Research Brief

RAND HOMELAND SECURITY AND DEFENSE CENTER

Identifying a Cost-Effective Aviation Fleet for the U.S. Forest Service

Wildfires are dangerous and costly. They threaten population centers and wildlife habitats, degrade watersheds, and contribute to air pollution. At the same time, they are a natural part of the ecosystem in much of the American West. The cost of fighting these fires has risen dramatically over the past decade—to an average of $1.65 billion annually.

The U.S. Forest Service currently operates an aging fleet of contracted fixed-wing airtankers that provide aerial support for wildland firefighting. After two fatal crashes in 2002 led to more than half of the fleet being taken out of service, the Forest Service sought to replace its fleet with newer, safer aircraft. In support of this effort, the agency asked RAND to determine the composition of a fleet of airtankers, scoopers, and helicopters that would minimize the total social costs of wildfires, including the cost of large fires and aircraft costs.

Key findings:

- Two models designed to estimate the optimal social cost–minimizing portfolio of U.S. Forest Service aircraft favored a fleet dominated by water-carrying scoopers.
- Airtankers, which carry retardant, have a role in fighting fires that are not close to water sources.
- Improved dispatch and allocation of aircraft could further reduce the overall required fleet size.

The Social Cost of Wildfires

The total social cost of a large wildfire includes the costs of federal, state, and local suppression efforts; aircraft; the rehabilitation of burned lands; insured losses; fatalities; and many outcomes that are difficult to monetize, such as changes in wildlife habitats, the recreational value of wildlands, and public health. Data on historical fires showed that, for those costs that can be monetized, large fires have an average social cost of between $2.1 million and $4.5 million. The study used $3.3 million as its average large fire cost estimate.

Aircraft Costs and Capabilities

The research team identified candidate replacement aircraft that spanned a range of sizes and capabilities: 1,500- and 3,000-gallon fixed-wing airtankers (military and commercial derivatives), a 1,600-gallon amphibious scooper aircraft, and 1,200- and 2,700-gallon helicopters. These three types of aircraft support on-the-ground firefighting by dropping retardant (in the case of airtankers) or water (in the case of scoopers and helicopters) at the burning edge of a fire or on grass, wood, or other potential fuels that are not yet burning. This helps build the fire-control line, a buffer of cleared or treated ground that contains a fire's growth.

Cost analysis of the candidate aircraft options found that scoopers are considerably less expensive to acquire and operate than large helicopters or airtankers. Scoopers cost an estimated $2.8 million per year (versus $7.1 million for a 3,000-gallon airtanker or a 2,700-gallon helicopter). Furthermore, when fires are proximate to water sources, scoopers can drop far more water on a fire than a retardant-bearing airtanker can drop retardant.

It is important to note that, in some cases, water is less effective in supporting fire-control line construction. Specifically, it cannot be used for "indirect attack," when a fire-control line is built some distance from the burning edge of a fire. To evaluate how the Forest Service fleet might be affected by this limitation of water, the researchers considered scenarios in which water was equally effective, half as effective, and significantly less effective than retardant in supporting fire-control line construction.

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Identifying the Optimal Aviation Fleet Mix

The research team developed two separate but complementary models to estimate the optimal cost-minimizing portfolio of initial attack aircraft—that is, aircraft that support on-the-ground firefighters in containing potentially costly fires while they are still small.

The RAND National Model

The National Model compares different prospective portfolios of aircraft against simulated fire seasons comprising historical wildfires in the United States between 1999 and 2008, showing how outcomes might have differed with more or fewer available aircraft. One important limitation of the National Model is that it assumes that a uniform level of local firefighting resources, such as ground crews, bulldozers, and fire engines, is available to fight every fire.

The baseline National Model simulation suggests that a fleet of five 3,000-gallon airtankers and 43 1,600-gallon scoopers would minimize total social costs, using the assumption that water is half as effective as retardant.

