

National Park Service

U.S. Department of the Interior

Fire and Aviation Management



Grand Canyon National Park / Northern Arizona *Preliminary* Fire Ecology Annual Report Calendar Year 2025

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Top left: Inventory & Monitoring and Fire Effects staff sharing data collection efforts.
Top right: North Rim staff and chaperones celebrate a successful mission to recover equipment/supplies during the Dragon Bravo Fire.
Bottom center: Aurora borealis over the November North Rim sky.
(photos by NPS)

The National Park Service (NPS) Division of Fire and Aviation Management relies on science and long-term monitoring to inform an adaptive management approach for assessing and improving fire management programs and activities at park units. Adaptive management, along with policies, standards, and responsibilities for monitoring are described in Chapter 8 of [Reference Manual 18](#). The NPS Fire Ecology Program is responsible for the collection, analysis, and interpretation of fire effects monitoring data for park managers to use for program evaluation and decision making. This annual report is intended to partially fulfill reporting requirements for the Fire Ecology Program and does not constitute a complete analysis of any NPS fire management program or activity. Additional interpretation and reporting can be found in previous annual reports at [NPS DataStore](#) or by contacting the author(s) of this report.

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This 2025 Annual Report is preliminary. The Dragon Bravo Fire, extension of the fire ecology and fire effects field season requiring all program staff in the field to December 2025 to collect fire severity and effects data, and the requested deadline for this report (1/9/2025) preclude presentation of the 2025 data analysis in this preliminary 2025 report. Once quality checks and analysis are complete, an updated version of this report will be made available.

A. Summary

Due to the preliminary nature of this report, focus is on 2025 achievements and key tasks for 2026-28. Comprehensive findings from data analysis will be presented in the final report.

Key 2025 Achievements

Fire Effects & Severity Data Collection

- Collected high resolution fire effects data on 108 plots, including **79 immediate post-fire plots with severity information for the Dragon Bravo fire.**
 - Post-fire reads were completed with a swift, late-season pivot due to timing, under-budget and with half-staffing due to the government shutdown, thanks to the crew's extraordinary dedication and work.

Operational Support During Dragon Bravo Fire

- Provided crucial fire weather and behavior data during the incident.
- Delivered geo-referenced fuel loading information for decision support.
- Successfully evacuated crew.

Post-Fire Staffing, Mental Health Support & Strategic Re-Tasking

- Re-tasked staff, addressing crew mental health needs and operational efficiency:
 - Resource Advisor roles and emergency stabilization efforts;
 - Engine assignments and resources for fire operations;
 - Crew Lead detailed at Natchez Trace Parkway to improve digital data collection;
 - Assistance to Yosemite National Park during staffing shortages.

Programmatic Modernization & Innovation

- Prior to 2025, annual report and fuel loading analyses relied on now outdated, labor-intensive methods; some forest types lacked objectives/reporting; and analyses for all forest types lacked automation, geo-referencing, and full incorporation of **Integrated Fire Risk Management (IFRM) principles.**
 - In 2025, automation, geo-referencing, and IFRM principles were introduced to address fire-aridity feedbacks, with work in these areas ongoing (see **Section C and Appendix C for additional details**).
 - Enabled rapid pivot in monitoring from severity acreage to forest function.

Strategic Collaboration & Capacity Building

- Partnered with the Southwest Fire Science Consortium to establish a 2026 workshop on Integrated Fire Risk Management (IFRM).
- Led interagency collaboration on projects addressing fuel-aridity crisis.
- Secured funding for IFRM internships through Grand Canyon Conservancy and GRCA Science & Resource Management; supervised and mentored 2025 intern.
- Directed first-year tasks for the Fuller Fire Burned Area Rehabilitation (BAR) project.

2025 Workload & Key Tasks for 2026-2028

Appendix A details staff workloads and accomplishments. **Appendix B** outlines the key tasks for evidence-driven risk management at GRCA and area monuments for 2026-2028.

Table 1A: 2025 Grand Canyon National Park Fire Effects Plots Established/Sampled

Rim	Code	Monitoring Unit	Plot Type	Total Plots ¹	Years Data Collected (start-end)	Annual Total (2025)	2025 Collections		
							Install / Pre-burn	Post - Burn	Years 1 - 20
South	PIPO	Ponderosa Pine	FMH - Forest	41	1990 - 2025	6			6
South	PIED ²	Pinyon-Juniper Woodland	FMH - Forest	17	1990 - 2023	0			
South	I&M PJ	Pinyon-Juniper	I&M ³	30	2021 - 2025	20	19		1
South		Moqui Rx	RAP ⁴	5	2008 - 2011	0			
South		Picnic Rx	RAP ⁴	10	2008 - 2011	0			
South		Quarry Rx	RAP ⁴	10	2008 - 2011	0			
South		Tusayan Pueblo (Thinning)	RAP ⁴	20	2023	0			
North	PIPN	Ponderosa Pine	FMH - Forest	30	1992 – 2025	9		6	3
North	PIAB	Ponderosa Pine with White Fir Encroachment	FMH - Forest	27	1993 – 2025	21		21	
North	PIEN	Rocky Mountain Subalpine Conifer	FMH - Forest	17	1993 - 2025	11		11	
North	GRIN	Grassland Interior	FMH - Brush	10	2001 - 2002	0			
North	GRED	Grassland Edge	FMH - Forest	6	2001	0			
North	I&M Mix	Mixed Conifer	I&M ³	46	2010 - 2025	41		41	
North		Fawn Spring Rx ⁵	RAP ⁴	20	2010 - 2022	0			
North		Highway 67 Rx ⁵	RAP ⁴	20	2015 - 2022	0			
North		Range Rx	RAP ⁴	20	2008 - 2014	0			
North		Spring Canyon Rx ⁵	RAP ⁴	20	2010 - 2022	0			
North		Thompson Rx	RAP ⁴	20	2009 - 2017	0			
North		Burnt Corral-NKRD	RAP ⁴	50	2015	0			
North		Tipover Rx-NKRD	RAP ⁴	40	2013 - 2022	0			
North		Walla Valley Rx	RAP ⁴	6	2008	0			
Total				485		108	19	79	10

¹ Total Plots includes all permanent plots (FMH, RAP, or I&M) installed to date within a monitoring unit/type.

² PIED monitoring type reads were discontinued in 2000 & resurrected in 2021 due to shifts in environmental/fire conditions.

³ Fuel and tree data collected to add to data collected by I&M crews.

⁴ Rapid Assessment Plots; Pilot sampling.

⁵ While RAP plots were installed with specific projects in mind, the decision was made in 2014 to collect post-burn data on individual plots regardless of what fire affected them - as such, plots in these project units were read after burning in Tipover East Rx and Slopes Rx.

Table 1B: 2025 Flagstaff National Monuments Fire Effects Plots Established/Sampled

Park	Code	Monitoring Unit	Plot Type	Total Plots ¹	Years Data Collected (start-end)	Annual Total (2025)	2025 Collections		
							Install / Pre-burn	Post - Burn	Years 1 - 20
Walnut Canyon NM	PIPO	Ponderosa Pine	FMH – Forest / I&M	13	1993 - 2024	0			
Walnut Canyon NM	PIED	Pinyon-Juniper Woodland	FMH – Forest	2	1997 – 2000	All Plots Discontinued ²			
Sunset Crater NM	BOGR	Montane Meadow	FMH - Grass	10	2002 - 2003	All Plots Discontinued ³			
Sunset Crater NM	PIPO	Pine Encroachment of Montane Meadow	FMH - Brush	5	2002 - 2003	All Plots Discontinued ³			
Wupatki NM	BOER	Plains/Great Basin Grassland	FMH - Grass	4	2002 - 2003	All Plots Discontinued ⁴			
Wupatki NM	HIJA	Plains/Great Basin Grassland	FMH - Grass	12	2002 - 2003	All Plots Discontinued ⁴			
Total				46		0			

¹ Total Plots includes all permanent plots (FMH or I&M) installed to date within a monitoring unit/type.

² Walnut Canyon NM FFI database containing the PIED plot data, including plot coordinates, is archived on the NPS IRMA portal (Reference Code: 2222935).

³ Sunset Crater NM FFI database containing the plot data, including plot coordinates, is archived on the NPS Integrated Resource Management Applications (IRMA) portal (Reference Code: 2221713).

⁴ Wupatki NM FFI database containing all plot data, including plot coordinates, is archived on the NPS IRMA portal (Reference Code: 2222001).

During 2015, fire effects monitoring plots within the three Flagstaff Area National Monuments were evaluated to determine their utility in providing feedback for fire management activities in the monuments. As a result of the evaluation, five monitoring types containing 33 total plots were discontinued and archived. The details of the evaluation and decision process are contained in the report “Fire Effects Monitoring for the Flagstaff Area National Monuments: Overview, Status, and Future Direction” (Bunn 2015; National Park Service Integrated Resource Management Applications Data Store Reference Code: 2223756). GRCA has worked with the I&M program since 2015 to share data and repeat the pre-burn fuel, pole-sized tree, and overstory tree measurements in eleven FMH-established ponderosa pine (PIPO) plots and two I&M-established PIPO plots in Walnut Canyon National Monument. A copy of the FFI database containing the existing plot data is available on the NPS IRMA portal.

