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Fire and Aviation Management

Grand Canyon National Park / GRCA
Fire Ecology Annual Report
Calendar Year 2020

Prepared by: Matt Engbring and Li Brannfors

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1. Summary

The 2020 season again brought turnover in every position other than the Lead Monitor for the Grand Canyon National Park (GRCA) Fire Ecology Program. A new Fire Ecologist, Matt Engbring, started work March 15, interfacing with the Lead and getting acquainted with the program before the field season began. The permanent Assistant Lead Monitor position remained vacant, but an experienced temporary GS-6 employee was hired to fill the role, along with two new seasonal crewmembers. A global pandemic caused by a novel coronavirus and its corresponding COVID-19 illness began to have impacts in March in the United States and had far-reaching and long-lasting consequences within every part of work and personal life. Within a week of the North Rim re-opening from COVID closure, the largest wildfire in the history of the Kaibab Plateau caused visitor evacuations and re-closure of the North Rim. The driest monsoon season ever recorded in the Southwest combined with the longest time ever spent in severity locally and Level 5 fire preparedness nationally to keep everyone on edge virtually all year. Even in the face of these challenges, the crew monitored 29 Fire Monitoring Handbook (FMH) plots at GRCA (Table 5); 13 combination FMH-Inventory and Monitoring (I&M) plots at Walnut Canyon National Monument (WACA) (Table 6); and 20 FMH plots at Saguaro National Park (SAGU). With a relatively light year for plotwork in this program, crewmembers got the opportunity to work on several wildfires both locally and nationally. Ultimately it proved to be a diverse, successful, and rewarding year, if a bit non-standard.

Grand Canyon Fire Ecology maintained its history of assisting and partnering with other long-term monitoring programs. Once again, the entire crew traveled to Saguaro National Park, this time late in the season to accomplish planned and unplanned work for the Southern Arizona Fire Ecology Program. The combination of 11 Year 1 visits from the recent Mica Bowl Prescribed Burn with 9 unplanned reads from the 2020 Spud Rock Fire created a total workload of 20 plots, necessitating extra assistance from the Teton Interagency and Yellowstone Fire Effects crews to accomplish all work in one visit. Additionally, the fieldwork partnership with the I&M Southern Colorado Plateau Network (SCPN) was renewed remotely. Visits to 13 shared plots and work distribution at Walnut Canyon National Monument were planned together for the first time since 2015; however, realities of COVID precautions prevented the crews from working together in the field. Nonetheless, new baseline data were gathered by both programs at the same time of the year to ensure the best-available snapshot of conditions prior to the next prescribed burn treatment.

For the first time since having the crew start directly on the North Rim, the season began and ended without major complications. The Lead was able to telework from Flagstaff for 3 weeks in April after returning from furlough and was able to finish the season at home on the N Rim rather than be displaced by unprecedented early season snowfall. For the crew, water availability to solo housing and a limitation on shared housing

capacity due to COVID-19 ultimately delayed start dates for a couple crewmembers by only one week. South Rim travel was targeted and accomplished within one defined 8-day trip in June after the crew had settled in on the North Rim, finished pre-season training, and learned the basics of their positions. This structure helped reduce budgetary costs and facilitated better integration of the crew as both community members of the North Rim of Grand Canyon and fire resources for North Zone Fire Management (USFS North Kaibab Ranger District-Kaibab National Forest & NPS North Rim-Grand Canyon National Park).

A seventh full season of 100 percent tablet-based, electronic field data collection and office data management again enhanced efficiency. This year, however, in-season beta-testing of the new cloud-based FFI Remote App was performed by the crew, giving the National office much-needed insight on performance for multiple users on networks with very slow network speeds. In the field, the crew expanded beyond using just FFI (FEAT/FIREMON Integrated) and FFI Lite software to collect data, as the new beta-version of FFI supported the ability to export and import protocol data as simple CSV files. Working in conjunction with multiple National office Fire Ecologists and software programmers, in the second half of the season the GRCA Fire Effects crew helped test the capabilities and limitations of this new feature by developing Excel-based templates for field data collection and gathering data on iPads, iPhones, and Android tablets rather than full-Windows tablets. The trials proved so successful that full data collection for the 13 plots at WACA and 20 plots at SAGU was performed in this manner by the end of the year. We hope that our testing helps open the door as soon as the 2021 field season for more programs to utilize electronic data collection using familiar, more customizable software and less expensive hardware.

Even with the extensive time dedicated to testing new software and techniques, exclusive use of tablets for data collection still saved enough time compared to traditional data entry that seasonal crewmembers learned advanced skills by performing query-based quality assessment-quality control (QAQC); creating Access-based, PDF exports of our electronic datasheets ready for filing in hardcopy format; and performing standardized data analysis on one of our programmatic objective for this annual report. We cannot recommend this approach enough to both increase programmatic efficiency and advance employee development.

An unexpected break in plot-related work in the first half of September due to SCPN needing a COVID pause for WACA coincided with national Level 5 fire preparedness, allowing all seasonal crewmembers to simultaneously leave on full 14-day fire assignments. The program also supported several very late-season local fires, with crewmembers expanding their skill sets and their variety of contributions to fire operations. In some capacity, the crew worked on 7 incidents over 79 operational periods and completed 5 different NWCG training classes (basic firefighter course bundle counted as 1 class). Highlights of this experience included assisting visitor evacuations for the Mangum Fire; 5 days as Resource Advisor trainee on the Thumb Fire at GRCA; 2 weeks as READ/REAF-t on the Dolan Fire in CA; detailing with North Rim Engine 831 for severity and the Cameron Peak Fire at Rocky Mountain National Park; 1.5 weeks as READ/REAF-t on the Cameron Peak fire in CO; assisting E-831 with initial attack on 2 different fires after much of their own crew had left for the season; and in the final week of work burning the same piles the crew previously help construct over the course of many days of severity-funded fuels work.

