Use and benefits of NASA's RECOVER for post-fire decision support

Article *in* International Journal of Wildland Fire · May 2018

DOI: 10.1071/WF18010

6 authors, including:

William Toombs
Idaho State University

Keith Weber
Idaho State University

Tesa Stegner
Idaho State University

Use and benefits of NASA’s RECOVER for post-fire decision support

William Toombs[a], Keith Weber[ae], Tesa Stegner[b], John L. Schnase[c], Eric Lindquist[d], and Frances Lippitt[d]

[a]GIS Training and Research Center, Idaho State University, Pocatello, ID 83209, USA.
[b]Department of Economics, Idaho State University, Pocatello, ID 83209, USA.
[c]Office of Computational and Information Sciences and Technology, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA.
[d]School of Public Service, Boise State University, Boise, ID 83725, USA.
[e]Corresponding author. Email: webekeit@isu.edu

Abstract. Today’s extended fire seasons and large fire footprints have prompted state and federal land management agencies to devote increasingly larger portions of their budgets to wildfire management. As fire costs continue to rise, timely and comprehensive fire information becomes increasingly critical to response and rehabilitation efforts. The NASA Rehabilitation Capability Convergence for Ecosystem Recovery (RECOVER) post-fire decision support system is a server-based application designed to rapidly provide land managers with the information needed to develop a comprehensive rehabilitation plan. This study evaluated the efficacy of RECOVER through structured interviews with land managers (n=19) who used RECOVER and were responsible for post-fire rehabilitation efforts on over 715 000 ha of fire-affected lands. Although the benefit of better-informed decisions is difficult to quantify, the results of this study illustrate that RECOVER’s decision support capabilities provided information to land managers that either validated or altered their decisions on post-fire treatments estimated at over $1.2 million (USD) and saved nearly 800 hours of staff time by streamlining data collection as well as communication with local stakeholders and partnering agencies.

Brief Summary. The NASA Rehabilitation Capability Convergence for Ecosystem Recovery (RECOVER) post-fire decision support system is designed to rapidly assist land managers with developing a rehabilitation plan. Through structured interviews with land managers using RECOVER, this study revealed a significant cost- and time- savings to these agencies. These benefits rest in streamlining data collection and improving cross-organizational communication.

Additional keywords: Communication, Planning, Remote Sensing, Decision Support

Introduction

After a large fire is contained, land managers often assess post-fire conditions and develop a stabilization and rehabilitation plan. Due to regulatory time constraints, land managers are tasked with rapid data assembly, analysis, and decision making (Robichaud et al. 2009). Currently, information used for post-fire planning may be limited by the availability of staff time, funding, or consistent and site specific data for a given fire (Dombeck et al. 2003; Schnase et al. 2014). This lack of information or quality data may result in key knowledge gaps hindering post-fire planning efforts (Venn and Calkin 2008; Thompson and Calkin 2011). Given the potential importance of post-fire stabilization and rehabilitation for ecosystem recovery, rapidly acquiring critical data such as fire severity or debris-flow probability becomes essential for the decision making process (Venn and Calkin 2008; Robichaud 2009; Curth et al. 2012; Schnase et al. 2014). Although there is a wide variety of geospatial tools designed to support post-fire decision making– i.e. USGS debris flow modeling (Staley et al. 2016), Rapid Response Erosion Database (Miller et al. 2016), and USDA Forest Service tools (Lew et al. 2017) – none comprehensively address the need of stabilization and rehabilitation planning (Calkin et al. 2011; Schnase et al. 2014).

Through the rapid collection and deployment of the actionable information needed to submitting a rehabilitation plan, access to fire-specific geospatial data can reduce uncertainty in the post-fire planning environment, facilitating better-informed decisions that may reduce direct and indirect costs (Macauley 2006; Kangas et al. 2010). These better-informed decisions are not only beneficial to the individual or agency tasked with post-fire rehabilitation but also to community members impacted in a variety of ways (Wigtil et al. 2016). To help illustrate the potential societal value of geospatial tools and earth observing satellite imagery, this research used the NASA Rehabilitation Capability Convergence for Ecosystem Recovery (RECOVER) post-fire decision support system (DSS) as a case study.