B. Monitoring Results & Recommendations

Grand Canyon National Park's Fire Ecology Program has installed 148 permanent FMH-style plots to date. As of 2025, 128 of the 148 plots have burned. This large body of data allows us to report results to our desired level of statistical accuracy for many of our major management objectives.

Specific management objectives have been created for three monitoring / plots types within the Park boundary. Objectives for PIPO (Ponderosa Pine South Rim), PIPN (Ponderosa Pine North Rim), and PIAB (Ponderosa Pine with White Fir Encroachment) were identified within the 2012 monitoring plan and are regularly assessed as new data become available.

PIEN (Spruce-Fir) and PIED (Pinyon-Juniper) and I&M shared plots have previously not been included in regular assessments as: (1) these areas were previously thought to be within the natural fire regime, (2) prescribed fires are not the management focus in these areas, and (3) quantitative objectives have not been updated or established. Due to shifting environmental and fire conditions, this now represents a large data gap being evaluated and addressed during 2025-2028.

During the 2025 field season new FMH data were collected as indicated in **Table 2A**. ***This 2025 Annual Report is preliminary. The Dragon Bravo Fire, extension of the fire ecology and fire effects field season requiring all program staff in the field to December 2025 to collect fire severity and effects data, and the requested deadline for this report (1/9/2025) preclude presentation of the 2025 data analysis in this preliminary 2025 report. Once quality checks and analysis are complete, an updated version of this report will be made available.*** In the interim, please refer to the 2024 annual report for further details on objectives, data, quality assurance and analysis procedures, and the status of fuel loadings prior to 2025 events.



Dragon Bravo Fire in early July (left) vs. late July (right) as viewed from the South Rim (photos by NPS).

C. Advancing Modern, Integrated Fire Risk Management & Metrics

In response to scientific and technological advances since the last program update, a main focus for the fire ecology program in 2025 has been on modernizing fire risk management, data collection, monitoring, and decision support metrics. This effort began during 2025 in two ways:

- developing a vision and foundation to implement modern Integrated Fire Risk Management (IFRM), and
- making headway on modernizing monitoring, reporting, and metrics to support IFRM.

Integrated Risk Management (IRM) combines the objectives, expertise and approaches from many disciplines to maximize resiliency to interrelated natural disasters that can occur as part of increasingly extreme fire and weather events. In particular, Integrated Fire Risk Management (IFRM) addresses fuel-aridity feedbacks and the watershed-wildfire nexus to maximize the success of fuel treatments, reduce wildland fire severity, provide natural fire breaks, and minimize post-fire impacts that can be compounded by extreme precipitation events (Kalapodis & Sakkas 2025 v. 4; Robinne et al. 2021; Robinne et al. 2018; Rego et al. 2018).

Modern approaches to IFRM build on the more established practice of utilizing beneficial fire and thoughtful thinning to reduce fuel build-up. Modern approaches incorporate scientific and technological advances across disciplines to address interrelated challenges simultaneously, especially surrounding fire-aridity feedbacks. For example, modern technological and scientific advances reveal that the fuel crisis is a fuel + aridity crisis. The aridity portion of this relationship must be addressed alongside prescribed fire and fuel reductions for successful moderation of fire behavior (for examples, see Abatzoglou et al. 2021, Pascolini-Campbell et al. 2022), as demonstrated by both modeling and the fact that even during extreme fire weather/behavior and highly severe megafires, evapotranspiration and plant water use efficiency are highly important determinants of fire severity.

Appendix C further describes the context and details of GRCA efforts in this area.

D. References, Links, and Additional Reading

Links

Link to NPS Data Store and the 2010 Grand Canyon National Park Wildland and Prescribed Fire Monitoring and Research Plan <https://irma.nps.gov/DataStore/Reference/Profile/2193323>

Link to NPS Data Store and FFI Database Backups [DataStore - Collection Profile - Collection ID 7625](#)

Relevant Supporting Documentation

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Appendix A. Staffing and Accomplishments

Table A-1 outlines 2025 staffing for GRCA and Flagstaff area monuments fire ecology and effects programs.

Table A-1: Fire Ecology and Effects Staffing 2025

Employee	Position	Appointment Length	# Pay Periods	Training	NWGG Taskbooks ¹
Lisa Handforth, GS-11	Fire Ecologist	PFT	26	National Park Service Intermountain Region Fuels Management Workshop; Colorado Plateau Biennial Conference; GRCA Leadership Development Workshops	
Li Brannfors, GS-07²	Lead Monitor	PFT	26	RT130 First Aid/CPR	LTAN-t
Madison Tumicki, GS-05, GS-06³	Monitor; Asst Lead Monitor	Temp (5/4/25 - 7/12/25) STF (7/13/25 - 12/13/25)	15	RT130 IS-200 First Aid/CPR	READ/REAF-t ⁴ FFT1-t ICT5-t FAL3-t
Haley Ramstorf, GS-05	Monitor	Temp (5/4/25 - 11/15/25)	14	S110/130/190 L180 ICS100 IS700 S212 S290 Ambulance Driver First Aid/CPR	FEMO-t FAL3 ⁵
Dante Hernandez, GS-05	Monitor	Temp (5/11/25 - 11/15/25)	13.5	S110/130/190 L180 ICS100 IS700 S290 Ambulance Driver First Aid/CPR	FEMO-t
Alexandra Lalor, GS-06⁶	Asst Lead Monitor	STF (1/1/25 - 6/14/25)	8.5	RT130 First Aid/CPR	FEMO-t FFT1-t ICT5-t FAL3-t

¹ This represents both open (trainee) taskbooks and those completed in the 2025 season.

² Time for Li Brannfors includes 2 PPs detailed at Natchez Trace Parkway as Fire Ecologist.

³ Madison Tumicki started as a temp crewmember but was hired as the Assistant Lead after Alexandra Lalor's departure mid-way through the season; her time excludes 1 PP of furlough and 1 PP of unpaid leave.

⁴ NWCG taskbooks do not yet exist for the READ & REAF positions.

⁵ Taskbook plus required courses completed and submitted for qualification.

⁶ Time for Alexandra Lalor excludes 1 week of furlough and 3 PPs working with GRCA Vegetation.

Fire Effects & Ecology Crew Accomplishments & Workload

The 2025 season presented unprecedented challenges. Reductions in support staff increased workloads. The Dragon Bravo Fire ignited on the North Rim in July and became the largest recorded fire in the United States in 2025. This event caused indefinite North Rim evacuation, including for program staff, presenting additional mental health, administrative, and re-tasking needs, and housing challenges for post-fire field work. Starting in October, a 45 day government shutdown further reduced support staffing and raised additional funding and travel questions and barriers, precluding the ability to receive staffing help from other parks for post-fire field work.

Despite this year's hardships, program staff showed incredible resilience and commitment. Staff provided direct and indirect operational fire support, assisted the Southern Colorado Plateau Network (SCPN) I&M program and Yellowstone National Park during staffing shortages, and read 108 GRCA fire effects plots, including all long-term monitoring plots burned in Dragon Bravo. Ultimately, 50% of all active FMH plots and 89% of all active plots shared with I&M on the North Rim burned – and were read, providing high resolution data to calibrate remote sensing and support ongoing risk management.

To start the season, all three permanent positions remained filled and three seasonal crewmembers were hired and onboarded by mid-May. In mid-June, the Assistant Crew Lead left GRCA to begin a Fire Ecologist position at another park. An exemplary multi-year returning seasonal crewmember was hired to fill this vacancy, and officially began the position in mid-July, one day after being evacuated from the North Rim. In August, the Crew Lead detailed for one month at the Mississippi River Zone/Natchez Trace (NATR) program as Fire Ecologist to assist with program assessment, data improvement, field data collection, and fire and data management training. The flexibility and dedication of new crewmembers along with the expertise and leadership of the returning staff allowed the program to continue to operate effectively during mid-season personnel changes and the challenges presented by 2025.

Increasing efficiency and building on past collaborations, one GRCA crewmember traveled to Mesa Verde National Park to assist SCPN with their data collection in August when they were understaffed. For a week in October during the shutdown, two SCPN crewmembers traveled to the North Rim to assist GRCA Fire Effects with late season post-burn data collection. Both crews partnered to collect data from all scheduled pinyon-juniper plots on the South Rim, resulting in the only comprehensive data collection performed at any of the SCPN parks in 2025 due to programmatic uncertainties and government shutdown. The continued cross-training among the crews and ongoing work to create data sharing productivities with R and R Studio and GRCA's FEAT-FIREMON (FFI) database, increase effectiveness and efficiencies each year.

