National Park Service
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Fire and Aviation Management

Grand Canyon National Park / Northern Arizona
Fire Ecology Annual Report
Calendar Year 2023

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Top left: Gathering measurements for the new Tusayan Pueblo Thinning Project on the South Rim
Top right: Crew overlooks the Grand Canyon from the North Rim during the Rainbow Wildfire
Bottom center: Grapevine Prescribed Fire smoke dispersion from Duck-on-a-Rock viewpoint on the South Rim
(photos by Li Brannfors)

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.

Table of Contents

A. Summary

In 2023, the Northern Arizona/Grand Canyon (GRCA) Fire Ecology program met both planned and unplanned challenges, accomplishing a wide variety of work with internal and external partners as well as providing support to multiple fires and local planning efforts. A total of 68 fire effects plots were read at Grand Canyon National Park, prescribed fires and managed wildfires burned on both South and North Rims, relationships with resource staff at multiple parks were fostered, and programmatic duties were executed by the Fire Ecology program in the absence of key leadership positions within the Branch.

Staff turnover occurred at multiple positions over the course of the year. After serving the second-longest tenure of any Fire Ecologist at Grand Canyon, Matt Engbring left for a new position in May. His three years of service were greatly appreciated, and he left Fire Ecology as well as the entire Fire & Aviation Management program better for his time here. In the absence of an Ecologist for the remainder of the year, the Lead Monitor assumed day-to-day programmatic and budgetary oversight. Four seasonal Fire Effects staff were hired, including the unexpected return of a 2022 crewmember in the second half of the year to maintain full staffing. In November, the Assistant Lead Monitor position was filled as a permanent hire for the first time since 2019, marking the return of Alexandra Lalor to GRCA Fire Ecology. By December, Lisa Handforth was hired to fill the Fire Ecologist vacancy.

Near record winter moisture across northern Arizona subdued early season fire danger, including the second highest seasonal snowfall ever recorded on the North Rim at over 250 inches. Both the onboarding of staff and the start of the field season were delayed, yet monitoring was still able to exceed expectations. Within the 68 total plots visited (Table 1), 37 Fire Monitoring Handbook (FMH), 1 Inventory and Monitoring (I&M) mixed conifer, 10 I&M pinyon-juniper, and 20 Rapid Assessment Protocol (RAP) plots were read at GRCA. All FMH and RAP data were entered and checked, with only I&M data still outstanding due to ongoing testing of new data sharing methods between programs. The crew assisted other divisions and diversified their experience by working with archeology, vegetation, and wildlife staff on several occasions. In return, staff from other North Rim work units joined the Fire Effects crew to learn about our operation and help read plots multiple times.

Grand Canyon Fire Ecology returned to its tradition of assisting and partnering with other long-term monitoring programs this season. After a one-year hiatus, Saguaro National Park (SAGU) again served as host. Three crewmembers from GRCA combined forces with Yellowstone, Rocky Mountain, and Saguaro Fire Ecology staff, reading 12 plots for the Southern Arizona Fire Ecology program which had burned 20 years prior in the Helen's 2 Fire. Late-season assistance was requested by the Pueblo & Four Winds Fire Ecology program to read 9 plots at El Malpais (ELMA) National Monument in New Mexico and offer in-person instruction on setting up mobile device data collection, providing the second opportunity for Grand Canyon and Bandelier Fire Effects crews to work together since 2021.

Our yearly partnership with the Southern Colorado Plateau Network (SCPN) I&M program continued, completing a multi-year effort to collect shared baseline data on all 30 pinyon-juniper I&M plots on the South Rim. Eight existing upland forest plots were collaboratively measured by both crews, and two plots were individually read by the SCPN crew after training from GRCA staff. Data sharing improved and redundancy was reduced by again gathering tree data exclusively in the I&M database, facilitated by new data manipulation capabilities with R software via SCPN Ecologist Megan Swan and CSV files with the GRCA FEAT-Firemon Integrated (FFI) database. Collecting these data on a pre- and post-disturbance schedule similar to FMH protocols continues to facilitate comparable landscape-scale, long-term monitoring of forest structure, fuel loading, and herbaceous species diversity across all forested vegetation types. This sharing of knowledge and skills, collaboration, and relationship building are high values worth perpetuating.

Continuing the resurrection of pinyon-juniper monitoring, all 15 Pinyon-Juniper Woodland (PIED) FMH plots were revisited to complete the full suite of standard FMH protocols. Due to time constraints, only the historic variables with the most interest were sampled in 2021. To paint a complete picture and allow for future data analysis comparable with the rest of our FMH plot network, new pole-sized and overstory trees were documented along with measuring seedlings and shrubs in 2023. Ultimately the Fire Effects crew had to split to simultaneously gather data on both FMH and I&M plots in September, but all targeted data were gathered for both programs due the strong partnership and efforts by both crews.

