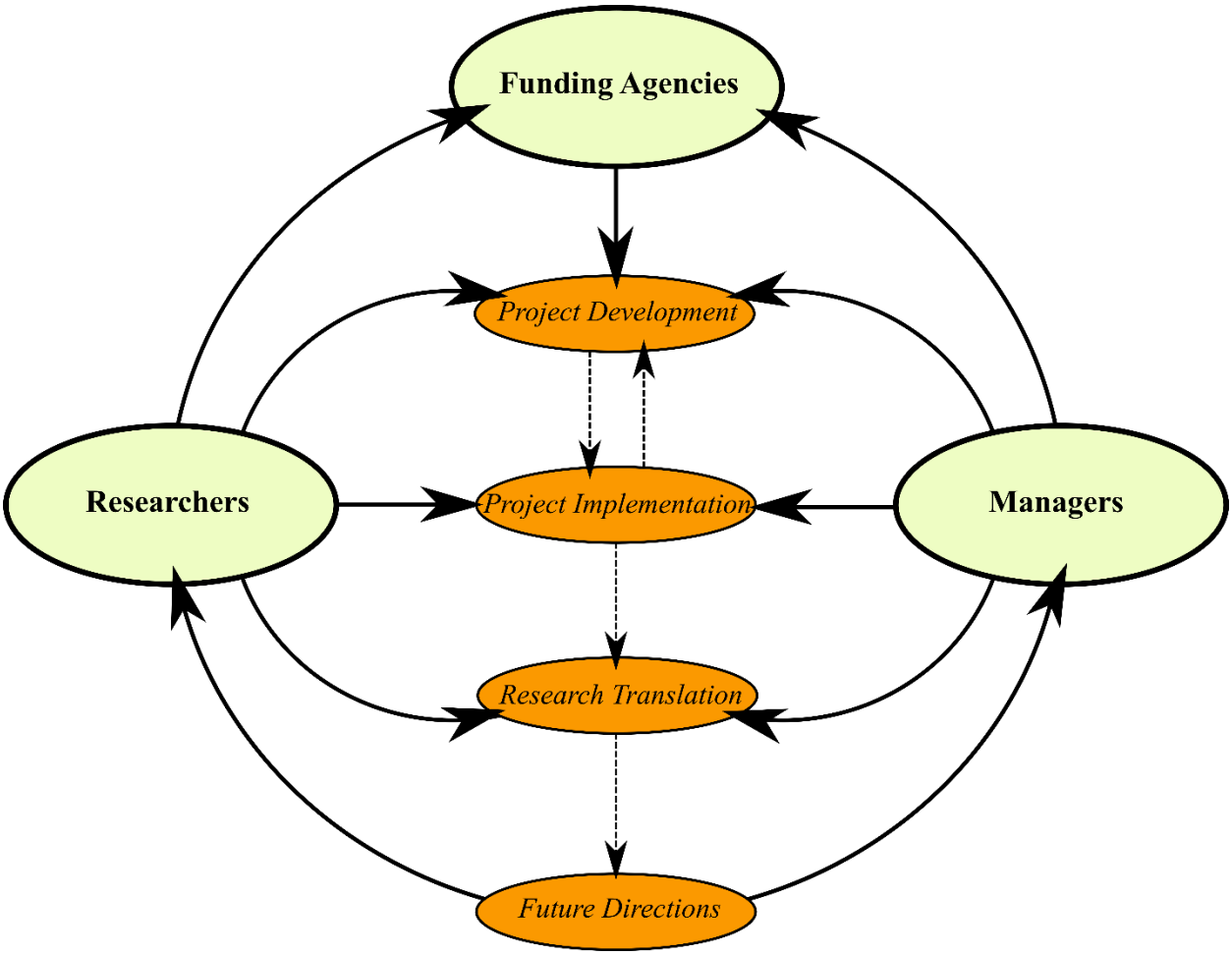

Figure 1. Conceptual model of coproduction in wildland fire science. Solid arrows represent interaction and collaboration between research, management, and funding. Dashed arrows represent the progression of a research project.

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Appendix A: Contact Information for Key project Personnel

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Appendix B: List of Completed/ Planned Scientific/ Technical Publications/ Science Delivery Products

1. Articles in peer-reviewed journals

Hiers, J.K., J.J O'Brien, J.M. Varner, B.W. Butler, M. Dickinson, J. Furman, M. Gallagher, D. Godwin, S.L. Goodrick, S.M. Hood, A. Hudak, L.N. Kobziar, R. Linn, E.L. Loudermilk, S. McCaffrey, K. Robertson, E.M. Rowell, N. Skowronski, A.C. Watts, and K.M. Yedinak. **2020.** Prescribed fire science: the case for a refined research agenda. *Fire Ecology* 16: art11.

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2. Technical Reports

3. Books, chapters

4. Graduate thesis (masters or doctoral)

5. Conference or symposium proceedings scientifically recognized and referenced (other than abstracts)

6. Conference or symposium abstracts

7. Posters

8. Workshop materials and outcome reports

9. Field demonstration/ tour summaries

Prescribed Fire Science Coproduction Event. Field workshop at Annabella Burn Unit, Fishlake National Forest, Utah. Conducted October 26-November 2, 2019.

Prescribed Fire Science Coproduction Event. Field workshop at Osceola National Forest, Florida. Conducted February 28, 2020.

Prescribed Fire Science Coproduction Workshop. Virtual workshop at New Jersey Pine Barrens Reserve, New Jersey. Conducted September 15-17, 2020.

10. Website development

11. Presentations/ webinars/ other outreach/ science delivery materials