Over 140 monitoring plots in GRCA Fire Ecology's active plot network were within the final Dragon Bravo Fire perimeter. Of these, 82 were long-term FMH and I&M plots, and 60 were project-specific Rapid Assessment Protocol (RAP) plots. Due to the fire continuing to actively burn into September, and the RAP plots already serving their purpose to monitor past prescribed burns, the decision was made to focus on maintaining long-term data continuity for the most important protocols in the landscape-scale I&M and FMH plots. Rather than immediately scaling-back standards due to limited staffing and government shutdown, staff began collecting

full immediate post-burn protocols to see what amount of work might be possible to accomplish. After the initial 3 plots were visited and post-fire conditions and road access were assessed, the crew and Fire Ecologist worked extensive overtime under extraordinarily challenging field and housing conditions to complete the full suite of data on all long-term monitoring plots that burned. Requested and needed staffing for this effort was much higher, but unavailable due to the government shutdown and travel restrictions. Results reflect the efficiency and dedication of the crew and Crew Lead, and ongoing effort to continually increase program efficiency.

For the twelfth season, 100 percent of Grand Canyon field data were collected on digital tablets and managed electronically. The crew further refined the process of using Google Sheets to collect field data by simplifying templates and using conditional formatting to notice errors more readily in the field. Electronic data collection discoveries were directly shared with additional programs, including the Yosemite and Mississippi River Zone/NATR Fire Ecology groups. Using R scripts to convert large batches of files for importing to FFI proved approachable for new crewmembers, flexible with different file storage systems, and continued to be the primary method used. The outgoing Assistant Lead developed additional R scripts for quality control/quality assurance (QAQC) and trained the crew on using them. As utilization of these scripts increases with 2025 and historical data, they should improve data quality across datasets at GRCA and in other programs as R usage continues to expand across the NPS Fire Ecology community.

In addition to the data collection and management from a heavy plot load, the Fire Effects crew gained diverse operational fire experience during the Dragon Bravo Fire as well as on other local fuels projects and in preparation for prescribed burns. In collaboration with North Zone Fire Management (USFS North Kaibab Ranger District-Kaibab National Forest & NPS North Rim-Grand Canyon National Park), the crew performed and reported bi-monthly fuel moistures for the North Rim sites. When Dragon Bravo started as a managed wildfire, the crew served as lead Fire Effects Monitor (FEMO) and FEMO trainees, reporting fire weather and behavior and gathering initial fuel moisture data. The crew's reports provided documentation to help better understand the fire's later unexpected growth. Following evacuation, crewmembers returned to Dragon Bravo and gained experience working with an engine and performing Resource Advisor (READ/REAF) and Burned Area Emergency Rehabilitation (BAER) work. The crew additionally helped boost Severity staffing on both rims and assisted with a hand thinning project on the South Rim. In total, Fire Ecology staff worked on 6 incidents and Severity, prep, or READ surveys over 86 total operational periods and completed 10 different NWCG training courses, continuing the program's commitment to provide valuable support to operational fire activities and experience to employees working toward careers in wildland fire.

The GRCA program extends gratitude to outgoing Assistant Lead Monitor for five years of exemplary service, leadership, and innovation in data management. The GRCA program also extends gratitude to the Crew Lead, incoming Assistant Crew Lead, and all seasonal crew members for their exemplary dedication, hard work, and efficiency in an incredibly challenging year.

Table A-2 below details crew member workload and accomplishments.

Table A-2: Fire Effects Crew 2025 Accomplishments/Focus Areas

Focus Area	Percent Time ¹	Accomplishments and Activities
FMH Plots	21	38 immediate post-burn measurements and 9 remeasurements at GRCA
RAP Plots	3	- No scheduled remeasurements or immediate post-burn reads in 2025 at GRCA - RAP plots read by GRCA staff at YOSE and NATR program parks
I&M Plots	9	19 new baseline measurements and 1 remeasurement of fuel and tree data in Pinyon-Juniper plots at GRCA in partnership w/ SCPN staff 41 immediate post-burn reads in Mixed Conifer plots at GRCA
Data Entry/ Management	7	<i>Field data entry/checking (via tablets) is included under the corresponding plot type.</i> - Asst Lead developed R scripts to find cross-year data errors and trained crew - QAQC compared between FFI queries and new R scripts for 2024 GRCA data - QAQC completed for 2024 WACA data - QAQC completed for 2019-2023 I&M data - SCPN Ecologist refined R scripts to export I&M tree data in conjunction w/ Lead - Imported 2024 I&M tree data 2024 GRCA and WACA field data backed up to NPS DataStore - Includes FFI/Google Sheets/Excel electronic data prepping, merging, and checking
Data Analysis	2	<i>Due to data collection continuing into mid-Nov and an early due date for the 2025 report, analysis on 2025 data will be performed later in 2026.</i> 2024 Annual Report analysis on all major variables in program completed in January 2025 - Asst Lead worked with Ecologist to develop R-based exporting of data from FFI to facilitate analysis - Lead and Asst contributed to the Fire Ecology Annual Report
Plot Office	12	Includes plot preparation, plant ID, photo filing, tree mapping, hardcopy data filing/organization, gear repair, and plot-related projects.
General Office/ Supervision/ Admin/Non-FX duties	23	<i>The winter was devoted almost exclusively to office work, with both the permanent Assistant Lead and Lead focusing on tasks in the office with minimal furlough. Duties previously categorized as Other/Miscellaneous were lumped into this category in 2025. Uncategorizable duties related to unplanned fire evacuation from the N Rim and a 43-day government shutdown are included. Hence, a larger percentage of general office time than in years past is reflected.</i> - Includes paperwork for travel, credit cards, non-plot related projects - Hiring, evaluations, and daily leadership of 3 seasonals by Asst & Lead - Fire evacuation meetings and paperwork - Government shutdown planning, meetings, and paperwork 2 crewmembers participated in GRCA Vegetation river trip for 7 days
Fire Monitoring (Rx or Wildfire)	2	4 crewmembers served as Lead FEMO and FEMO trainees on Dragon Bravo for ~1 week
Fire Operations/ Assignments (Rx, Wildfire, Engine, Helitack, Non-fire Fuels Projects)	13	<i>Includes all collateral duty time on Rx or Wildland Fire operations (excluding FEMO).</i> - Asst went on READ/REAF-trainee assignment for 2 weeks on Dragon Bravo Fire - Asst performed as FFT1-t while performing READ/REAF and FEMO duties 2 crewmembers went on FAL3-t and FFT2 assignments for 4 weeks on Dragon Bravo Fire (2 weeks each) - Severity staffing support on both North and South Rims (3 crewmembers, multiple days each) - FAL3-t support on Tusayan Museum fuels project (1 crewmember, 3 days) - READ/REAF surveys on North Rim (3 crewmembers, 1 day) - Bi-monthly and project-specific fuel sampling in coordination with North Zone
Training	8	- All attended annual fire refresher 2 completed initial fire training courses: S110/130/190, L180, ICS100, IS700 1 completed S212 2 completed S290 2 completed ambulance driver training to assist with medical incidents - All crewmembers completed/refreshed CPR/first-aid training ~3% of crew time spent on PT

Focus Area	Percent Time ¹	Accomplishments and Activities
Travel Away from Duty Station²	—	• ~2 weeks total for plots and botany training on South Rim • ~2 weeks for 3 crewmembers assisting Yosemite FX with their plot work • ~5 months total for Lead teleworking in Flagstaff & detailed at NATR • ~3 months for Asst dual duty stationed on South Rim during winter • ~1.5 months total for plot work, gear recovery, and fire assignments on North Rim post-evacuation
Leave/Holidays Off	—	• ~11% of crew time spent on leave or holidays not worked³

¹1226 hours of combined overtime and comp time, equaling 17 percent of total crew work time (base + OT + CTE), are not reflected.

²Following evacuation from the North Rim due to the Dragon Bravo Fire in July, the Lead, Asst, and crew spent the remaining 5 months of the calendar year on the South Rim in travel status.

³Leave taken and holidays not worked were included in focus area percentages of time in previous annual reports. The percentage listed here is provided for reference/comparison with prior reports but is not included in the percentage calculations listed for major duties.

Fire Ecologist Accomplishments & Workload

Table A-3 below details the accomplishments, focus areas, and workload of the Fire Ecologist.