For the first time at Grand Canyon, a larger-scale mechanical treatment project with ecological objectives is planned. To best implement and understand the effects of the Tusayan Pueblo Thinning Project using Stand Density Index (SDI) as a primary measure, Fire Ecology was called upon to develop new monitoring protocols and provide feedback on plan objectives for the South Rim Fire Management Officer (FMO). With input from multiple Fire Ecology programs

and Ecologists across agencies and disciplines, the Lead developed a monitoring plan and protocols based on RAP plots. This project gathering pre-treatment data from the experimental thinning project was not part of the workplan developed at the start of the season, and it was unknown what scope of work could truly be accomplished mid-year, including logistical and coordination efforts with outside parties. With the crew's dedication and GIS support from the Fire Archeologist and Regional Fire GIS staff for this special project, all planned 20 plots were installed, including gathering extra data to help meet the needs of vegetation and wildlife staff.

For the tenth straight season, 100 percent of Grand Canyon field data were collected on tablets and managed electronically, enhancing efficiency. Once again only Excel and mobile devices were used all year at GRCA and SAGU, with great success. This knowledge continues to be expanded by sharing electronic data collection discoveries with additional programs, including the Yellowstone, Klamath/Redwood, and Southern Plans/Lake Meredith Fire Ecology groups.

In addition to completion of the core plot load within the park, the Fire Ecology program and Fire Ecologist facilitated critical programmatic tasks for the Branch of Fire and Aviation. Tasks such as serving as an Interdisciplinary Team (IDT) lead in the Planning Environment and Public Comment (PEPC) program, development and documentation of a program of work within the National Fire Plan Operating and Reporting System (NFPORS), collaborating with GRCA Division of Science and Resource Management (SRM), Monitoring Trends in Burn Severity (MTBS) model building for Mexican Spotted Owl (MSO) compliance, coordination of Geographic Information System (GIS) products, Burn Plan Technical Reviews, Wildfire Decision Support System (WFDSS) authorship, and various administrative tasks including budgeting were conducted to support operations. Our program continues to proactively support a dynamic Fire & Aviation Branch at GRCA.

Igniting on the North Rim on July 24, the Rainbow Fire was Grand Canyon's second wildfire of notable size managed for resource benefit in the last two years which was allowed to burn with no direct management actions taken on the fire itself. Current and former Ecology staff were heavily involved from the beginning, providing the following functions:

- Initial Incident Commander (IC)
- Wildland Fire Decision Support System (WFDSS) authorship
- First-hand knowledge of the 2022 Dragon Fire in a similar area and time of year
- On-site Fire Effects Monitor (FEMO) weather, fire behavior, and perimeter updates
- FSPro fire modeling calibration via on-scene observations, weather station climatology, and discussions with the remote Long Term Fire Analyst (LTAN)
- Testing of Field Maps app new data collection and field editing capabilities with the Regional Fire GIS Specialist
- Resource Advisor (READ) support for the Fire Archeologist

Combined with the success of the similar 2022 Dragon Fire, efforts of the Ecology group continue to build confidence to once again manage wildfire on the North Rim with minimum intervention.

Interspersed with plot data collection at Grand Canyon and other parks was the busiest local prescribed and managed fire season in memory. Fire Ecology staff provided primary Fire Effects Monitor (FEMO) or Resource Advisor (READ) support on 9 prescribed and 3 managed fires on both rims of GRCA as well the USFS North Kaibab Ranger District. Fire assignments with the Saguaro and Olympic Wildland Fire Modules, as well as 2 weeks of READ work in

northern California, provided additional experience away from Grand Canyon for crewmembers. Overtime work boosted Severity staffing, multiple initial attacks & sizeups, prescribed fire prep work, and hand thinning projects for North Zone Fire Management (USFS North Kaibab Ranger District-Kaibab National Forest & NPS North Rim-Grand Canyon National Park). So many quality opportunities occurred that 3 individuals were recommended for FEMO, 1 for READ, and 1 for ICT5 certification. In total, Ecology staff worked on 19 incidents and Severity or prep work over 132 total operational periods, continuing our commitment to provide valuable support to operational fire activities while offering invaluable experience to our employees for continuing careers in wildland fire.