Because the model approaches aircraft allocation on a national level and the number of airtankers is small (five), it exaggerates the capabilities of airtankers to quickly deploy anywhere in the United States. To counter this shortcoming, the research team created a restricted variant of the model with zones correlating to Forest Service Geographic Area Coordinating Centers, making the airtanker's assumed 45-minute average mission time more realistic. In this restricted variant, the optimal fleet is composed of eight 3,000-gallon airtankers and 48 1,600-gallon scoopers.

An additional shortcoming of the National Model is that it does not permit three-way comparisons of airtankers, scoopers, and helicopters, so the model's results exclude helicopters. The RAND Local Resources Model addresses this limitation.

The RAND Local Resources Model

The Local Resources Model uses realistic estimates of the local firefighting capabilities available to fight each fire when estimating the appropriate aircraft fleet size and mix. Specifically, it uses data on the fire season and ground resources, and it relies on estimates of containment outcomes generated by the Fire Program Analysis (FPA) system, a Forest Service system designed to facilitate resource allocation decisions. The Local Resources Model also allows the costs of large fires to vary by location and fire condition (e.g., large fires near urban areas are more costly).

The Local Resources Model suggests an optimal initial attack fleet composed of one 3,000-gallon airtanker, two 2,700-gallon helicopters, and 15 1,600-gallon scoopers.

An important limitation of the FPA system and, hence, the Local Resources Model is that it attributes as much efficacy to a gallon of water dropped from a scooper as to a gallon of retardant dropped from an airtanker. However, the National Model suggests that even when the efficacy of water relative to retardant is degraded to just 20 percent—or even 5 percent—the optimal fleet mix remains dominated by scoopers. Thus, the FPA system's assumption that water and retardant are equivalent does not explain the models' consensus that the optimal Forest Service fleet is scooper-dominated.

Estimating Requirements for Already-Large Fires

The National Model and the Local Resources Model only consider the fleets required for the initial attack of fires before they become large. However, the Forest Service also uses large aircraft to fight already-large fires. To continue to provide this service, the agency would need to supplement its initial attack fleet with additional large aircraft. Unfortunately, the RAND study found no credible estimates of the effectiveness of large aircraft against such fires, so it was not possible to model large fire operations.

Instead, the researchers developed an analytic framework for determining the number of aircraft needed for large fires—in addition to those acquired for initial attack. The framework requires the Forest Service to estimate the daily cost savings attributable to the use of aircraft against already-large fires. With this information, along with data on the initial attack fleet's historical utilization rates, the framework can be used to calculate the number of additional aircraft that would be cost-effective for the Forest Service to acquire to ensure that its fleet can support both initial attack and large fire operations.

Conclusions

Both the National Model and the Local Resources Model found that the most cost-effective fleet of initial attack aircraft is dominated by scoopers, but airtankers play a niche role, particularly in fires that are not close to appropriate water sources. In both models, improved information about the use of aircraft against already-large fires and improved dispatch and aircraft allocation algorithms would lead to adjustments (up and down, respectively) in the optimal overall fleet size. ■

This research brief describes work done for the RAND Homeland Security and Defense Center, a joint center of the RAND National Security Research Division and RAND Infrastructure, Safety, and Environment, documented in *Air Attack Against Wildfires: Understanding U.S. Forest Service Requirements for Large Aircraft*, by Edward G. Keating, Andrew R. Morral, Carter C. Price, Dulani Woods, Daniel M. Norton, Christina Panis, Evan Saltzman, and Ricardo Sanchez, MG-1234-USDAFS, 2012, 140 pp. $29.95, ISBN: 978-0-8330-7677-9 (available at http://www.rand.org/pubs/monographs/MG1234.html). This research brief was written by Lauren Skrabala. The RAND Corporation is a nonprofit institution that helps improve policy and decisionmaking through research and analysis. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. RAND® is a registered trademark.

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