Through semi-structured stakeholder interviews, this project sought to identify the actual impact of rapid assembly and deployment of geospatial data in wildfire emergency response planning in order to assess the value of information derived from RECOVER's geospatial data layers (n=26) and how these data influence and improve post-fire decision making. These data layers include roads, hydrography, soils, critical habitat, past fires, land cover, and topography. An analysis of the value of information derived from RECOVER provided a rich contextual comparison to those decisions made in the absence of geospatial tools. This approach also assisted in determining a monetary value for the immediate outcomes of land managers' better-informed decisions enabled by RECOVER-based data. In addition, we hoped these interviews would highlight any time- and cost-savings for decision makers and support staff who utilized RECOVER, which are expressed later as approximate dollars saved. Finally, although more difficult to quantify, the ultimate social benefits of better-informed decisions – i.e. impacts on the ecosystem, recreation, and land use – are also considered in the final estimation of RECOVER's overall socioeconomic impact in the post-fire emergency response planning process.

Background

RECOVER Decision Support System

The RECOVER DSS is made up of a RECOVER Server and a RECOVER Client. The RECOVER Server is highly automated using Python scripting within the ArcGIS platform (ESRI 2018). The RECOVER Client is a full-featured Web Map/GIS analysis environment. When provided a wildfire name and geospatial extent, the RECOVER Server aggregates site-specific data residing on the server and exposes it to the RECOVER Client through web services. RECOVER reduces the time required to assemble and deliver crucial post-fire related data from days to minutes (Schnase et al. 2014).

RECOVER's Purpose

According to agency partners – primarily the Idaho Department of Lands, Forest Service (USFS), and Bureau of Land Management (BLM), prior to RECOVER, data assembly was the most significant bottleneck in post-fire related decision making (Schnase et al. 2014). After a major wildfire event, federal land management agencies are required to develop and certify a comprehensive plan for public safety, burned area stabilization, resource protection, and site recovery within 21 days of fire containment (USFWS 2001). Initial rehabilitation plans, however, must be submitted within one week of when the fire was contained, which places a substantial burden on the agencies' resources, mainly staff time and availability, to collect and synthesize the necessary data for the decision making process. RECOVER benefits the land manager by providing the manager with actionable information very quickly and providing him/her with additional post-fire data describing the event (e.g., fire severity (dNBR)), identifying areas in need of reseeding or other post-fire treatment, and monitoring subsequent ecosystem recovery in response to prescribed treatments (Schnase et al. 2014). Given the potential importance of reseeding after a significant fire event – i.e. to stabilize hydrophobic soils in order to minimize the probability of a debris-flow or to restore wildlife habitat and livestock rangeland to productive levels – RECOVER's features can significantly reduce the costs associated with assessment and planning phases, as well as better improve the land through rapid and accurate assessments of the effects of a fire event.

During the early phases of RECOVER's development, efforts were taken to develop system requirements that accounted for the actual decision making process of the land manager in response to a fire event. Through the rapid acquisition of data, one of the objectives of RECOVER was to allow fire managers to shift their attention to more important and potentially impactful tasks of analysis, planning, and monitoring (Schnase et al. 2014). Since the 2013 fire season, RECOVER has been called upon to provide web maps for 60 wildland fires in seven states (Table 1) and has supported and improved the work and decision making of sixteen different state and federal agencies throughout the western United States.

Methodology

Interview Process

Nineteen semi-structured interviews were conducted with personnel from federal, state, and local agencies, representing a wide range of job functions and responsibilities, who had used RECOVER as part of their duties. These nineteen participants represent 78% (n=47) of the fires mapped by RECOVER, an area covering over 715 000 ha. Through the semi-structured interviews we sought to acquire insight into how RECOVER was being used, which features were thought to be most beneficial, whether uncertainty in the post-fire decision making process was reduced, and whether the individual or agency intended to adopt the tool (Table 2). Further, we requested the participants attempt to quantify the total staff time or dollars saved, as well as to highlight specific instances where RECOVER data enabled the user to make a better-informed decision that either prevented or validated a potentially expensive rehabilitation treatment. Although attempting to quantify the indirect benefits of RECOVER proved a difficult task, several respondents provided data that could be aggregated and analyzed for trends, which helped assess the economic value of RECOVER's use.