Cross-training Fire Ecology crewmembers with other field disciplines in the fire management program continued to allow the crew to build myriad skills and increase staffing flexibility. Personal interest by the crew greatly facilitated this multi-disciplinary learning, be it assisting with fuels sampling, saw work on prescribed burn prep, or backfilling on the Type 6 engine. To spread the wealth of knowledge further, multiple crewmembers from both South and North Rim engines, staff from the Vegetation program, the Kaibab NF Fire Ecologist, and the GRCA Fire Ecologist (totaling 9 people) were trained in Fire Effects plot protocols.

As mentioned above, a new Fire Ecologist started with Grand Canyon National Park in March of 2020. Matt Engbring, who was previously employed by the Coconino National Forest and Alumni of Utah State University, began a new career with the Park Service and tiered off his previous ventures to pursue proficiency as a Fire Ecologist.

Starting with the Park Service in March had an unexpected complexity for the new Fire Ecologist. In addition to learning a new position, the emerging COVID pandemic forced restrictions on the workplace for GRCA and the new Fire Ecologist began teleworking at his home in Flagstaff, Arizona. Even with the incredible challenges and complexities within the workplace, the Grand Canyon Fire Leadership was able to adapt and overcome to the changes. Because of the flexibility from leadership, everyone's understanding of personal situations, and the internal drive to succeed, the Fire Ecology Program was still able to have a productive year.

Throughout the season the recently hired Fire Ecologist navigated his way through the agency learning numerous fundamentals. On the job training (OJT) occurred in many areas essential to the position as a program manager for the Grand Canyon. OJT was facilitated by the Deputy Chief of Fire and Aviation, budgetary staff, internal and external partners, and the Lead Monitor. The Fire Ecologist embraced the attitude of a "beginners mind" and rapidly absorbed the necessary information to not only run an ecology program, but actively participate in the fundamental decision making that will make the crew a success for the coming years.

It is important to note that beyond an intermittent four-week period with the crew gathering data, the Fire Ecologist worked 100% virtual for the 2020 season as the COVID pandemic forced the workplace to reimagine their daily routines. Throughout the season, the Fire Ecologist leaned heavily on virtual communication, in particular Microsoft Teams to complete his daily work assignments. The outcome of the virtual existence for 2020 was positive and all programmatic responsibilities were met and verified with an outstanding performance appraisal for this difficult year.

In addition to the Ecologist "learning the ropes" with the Grand Canyon, initiatives that were crafted by previous Ecologists were supported and brought to fruition. Previous initiatives include research on, "Climate Drivers that Predict Extent and Severity of Wildfires at Grand Canyon" and an internship agreement through the Colorado Plateau Cooperative Ecosystem Studies Unit (CPCESU).

Through the recording of Daily Logs, the Ecologist has made estimates on his time spent within specific focus areas and accomplishments. See Table 4 below for a detailed workload analysis.

2. Staff Accomplishments and Areas of Focus

Table 1. Fire Ecology staffing for the 2020 calendar year.

Employee	Starting Date	Ending Date	# Pay Periods	READ Qualified (Yes or No)	Training	NWGG Taskbooks[1]
Matt Engbring, GS-09	3/15/20	12/31/20	26	No	OJT	PIOF-t
Li Brannfors, GS-07	1/1/20 2/2/20[2] 4/12/20	1/4/20 2/29/20 12/31/20	21[2]	No	RT130	LTAN-t
Amanda Knauf, GS-6	5/24/20	11/7/20	12	No (READ/REAF-t)	RT130 S212	FEMO-t READ/REAF-t[3] ICT5-t FFT1-t FAL3-t
Alexandra Lalor, GS-5	5/10/20	11/21/20	14	No (READ/REAF-t)	RT130 N9042 IS200 S212	FEMO-t READ/REAF-t[3] FAL3-t HECM-t SRT2-t
Chazz Lakin, GS-4	5/10/20	11/21/20	14	No (READ/REAF-t)	S130/190 L180 ICS100 IS700 N9042 IS200 S212 Tech SAR	FAL3 FEMO-t READ/REAF-t[3] HECM-t

[1]This represents both open (trainee) taskbooks and those completed in the 2020 season.
[2]Time for Li Brannfors reflects part-time work across 2 different payperiods.
[3]NWCG taskbooks do not yet exist for the READ & REAF positions.

Table 2. Base hour Fire Effects Crew activities by percent and category.

Employee	FMH Plots	RAP Plots	CBI Plots	I&M Plots	Data Entry/ Mgmt	Plot Office	Other Office	Monitoring (Rx or Wildfire)	Rx Fire Ops	Wildfire/ Incident Ops	Training Courses	Other
Li Brannfors, GS-7	15	0	1	2	11	15	24	<1	1	2	1	28
Amanda Knauf, GS-6	25	0	1	3	13	14	10	<1	<1	16	4	13
Alexandra Lalor, GS-5	20	0	1	0	19	14	12	<1	3	14	5	11
Chazz Lakin, GS-4	22	0	1	2	18	16	10	<1	2	11	6	11

"Plot Office" includes miscellaneous plot data preparation and management time, plant ID, photo filing, etc.
"Rx Fire Ops" includes time spent on non-fire fuels projects and fuel sampling.
"Wildfire/Incident Ops" includes details with GRCA Helitack, GRCA and NKRD engines, admin. leave associated with fire assignments.
"Other" includes PT, leave taken, official meetings, conferences, webinars, paid holidays off, non-fire duties, etc.