Table A-3 Fire Ecologist 2025 Accomplishments/Focus Areas

Focus Area	Time (%)	Accomplishments and Activities
Supervision & Administrative Tasks	30	• Routine Program Manager responsibilities (housing requests, timesheet approvals and time off and overtime requests, travel authorizations, equipment and vehicle inventories, yearly budgeting and planning, performance reviews, etc.) • Provided ongoing guidance to the crew on how to respond most effectively to a variety of changing conditions in response to reductions in staffing, the Dragon Bravo Fire, ongoing evacuation impacts, and a large volume of updates to agency deadlines and guidance • Led crew through post-Dragon Bravo mental health check-ins and adjustments because of evacuations and other fire-related issues, including an increased level of involvement that allowed the Crew Lead to step away and serve as Fire Ecologist at Natchez Trace Parkway • Re-tasked and re-prioritized work for the crew after the Dragon Bravo Fire to ensure mental health needs of each individual were met, and their efforts could be of maximum benefit to the government and taxpayers • Coordinated funding and logistics to allow for urgent post-fire evaluations at the North Rim under reduced staffing and North Rim out-of-season/evacuation conditions • Oversaw hiring, HR, and intake and qualifications updates of seasonal fire positions, and assistant Crew Lead permanent staff • Conducted IFRM intern search and interviews • Worked with GCC and ACE partners to hire Integrated Fire Risk Management intern • Conducted ongoing oversight, tasking and prioritization for IFRM intern • Developed detailed travel, work, and budget plans responding to changing conditions repeatedly over the course of a highly unusual year, and met with administrative and financial experts for guidance as needed
Data Analysis & Reporting	20	• Graphical & statistical analyses in R to support decision making & reporting • Worked across agencies and parks with other Fire Ecologists and R experts to create fuel loading reporting code in R and otherwise advance the modernization of data analysis and reporting • Co-authored the Fire Ecology Annual Report.

Focus Area	Time (%)	Accomplishments and Activities
		• Co-authored USFWS annual report • Reviewed and provided input on annual fire program reporting • Worked with regional Fire Ecologist, national & IMR GIS experts to update Monitoring Trends in Burn Severity mapping, and update and conduct quality assurance fuel treatment and fire history data • Worked with regional GIS staff to provide geo-referenced fuel loading information, merging data from FFI and R with GIS • Developed a vision/goal for future, automated, geo-referenced, integrated, intervention focused metrics merging FFI, R, and GIS • Designed, and began implementing, step by step improvements to local decision support tools to advance objectives stemming from that vision/goal
Planning	15	• Collaboratively designed interagency projects and proposals for modernizing the decision tools and activities needed for Integrated Fire Risk Management • Collaborated with and met with Grand Canyon Conservancy (GCC) staff multiple times throughout the year to coordinate fundraising activities for Integrated Fire Risk Management staff and projects • Obtained GCC funding to hire an Integrated Fire Risk Management intern • Provided technical review and decision support for prescribed fire burn and fuels treatment plans, and advised on risk assessments, • Served as technical expert in IDTs for PEPC and SRM and other projects for GRCA Branch of Fire & Aviation Management, assisted with a variety of fire planning and reporting • Reviewed projects & permit requests for fire-related concerns • Coordinated with regional and national staff and other fire ecology programs, created budget estimates and sought funding, and facilitated crew, Crew Lead, and assistant Crew Lead in obtaining appropriate experience and opportunities for fire assignments, fire effects data collection, and prescribed fire FEMO duties – particularly during and after the Dragon Bravo Fire, in addition to the usual fire assignments and support
Field Work & Data Collection	15	• Assisted I&M and fire effects crew with data collection at the South Rim, Wupatki National Monument, and urgently collecting GRCA post-fire severity and effects data on the North Rim for 79 plots • Conducted site visits to ground-truth burn plan, fuel reduction, and other assumptions & techniques • Formal & informal field trips to ground-truth the extent to which plot data is capturing the landscape & fire program's assumptions, examine holding lines for Rx plans, collect gps points and photographs of fuels, erosion, vegetation challenges, and other risk and resource protection variables
Meetings & Collaboration	13	• Participated in and led national-level, interagency focus groups on responding effectively to the fuel+aridity crisis and designing effective Integrated Fire Risk Management techniques, monitoring, and metrics • Participated in the interagency emergency stabilization discussions and BAER Team process after the Dragon Bravo Fire; oversaw intern and crew members who assisted in emergency stabilization data collection • Participated in / led meetings with USFWS to update reporting metrics, conduct required annual report, etc. • Consultations with Southwest Fire Science Consortium • Preparatory meetings and content development for teaching 2026 Interagency Wildland Fire Apprentice Program academy offerings • Fire and aviation weekly staff and strategy meetings • R + FFI monthly meetings • Bi-monthly SRM program manager meetings to provide updates • FMO monthly meetings (periodically as needed) • IMR fire planning office hours (periodically as needed) • IMR fire ecology meetings • GRCA weekly fire ecology team meetings • GRCA weekly Integrated Fire Risk Management meetings to guide, facilitate, and oversee intern focused on these projects

Focus Area	Time (%)	Accomplishments and Activities
		• Mentoring calls other Fire Ecologists to share strategies and eliminate duplication of effort • R & FFI follow-up meetings specifically focused on improving FFI/R workflows and creating code for existing and modernized, integrated reporting, and translating code into more broadly usable products • Follow-up meetings with individual resource managers and specialists, to provide updates on GRCA Fire activities and coordinate Integrated Fire Risk Management efforts across disciplines • Mentoring calls for R & FFI – seeking and/or providing mentoring to other ecologists and R and/or FFI experts • Cooperative efforts with tribal partners, universities, and non-profits • Meetings to plan regional training on adapting to the fuel+aridity crisis • Meetings and collaboration to share data collection efforts, data, R and FFI expertise and development of modern metrics for Integrated Fire Risk Management, with the Southern Colorado Plateau Network Inventory & Monitoring program for Mixed Conifer & Pinyon-Juniper fuel types at Grand Canyon, to increase efficiency and effectiveness of both programs
Wildfire Assignments & BAER/BAR Activities	2	• Directed Fuller Fire Burned Area Rehabilitation needed to maintain GRCA landscapes, viewsheds, visitor experience, listed species, and prescribed fire program – thousands of trees are now ready to plant, including culturally important plants requested by tribal representatives • Participated in Dragon Bravo BAER and emergency stabilization discussions; facilitated crew field participation in emergency stabilization
Research	2	• Provided summaries of key advances in knowledge impacting wildland fire behavior and management to inform GRCA and monument staff and the wildland fire team • Reviewed research to recommend technological and scientific advances, particularly with regard to fuel and aridity monitoring and interventions • Continued to develop and submit funding proposals for projects focused on improving programmatic modernization incorporating technological and scientific advances
Data Management	1	• Worked with previous Fire Ecologist, regional Fire Ecologist, Crew Lead and assistant lead to understand and carry-out existing FFI / Excel / FFI / R / Google sheets workflows for data collection, QA/QC, analysis, and reporting.
Training	1	In addition to generally required trainings: • NPS IMR Fuel Management Workshop • Colorado Plateau Biennial Conference (including a focus on the fuel+aridity crisis and regional, inter-agency cooperative efforts) • GRCA Leadership Development Workshop • Various trainings on FFI, IFPRS, InFORM, IFTDSS, WFDSS • Coaching meetings with interagency coach, supervisor, etc. • Drought Learning Network meetings to stay up-to-date with latest developments on the fuel+aridity crisis
Presentations	1	• Presented at meetings for resource managers from various disciplines, interpretive staff, education staff, visual information specialists, tribal liaisons and many others to inform folks on what the GRCA fire and fire ecology programs do • Designed outreach, partnership, and education events and presentations, including overseeing intern work on a series of short, animated social media videos focused on Integrated Fire Risk Management and responding to the fuel+aridity crisis



Walking the perimeter of the Dragon Bravo Fire in early July (photo by Li Brannfors).

Appendix B. Key Tasks Required to Support GRCA and Flagstaff area Monuments Risk Management, Fire Ecology and Effects for 2026-2028

Year	Task: Description	Qualifications
2026-2028	Supervision / Administration of Fire Ecology/Effects Crew: Hire, train, staff, and run the crew.	Extensive knowledge of GRCA's FMH and modified FMH protocols for each habitat type, detailed knowledge of specific North Rim and South Rim locations and plot history, and detailed understanding of NPS personnel and hiring policies, detailed understanding of plot histories, and GRCA-specific FFI, digital data collection, data management, quality assurance, and reporting. Qualifications and experience in GRCA and NPS FEMO and READ roles.
2026-28	Standard Data Collection: Collect year 1 and 2 fire effects and severity data on 79 Dragon Bravo plots, plus other data on plots on the standard schedule from other fires to inform fuel reductions and other IFRM interventions, maintaining the protocols, systematic approach, and attention to detail and quality provided by the Crew Lead for the last 20+ years.	See 2025 Crew Lead, assistant Crew Lead, and seasonal crew member position descriptions currently in place. Long-term, local knowledge to the South and North Rims will be key to avoid common errors made by inexperienced or non-local personnel.
2026-2028	Standard FEMO / READ / Fire Support: Continue to support wildland fire as READs, FEMOs, and direct and indirect support for fire fighting, preparedness, and risk reduction activities. Maintain a focus on the specific mission of the location, and details of the land crucial to effective and efficient action, and to data quality for highly effective decision support.	See 2025 Crew Lead, assistant Crew Lead, and seasonal crew member position descriptions currently in place, and ICQS records for current staff. Long-term, local knowledge to the South and North Rims will be key to avoid common errors made by inexperienced or non-local personnel.
2026-2028	Interagency WFAP Offerings: Collaborate with experts across wildland fire agencies to teach Wildland Fire Apprentice Program academy offerings across the nation.	3+ years experience in fire ecology, FFI, NPS FMH and modified-FMH protocols, plant identification, data management and analysis, ecological monitoring, and management.
2026-2028	Automating FFI/R Workflows: Work with national FFI developers and contract managers to advance automation of the connection between FFI and R code	3+ years of experience moving large SQL databases in and out of FFI or other national SQL databases and conducting quality assurance on them. 5+ years of experience coding data analysis, statistical tests, and work flows between data management software suites specifically include R and R Studio. 5+ years presenting data in formats that clearly help managers know exactly what steps to take. A PhD in Biology or MS in Statistics.