Table 1: 2023 Grand Canyon National Park Fire Effects plot workload

Rim (GRCA)	Monitoring Unit	Plot Type	Install/ Pre-burn	Immediate Post-burn	Year 1 - 20	Years Data Collected (start-end)	Annual Total (2023)	Total Plots[1]
South	Ponderosa Pine **PIPO**	FMH - Forest		1	4	1990-2023	5	41
South	Pinyon-Juniper Woodland **PIED**[2]	FMH - Forest	15			1990-2023	15	17
South	Moqui Rx	RAP[3]				2008-2011	0	5
South	Picnic Rx	RAP[3]				2008-2011	0	10
South	Quarry Rx	RAP[3]				2008-2011	0	10
South	Tusayan Pueblo (Thinning)	RAP[3]	20			2023	20	20
South	Pinyon-Juniper	I&M[4]	10			2021-2023	10	30
North	Ponderosa Pine **PIPN**	FMH - Forest			12	1992-2023	12	30
North	Ponderosa Pine with White Fir Encroachment **PIAB**	FMH - Forest			4	1993-2023	4	27
North	Rocky Mountain Subalpine Conifer **PIEN**	FMH - Forest			1	1993-2023	1	17
North	Grassland Interior **GRIN**	FMH - Brush				2001-2002	0	10
North	Grassland Edge **GRED**	FMH - Forest				2001	0	6
North	Fawn Spring Rx[5]	RAP[3]				2010-2022	0	20
North	Highway 67 Rx[5]	RAP[3]				2015-2022	0	20
North	Range Rx	RAP[3]				2008-2014	0	20
North	Spring Canyon Rx[5]	RAP[3]				2010-2022	0	20
North	Thompson Rx	RAP[3]				2009-2017	0	20
North	Burnt Corral-NKRD	RAP[3]				2015	0	50
North	Tipover Rx-NKRD	RAP[3]				2013-2022	0	40
North	Walla Valley Rx	RAP[3]				2008	0	6
North	Mixed Conifer	I&M[4]		1		2010-2023	1	46
Total			**45**	**2**	**21**		**68**	**485**

[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 for protocols of interest.
[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.

Table 1A: 2023 Flagstaff Area National Monuments Fire Effects plot workload

Park	Monitoring Unit	Plot Type	Install/ Pre-burn	Immediate Post-burn	Year 1 - 20	Years Data Collected (start-end)	Annual Total (2023)	Total Plots[1]
Walnut Canyon NM	Ponderosa Pine **PIPO**	FMH – Forest / I&M				1993-2020	0	13
Total						**0**	**0**	**13**

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

Fire Effects staff taking a break from monitoring the Rainbow Fire (photo by NPS)

B. Monitoring Results

Highlights for 2023 FMH Monitoring

Grand Canyon National Park's Fire Ecology Program has installed 148 permanent FMH-style plots to date. As of 2023, 126 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 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 / Mixed Conifer) were identified within the 2012 monitoring plan and are regularly assessed as new data become available.

Two additional monitoring types, PIEN (Spruce-Fir) and PIED (Pinyon-Juniper) are not included in regular assessments as: (1) these areas are 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.

Within the 2023 field season new FMH data were collected for PIPO, PIED, PIAB, PIEN, and PIPN. Data were analyzed and presented in tables 2 and 2A. Newly created results are highlighted with a red outline.

Restoration Management Objectives Overview

Restoration objectives are centered around first and second entry fires and help to refine desired conditions for each monitoring type (PIPO, PIPN, and PIAB) being managed at GRCA. Objectives for first and second entry fires are listed in Table 2 and briefly outline management objectives for fuel loading and tree density.

Fuel Loading Restoration Results

When examining the results of our FMH analysis, Grand Canyon Fire Management has achieved its first entry, total fuel loading objectives (desired range in parentheses) in the PIPO (0.2 – 9.3 tons/acre), PIPN (0.2 – 15.7 tons/acre), and PIAB (1.7 – 19 tons/acre) monitoring types.

After second entry fires, fuel loading values were also within the targeted range for PIPO, PIPN, and PIAB; however, there may be more fuel loading than desired for PIAB as confidence limits include values outside the objective range.

Pole and Overstory Tree Density Restoration Results

In the PIPO and PIPN monitoring types, it is important to note that GRCA has not installed the number of plots needed to gain statistical confidence to overcome the variability in pole-sized tree (1-6" DBH) density. Within the PIAB monitoring type, current sample sizes for pole-sized trees do indicate that statistical confidence can be achieved for post-burn values.

In the PIPO monitoring type, pole-sized tree density objectives (16-81 trees/acre) are likely being met after first entry, and they are probably not being met after second entry. Confidence limits outside the objective range for first entry fire indicate there may be more poles than desired; contrary to this, for second entry the mean density is outside the desired range, but the lower confidence limit is within the targeted range.

When evaluating data for the PIPN monitoring type, pole-sized tree density objectives (16-81 trees/acre) are likely being met for both first and second entry fire. However, there may still be too many poles after first entry with confidence limits extending above the targeted range, and conversely too few poles after second entry with limits below the range. These results indicate the extreme variability in pole-sized trees within North Rim Ponderosa Pine.

After first entry fires in the PIAB monitoring type, pole-sized tree density (16-100 trees/acre) objectives are being met. After second entry fires in PIAB, pole-sized tree density also fell within the objective range, but the confidence limits extended below the target, indicating the possibility of more mortality in this size class than desired.

For large tree (>16" DBH) density, minimum plot numbers have been reached for all three analyzed monitoring types and can provide reliable analysis. Mean large tree density objectives are being met in PIPO (>14 trees/acre), PIPN (>17 trees/acre), and PIAB (>20 trees/acre) for all first entry burns. When looking at second entry fire, values five years post-burn were within the targeted range for PIPO and PIPN, with only PIAB failing to meet the objective with too few large trees.

Conclusion

Of the nine restoration objectives listed in Table 2, we can say that we are likely achieving nine of the objectives after first entry fire, and seven of the objectives after second entry fire. Where confidence limits extend outside of the desired range, we are less certain about five of our management objectives.