Table 3. Base hour Fire Effects Crew focus areas and accomplishments for the 2020 calendar year.

Focus Area	Percent Time	Accomplishments and Activities
FMH Plots	20*	• 29 remeasurements at GRCA • 13 new baseline remeasurements at WACA (combo FMH-I&M plots) • 11 remeasurements and 9 immediate post-burn reads at SAGU
RAP Plots	0	• No scheduled remeasurements or immediate post-burn reads in 2020
CBI Plots	1	• Assisted Kaibab NF Fire Ecologist w/ initial burn severity assessment of Mangum Fire for 2 days
I&M Plots	2*	• 13 new baseline remeasurements at WACA (combo FMH-I&M plots)
Data Entry/ Management	15*	• *ALL 2020 plot data collected and checked electronically with tablet computers in the field; data entry and field checking is included in percent time under each plot type* • QAQC queries completed for 2020 GRCA data by Oct 6 • QAQC queries completed for 2020 WACA data by Oct 5 • Developed & tested new electronic data entry using FFI CSV file exports, Excel, and iOS tablets/phones • Assisted National office w/ testing cloud-based FFI Remote App • Refined & further automated Access-based hardcopy datasheet creation process • Includes FFI/FFI Lite/Excel electronic data prepping, merging, checking, and hardcopy datasheet creation for all plots at GRCA, WACA, & SAGU
Data Analysis	<1	• *Annual Report analysis on all major variables in program completed in January 2021* • Seasonal Fire Ecology staff analyzed data on one objective for annual report
Plot Office	15*	• Includes plot preparation, plant ID, photo filing, tree mapping, hardcopy data filing/organization, and plot-related projects
General Office/ Supervision/ Admin	15	• Includes paperwork for travel, credit cards, non-plot related projects • Hiring, evaluations, and supervision by Lead • Lead hired seasonal crew • Lead supervised 3 seasonals for 6 months
Fire Monitoring (Rx or Wildfire)	<1	• No FEMO support was requested for any fires staff assisted in 2020
Fire Operations/ Assignments (Rx, Wildfire, Engine, Helitack, Non-fire Fuels Projects)	11*	• Completed taskbook for 1 crewmember as FAL3 • 1 crewmember detailed on READ/REAF trainee assignment for 2 weeks in CA • 1 crewmember detailed on READ/REAF trainee assignment for 1.5 weeks in CO • 1 crewmember detailed on READ/REAF trainee assignment for 5 days at GRCA 2 crewmembers detailed with GRCA engine 831 for 2 weeks in CO • FFT1 and FFT2 support on total of 3 North Zone fires • Cross-trained crewmembers with GRCA engines and fuel sampling
Training	3*	• All attended annual fire refresher • 1 completed S130/190, L180, ICS100, & IS700 (Basic Firefighter Training) • 3 completed S212 • 2 completed N9042 READ/REAF & IS200 training • 1 completed Technical Search & Rescue (SAR) training
Travel Away from Duty Station	–	• Total of ~1 month for crew spent on South Rim, at Walnut Canyon National Monument, and at Saguaro National Park for plot work & training, ~2.5 months for Lead including an extra 1.5 months teleworking in Flagstaff
Other	17	• ~5% of crew time spent on PT • ~8% of crew time spent on leave

*1297 hours of combined overtime and comp time on both fire and plot duties, equaling 27 percent of total crew work time (base + OT + CTE), are not reflected.

Table 4. Fire Ecologist Focus Areas and Accomplishments March 15, 2020 - January 31, 2021

Focus Area	Percent Time	Accomplishments and Activities
Planning	15	• Managed activities in NFPORS • Reviewed internal research proposals for Ronda Newton • Reviewed prescribed fire burn plans for fire organization • Provided GIS support and data organization for Fire Division • Regularly coordinated with administrative support staff on budget and programming • Co-Author on Fire Ecology Annual Report
Presentations/ Education	<1	• Attended coordination meeting with education Division to discuss future opportunities
NPS Meetings/ Task Groups	10	• Fire and aviation staff and strategy meetings • Attended SRM program manager meetings • Participated in regional Fuels calls and annual Fuels workshop • Attended Regional Fire Ecology collaboration call
Interagency Work	<1	• Coordinated with Kaibab NF and GRCA Lead monitor on data requests for smoke production study
Internal Collaboration	5	• Outreached to employees in SRM to initiate relationships and collaborations • Coordinated with vegetation program manager on the Cottonwood Creek Fire BAR • Contributed to the internal discussion of Workforce Planning and Development • Coordinated with GIS shared services to introduce GRCA users new applications offered by NPS • Virtual Meet and Greet with Superintendent
Fire Assignments and Project Work	0	• Ecologist chose to "stand down" for 2020
Research	5	• Processed GRCA Research permit reviews • Worked through the CESU Funding Request Process for GIS work and a research project, "Fire Weather Drivers of Large Fires" • Provided GIS data for Sara Burch to aid in research on the Cottonwood Creek Fire • Coordinated with Soundscape crew at GRCA for new research and collaboration
Data Collection	5	• South Rim FMH and North Rim FMH and WACA plot data collection totaling 160 hours (four weeks) of Ecologist time
Data Analysis	5	• Co Authored the Fire Ecology Annual Report analyses
GIS	5	• Created FWS Report maps, Coordinated with Shared Service on program responsibilities • Created maps and shapefiles for planning and support • Worked on Fire geodatabase updating and worked with GIS contractor
Supervision/ Administration	25	• Supervised the Lead monitor and aided in administrative functions for seasonal workforce • Managed fire monitoring and ecology budgets and purchasing • Facilitated training opportunities for seasonal crew as REAF/READ • Fire Effects crew PTBs, QuickTime, Concur, e-mails, EPAPs
Training and Conferences	20	• Daily experiences equated to OJT for first 10 months of Ecologist tour of duty • Familiarized with the Grand Canyon, Fire Management Plan and Environmental Impact Statement • Reviewed the Grand Canyon Fire Monitoring Plan • FFI Virtual training and OJT with Brannfors • During a difficult pandemic was able to coordinate two weeks of travel to the North Rim, one week of travel to the South Rim, and one week at Walnut Canyon to aid in plot reads and "learn the ropes" with the Fire Effects crew • Attended webinars on IFTDSS, SWFSC research presentations, GRCA wildlife research to increase knowledge about fire science and natural resources
COVID and Other	5	• COVID related information and emails • COVID Family Leave • Other forms of leave • PT