Year	Task: Description	Qualifications
2026-2028	Ground-truthing and calibrating LiDAR data for GRCA and National Forests using GRCA Fire Ecology and Effects field data: Work with GRCA GIS to advance the comparison of field data to LiDAR data to gauge accuracy, utility, and to calibrate LiDAR data to exact values on the ground for LiDAR data being collected for GRCA and Kaibab NF	Solid understanding of GRCA's FFI data (which is much more detailed than that collected by other agencies), 5+ years of statical analysis and R and R Studio coding experience. A PhD in Biology and/or MS in Statistics with 5+ years interpreting biological data.
2026	Mixed-Conifer Pilot Integrated Metrics: Develop final limited (pilot) mixed-conifer IFRM objectives and metrics /their calculations for fuel loadings and forest function/habitat elements (as pilot for full suite of IFRM metrics), including geo-referenced, intervention focused visualizations for swift, focused decision support.	3+ years of experience moving large SQL databases in and out of FFI or other national SQL databases and conducting quality assurance on them. 5+ years of experience coding data analysis, statistical tests, and work flows between data management software suites specifically include R and R Studio. 5+ years presenting data in formats that clearly help managers know exactly what steps to take. Thorough understanding of fire management, fire ecology, plant ecophysiology, and how hydrology and other plant, microbial, and ecosystem functions contribute to or reduce fire risk. 5+ years experience with each of the following disciplines and a PhD: fire ecology and management, plant ecophysiology, microbial ecology focused on drought tolerance and biomass decomposition in forests, and ecohydrological concerns surrounding IFRM.
2027-2028	Full Suite of Integrated Metrics: Develop full suite IFRM objectives and metrics/their calculations for all forest/plot types, including geo-referenced, intervention focused visualizations for swift, focused decision support.	3+ years of experience moving large SQL databases in and out of FFI or other national SQL databases and conducting quality assurance on them. 5+ years of experience coding data analysis, statistical tests, and work flows between data management software suites specifically include R and R Studio. 5+ years presenting data in formats that clearly help managers know exactly what steps to take. Thorough understanding of fire management, fire ecology, plant ecophysiology, and how hydrology and other plant, microbial, and ecosystem functions contribute to or reduce fire risk. 5+ years experience with each of the following disciplines and a PhD: fire ecology and management, plant ecophysiology, microbial ecology focused on drought tolerance and biomass decomposition in forests, and ecohydrological concerns surrounding IFRM.
2028	Automation of R, FFI, and IFRM Metrics: Work with national FFI developers and contract managers, Fire Ecologists and F+FFI working group members data workflow group members and experts, and GRCA and NPS GIS	3+ years of experience moving large SQL databases in and out of FFI or other national SQL databases and conducting quality assurance on them. 5+ years of experience coding data analysis, statistical tests, and work flows between data management software suites specifically include R and R Studio. 5+ years

Year	Task: Description	Qualifications
	experts to fully automate connections between FFI, R, LiDAR, and GIS such that the full suite of selected IFRM metrics are available at each location across the landscape at the touch of a button, with drill-down features to swiftly inform interventions and decision support. If helpful, plan for hiring an intern for this purpose and jointly oversee with local and national R, FFI, and GIS experts.	presenting data in formats that clearly help managers know exactly what steps to take. Thorough understanding of fire management, fire ecology, plant ecophysiology, and how hydrology and other plant, microbial, and ecosystem functions contribute to or reduce fire risk. 5+ years experience with each of the following disciplines and a PhD: fire ecology and management, plant ecophysiology, microbial ecology focused on drought tolerance and biomass decomposition in forests, and ecohydrological concerns surrounding IFRM.
2026-2028	Fuller Fire BAR: Oversee implementation of Fuller Fire BAR and follow-up monitoring – directing and overseeing the following tasks: select precise locations, collect mycorrhizae for inoculation, continue collecting and propagating plants, install plantings, decide on most appropriate access and herbivore-protection for sensitive seedlings given locust thickets, monitor for 2 years, identify aridity feedback monitoring opportunities based on other IFRM projects.	Understanding of plant ecophysiology and how it relates to soil moisture, drought, and is impacted by micro-migrations and symbiotic microbial partners including mycorrhizal fungi – and how inappropriate pairings of symbionts can have negative impacts. Full understanding of the techniques required for successful mycorrhizal restoration.
2026	IFRM Vision, Planning, and Implementation: Flesh out IFRM vision so it is ready for grant proposals, scopes of work, etc and obtain input from park experts and resource managers, as well as cooperators and topic experts across disciplines, share with park management, tribes and GCC for fundraising input, and approvals, work with GCC on final wording for their work.	Understanding of plant ecophysiology and how it relates to soil moisture, drought, and is impacted by micro-migrations and symbiotic microbial partners including mycorrhizal fungi – and how inappropriate pairings of symbionts can have negative impacts. Understanding of limitations of assisted migration, interactions of dry soil in aridity feedbacks, positive effects of NIDS, and interconnections between forest canopy and fuel reductions and snow pack, micro-climate buffering, and soil moisture retention.
2026-2027	Southwest Fire Consortium Collaboration: Work with the Southwest Fire Consortium Program Manager to plan a 2026 workshop and field trip focused on manager needs for implementing Integrated Fire Risk Management, using GRCA as a case study for discussion. Implement ideas arising out of this workshop.	Thorough understanding of fire management, fire ecology, plant ecophysiology, and how hydrology and other plant, microbial, and ecosystem functions contribute to or reduce fire risk. 5+ years experience with each of the following disciplines and a PhD: fire ecology and management, plant ecophysiology, microbial ecology focused on drought tolerance and biomass decomposition in forests, and ecohydrological concerns surrounding IFRM.
2026-2028	Local/Regional IFRM Working Group: Coordinate and flesh-out IFRM projects across agency boundaries and disciplines to allow for regional scaling-	Thorough understanding of fire management, fire ecology, plant ecophysiology and how hydrology and other plant, microbial, and ecosystem functions contribute to or reduce fire risk. 5+ years experience

Year	Task: Description	Qualifications
	up of lessons learned, implementation efficiencies, and monitoring across GRCA, Coconino National Forest, and Kaibab National Forest and other land owners. Design and implement projects and monitoring targeting the aridity portion of the fuel+aridity crisis that can work hand-in-hand with fuel reduction efforts. Implement projects and work across agencies & disciplines to scale-up for local/regional effectiveness.	with each of the following disciplines and a PhD: fire ecology and management, plant ecophysiology, microbial ecology focused on drought tolerance and biomass decomposition in forests, and ecohydrological concerns surrounding IFRM.
2026-2028	IFRM Intern: Continue to work with GCC, GRCA SRM, and other IFRM project partners to outline IFRM intern projects and tasks, supervise and mentor intern, and guide intern from planning phases of projects through implementation.	Understanding of plant ecophysiology and how it relates to soil moisture, drought, and is impacted by micro-migrations and symbiotic microbial partners including mycorrhizal fungi – and how inappropriate pairings of symbionts can have negative impacts. Understanding of limitations of micro-migrations and plant physiology, interactions of dry soil in aridity feedbacks, positive effects of NIDS, and interconnections between forest canopy and fuel reductions and snow pack, micro-climate buffering, and soil moisture retention. Thorough understanding of fire management, fire ecology, plant ecophysiology, and how hydrology and other plant, microbial, and ecosystem functions contribute to or reduce fire risk. 5+ years experience with each of the following disciplines and a PhD: fire ecology and management, plant ecophysiology, microbial ecology focused on drought tolerance and biomass decomposition in forests, and ecohydrological concerns surrounding IFRM.

Appendix C: Advancing Modern, Integrated Fire Risk Management & Metrics

In response to scientific and technological advances since the last program update, including in data analysis, statistics and visualization, automation of data management and reporting, and understanding of causes and mitigations for the fuel+aridity crisis that address the wildfire-watershed nexus, the focus in 2025 has been on modernizing fire risk management, data collection, and monitoring. This effort began during 2025 in two ways:

- developing a vision and foundation to implement modern Integrated Fire Risk Management (IFRM), and
- making headway on modernizing monitoring, reporting, and metrics to support IFRM.