Table 2: Restoration Management Objectives

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	**7.2** ± 0.8 tons/acre (-48%) (n=40)	**7.3** ± 1.4 tons/acre (-52% due to fire 1 & 2) (-13% due to fire 2 only) (n=25)	**YES** (1992 – 2023)	**YES** (1998 – 2022)	**YES** n=10
	Reduce poles (PIPO) with DBH of 1-6" to 16-81 trees/acre 2 years post-burn	**75.9** ± 29 trees/acre (-24%) (n=40)	**86.8** ± 35 trees/acre (-37% due to fire 1 & 2) (-11% due to fire 2 only) (n=25)	**YES*** (1994 – 2021)	**NO*** (2000 – 2023)	**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)	**20.4** ± 3.6 trees/acre (0% due to fire 1 & 2) (-1% due to fire 2 only) (n=21)	**YES** (1997 – 2018)	**YES** (2003 – 2022)	**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)	**38.6** ± 6.6 trees/acre (-17% due to fire 1 & 2) (-4% due to fire 2 only) (n=17)	**YES** (1997 – 2016)	**YES** (2010 – 2023)	**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)	**28.0** ± 24.8 trees/acre (-87% due to fire 1 & 2) (-45% due to fire 2 only) (n=17)	**YES** (1995 – 2019)	**YES*** (2002 – 2021)	**YES** n=9
	Maintain overstory conifer density with DBH ≥16" of >20 trees/acre 5 years post-burn	**24.6** ± 3.6 trees/acre (-30%) (n=25)	**14.0** ± 5.2 trees/acre (-50% due to fire 1 & 2) (-13% due to fire 2 only) (n=15)	**YES** (1998 – 2022)	**NO** (2005 – 2021)	**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 newly updated results

Maintenance Management Objectives Overview

Maintenance objectives for third and fourth entry fire help GRCA to refine the desired conditions of the landscape within each monitoring type and are described briefly in Table 2A. 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 utilized to achieve maintenance objectives. In the absence of wildfires utilized for resource objectives, prescribed fire will also be a tool to achieve management objectives on the North Rim.

Fuel Loading Maintenance Results

Grand Canyon Fire Management has achieved third and fourth entry total fuel loading objectives in the PIPO (0.2 – 9.3 tons/acre) and PIPN (0.2 – 15.7 tons/acre) monitoring types.

Results for PIAB unfortunately fall above the desired range. However, within this monitoring type, confidence limits do include acceptable values.

Tree Density Maintenance Results

Within in all three monitoring types (PIPO, PIPN, and PIAB), GRCA has not burned the number of plots needed to overcome the extreme variability in tree density to produce reliable statistics.

Preliminary results utilizing our current sample size show that in the PIPO monitoring type, objectives (43-135 trees/acre) are not likely being met for trees >1" DBH. Mean density is outside the desired range, but the lower confidence limit is within the targeted range.

Maintenance objectives for pole sized trees (1-6" DBH) are being met when evaluating data for the PIPN monitoring type (<81 trees/acre), acknowledging that the sample size is still insufficient.

PIAB pole sized tree density objectives (<100 trees/acre) are on track. However, when viewing the confidence intervals, lower limits extend well below the targeted threshold and values outside the interval are rejected as plausible. These values reflect our inadequate sample size and reinforce the need to increase our number of plots burned, as well as evaluate our minimum plot numbers needed for reliable statistics for pole sized trees.

When considering maintenance objectives for poles in all three active monitoring types there is extreme variability in the number of pole sized trees, both pre- and post-fire. Our current methodology includes all qualifying plot reads and outliers are not being excluded. Currently calculations represent the full range of natural landscape variability within these monitoring types. It should also 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. Any interpretation of results should take this lack of statistical confidence in existing values into account.

Conclusion

Of the six maintenance objectives listed in Table 2A, we can say with reasonable confidence that we are achieving four objectives after third and fourth entry fire. Where confidence limits extend outside of the desired range or minimum sample sizes are not close to being reached, we are less certain about two of our management objectives.

Table 2A: Maintenance Management Objectives

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	**10.8** ± 2.8 tons/acre (-55% due to fire 1, 2, & 3 or 4)[1] (-18% due to most recent entry) (n=17)	**YES** (2007 – 2022)	**YES** n=11
	Maintain conifer pole density with DBH of 1-6" of <81 trees/acre 2 years post-burn	**15.7** ± 7.2 trees/acre (-80% due to fire 1, 2, & 3 or 4)[1] (-5% due to most recent entry) (n=16)	**YES** (2009 – 2021)	**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	41.6 ± 50.5 trees/acre (-48% due to fire 1, 2, & 3 or 4)[1] (+16% due to most recent entry) (n=7)	**YES*** (2019-2021)	**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 newly updated results

C. Research, Planning, and Communication

Monitoring Plan Status

The Grand Canyon National Park Wildland and Prescribed Fire Monitoring Plan was constructed and approved in 2010. The plan outlines the program of work for Fire Ecology as well as management goals / objectives, monitoring design, data analysis, reporting, and staff roles / responsibilities. The plan incorporates adaptative management practices and promotes a science-based program that relies on current and best available information.