3. Fire Effects Plot Workload

3.1. Grand Canyon National Park Fire Effects Plot Workload

The 2020 season was the smallest workload for our program in over 20 years at Grand Canyon proper, with only a light amount of FMH plots scheduled. Additional plot visits at Walnut Canyon National Monument and assisting Saguaro National Park amounted to more plots being read at sites other than GRCA in 2020 (33 total non-GRCA plots).

Table 5. Grand Canyon National Park Fire Effects plot workload for the 2020 calendar year

Rim	Monitoring Unit	Plot Type	Install/ Pre-burn	Immed. Post-burn	Year 1	Year 2	Year 5	Year 10/ 20	Annual Total	Total Plots[1]
South	Ponderosa Pine **PIPO**	FMH - Forest			4			2	6	41
South	Pinyon-Juniper Woodland **PIED**[2]	FMH - Forest							0	17
South	Moqui Rx	RAP[3]							0	5
South	Picnic Rx	RAP[3]							0	10
South	Quarry Rx	RAP[3]							0	10
North	Ponderosa Pine **PIPN**	FMH - Forest			2	11			13	30
North	Ponderosa Pine with White Fir Encroachment **PIAB**	FMH - Forest			4	4		1	9	27
North	Rocky Mountain Subalpine Conifer **PIEN**	FMH - Forest	1						1	17
North	Grassland Interior **GRIN**	FMH - Brush							0	10
North	Grassland Edge **GRED**	FMH - Forest							0	6
North	Fawn Spring Rx[5]	RAP[3]							0	20[6]
North	Highway 67 Rx[5]	RAP[3]							0	20
North	Range Rx	RAP[3]							0	20[6]
North	Spring Canyon Rx[5]	RAP[3]							0	20
North	Thompson Rx	RAP[3]							0	20[6]
North	Burnt Corral-NKRD	RAP[3]							0	50
North	Tipover Rx-NKRD	RAP[3]							0	40[6]
North	Walla Valley Rx	RAP[3]							0	6
North	Mixed Conifer	I&M[4]							0	46
Total			**1**	**0**	**10**	**15**	**0**	**3**	**29**	**415**

[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.
[3] Pilot sampling.
[4] Fuel and tree data collected to add to data collected by I&M crews.
[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.
[6] To allow for increased analysis of the Rx burns, both burned & unburned plots were read in four RAP project units which managers attempted to burn in their entirety – 15 of 20 Fawn Spring, 12 of 20 Range, 11 of 20 Thompson, & 29 of 40 Tipover plots burned.

3.2. Flagstaff Area National Monuments Fire Effects Plot Workload

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 worked with the I&M program in 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 (WACA). Going forward, these 13 plots will comprise the foundation of the active network at WACA. A copy of the FFI database containing the existing plot data, as well as the three archived databases, are available on the NPS IRMA portal (Reference Codes: Walnut Canyon NM current-2194013, Walnut Canyon NM historic-2222935, Sunset Crater NM historic-2221713, Wupatki NM historic-2222001).

In 2020, we collected new baseline data for all 13 plots on fuels, pole-sized trees, and overstory trees, including crown base heights and tree heights. Although we attempted to simultaneously visit the plots with the Southern Colorado Plateau Network I&M crew to continue our partnership at WACA, differences in COVID-mitigation requirements and last-minute COVID exposures on their crew prevented the two programs from gathering data together. However, complimentary data were gathered independently by both crews during a similar time period, ensuring all data at WACA are on identical schedules in both time and phenology. The I&M crew is scheduled to re-visit these plots again in 2022, and the Fire Effects crew will collaborate with I&M on those plot reads if no prescribed burns occur beforehand.

Table 6. Flagstaff Area National Monuments Fire Effects plot workload for the 2020 calendar year.

Park	Monitoring Unit	Plot Type	Install/ Pre-burn	Immed. Post-burn	Year 1 - 20	Annual Total	Total Plots[1]
Walnut Canyon NM	Ponderosa Pine Forest **PIPO**	FMH – Forest / I&M	13			13	13
Total			**13**			**13**	**13**

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

Fire Effects staff from Grand Canyon, Yellowstone, and Grand Teton team up to read plots at Saguaro National Park

4. Monitoring Objectives and Results

4.1. Restoration Fuel Loading and Tree Density – FMH plots

Grand Canyon National Park's Fire Ecology Program has installed 148 permanent FMH-style plots to date. As of 2020, 124 of the 148 plots (83 percent) 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. The PIEN and PIED monitoring types are not included in these tables because (1) these areas are thought to be within the natural fire regime and (2) prescribed fires are not the management focus in these areas. Of the nine restoration objectives listed in Table 7, we can say with statistical confidence we are achieving seven of the objectives after first entry fire, and four of the objectives after second entry fire.