Below we focus on the progress made and vision for each of these at GRCA, as developed in collaboration with GRCA SRM and interagency experts across disciplines from a variety of meetings and consultations. The foundation and vision were established in 2025 so that they can be fleshed-out, reviewed and improved, and implemented during 2026-2028.

Developing a Vision & Foundation for Modern Integrated Fire Risk Management (IFRM)

Integrated Risk Management (IRM) combines the objectives, expertise and approaches from many disciplines to maximize resiliency to interrelated natural disasters that can occur as part of increasingly extreme fire and weather events. In particular, Integrated Fire Risk Management (IFRM) addresses the crucial fuel+aridity crisis, fuel-aridity feedbacks, and watershed-wildfire nexus to maximize positive effects of beneficial fire, reduce wildland fire severity, provide natural fire breaks, and prevent and minimize post-fire impacts that can be compounded by extreme precipitation events (Kalapodis & Sakkas 2025 v. 4; Robinne et al. 2021; Robinne et al. 2018; Rego et al. 2018).

Modern approaches to IRM build on the more established practice of utilizing beneficial fire and thoughtful thinning to reduce fuel build-up. Modern approaches incorporate scientific and technological advances across disciplines to address interrelated challenges simultaneously, especially surrounding fire-aridity feedbacks and the watershed-wildfire nexus. For example, the fuel crisis is a fuel + aridity crisis. We now know that the aridity portion of this must be addressed alongside prescribed fire and fuel reductions for successful moderation of fire behavior (for examples, see Abatzoglou et al. 2021, Pascolini-Campbell et al. 2022), as demonstrated by both modeling and the fact that even during extreme fire weather/behavior and highly severe megafires, evapotranspiration and plant water use efficiency are highly important determinants of fire severity.

Thus, modern IRM and IFRM incorporate strategies to interrupt fire-aridity feedbacks, improve and support micro-climate buffering crucial to snowpack, protecting drinking water supplies, and supporting soil moisture and plant water use efficiency during drought conditions - simultaneously creating fire breaks, and optimizing the effectiveness of beneficial fire and fuel reduction activities, and slowing post-fire erosion and debris flows to prevent compounding disasters (Martin 2016; Robinne et al. 2021; Rego et al. 2018; Dickerson-Lange et al. 2023; Norman 2022; Norman et al. 2022). For example, pilot projects across the West regionally, and

more locally in Coconino and Kaibab National Forests, include projects that slow post-fire erosion and debris flows, and support plant hydration ahead of and during fires to create fire breaks that complement fuel reduction projects (the two can even be done in tandem at the same locations). Recent scientific innovations and monitoring reveal the effectiveness of, and build on, simple traditional methods employed by first nations and that occur naturally.

In forests with more perennial water and mixed-conifer or riparian forests similar to those found at the North Rim and in North Rim side canyons and springs that contribute to the Colorado River and its store of drinking water, beaver dams and beaver dam analogs are increasingly demonstrating effectiveness as fire breaks and natural solutions that reduce fire severity even during megafires, reduce erosion, channelization, and debris flows, attenuate floods, improve water quality, and interrupt drought and aridity feedback cycles (Moravek et al. 2025; Fairfax et al. 2024; Fairfax & Westbrook 2024; Fairfax & Whittle 2020; Denton & Fairfax 2024; Griffen 2025).

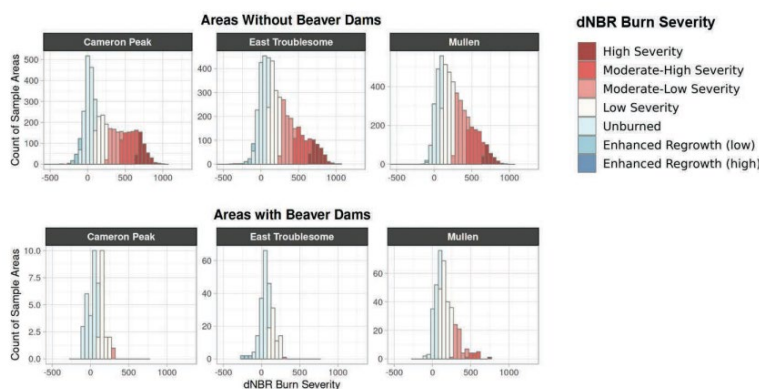
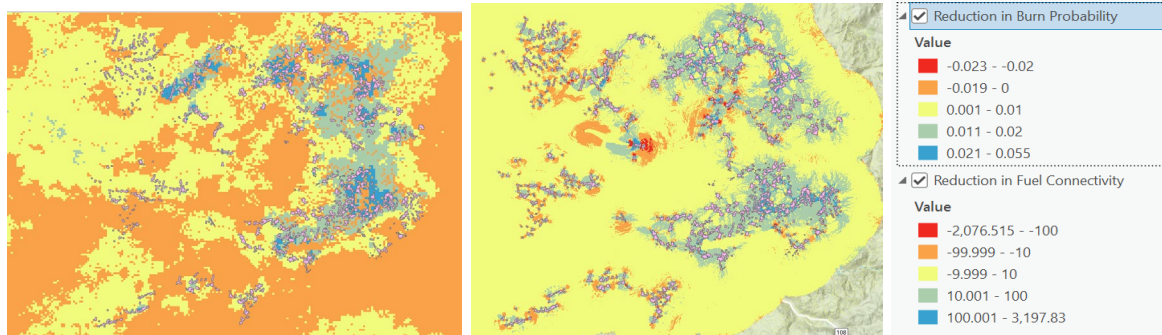


Figure 4. Distribution of sample differential normalized burn ratio (dNBR) burn severity by fire and landscape type.

Reductions in burn severity in megafires from the slowing of water, in this case provided by beaver dams (Figure 4 from Fairfax et al. 2024).

In drier southwestern landscapes similar to those found at the South Rim, Natural Infrastructure in Dryland Streams (NIDS; small rock structures placed in dry creek beds, designed to leak water but slow it down) achieve similar outcomes using techniques modelled off past Indigenous management techniques (Norman et al. 2022; Norman 2022; Gooden & Pritzlaff 2021). In fact, ruins of these past structures can be found at GRCA. Recent dialogue with tribal members at 2024 and 2025 ITWG meetings demonstrated support for this approach, as well as willingness to partner and share traditional expertise related to building these structures. The vision for GRCA's resiliency includes a concentrated effort to get these types (and others) of pilot projects on the ground, working hand-in-hand with prescribed fire and fuels reduction activities, and with our tribal sovereign nations.

USFS fire behavior modelling reveal the difference that these IFRM projects can make in fire behavior and complementing fuel reductions and beneficial fire activities (below).



Preliminary fire behavior modeling by USFS PSW showing reductions in burn probability and fuel connectivity due to IFRM projects that slow water – publications are forthcoming (personal communication, K. Pope, 2025).

During 2025 we advanced IFRM at GRCA and laid a foundation for the IFRM vision and implementation, with the following actions:

- Meeting with experts from across agencies and disciplines to understand lessons learned and progress made in the region implementing IFRM projects, including:
 - Coconino and Kaibab National Forests
 - USGS regional experts
 - USFS regional experts
 - Southwest Fire Science Consortium
 - Drought Learning Network
 - Northern Arizona University experts
 - GRCA's Tribal Liaison Office & tribal partners
- Working with GRCA's resource managers across disciplines to identify combined goals for pilot projects
- Working with Grand Canyon Conservancy to support their fundraising efforts around an IFRM vision for GRCA, and obtain funding from them for an IFRM intern for 2025 and 2026
- Hiring, mentoring, and supervising an IFRM intern to conduct literature reviews, feasibility and cost-benefit analyses, and summarize the most promising IFRM strategies that are tested and ready to implement, and create a series of brief videos for social media
- Mentoring the IFRM intern through the process of collecting the literature, interviewing experts and managers, thinking critically about fire manager needs and implementation challenges, and summarizing of cost-benefit and feasibility analyses for the most promising techniques, and sharing them with resource managers for input – the draft product will be gathered into a planning document during the spring of 2026
- Working collaboratively with interdisciplinary, interagency experts to create working groups, workshops, and other information sharing vehicles to flesh out pilot project and monitoring designs and needs, and find methods to scale up IFRM efforts in our region across jurisdictional boundaries – including USFS, USGS, and the Southwest Fire Science Consortium