Calculations
The participants' responses to questions about the value of information provided and whether staff time and related expenses were saved by using RECOVER were not easily quantifiable, because, to our knowledge, there are no universally accepted approaches. Therefore, we took the following approach. Where respondents gave ambiguous answers or rough estimates – i.e. "several days," "ten to twelve staff," and "a few hours" – we took the liberty of assigning values to these responses. Where public records were available, we used the actual hourly wage reported for the previous fiscal year (FY 2016-17) of the participants who provided measurable data and when public records were unavailable we used the 2016 US general schedule (GS) pay rates for mid-level federal employees.

Findings

Several recurring themes and trends consistently emerged throughout the interviews that strongly indicated the use of RECOVER played a critical role for land management personnel and agencies in their post-fire rehabilitation efforts. All nineteen respondents, regardless of actual level of use, initially sought to employ RECOVER for a variety of duties and objectives. For instance, attaining data and information on burn severity, debris-flow probability, and pre-fire vegetative cover were the most common responses (n=14). Land managers finding these specific web maps to be of value is not surprising as land rehabilitation and recovery is their primary concern, and these web maps directly address the health and status of the affected ecosystem. Further, 94% (n=18) of the interviewees reported they plan to use RECOVER in future fire seasons, potentially highlighting RECOVER's usability and perceived effectiveness assisting in the post-fire decision making.

Assistance in reducing uncertainty
As RECOVER was designed to support the development of BLM's Emergency Stabilization and Rehabilitation (ES&R) plans and USFS BAER plans, ascertaining whether its use actually reduced uncertainty in core areas of rehabilitation planning was crucial. Over 30% (n=6) of respondents reported they were able to mitigate some sort of post-fire hazard, like a debris-flow, by utilizing in a timely manner RECOVER's web maps. Quantifying the ultimate benefit of avoiding a post-fire hazard like a debris-flow is difficult because of the unique circumstances of each wildfire, but the occurrence of such an event can easily have catastrophic social and economic repercussions totaling in the millions of dollars (USD) (De Graff, 2014). Furthermore, over 36% (n=7) of users agreed that RECOVER assisted with the overall planning of reseeding efforts and 63% (n=12) relied on RECOVER to help determine burn severity. Reducing uncertainty in these areas has the potential to save the agency costs and increase the effectiveness of their ecosystem stabilization and rehabilitation efforts. Finally, over 30% (n=6) of users reported that RECOVER significantly improved their ability to develop a comprehensive rehabilitation plan. Without RECOVER, these land managers would have likely had to rely exclusively on field observations and invested significant agency resources over several days to acquire the data necessary to submit their plan.

Staff time and related costs saved
Based on our interviews, twelve participants stated that RECOVER had saved their agencies a cumulative 800 hours of staff time, or roughly $43 000 (USD), of data collection expenses related to the rehabilitation plans. Similarly, 63% (n=12) of users stated RECOVER improved overall communications by providing comprehensive and reliable maps automatically. Twenty-six percent (n=5) recorded improvements within the agency and 52% (n=10) with partnering agencies as well as with the public. Improved communication between partnering agencies is particularly important because wildfires typically expand into multiple jurisdictions – i.e. federal, state, and private – where several different landowners may be affected. Cooperation and information sharing among the affected landowners will benefit the lead agency responsible for the rehabilitation planning as well as the primary users of the land. In total, participants determined approximately $2 000 (USD) of staff time were saved using RECOVER for communications instead of previous methods.

Better-informed decisions
Almost eighty percent (n=15) of RECOVER users reported the information RECOVER provided helped personnel make better-informed decisions that both directly and indirectly affected the roughly 715 000 ha of land they managed or monitored. Three users attempted to place a monetary value on the benefits of RECOVER's use and value of information by citing approximate staff time savings and immediate outcomes enabled by RECOVER. One participant stated they had requested RECOVER's debris-flow probability feature before finalizing a $500 000 (USD) wood mulch aerial application. After analyzing RECOVER's data with the results from the field observation assessment, they determined the probability of a debris-flow event occurring was minimal and no longer justified the expense, thus saving $500 000 (USD). A second interviewee explained the value of information provided by RECOVER would have taken several support staff working an entire week, or 280 hours, an expense we estimate at $15 814 (USD), to gather all of the data RECOVER can rapidly deliver in a matter of minutes. A third participant discussed how RECOVER was used to validate a $700 000 (USD) wood mulch application treatment and confirm the accuracy of field observation assessments. In all, the actionable data and information RECOVER supported decisions that had a minimum economic value of over $1.2 million (USD) to its users.