Targeted mean fuel loading values were achieved during first entry fires in the PIPO, PIPN, and PIAB monitoring types. After second entry fires, mean fuel loading values in all monitoring types were within the targeted range, but the confidence limits extend above the targeted range (too much fuel remaining) in the PIAB monitoring type (Table 7).

In the PIPO and PIPN monitoring types, we have not installed the number of plots needed to overcome the variability in pole-sized tree (1 to 6 inch DBH) density. In the PIPO monitoring type, mean pole-sized tree density fell within the targeted range after first entry fire, but the confidence limits extend above the targeted range (too many pole-sized trees). After second entry fire in PIPO, the mean pole-sized tree density was above the targeted range, although the lower confidence limits fall within the targeted values. In the PIPN monitoring type, mean pole-sized tree density fell within the targeted range after both first and second entry fire. However, the confidence limits extend above the targeted range (too many pole-sized trees) after the first entry fires and below the targeted range (too few pole-sized trees) after the second entry fires. The PIAB monitoring type has the minimum number of plots required to overcome variability in pole-sized tree density. After first entry fires in the PIAB type, mean pole-sized tree density was within the targeted range. After second entry fires in the PIAB type, mean pole-sized tree density was well below the targeted range (Table 7).

For large tree density (greater than 16 inch DBH), minimum plot numbers have been reached for all monitoring types. Mean large tree density remained within the targeted range (and showed little change from pre-fire values) for first and second entry fires in the PIPO monitoring type. Mean large tree density decreased from pre-fire values in the PIPN monitoring type in both first and second entry fires, but mean values remained within the targeted range. In the PIAB monitoring type, mean large tree density decreased from pre-fire values, but remained within target values after first entry fire. However, after second entry fire, mean large tree density fell below the desired range with confidence limits extending back into the targeted range (i.e. there is some uncertainty about whether tree density is at the low end of the target or below the target) (Table 7).

Table 7. Restoration Management Objectives and Monitoring Results for FMH plots in 2020. 1st entry and 2nd entry refer, respectively, to the first and second times an area has burned in any fire type (prescribed fire or wildfire).

Monitoring Unit	Restoration Management Objectives	Monitoring Results (n = # of plots)		Objectives Achieved? (Data Years)		Minimum Plot #s Achieved?
		1st Entry	2nd Entry	1st Entry	2nd Entry	
Ponderosa Pine (PIPO) South Rim	Reduce total fuel load to 0.2-9.3 tons/acre immediate post-burn	**7.1** ± 0.8 tons/acre (-48%) (n=39)	**7.2** ± 1.5 tons/acre (-51% due to fire 1 & 2) (-12% due to fire 2 only) (n=24)	**YES** (1992 – 2019)	**YES** (1998 – 2019)	**YES** n=10
	Reduce poles (PIPO) with DBH of 1-6" to 16-81 trees/acre 2 years post-burn	**77.0** ± 29.5 trees/acre (-24%) (n=39)	**101.4** ± 41 trees/acre (-32% due to fire 1 & 2) (-7% due to fire 2 only) (n=21)	**YES*** (1994 – 2015)	**NO*** (2000 – 2019)	**NO** n=61
	Maintain overstory (PIPO) density with DBH ≥16" of >14 trees/acre 5 years post-burn	**21.2** ± 2.5 trees/acre (0%) (n=39)	**19.2** ± 3.4 trees/acre (0% due to fire 1 & 2) (-1% due to fire 2 only) (n=20)	**YES** (1997 – 2018)	**YES** (2003 – 2016)	**YES** n=14
Ponderosa Pine (PIPN) North Rim	Reduce total fuel load to 0.2-15.7 tons/acre immediate post-burn	**12.1** ± 1.6 tons/acre (-56%) (n=30)	**9.9** ± 1.9 tons/acre (-63% due to fire 1 & 2) (-40% due to fire 2 only) (n=28)	**YES** (1992 – 2011)	**YES** (2005 – 2018)	**YES** n=11
	Reduce conifer poles with DBH of 1-6" to 16-81 trees/acre 2 years post-burn	**70.2** ± 33.4 trees/acre (-58%) (n=30)	**17.9** ± 6.5 trees/acre (-80% due to fire 1 & 2) (-23% due to fire 2 only) (n=28)	**YES*** (1994 – 2013)	**YES*** (2007 – 2020)	**NO** n=48
	Maintain overstory conifer density with DBH ≥16" of >17 trees/acre 5 years post-burn	**40.9** ± 3.8 trees/acre (-10%) (n=30)	**40.1** ± 9.0 trees/acre (-18% due to fire 1 & 2) (-8% due to fire 2 only) (n=11)	**YES** (1997 – 2016)	**YES** (2010 – 2019)	**YES** n=4
Ponderosa Pine w/ White Fir Encroachment (PIAB) North Rim	Reduce total fuel load to 1.7-19.0 tons/acre immediate post-burn	**15.9** ± 2.9 tons/acre (-55%) (n=25)	**16.0** ± 5.0 tons/acre (-58% due to fire 1 & 2) (-43% due to fire 2 only) (n=17)	**YES** (1993 – 2017)	**YES*** (2000 – 2019)	**YES** n=5
	Reduce conifer poles with DBH of 1-6" to 16-100 trees/acre 2 years post-burn	**71.3**± 20.5 trees/acre (-70%) (n=26)	**1.2** ± 1.1 trees/acre (-99% due to fire 1 & 2) (-45% due to fire 2 only) (n=14)	**YES** (1995 – 2019)	**NO** (2002 – 2018)	**YES** n=9
	Maintain overstory conifer density with DBH ≥16" of >20 trees/acre 5 years post-burn	**24.8** ± 3.5 trees/acre (-32%) (n=24)	**18.0** ± 6.4 trees/acre (-38% due to fire 1 & 2) (-33% due to fire 2 only) (n=11)	**YES** (1998 – 2017)	**NO*** (2005 – 2014)	**YES** n=7