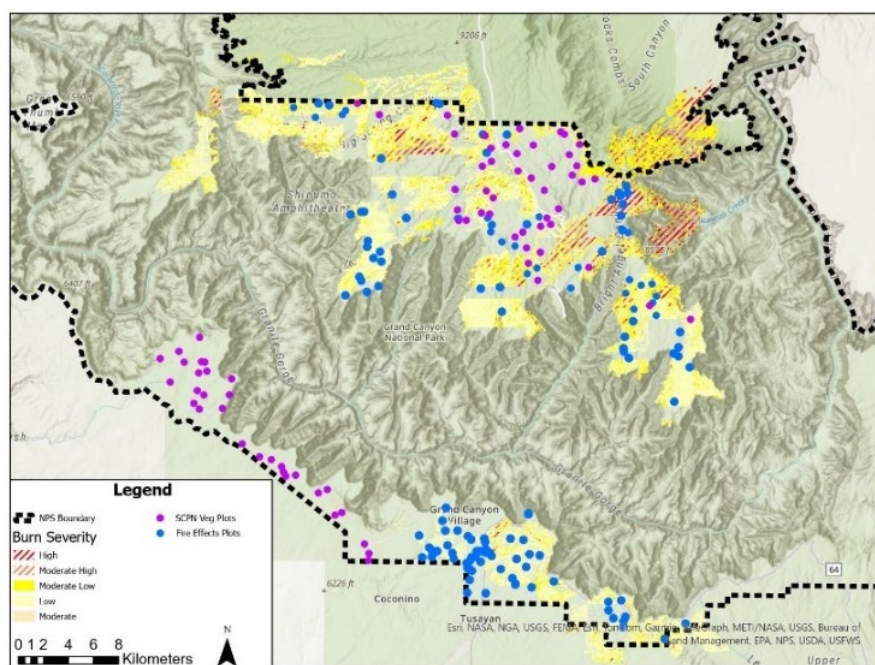
- Working the Tribal Liaison Office to follow-up with tribes interested in collaborating, beginning with a survey of interest
- Supporting GCC fundraising and funding proposals and statements of need surrounding IFRM project design and implementation

As detailed in the Executive Summary, key tasks for 2026-2028 require building upon this foundation for IFRM to support the success of beneficial fire, fuel reductions, and fire preparedness. Building on the foundation laid in 2025 with the tasks outlined for 2026-2028 is even more crucial to interrupting fire-aridity feedback loops and addressing the wildfire-watershed nexus after the Dragon Bravo Fire.

Modernizing Monitoring, Reporting & Metrics to Support IFRM

Monitoring

Since 1990, GRCA's Fire Ecology Program has collected long-term ecological and fire risk data across the park. Data collected include plant species; tree growth, heights, and mortality; tree density, sizes, and health; organic matter depth; size and abundance of large and small woody debris; and char heights and other post-fire effects on soil, understory, and forest canopy. Having this long-term database in good condition is a rare and huge asset.



GRCA fire severity history (prior to Dragon Bravo in 2025) and fire ecology monitoring plots (blue & purple dots; purple are shared with SCPN).

Yet, many technological and scientific advances have occurred since 1990, and our monitoring protocols have not been updated to incorporate these advances. For example, we now know that evapotranspiration and plant water use efficiency are primary determinants of fire behavior and post-fire outcomes under drought conditions – and they vary for a variety of biotic and abiotic reasons that can be managed for (Pascolini-Campbell et al. 2022; Simafranca et al. 2023; Joshi et

al. 2024; Abatzoglou et al. 2021; Sevanto et al. 2023; Trimber 2023; Markovchick et al. 2023). Additionally, tracking micro-climate buffering of temperatures and humidity, plant water use and water stress has become increasingly easy and efficient, utilizing tools such as small, handheld thermal cameras and plant gas exchange systems that deliver instantaneous results. Park Li-DAR and other forms of remote sensing can also provide some of the best measures of forest canopy and health with continuous data across the landscape – and data from the long-term monitoring plots is perfect for calibrating and validating this data. Our vision for GRCA includes a concentrated effort in these two distinct areas: synchronizing plot data collection with ongoing efforts from LiDAR and remote sensing, and efficiently and effectively incorporating technological advances into the existing on the ground monitoring.

Unfortunately, due to lack of funding for additional support and technical expertise in this area, and the many challenging events experienced by staff this year, including the Dragon Bravo Fire and subsequent evacuations and extensive follow-up work, notable progress on modernizing monitoring was not possible this year. The main advancement for 2025 in this area was the addition of thermal cameras to the fire ecology and effects equipment. These cameras take a snapshot of heat and thermal energy with the touch of a button, and can be easily added to the systematic plot photograph protocol. They provide one, easy method of swiftly, systematically monitoring changes in heat, heat distribution, and the micro-climate buffering that acts on fire-aridity feedbacks at any location due for management. Incorporation of these snapshots into existing monitoring will be tested, adjusted, and retested during 2026-2028. Other methods that address management effects on crucial fire behavior determinants that can be managed for, such as plant water use efficiency, will continue to be addressed, including identifying the most feasible, inexpensive and easy tracking methods, in following years. During 2026-2028, we will be working with GCC and other collaborators in an effort to make sure this objective can be more adequately staffed in the future.

Reporting & Metrics

Modernized monitoring will only produce better management if accompanied by updated, automated reporting that can deliver interdisciplinary, intervention-focused metrics in a swift, geographically-referenced manner. However, GRCA's Fire Ecology long-term monitoring program has been using the same database and reporting developed in the 1990-2012 time periods – they were extremely advanced at the time and have served this program and many others extremely well for a very long time. This database (FFI) and its corresponding reporting were intended to report annually on how well prescribed fires met their fuel-loading reduction goals. Data analyses were typically summarized by forest type (no location information), using non-dynamic, time-consuming methods that require our crew to take data back and forth between the cumbersome database and MS Excel multiple times to obtain a single metric. While state of the art at the time, this clearly can't accommodate today's IRM needs.

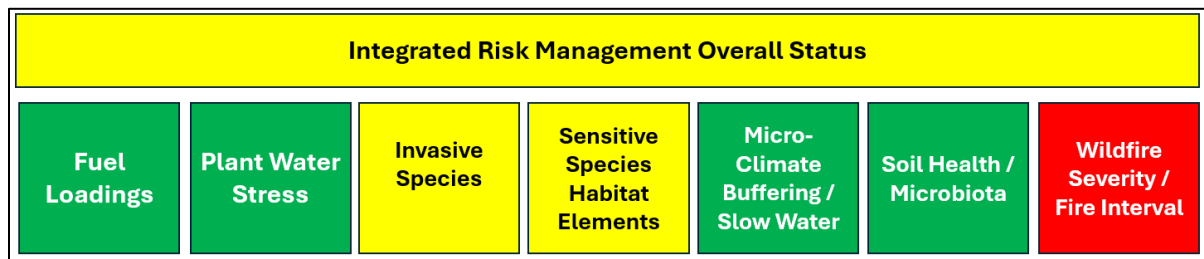
During 2024 and 2025, we have made progress at outlining a vision for, and laying a foundation for, updating both reporting and metrics. Here, we refer to the processes involved in managing, reviewing for quality assurance, analyzing, interpreting, and presenting data as “reporting”; and

we refer to the manner in which the data is summarized such that it can be most useful to managers and present them with actionable, objective goals, as “metrics”. For example, automating data analyses and making them more flexible and repeatable and visually accessible would largely fall into the reporting category, while selecting the exact measures to present, at what scale, in what way, would largely fall into the “metrics” category. Although the two work hand-in-hand for successful management, both are necessary. It won’t help managers make better decisions just to have automated calculations – those automations must be accompanied by actionable, targeted, easily understandable metrics representing specific objectives and goals for mitigating risk and maintaining ecosystem function.

During the Dragon Bravo Fire, our Fire Ecologist worked with regional GIS to provide more modern, location-specific fuel loading information – rather than summarizing fuel loadings simply by forest type, managers could see exactly where on the map fuel loadings were within desired ranges or well outside desired ranges. Although it was a good first step, it could not be provided to managers as swiftly as desired, due to a lack of automation. Additionally, it does not represent a fuller suite of metrics that can help managers make good decisions in line with a modern, Integrated Fire Risk Management approach. For example, a suite of such metrics might include things like how long it has been since the last fire or how far out of the appropriate fire return interval those same locations (presented by location, since this varies over the landscape). Such a suite of metrics might also include where parameters of forest function or protected species habitat elements are outside of desired ranges – posing increased plant water stress, wind, and other kinds of risks that contribute to fire behavior and/or the ability to conduct fire preparedness activities.