Discussion and Conclusion
The sample of interviewees, although relatively small, represents a substantial number of the larger fires that occurred in the targeted states and a majority of land managers who used RECOVER. These participants were responsible for over 715 000 ha of fire-affected land, including the subsequent post-fire planning and rehabilitation to ensure ecosystem recovery. Participants reported RECOVER's rapidly assembled and site-specific data provided key decision-makers with the information needed to identify sites that had the greatest potential for negatively impacting the fire affected area and helped them determine appropriate treatment plans. This rapid acquisition of data may also benefit the public by allowing land managers more time to focus their attention on more important aspects of the rehabilitation and recovery process. Due to the tight time constraint on reporting and the competition for funding these agencies face, RECOVER's ability to reduce data collection time by hundreds of hours per fire makes it a valuable and cost-effective tool for adoption by land management agencies.

RECOVER's greatest potential benefit arises from the better-informed decisions it enables. RECOVER allows land managers to effectively identify areas of high risk and determine more efficient treatments or management strategies that will restore or improve the land. By providing critical data quickly, land managers can complete thorough analyses in time to meet critical deadlines. Without this ability, land management agencies run the risk of recommending unnecessary and expensive treatment strategies, or foregoing a much needed rehabilitation technique.

These results illustrate a significant social and economic value for land management agencies, as well as for the land and land users, in using RECOVER and other geospatial data to assist in post-fire rehabilitation planning. Although much of the added value is found in improved communication and decision making by RECOVER users, a significant portion arises from staff time and cost savings from the reduction of data collection duties. In total, RECOVER saved 788.75 hours of staff time and had a minimum positive economic impact of $1.2 million (USD) on land management agencies.

Acknowledgements
This study was made possible by a grant from the National Aeronautics and Space Administration (NASA) Applied Sciences, A.35 Wildfires Program (NNX12AQ78G). This project was led by Keith T. Weber (PI), John L. Schnase (Co-PI) and Mark Carroll (Co-PI).

Conflicts of Interest
The authors declare no conflicts of interest.