NOTE: Assessment of objective success and fulfillment of minimum plot requirements are based on 80 percent confidence intervals. Minimum plot calculations are based on pre-fire values, with R-value of 20 for overstory tree and fuel assessment and R-value of 25 for pole-sized tree assessment; variable fire conditions increase the minimum number of recommended plots for post-fire analysis.
YES* indicates that the mean value meets stated objectives but the confidence interval is outside the range of objective values.
NO* indicates that the mean value does not meet stated objectives but the confidence interval is inside the range of objective values.
Red box indicates updated results in 2020

4.2. Maintenance Fuel Loading and Tree Density – FMH plots

Maintenance objectives help to refine long-term desired states for each monitoring type and are described briefly in Table 8. On the South Rim, maintenance burning will likely continue in the form of prescribed fires, while on the North Rim, the expectation is that wildfires will be managed to achieve maintenance objectives. These objectives are for the general state of the landscape. The objectives help define fire return intervals for prescribed fires on the South Rim, and initiate planning for prescribed fires on the North Rim (if wildfires are regularly suppressed or opportunities for managed fires are insufficient). Measurement periods currently correspond to those for restoration targets but can be adjusted based on management needs. Of the six maintenance objectives listed in Table 8, we can say with statistical confidence we are achieving three of the objectives after third or fourth entry fire.

Maintenance burning in the PIPO and PIPN monitoring types has resulted in achievement of the fuel loading objectives for each type. Although the sample size in the PIAB monitoring type is smaller, minimum plot numbers have been achieved and total mean fuel loading just exceeds the targeted range, with lower confidence limits falling within the targeted values.

However, in all three monitoring types, we have not both installed and burned the number of plots needed to overcome the variability in tree density. In the PIPO type, mean tree density now falls outside the targeted range after maintenance burning, but the confidence limits extend within the targeted range of objective values. The PIPN monitoring type has achieved the target range for maintenance of conifer pole-sized tree density objectives, although minimum plot numbers have not been met. This precautionary statement should be extended to the PIAB monitoring type, where only five plots have provided data two years post-burn following a third entry fire and one plot following a fourth entry. Mean conifer pole density for PIAB was within the targeted range; however, when viewing the confidence interval, limits extend well below the targeted threshold and values outside the interval are rejected as plausible values for that parameter. Because the statistical viability of computing a percent average for the "most recent entry" was implausible due to the large variability, that number is not included in this analysis and more samples will be needed to compute the "most recent entry" percentage net gain or loss for PIAB poles.

It should be noted that in all instances where the sample size is small and the minimum number of plots has not been reached, each additional plot reading in that monitoring type has the potential to greatly influence the result, and any interpretation of results should take this lack of statistical confidence in existing values into account.

Table 8. Maintenance Management Objectives and Monitoring Results for FMH plots in 2020. 3rd entry and 4th entry refer to the third and fourth time an area has burned in any fire type (prescribed fire or wildfire).

Monitoring Unit	Maintenance Management Objectives	Monitoring Results 3rd/4th Entry (n = # of plots)	Objectives Achieved? (Data Years)	Minimum Plot #s Achieved?
Ponderosa Pine (PIPO) South Rim	Maintain total fuel load of 0.2-9.3 tons/acre immediate post-burn	**6.4** ± 1.9 tons/acre (-59 percent due to fire 1, 2, & 3) (-25% due to fire 3 only) (n=16)	**YES** (2005 – 2011)	**YES** n=10
	Maintain tree (PIPO) density with DBH ≥1" of 43-135 trees/acre 5 years post-burn	**151.3** ± 34.5 trees/acre (-21% due to fire 1, 2, & 3) (-8% due to fire 3 only) (n=16)	**NO*** (2010 – 2016)	**NO** n=43
Ponderosa Pine (PIPN) North Rim	Maintain total fuel load of 0.2-15.7 tons/acre immediate post-burn	**10.9** ± 3.0 tons/acre (-56% due to fire 1, 2, & 3 or 4)[1] (-18% due to most recent entry) (n=16)	**YES** (2007 – 2019)	**YES** n=11
	Maintain conifer pole density with DBH of 1-6" of <81 trees/acre 2 years post-burn	**17.3** ± 8.1 trees/acre (-78% due to fire 1, 2, & 3 or 4)[1] (-5% due to most recent entry) (n=14)	**YES** (2009 – 2020)	**NO** n=48
Ponderosa Pine w/ White Fir Encroachment (PIAB) North Rim	Maintain total fuel load of 1.7-19.0 tons/acre immediate post-burn	**19.5** ± 5.8 tons/acre (-50% due to fire 1, 2, & 3 or 4)[1] (-14% due to most recent entry) (n=7)	**NO*** (2017 – 2019)	**YES** n=5
	Maintain conifer pole density with DBH of 1-6" of <100 trees/acre 2 years post-burn	**53.4** ± 75.8 trees/acre (-58% due to fire 1, 2, & 3 or 4)[1] (n=5)	**YES*** (2019-2020)	**NO** n=9