In 2022, during the Regional Review of the Fire Ecology program, the validity of the monitoring plan was discussed. It was determined that while although there have been changes in staffing and changes within the Ecology program of work at GRCA, the plan was still valid.

In response to the nationwide A-123 Corrective Action Plan, GRCA will be reformatting its Fire Management Plan (FMP) with a due date of October 1, 2024. Concurrent with these efforts, the Fire Ecology program will be evaluating the 2010 Wildland and Prescribed Fire Monitoring Plan for format and content and will submit the plan with any changes as an appendix to the FMP.

Publications

In 2023, no papers were knowingly published which directly used information from the GRCA Fire Ecology program. However, Fire Ecology staff (the new permanent Assistant Lead Monitor) published a paper focused on tree seedling survival during drought in Southwest forested ecosystems.

- Lalor, A.R.**,** Law, D.J., Breshears, D.D., Falk, D.A., Field, J.P., Loehman, R.A., Triepke, F.J., Barron-Gafford, G.A., 2023. Mortality Thresholds of Juvenile Trees to Drought and Heatwaves: Implications for Forest Regeneration across a Landscape Gradient. *Frontiers in Forests and Global Change* 6, 1-16. https://doi.org/10.3389/ffgc.2023.1198156

The following research projects that involve information extracted from the GRCA Fire program are still in the process of publication. Citations for these works are as follows:

- Bright, B.C., Hudak, A.T., McCarley, T.R. *et al.* Multitemporal lidar captures heterogeneity in fuel loads and consumption on the Kaibab Plateau. *fire ecol* 18, 18 (2022). https://doi.org/10.1186/s42408-022-00142-7
- Guiterman, C.H., Gregg, R.M., Marshall, L.A.E. *et al.* Vegetation type conversion in the US Southwest: frontline observations and management responses. *fire ecol* 18, 6 (2022). https://doi.org/10.1186/s42408-022-00131-wClimate Drivers
- McClure, E. J., Coop, J. D., Guiterman, C. D., Margolis, E. Q., & Parks, S. A. [2022] Divergence between historical and contemporary fire regimes at tree-ring fire history sites in dry conifer forests of the southwestern United States. Western Colorado University, master's thesis. Unpublished.
- Mueller, S., A.Thode, J. Young, M. Engbring, C. Marks (2021, July 29). Fire-weather Drivers of Severity and Spread: Learning from Past Fire Patterns at Grand Canyon National Park to Inform Future Wildfire Decision Making. Final Manuscript Submission to Journal of Fire Ecology.

- Springer, J.D., M.T. Stoddard, D.W. Huffman, D.C. Laughlin, P.Z. Fule, M.L. Daniels. 2022. Long-term plant community responses to resource objective wildfires in montane coniferous forests of Grand Canyon National Park, USA. Forest Ecology and Management, 515: 120224

Research and Technology

Grand Canyon Fire Ecology prides itself on innovation and encourages the development of new research and technology. Within the 2023 calendar year GRCA Fire Ecology:

- Continued its multi-year effort to refine the FFI remote application and promoted continual improvement of electronic data collection within GRCA and beyond.
- Facilitated logistics and herbaceous species identification for a graduate researcher from Utah State University collecting data focused on forest regeneration after multiple wildfire entries on the North Rim.
- Participated in Pinyon-Juniper Working Group, addressing novel vegetation responses to drought within this prevalent ecosystem.
- Collected data to quantify long-term drought impacts and multi-decade change in Pinyon-Juniper forests on the South Rim by coordinating a multi-year project with the Southern Colorado Plateau Network Inventory & Monitoring program.

Outreach and Communication

Outreach and communication are principal values of the Fire Ecology program within GRCA. Outreaching to internal / external partners increases collaboration and communicating results aids in fire planning and the adaptative management process. Within the 2023 calendar year GRCA Fire Ecology:

- Took a lead role in the WFDSS refresher for the Flagstaff Monuments (FLAG) and GRCA.
- Provided timely FEMO reports to Burn Bosses and Fire Leadership at Grand Canyon and the Kaibab National Forest for 9 prescribed burns on both the North and South rims, including: Grapevine, Jolly Sink, Road Hollow North, Billy Sink, Road Hollow, Atoko, Blowdown, Red Point, and Bright Angel Rx Fires.
- Provided timely FEMO support for the Rainbow and Kanabownits Fires. Real-time FEMO monitoring was instrumental in updating WFDSS and refining fire modeling predictions with the LTANs assigned to the incidents.

Planning and Compliance

Within the 2023 calendar year, the Fire Ecology program at GRCA provided the following critical planning and compliance support to the Park:

- Created a new, standardized model for Mexican Spotted Owl (MSO) compliance using Monitoring Trends in Burn Severity (MTBS) data in conjunction with national Fire GIS staff.
- Provided comments to the SRM Research Permit review process.
- Co-authored the Section 7 Annual Fire and Fuels Report.
- Served as Prescribed Fire Burn Plan technical reviewers.