The published paper is available here http://www.publish.csiro.au/WF/WF18010

References

Calkin DE, Thompson MP, Finney MA, Hyde KD (2011) A real-time risk assessment tool supporting wildland fire decsionmaking. *Journal of Forestry* **5**, 274-280.
Curth MT, Biscayart C, Ghermandi L, Pfister G (2012). Wildland-Urban interface fires and socioeconomic conditions: a case study of a northwestern Patagonia city. *Environmental Management* **49**, 876-891. doi: 10.1007/s00267-012-9825-6
De Graff JV (2014) Improvement in quantifying debris flow risk for post-wildfire emergency response. *Geoenvironmental Disasters* **1**, 5-15. doi: 10.1186/s40677-014-0005-2
Dombeck MP, Williams JE, Wood CA (2003) Wildfire policy and public lands: Integrating scientific understanding with social concerns across landscapes. *Conservation Biology* **18**, 883-889. doi: 10.1111/j.1523-1739.2004.00491.x
ESRI (2018) *Python for ArcGIS*. Available at http://desktop.arcgis.com/en/analytics/python/ [Verified 16 April 2018]
Kangas AS, Horne P, Leskinen, P (2010) Measuring the value of information in multicriteria decisionmaking. *Forest Science* **56**, 558-566.
Lew R, Dobre M, Elliot W, Robichaud PR, Brooks E, and Frankenberger J (2017) *Usability and functional enhancements to an online interface for predicting post fire erosion (WEPP-PEP)*. In EGU General Assembly Conference Abstracts 19, 184-186.
Macauley MK (2006) The value of information: measuring the contribution of space-derived earth science data to resource management. *Space Policy* **22**, 274-282. doi: 10.1016/j.spacepol.2006.08.003
Miller ME, Elliot WJ, Billmire M, Robichaud PR, and Endsley KA (2016) Rapid-response tools and datasets for post-fire remediation: linking remote sensing and process-based hydrological models. *International Journal of Wildland Fire* **25**, 1061-1073.
Robichaud PR, Lewis SA, Brown RE, Ashmun LE (2009) Emergency post-fire rehabilitation treatment effects on burned area ecology and long-term restoration. *Fire Ecology* **5**, 115-128. doi: 10.4996/fireecology.050115
Robichaud PR (2009) Post-fire stabilization and rehabilitation. In P. Robichaud & A. Cerda, *Fire effects on soils and restoration strategies*. CRC Press: Boca Raton, FL. ISB: 978-1-4398-4333-8.
Schnase JL, Carroll ML, Weber KT, Brown ME, Gill RL, Wooten M, May J, Serr K, Smith E, Goldsby R, Newtoff K, Bradford K, Doyle C, Volker E, and Weber S (2014) RECOVER: an automated cloud-based decision support system for post-fire rehabilitation planning. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* **XL-1**, 363-370. Available at https://archive.org/details/NASA_NTRS_Archive_20150000369 [Verified 7 August 2017]
Staley DM, Negri JA, Kean JW, Tillery AC, and Youberg AM (2016) *Updated logistic regression equations for the calculation of post-fire debris-flow likelihood in the western United States*. U.S. Geological Survey Open-file Report 2016-1106. Available at https://pubs.usgs.gov/of/2016/1106 [Verified 16 April 2018]
Thompson MP, Calkin DE (2011) Uncertainty and risk in wildland fire management: a review. *Journal of Environmental Management* **92**, 1895-1909. doi: 10.1016/j.jenvman.2011.03.015
USFWS (2001) *Interagency Burned Area Emergency Stabilization and Rehabilitation Handbook.* Available at http://ordvac.com/soro/library/Operations/interagency%20esr.pdf [Verified 16 April 2018]

Venn TJ, Calkin DE (2008) Challenges of socio-economically evaluating wildfire management on non-industrial private and public forestland in the western United States. *Small-scale Forestry* **8**, 43-61.
Wigtil G, Hammer RB, Kline JD, Mockrin MH, Stewart SI (2016) Places where wildfire potential and social vulnerability coincide in the coterminous United States. *International Journal of Wildland Fire* **25**, 896-908. doi: 10.1071/WF15109

Table 1: List of wildfire events in which RECOVER provided web maps

Specific Fire	Year	State	Area Burned (ha)	Processing Time (min.)	Active User
Adobe	2017	California	16,797	6	California National Guard
Atlas	2017	California	19,790	5	California National Guard
Brianhead	2017	Utah	29,011	5	Utah DNR
Chetco	2017	Oregon	75,346	5	USFS
Clear Lake	2017	California	702	6	FEMA
Deer Park	2017	Idaho	7,122	5	ID-BLM
Delano	2017	Nevada	6,100	5	NV-BLM
Eclipse Complex	2017	California	52,651	5	FEMA
Grass Valley	2017	California	6,881	7	FEMA
I84MM271	2017	Idaho	1,420	5	ID-BLM
Lava Flow	2017	Idaho	9,163	5	ID-BLM
Lolo Peak	2017	Montana	19,330	6	National Center for Landscape Fire Analysis
Loveridge	2017	Idaho	12,964	5	ID-Military Division
Mendocino Complex	2017	California	14,578	8	FEMA
Orleans	2017	California	11,050	5	FEMA
Pocket	2017	California	3,241	5	FEMA
Powerline	2017	Idaho	22,477	5	Shoshone-Bannock Tribe
Raven	2017	Nevada	172	5	NV-BLM
Thomas	2017	California	90,533	5	FEMA
Tubbs	2017	California	13,283	6	California National Guard
Wildhorse	2017	Idaho	11,001	5	ID-BLM
Gap	2017	Idaho	487	5	ID-BLM
Copper King	2016	Montana	11,555	5	USFS
Timber Dome	2016	Idaho	2,096	5	ID-BLM
Juntura Complex	2016	Oregon	160,418	5	OR-BLM
Baker-ORPAC	2016	Oregon	336,504	5	OR-BLM
Henry's Creek	2016	Idaho	52,935	3	ID-BLM
Yale Road	2016	Washington	5,873	4	WHATCOM Conservation District
Spokane Complex	2016	Washington	6,358	3	NOAA & WHATCOM Conservation District