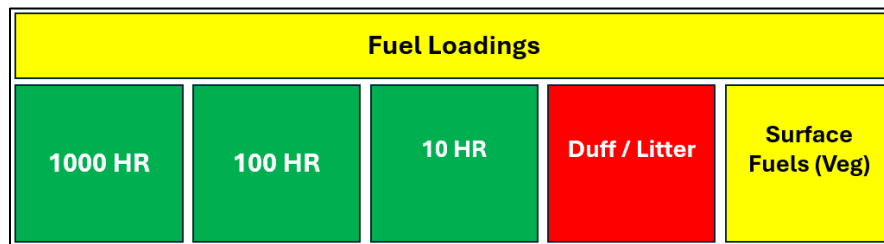
To address the need for developing a full suite of swiftly available, intervention-focused, geo-referenced, metrics of this kind, during 2025 GRCA Fire Ecologist began developing a vision for this suite of metrics, presented it to fire managers for input, incorporated fire manager input (e.g. yielding the simple red, yellow, green presentation), and worked with collaborators to flesh out and begin producing portions of this suite as a pilot project. Below is a depiction of the vision for a fuller suite of intervention-focused metrics to support IFRM that can be presented for each plot location, as well as summarized for whatever portion of the park managers desire. Some key features of the vision include:

- Red, yellow, and green color coding by category, so that managers can easily see areas needing attention and urgent attention
- Eventual full automation between R, FFI, and GIS, so that results can be swiftly summarized at whatever scale managers most need at the time, as well as provide for viewing the variability of the nature (and causes) of the risk across the landscape
- Ability to drill-down within each category for more information on why a specific area needs attention, and to keep drilling down within each topic area until specific data are visualized
- Thoughtful and repeated testing with managers to ensure data is presented in the most understandable, and easily actionable manner, and can provide swift decision support when most needed



Example Integrated Risk Metric Scale	
Color	Interpretation
Green	Within Desired Ranges
Yellow	Starting to Fall Out of Desired Ranges
Red	Well Outside Desired Ranges - Needs Urgent Attention

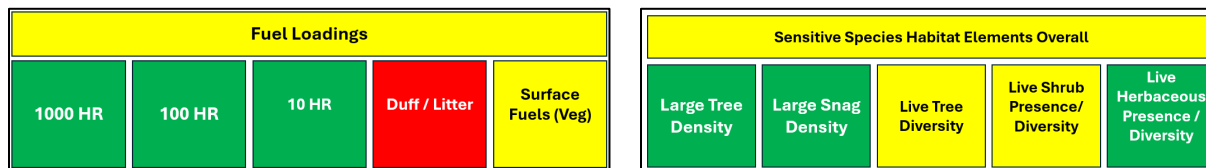
Draft conceptualization of what a fuller suite of intervention-focused, easily understandable metrics that can support IFRM would look like, based on existing data and scientific and technological advances that are both crucial to decision support and IFRM, as well as feasible for implementation.



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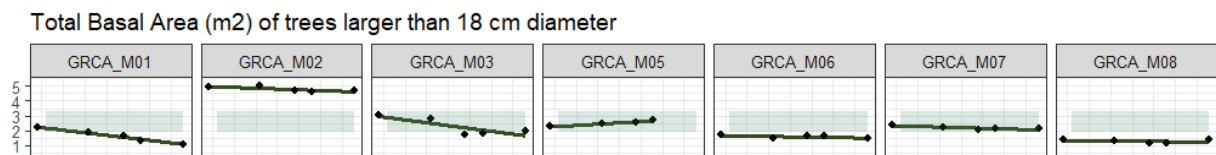
Draft conceptualization of what drilling-down within a particular category would look like, presenting additional information for managers on what interventions are most needed. Presented here is the conceptual mock-up of what a drill-down into the fuel loadings category would look like, with additional drill-downs potentially available to provide graphical depictions, as determined by future testing and feedback from fire managers.

As a pilot for calculating, testing, and attempting to automate or at least partially automate this kind of more integrated suite of metrics, GRCA Fire Ecologist selected mixed-conifer plot data shared with the SCPN regional program, and selected fuel loading information (crucial for fire managers and fire behavior) and sensitive species habitat elements (which had often come into question for fire and other management and had collected but previously un-reported/un-summarized data). This combination was selected to meet the needs of fire and resource managers – fuel loading data for these plots had not previously been presented since fuel reductions objectives for this habitat type had not been formalized, and the presence/absence of MSO habitat elements and MSO habitat suitability often arose as questionable and an issue that complicated prescribed fire and fire preparedness activities. This combination of metrics also provided a test case to allow GRCA GIS and GRCA Fire Ecology to marry data from LiDAR and plots to calibrate and validate the ability of LiDAR to provide precise information on metrics desired by the park and fire and resource managers.



Mock-up of pilot metrics for fuel loadings and MSO-habitat elements currently in development in R and R Studio - as the first step toward developing a full suite of intervention-focused IFRM metrics that can be automated and geo-referenced.

Metrics and calculations for fuel loadings were taken from previous objectives, and calculations and constants in FFI. Metrics and calculations for the sensitive species habitat elements portion of the metrics focused on delivering factual information from plot data on the quality of habitat on the North Rim for Mexican Spotted Owls (MSO). The suitability of these areas for MSO were often previously questioned although protected by the Endangered Species Act, and factual data from plots and LiDAR existed but had never been sufficiently analyzed to provide consensus on the historical and current status of MSO habitat elements. Metrics and their calculations were developed in collaboration with USFWS species experts, GRCA SRM and wildlife and species experts, SCPN Botanist, and GRCA GIS LiDAR experts, and calculations and visualizations were coded into R and R Studio software by GRCA Fire Ecologist and the SCPN Botanist.



Example of work completed to-date by the SCPN Botanist for several fire ecology and effects plots to provide a geo-referenced metric for “Large Tree Density” under the “Sensitive Species Habitat Elements” drill-down. Collaboration with species experts suggested a steady trend would be a quality objective that could yield a “Green” coding, but this requires further testing and collaboration with species experts and fire managers once data can be viewed and discussed – for example, an envelope or minimum and maximum threshold might be better, or be combined with considerations of the trend line to get to the “Red”, “Yellow”, and “Green” codings that highlight for managers where attention/action is needed.

Calculations have been coded in R, and are awaiting further work on statistical summaries and visualizations, coding into the appropriate red, yellow, and green categories and other fine tuning required to produce a clean end-product that is easily interpreted. Additionally, in the wake of the Dragon Bravo Fire, work will be needed to develop representations of conditions before and after the fire to help illustrate where and what goals might have been reasonable based on historic conditions, as well as what goals and objectives are reasonable for the future.

Notably, this effort is currently allowing a swift, seamless pivot from prior tracking and reporting of, and target “cap” on, moderately high and high severity acres burned within MSO critical habitat on the North Rim to tracking MSO habitat elements as had already been proposed to USFWS for this pilot effort. This represents a huge stride forward for both fire and resource managers, so that all can be focused on factual information of what habitat elements historically and currently exist, and on what types of interventions support or fail to support that goal, rather than on a metric that is both difficult to calculate due to changes in the Monitoring Trends in Burn Severity methods and staffing, and does not explicitly track an actionable item (acres

burned at different severities). For additional information on the challenges presented by the previous method, refer to prior annual reports.

This effort is a huge stride forward. At the same time, the product that will be available in 2026 will still be *far* from the fully integrated and automated metrics that provide indicators from across many disciplines, incorporate updates in monitoring technology discussed above, and are fully automated using GIS, R and R Studio working in synchrony. A concentrated effort with cooperators to do the heavy lifting would reach this goal much faster. As we continue to work on the pilot case of MSO habitat elements and fuel loadings for 2026, we will also continue to work with GCC, and local, regional, and national collaborators to advance the resources, vision, and additional steps needed to reach the ultimate goal as quickly as possible (hopefully 2027-2028). For example working with national FFI developers and contract managers to allow R to interface more directly with FFI (through R code and FFI server or server mirror access rather than a human conducting step by step downloads of tables), and likely additional expert labor and help (hopefully from other Fire Ecologists with the appropriate expertise and/or cooperators) will be needed to fully automate metrics and reporting. Similar steps, and possibly a GIS intern, will be needed to interface R and GIS such that results can be provided at whatever geographic scale managers need, swiftly, in an automated manner.

GRCA Fire Ecologist discovered in December 2025 that YELL Fire Ecologist had been working on R code to summarize fuel loadings by forest type. Thus, another key task for 2026 is for GRCA Fire Ecologist to work collaboratively with YELL Fire Ecologist, whose code can automate to some degree the reporting and visualizations of fuel loadings by forest type, but which needs the appropriate fuel constants for each of GRCA's forest types, R/FFI/GIS automation and integration, and has not yet begun to address other intervention-focused IFRM metrics or geo-referenced reporting and management goals. GRCA's Fire Ecologist will work collaboratively with YELL Fire Ecologist (and others with similar data and programs) in 2026 to merge efforts at data analysis and automation and ensure they are fully complementary.



Top: Grand Canyon Fire Effects crew prior to evacuation.
Bottom left: Fire Effects crew walks off into the sunset after reading the final FMH plot...a job well done.
Bottom center: 2025 GRCA Fire Ecology staff at Dragon Overlook.
Bottom right: Enjoying a brief rest at the sitting log while hiking to plots with GRCA Wildlife staff.
 (photos by Li Brannfors)