Reserve Fund Research

- One reserve fund research project submitted a final manuscript to the Journal of Fire Ecology. Currently the report is in the review process and is anticipated to be published soon. Review and edits for the manuscript were provided by Fire Ecology and Fire Staff within the prior calendar year.

Top: The Hull Fire creeps toward a spinystar cactus (*Escobaria vivipara*)
Bottom: Measuring the rate of fire spread during the Hull Fire
(photos by Li Brannfors)

D. Future Direction

As the Fire Ecology program reflects on the activities from 2023, program leadership is beginning to prepare for 2024 by addressing the future direction of Fire Ecology at GRCA. The primary areas of discussion for future program direction include workforce & staffing, relevancy of data & data presentation, burn severity analysis, monitoring plans, support for other ecology programs, and continued collaborations with universities & researchers.

Workforce and Staffing

To continue providing consistent and accurate products for the National Park Service, it is imperative to not only maintain, but bolster the workforce that supports the GRCA Fire Ecology program. Moving into 2024, Grand Canyon is looking to hire and retain seasonal employees that are interested in making long-term contributions (returning seasonals) to the National Park Service. Although we cannot yet permanently secure seasonal GS-5 or GS-4 level employees, Grand Canyon aims to identify individuals that have a passion for natural resources and give them opportunities to expand their experience working in natural resource management.

In addition to our seasonal workforce, is imperative for our profession that we increase our permanent candidate pool to backfill positions as they are vacated within the Ecology program. One strategy we would like to promote is creating a complete career ladder (GS-4, 5, 6, 7, 9, 11) within the NPS to accommodate a clear path to career positions and advancement within the profession. In 2023 the GRCA Fire Ecology program took a firm step in this direction by hiring a permanent GS-6 Assistant Lead Monitor, funded for 20 payperiods. This position is crucial for the program's leadership capabilities as well as to accommodate succession in the event the GS-7 Lead position is vacated.

While bolstering staffing, Fire Ecology will continue to provide monetary incentives to its employees for supporting fire operations locally and nationally. Monetary awards were provided in 2023 for each staff member that obtained a red card and provided support commensurate to their qualifications. Similar incentives will be sought out and provided to those participating in collateral fire duties for 2024.

When evaluating duty stations, the Fire Ecology program is going to maintain the current location for the Lead Monitor, Assistant Lead, and seasonal crew on the North Rim. To create additional flexibility for permanent employees, the program will continue to provide the opportunity to telework during the winter season or allow unique primary-secondary duty stations to accommodate the option for winter housing on the South Rim. Telework agreements and dual duty stations with the ability to retain the same housing aim to improve work/life satisfaction, increase housing options by accommodating flexible work locations, and ideally lead to retention of our permanent workforce.

Relevancy of Data

As a new Fire Ecologist begins her first year with the program, learning routine daily activities and program manager responsibilities will consume a great deal of time. Because of this, additional time to analyze and present data for 2024 will prove challenging.

To effectively showcase our data, the Fire Ecology program wishes to seek better ways to present FFI-generated results internally to GRCA's Fire Leadership and externally to partners. To accomplish this, more formal and on-the-job training will be needed, and the Ecologist will be seeking out additional opportunities to gain experience. It is our hope that more classes in FFI will be offered beyond the introductory class taught by Duncan Lutes. Additionally, to achieve this goal, assistance and instruction from the current Lead Monitor and Assistant Lead will be paramount. The Fire Ecologist will look to capitalize on opportunities to absorb more institutional knowledge from these knowledgeable, long-term employees.

Building on multiple years of testing and implementation with FFI, fire monitoring software, and tablet hardware platforms, GRCA will continue providing insight into the refinement of applications and protocols for cloud-based and mobile device-based data collection. Moving from paper datasheets to mobile applications has been maintained within GRCA's program, and we hope to stay heavily involved in the development and implementation of any future products.

Fire Severity Analysis

For 2024 the Fire Ecology program will continue to assist Intermountain Region's (IMR) Geographic Information Systems (GIS) Shared Services group with the refinement of the burn severity analysis for GRCA. Burn severity data is directly linked to Section 7 compliance for wildfire and prescribed fire at GRCA, and the current state of the burn severity program is in flux. New methodologies will need to be collaboratively reviewed in the coming season with involvement from SRM, Fish and Wildlife Service (USFWS), and the GRCA Fire Leadership.

Fire Management and Monitoring Plans

As indicated by the A-123 Corrective Action Plan, GRCA and Walnut Canyon National Monument (WACA) Fire Management Plans will need to be reformatted and re-certified by 2024. The newly hired Fire Planner plans to work collaboratively with the Fire Ecologist, Fire Leadership, and internal partners at GRCA and WACA to review and re-certify these plans and ensure they reflect the goals and objectives of the Fire Ecology program. In concert with these efforts, monitoring plans will also need to be reviewed and evaluated for inclusion into the 2024 reformatting / rewriting efforts for both park units.