Pioneer	2016	Idaho	64,369	7	IDL and USFS
MM14	2016	Idaho	4,311	5	ID-BLM
Blue Cut	2016	California	36,323	5	NOAA-NWS
Lawyer 2	2015	Idaho	2,213	4	IDL
Cape Horn	2015	Idaho	1,326	30	IDL
Soda	2015	Idaho-Oregon	279,144	30	ID-BLM
Dodge	2015	California	10,570	30	Caltrans
Clearwater	2015	Idaho	68,127	30	IDL
Valley	2015	California	76,067	30	Caltrans
Powerhouse	2015	California	30,274	30	Caltrans
Johnston (Prescribed)	2015	Idaho	0	-999	USDA-ARS
Motorway	2015	Idaho	33,983	30	IDL
Woodrat	2015	Idaho	7,797	5	IDL
Clearwater Complex	2015	Idaho	47,282	-999	IDL
Lolo 2	2015	Idaho	1,405	2	IDL
Parker Ridge	2015	Idaho	995	5	IDL
Tepee Springs	2015	Idaho	3,337	3	IDL
Big Cougar	2014	Idaho	65,279	45	IDL
Timber Butte	2014	Idaho	7,013	45	IDL
Whiskey	2014	Idaho	9,452	35	IDL
2 ½ Mile	2013	Idaho	924	30	ID-BLM
Pony	2013	Idaho	148,170	35	ID-BLM
Incendiary Creek	2013	Idaho	1,100	90	IDL
State-line	2013	Idaho-Utah	30,206	40	ID-BLM
Mabey	2013	Idaho	1,142	120	ID-BLM
Chips	2012	California	76,343	5	USFS
Charlotte	2012	Idaho	1,029	-999	ID-BLM
Ridgetop	2012	Idaho	16,616	35	ID-BLM
Drive-In	2011	Idaho	1,223	-999	ID-BLM
Jefferson	2010	Idaho	188,151	-999	ID-BLM
Crystal	2006	Idaho	220,000	-999	ID-BLM

Table 2: Question from the survey instrument used during interviews with RECOVER users.

1. How was RECOVER used in your efforts with fire X?
2. What specific data did you find most useful from the RECOVER DSS?
3. Pre-RECOVER, how much time on average did you, or your office, spend collecting and analyzing the relevant data needed to submit an ES&R or BAER plan?
4. Using RECOVER, how much time was spent collecting that same data?
5. How did RECOVER improve BAER or ES&R decision-making?
6. Were communications improved by using RECOVER?
    a. Between team members?
    b. Cooperating agencies?
    c. The public?
7. Roughly how much time was saved using RECOVER for improved communication?
8. Did RECOVER <u>reduce the cost</u> or improve the effectiveness of data assembly? Decision-making for ES&R plan? And post-fire recovery and rehabilitation monitoring?
    a. Approximate dollar amount saved.
    b. Approximate time saved – personal and staff.
9. How did RECOVER assist your team in assessing burn severity?
10. How did RECOVER assist/improve the planning or implementation of emergency watershed rehabilitation measures to help stabilize soils, control water movement and protect property?
11. How did data acquired using RECOVER help circumvent issues related to post-fire hazards such as debris-flows?
12. Was the data acquired using RECOVER helpful in planning reseeding efforts?
    a. Or targeting wildlife habitat areas for rehabilitation efforts?
13. Did RECOVER assist in reseeding efforts that helped place rangeland back into use for grazing in a reasonable timeframe?
14. How do you plan to continue using RECOVER in upcoming fire seasons?
15. Is there anything else you would like to tell us about the value of RECOVER, satellite imagery, and geospatial data for wildfire management?