NOTE: Assessment of objective success and fulfillment of minimum plot requirements are based on 80 percent confidence intervals. Minimum plot calculations are based on pre-fire values, with R-value of 20 for overstory tree and fuel assessment and R-value of 25 for pole-sized tree assessment; variable fire conditions increase the minimum number of recommended plots for post-fire analysis.
YES* indicates that the mean value meets stated objectives but the confidence interval is outside the range of objective values.
NO* indicates that the mean value does not meet stated objectives but the confidence interval is inside the range of objective values.
[1]Both 3rd and 4th entry fires are considered maintenance burns, and only the most recent maintenance burn data are analyzed for each plot. In future years, we will likely analyze 3rd and 4th entry results separately, but currently lack the statistical strength to do so.
Red box indicates updated results in 2020

4.3. Burn Severity – MTBS Data and CBI Plots

To augment the Monitoring Trends in Burn Severity (MTBS) program, Composite Burn Index (CBI) burn severity assessments have occurred annually at Grand Canyon from 2001 to 2019. In 2020 the CBI program came under question and an evaluation of the current 2020 programmatic priorities and capabilities of the Fire Ecology Program at GRCA was conducted. It was determined that for 2020, CBI verification would not be performed and standardized MTBS data would be used to determine burn severity for the previous fire year. In line with this decision, MTBS requests were made through the online portal and the associated products were obtained and will be used for the analysis of burn severity for fires that occurred in 2019.

5. Additional Program Information

Table 9. Additional Program Information through 2020.

Program Category	Measurement	Grand Canyon National Park	Flagstaff Area National Monuments
Planning	Does park have written Desired Future Conditions (DFCs)?	Yes	Yes
Planning	Date park-level monitoring plan completed (or revised)	2010	Not Completed
Planning	Total # project- or community-level monitoring plans	0	0
Planning	Assisted with how many Burned Area Emergency Response (BAER) or Burned Area Rehabilitation (BAR) plans in 2020?	1	0
Monitoring	Percent of total program data entered and quality checked	100	100
Monitoring	Percent of 2020 data entered	100	100
Monitoring	Percent of 2020 data quality checked	100	100
Monitoring	# 2020 prescribed fires monitored (# total prescribed fires monitored)[1]	0 (0)	0 (0)
Monitoring	# non-fire fuels treatments monitored	0	0
Monitoring	# 2020 wildfires monitored (# total wildfires monitored)[1]	0 (0)	0 (0)
Monitoring	# BAER BAR treatments monitored	0	0
Communication	# project monitoring reports completed in 2020[2]	0	0
Communication	# annual meeting(s) with park staff	0	0
Communication	# formal presentations of results	0	0
Communication	Did you use Minitab?	Yes	
Research	Are research needs identified in Fire Management Plan (FMP) or monitoring plan?	Yes	Yes
Research	# proposals submitted in 2020	0	0
Research	# proposals funded in 2020	1	0
Research	# research projects supported in 2020[3]	3	0
Research	Additional Comments		

[1]Number of fires/treatments completed in 2020 with fire/treatment effects monitoring conducted. Includes pre- and post-fire/treatment monitoring, but not on-site fire behavior monitoring. Number in parentheses represents 2020 post-fire/treatment monitoring of fires/treatments that occurred prior to 2020.
[2]Existing GRCA protocol burn-day monitoring reports are not included in this number.
[3]Number of research projects supported including logistical info or support, staffing, data sharing, product reviews, etc.

6. Research

6.1. NPS Fire Funded Research Update

Fire-weather Drivers of Extent and Severity: Learning from Past Fires' Patterns to Inform Future Wildfire Decision Making (Andrea Thode and Stephanie Mueller – NAU and Erin Banwell – GRCA)

We submitted a Federal Reserve Funding Request for this project in November of 2018. Although we did not receive the Federal Reserve Funding Request, this research project was funded by the NPS Intermountain Region in March of 2019 and a cooperative agreement through the Northern Arizona University CESU was completed. An extension of funding was granted in 2020 and a final completion of the project is targeted for Spring 2021. Our goal with this research is to answer the following questions:

1. When fires make "runs", or large increases in size (75th percentile), which weather and/or climatic conditions affect the amount of daily area burned?
2. Does a greater proportion of moderate-high to high burn severity within each fire progression day correlate with certain weather and/or climatic conditions?
3. Do the largest daily fire runs (95th percentile) result in a higher proportion of moderate-high to high burn severity?

Project deliverables include:

- Any applicable data layers, files, tables, and figures of the statistical analysis consistent with the objectives would be delivered to fire management staff.
- A detailed written report of findings
- Presentation of findings to fire and resource managers at Grand Canyon National Park and other interested regional managers and specialists
- Oral presentations at relevant local or regional conferences
- Webinar through the Southwest Fire Science Consortium

6.2. On-going Research Collaborations

GRCA Fire Ecology staff members fulfill data requests from numerous federal and university researchers each year. In addition to the projects described above, the following list illustrates the diversity of collaborators and the types of research to which GRCA Fire Ecology staff (shown in **bold**) made substantial contributions in 2020.

> ***Li Brannfors*** *provided Kaibab National Forest Fire Ecologist Alex Spannuth and Rocky Mountain Research Station researcher Andrew Hudak a subset of targeted data from the Grand Canyon FFI database for analysis on recent RAP and FMH post-burn plots, including a LIDAR-based biomass and smoke production project on the 2019 Castle and Ikes Fires*
>
> ***Matt Engbring*** *provided Sara Burch, a Northern Arizona University Masters Candidate in Geology, the Fire Geodatabase for a post fire sediment flow analysis on the Cottonwood Creek Fire*

6.3. Publications and Presentations by Collaborators

The following list of publications and presentations highlights the written and oral communication of research done this year (and in which Grand Canyon fire ecology and effects data have been used) by our collaborators. While explicit substantial contributions by Park Fire Ecology staff are not documented, these research projects are the culmination of past funding and partnerships with the GRCA Fire Ecology Program.

