Fire behavior from UAS drone ignition compared to hand and helicopter ignited fires on the William B. Bankhead National Forest, Alabama

Aerial ignition by helicopters has proven to be a more efficient technique for igniting prescribed fires on large burn units, but recent technological developments suggest that UAS, or unmanned aerial systems, may be advantageous over helicopter ignitions because of their increased safety and flexibility, and decreased cost. In a case study on the Bankhead National Forest, U.S. Forest Service researchers John Craycroft and Callie Schweitzer compare the fire behavior and fuel consumption of a UAS-ignited burn in 2022 with previous burns in the same stand, as well as hand-ignited burns from nearby stands the same year. Their findings were recently published in the journal *Fire Ecology*.

Study Sites:

Bankhead National Forest in northcentral Alabama (BNF). When the study began nearly 20 years ago, the study stands (unmanaged pine plantations) were dominated by loblolly pine, with Virginia and shortleaf pine also present. Upland oaks and red maple had also become common in the stands. The overall research project is examining the effectiveness of partial cutting and repeated burns to promote oak regeneration. The study stands were within larger landscape-scale burn units.

Characteristics of the study stands:

- Area: 9-19 hectare (ha) each
- Age: 30-60 years old
- Pre-treatment basal area: 28-30 m^2 ha^{-1}
- Completed 6th burn cycle in 2022 (UAS burn included)

Methods:

Prescribed fires -

- The UAS burn occurred March 6, 2022 in a 1,100 acre burn unit.
    - Ignited using a DJIS Matrice 600 Pro hexadrone with Pyro Shot Dragon Eggs.
- 5 previous burns in this unit had been ignited either by hand or by helicopter and occurred from late January to late March.
- The UAS ignition was in a grid pattern on ridgetops to generate a point ignition burn; flanking and backing fires from the ridgetop ignition then burned the slopes.
    - 6 batteries powered the drone, and were switched out after 15 minutes of flight and ignition- 18 flights were used to complete the ignition.

Five additional units were ignited by hand January-March 2022, using strip ignitions, also primarily on ridgetops.

DJI Matrice 600 Pro drone with attached hopper filled with dragon eggs.

Fire behavior and fuel consumption -

- In all burn units, several thermocouple probes were placed in sampling plots, one foot above the forest floor, with buried data loggers that recorded temperature data at 2-second intervals. **Three metrics** of fire behavior were calculated form the probes.

    - Near-Ground Heat Index (NGHI), the maximum recorded temperature
    - Time to maximum temperature, after probe temperature started to increase
    - AUC (area under curve), a metric combining temperature and duration.
- Researchers also compared **fuel consumption** estimates for 10-h, 1-h, litter, and duff.
    - Collected pre-fire fuel after abscission in late fall and post-fire fuel 2 weeks after each burn
    - Divided post-fuel mass by pre-fuel mass, then subtracted quotient from 100% to estimate consumption percentage

Key Findings:

Fire behavior metrics -

- The time to maximum temperature for the UAS burn was longer than previous burns in the stand as well as the other 2022 hand-ignited burns.
- The AUC, which integrates temperature and duration was mostly similar between the UAS and other burns.

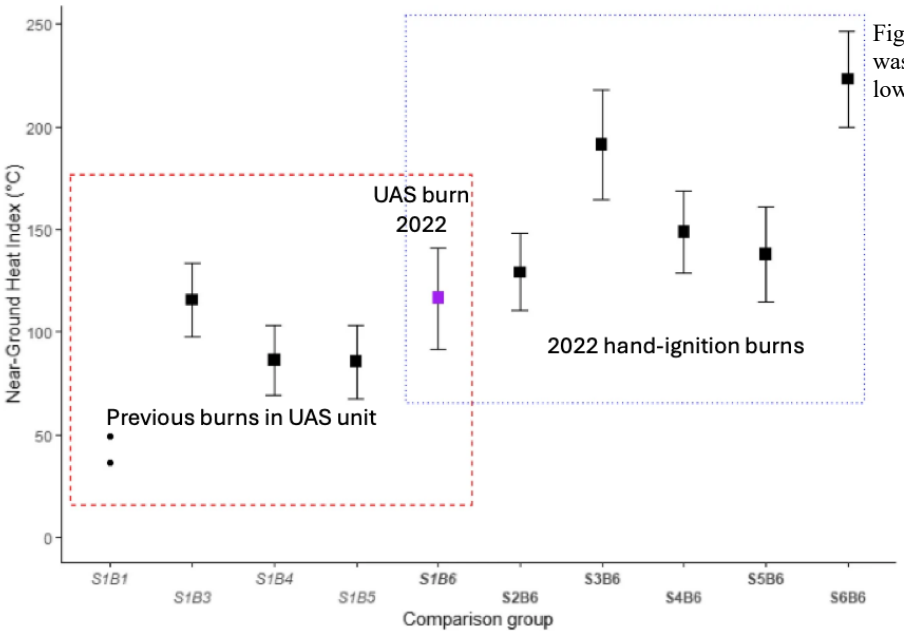

Figure: The average Near-Ground Heat Index of the UAS burn was 116 °C (241 °F), higher than previous burns in the unit but lower than other hand-ignited burns in 2022.

Fuel consumption -

- Compared to previous burns in the same stand, the UAS burn consumed more fuels in general, providing a more thorough burn.
- Compared to other 2022 hand-ignited burns, the UAS burn consumed similar quantities of fuels.

Take Home Points:

- Overall, the UAS-ignited burn performed comparably to the other (hand- and helicopter---ignited) ignition techniques and sufficiently met the burn objectives.
- The researchers emphasize that this was a case study of one UAS burn. Managers and researchers should continue testing the capabilities of UAS ignition to better determine how it would benefit the Appalachian landscape.

Links to Paper:

- Craycroft, J., Schweitzer, C. Case study of UAS ignition of prescribed fire in a mixedwood on the William B. Bankhead National Forest, Alabama. *fire ecol* **20**, 33 (2024). https://doi.org/10.1186/s42408-024-00263-1 https://www.appalachianfire.org/_files/ugd/696505_41d54f6a3d78438ca8e7619b4e262d0b.pdf

Related Research:

- Hiers, J.K., O'Brien, J.J., Varner, J.M. *et al.* Prescribed fire science: the case for a refined research agenda. *fire ecol* **16**, 11 (2020). https://doi.org/10.1186/s42408-020-0070-8 https://www.appalachianfire.org/_files/ugd/696505_529ce7d9757b4dfe9686b81513c2b884.pdf

- Lawrence, B.L., Mundorff, K. & Keith, E. The impact of UAS aerial ignition on prescribed fire: a case study in multiple ecoregions of Texas and Louisiana. *fire ecol* **19**, 11 (2023). https://doi.org/10.1186/s42408-023-00170-x https://www.appalachianfire.org/_files/ugd/696505_aba8dcb089c6424b8ff609efaf2e00b6.pdf
- https://www.appalachianfire.org/firetechniques

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Observation from Kerry Clark, Fire Management Officer on the Bankhead NF:

"As technology makes our jobs easier, we must be willing to adapt. The UAS technology is the wave of the future. As we continue to treat more landscapes with prescribed fire, the UAS is proving to be as effective in meeting our goals as helicopter and hand ignitions. But most importantly, ***the use of the UAS takes away considerable risk*** *– risk to staff who are igniting interior burns. It makes our jobs easier and safer."*

Kerry Clark, FMO Bankhead NF