Collaboration

For 2024, the Grand Canyon Fire Ecology program will continue to assess its ability to support other ecology programs. Currently, there are no formal agreements for the Grand Canyon Ecology group to assist with monitoring efforts outside of GRCA and Flagstaff Monuments. While Grand Canyon has a long history of exceptional collaboration, competing priorities or reduced support may inhibit future endeavors. For 2024, augmenting other programs capacities will be assessed on a case-by-case basis and ultimately the decision will be based on the current workload of the GRCA Fire Ecology program.

To help facilitate GRCA priority research questions, it is important to continue building relationships and collaborating with the Kaibab National Forest, Northern Arizona University, Ecological Restoration Institute, and the Southern Colorado Plateau Inventory & Monitoring Network. The Fire Ecology program will also continue our commitment to develop solid

scientific datasets for adaptative management decision-making and to educate internal and external audiences about fire at GRCA, within northern Arizona, and throughout the NPS.

E. References, Links, and Additional Reading

- 2012 Grand Canyon Fire Management Plan, PEPC Project ID 10959 https://pepc.nps.gov/projectHome.cfm?projectId=10959
- 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 https://irma.nps.gov/DataStore/

Appendix A. Staffing and Accomplishments

Table A-1: Fire Ecology Staffing 2023

Employee	Position	Appointment Length	# Pay Periods	Training	NWGG Taskbooks[1]
Matt Engbring, GS-11	Fire Ecologist	PFT (early Jan – mid May)	10	RT130 Fire GIS	DIVS-t LTAN-t
Li Brannfors, GS-07	Lead Monitor	PFT	26	RT130 Fire GIS	LTAN-t
Sarah Brey, GS-06	Asst Lead Monitor	Temp (early May-mid Nov)	14	S130/190 L180 ICS100 IS700 S212 S290 N9042 Basic SAR Women in Fire	FEMO[2] READ/REAF[2,3] FAL3-t
Baylee Christensen, GS-05	Monitor	Temp (mid May-mid Aug)	8.5	S130/190 L180 ICS100 IS700 S212 S290 Basic SAR Women in Fire	FEMO-t FAL3-t
Noah Humphrey, GS-05	Monitor	Temp (mid Aug-late Oct)	6.5	RT130 S290	FEMO[2] ICT5[2] FAL2-t
Madison Tumicki, GS-04	Monitor	Temp (mid May-mid Nov)	14	RT130 S212 S290 N9042 Basic SAR Women in Fire	FEMO[2] READ/REAF-t[3] FAL3-t
Alexandra Lalor, GS-06	Asst Lead Monitor	Permanent, STF (early Dec)	1		FEMO-t

[1] This represents both open (trainee) taskbooks and those completed in the 2023 season.
[2] Taskbook plus required courses completed and submitted for qualification.
[3] NWCG taskbooks do not yet exist for the READ & REAF positions.

Table A-2: Fire Ecologist 2023 Accomplishments/Focus Areas, January 1 - May 20, 2023

Focus Area	Percent Time	Accomplishments and Activities

Planning	60	• Managed activities in NFPORS
		• Technical Reviewer and editor for prescribed fire burn plans
		• Provided limited GIS support and data organization for Fire Branch
		• Assisted Lead Monitor with seasonal hiring process
		• Served as a WFDSS "driver" and "data manager" for GRCA and WACA
		• Served as an IDT lead for the Branch utilizing PEPC
		• Continued MSO project planning
		• Extensive work on compliance tasks, including:
		  ○ MTBS Section 7 burn severity analysis
		  ○ A-123 Audit
		  ○ FMP review
		  ○ IRMA maintenance
		• Bringing the new FMO up to speed, primary on compliance
		• Preparing to transition over to the next Ecologist, including:
		  ○ File backups
		  ○ Uploading all ecology hard drives to the GRCA intranet
		  ○ Uploading "historical" hard drives
		  ○ Setting up OneDrive with IT

Presentations/ Education	<1	• Co-Hosted WFDSS training for FLAG and GRCA
NPS Meetings/ Task Groups	<1	• Fire and aviation weekly staff and strategy meetings • Attended bi-monthly SRM program manager meetings • Periodically participated in Regional Fuels calls • Attended Regional Fire Ecology bi-annual collaboration calls • Attended Intra / Inter Agency Delegation meetings
Interagency Work	<1	• Continued to promote the Inventory & Monitoring collaboration for the monitoring of the Mixed Conifer & Pinyon-Juniper fuel types at Grand Canyon • Periodically attended Pinyon-Juniper working group Teams meetings • Programmatic interagency agreements
Internal Collaboration	<1	• Outreached to employees in SRM to initiate relationships and collaborations
Fire Assignments and Fire Support	0	
Research	0	
Data Collection	0	
Data Analysis & Reports	15	• Co-authored the Fire Ecology Annual Report
GIS	5	• Served as a liaison between GRCA Fire and IMR GIS Shared Services • Coordinated a review of the GRCA Fire Severity analysis
Supervision/ Administration	10	• Routine Program Manger responsibilities (housing, pay, JHA's, travel, etc.) • Supervised the Lead Monitor • Projected FY 24 budget
Training and Conferences	5	• NPS Fire Ecology Training Workshop in West Virginia • Fire GIS training in Flagstaff
Miscellaneous	<1	• PT