Publications

Stoddard, Michael T., Fulé, Peter Z., Huffman, David W., Meador, Andrew J. Sánchez, Roccaforte, John P. (2020). Ecosystem management applications of resource objective wildfires in forests of the Grand Canyon National Park, USA. *International Journal of Wildland Fire* *https://doi.org/10.1071/WF19067*.

Springer, Judith D., Stoddard, Michael T., Huffman, David W., Laughlin, Daniel C, Fulé, Peter Z., and Daniels, Mark L. (2020). Plant Community Responses to Wildfires Managed for Multiple Objectives Across a Climatic Gradient in Montane and Subalpine Forests, Arizona, USA. *To be submitted to, Journal of Vegetation Ecology.*

Mueller, Stephanie E., Thode, Andrea E., Margolis, Ellis Q., Yocom, Larissa L., Young, Jesse D., Iniguez, Jose M. (2020). Climate relationships with increasing wildfire in the southwestern US from 1984 to 2015. *Forest Ecology and Management* *www.elsevier.com/locate/foreco*.

Presentations

Due to the ongoing pandemic presentations were limited and Grand Canyon was not referenced in any of the limited virtual seminars for 2020.

7. Future Program Direction

As the Fire Ecology Program prepares for the next calendar year, planning for the future of the crew is being given much attention by the Fire Ecologist and the Lead Fire Effects Monitor. Within the discussions of how to maintain an effective program, six main topics have become apparent. Areas of discussion include workforce and succession planning, relevancy of data and presentation, burn severity analysis, monitoring plans, support for other parks' ecology programs, and continued collaborations with universities and independent researchers.

To continue providing consistent and accurate products for the National Park Service, it is imperative to address the workforce that comprises the Fire Ecology Program. Moving into 2021, Grand Canyon is looking to hire and retain individuals that are looking to make long term contributions to the National Park Service. It is imperative for our profession that we create an available candidate pool to backfill positions as they are vacated and additionally provide for a career ladder so that employees have a clear path to the Park and Regional Fire Ecologist positions. The current organizational structure needs to be re-evaluated so we may provide a better career path for incoming employees. Within Grand Canyon National Park, the Fire Ecology Program will be advocating for more permanent positions, specifically the GS-06 Assistant Lead Monitor as well as exploring an additional position description that would allow the Lead Fire Effects Monitor to be flown as a multi-grade position. This multi-grade position description would provide for a much larger and qualified candidate pool and aid in the long-term sustainability of the Fire Effects crew.

As the Fire Ecologist continues to have a better understanding of his day-to-day roles and responsibilities, additional time to analyze and present data for 2021 will be allocated to the program of work. The Fire Ecologist wishes to showcase FFI data internally to GRCA's Fire Leadership and externally to partners. To accomplish this, more on the job training will be needed and the Fire Ecologist has already begun to identify resources to receive this training. Additionally, to achieve this goal, help from the Lead Monitor will be paramount and the Fire Ecologist will look to capitalize on any opportunities to receive more institutional knowledge from the current Lead.

Building on our multiple years of testing and implementation with FFI Lite, fire monitoring software, and tablet hardware platforms, we would like to continue providing insight into the refinement of applications and protocols for cloud-based and mobile device-based data collection on both plots and active fires. Moving from paper datasheets to mobile applications has been realized and maintained within our program, and we hope to stay heavily involved in the development and implementation of future products.

For 2021 the Fire Ecologist wishes to take a deep dive into burn severity analysis for Grand Canyon. Burn severity data is directly linked to compliance for wildfire and prescribed fire at this park, and the current state of the severity program is in flux. Moving forward, all old severity data needs to be consolidated and the collection of new data will need to be evaluated on a case-by-case basis. Composite Burn Index (CBI) verification may, or may not take place in future severity analysis and the Fire Ecologist looks forward to the reorganization/reevaluation of this program for Grand Canyon.

As indicated by the end of the year reviews for Grand Canyon National Park and Walnut Canyon National Monument, Fire Monitoring Plans will need to be reevaluated and re-certified for 2021. The Fire Ecologist plans to work collaboratively with Fire/Fuels staff and internal partners at Walnut Canyon to review and re-certify these plans before the next annual review.

The Grand Canyon Fire Ecology Program wishes to continue support for other ecology groups in 2021. Examples of programs that have utilized Grand Canyon for varying levels of assistance in the past include Zion and Saguaro National Parks. Augmenting other programs' capacities will be assessed on a case-by-case

basis and ultimately the decision will be based on the current capacity of the Fire Ecology Program. In years where capacity is low, or the GRCA workload is immense, the Fire Ecology Program may not be able to respond to requests from benefitting external units.

To help facilitate GRCA priority research questions being analyzed by researchers, it is important to continue building relationships and collaborating with Northern Arizona University, Ecological Restoration Institute, and other research groups. We would also like to initiate more robust analyses of our data to better understand the space-time dimensions of our data in relation to our Fire Management Plan objectives. The program will also continue our commitment to develop solid scientific datasets for management decision-making and to educate internal and external audiences about fire in Grand Canyon National Park and the NPS as a whole.

GRCA FX Tower of Power

8. Annual Report Contributors

Matt Engbring
Fire Ecologist
matthew_engbring@nps.gov
928-607-3766

Li Brannfors
Lead Monitor
li_brannfors@nps.gov
928-638-7063

Alexandra Lalor & Chazz Lakin
Fire Effects Crewmembers