Table A-3: Fire Effects Crew 2023 Accomplishments/Focus Areas

Focus Area	Percent Time[1]	Accomplishments and Activities
FMH Plots	19	• 21 remeasurements and 1 immediate post-burn read at GRCA • 15 modified remeasurements of PIED plots (previously discontinued in 2000) • 12 remeasurements at SAGU • 9 remeasurements assisted at ELMA
RAP Plots	4	• 20 thinning installs coordinated w/ Vegetation & Wildlife staff in the planned Tusayan Pueblo Thinning Project at South Rim of GRCA
I&M Plots	2	• 1 immediate post-burn read in Mixed Conifer • 10 baseline measurements of fuel and tree data in existing I&M Pinyon-Juniper plots at GRCA (data on 2 plots collected exclusively by SCPN staff)
Data Entry/ Management	5	*ALL 2023 plot data collected and checked electronically with tablet computers in the field; data entry and field checking are included in percent time under each plot type* • QAQC queries completed for 2023 GRCA standard (non-I&M) data • Data imported and QAQC queries completed for 2023 GRCA PIED data • Refined new electronic data entry using FFI CSV file exports, Excel, and tablets/phones • Includes FFI/Excel electronic data prepping, merging, and checking
Data Analysis	2	• Annual Report analysis on all major variables in program completed in January 2024 • Lead co-authored the Fire Ecology Annual Report
Plot Office	13	• Includes plot preparation, plant ID, photo filing, tree mapping, hardcopy data filing/organization, and plot-related projects
General Office/ Supervision/ Admin	23	*The winter was devoted almost exclusively to office work, and the late season arrival of the permanent Assistant Lead meant that 100% of their time was spent in the office. Hence, a larger percentage of general office time than in years past is reflected* • Includes paperwork for travel, credit cards, non-plot related projects • Hiring, evaluations, and supervision by Lead • Lead hired and supervised 4 seasonals and permanent Assistant Lead • Lead closed out NPORS and programmed budget from May-Sept
Fire Monitoring (Rx or Wildfire)	11	• Lead FEMO & FEMO trainees on 9 Rx fires at GRCA and North Zone • Lead FEMO & FEMO trainees for 3 managed wildfires at GRCA • 2 crewmembers detailed with Olympic Wildland Fire Module for 2 weeks at WA • Trained 3 members of Dinosaur engine & Bandelier Wildland Fire Module as FEMO-trainees on 1 Rx fire at GRCA
Fire Operations/ Assignments (Rx, Wildfire, Engine, Helitack, Non-fire Fuels Projects)	9	*Includes all collateral duty time on Rx or Wildland Fire operations (excluding FEMO)* • Crewmembers assisted Fire Archeologist with READ/REAF surveys for 5 days • 1 crewmember detailed on READ/REAF trainee assignment for 2 weeks in CA • 2 crewmembers detailed with Saguaro Wildland Fire Module for 6 days in AZ • ICT5-t, FAL2-t, FFT1, and FFT2 support on total of 3 North Zone fires • FAL3-t support for North Zone Rx fire prep for 2 days • Cross-trained crewmembers with North Zone module and fuel sampling
Training	12	• All attended annual fire refresher • Lead attended NPS Fire Ecology Training Workshop in West Virginia • Crew attended Women in Fire Symposium virtually • 2 completed S130/190, L180, ICS100, & IS700 (Basic Firefighter Training) • 3 completed S212 • 4 completed S290 • 2 completed N9042 • 3 attended N Rim Basic Search & Rescue training • ~4% of crew time spent on PT
Travel Away from Duty Station	–	• ~2 months total for crew spent on South Rim, at El Malpais & Bandelier National Monuments, and at Saguaro National Park for plot work & training • ~ 4.5 months for Lead teleworking in Flagstaff
Other	–	• Assisted N Rim vegetation & wildlife staff for multiple days • ~9% of crew time spent on leave or holidays not worked[2]

[1]1515 hours of combined overtime and comp time, equaling 22 percent of total crew work time (base + OT + CTE), are not reflected.
[2]Leave taken and holidays not worked were included in focus area percentages of time in previous annual reports. The percent listed here is provided for reference to compare to prior reports, but is not included in the percentage calculations listed for major duties.

Top: 2023 Grand Canyon Fire Effects crew
Bottom left: Fire Ecology staff from Rocky Mountain, Yellowstone, Saguaro, and Grand Canyon celebrate at Manning Camp
Bottom right: Bandelier and Grand Canyon Fire Ecology personnel enjoy tacos…and a job well done at El Malpais
(photos by NPS)

Intermountain Fire Ecology strong!!