

**UNDERSTANDING THE DEARTH IN FIREFIGHTING AIRCRAFT FUNDING  
THROUGH THE LENS OF ACTOR-NETWORK THEORY**

A Research Paper submitted to the Department of Engineering and Society  
Presented to the Faculty of the School of Engineering and Applied Science  
University of Virginia • Charlottesville, Virginia  
In Partial Fulfillment of the Requirements for the Degree  
Bachelor of Science, School of Engineering

By

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March 28, 2022

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## **THE RACE BETWEEN WILDFIRES AND FIREFIGHTING TECHNOLOGY**

In the face of natural disaster, technology represents a tool developed by humans with the capability to provide security and safety. Given this relationship, it follows that as nature grows increasingly hostile to our presence, the tools we use to defend ourselves must improve in kind. However, when we ourselves are the architects of nature's hostility toward us, it can become difficult to discern whether it is more prudent to fight back with equal vigor, or to target the fundamental cause of the conflict and root it out. In the case of the impending threat that wildfires pose to our communities, it is clear that technology to combat the inferno and defend our homes is necessary. Nevertheless, understanding the root cause of this natural disaster and why it is worsening is instrumental to our long-term success against the forces of nature.

### **AN ACCELERATED BURNING**

In the past 30 years, the United States has seen an interesting, seemingly contradictory set of trends concerning wildfires. Namely, the net quantity of wildfires has decreased whereas the acreage burned as a result thereof has increased (Hoover & Hanson, 2021, p. 1). For example, despite discovering a decrease in the average wildfires per annum from the 1990s to the years 2000-2020, Hoover and Hanson nevertheless reported an increase exceeding 200% in the average annual acreage burned due to wildfire when comparing the two groups (p. 1). Such an inverse relationship becomes intuitive when one accounts for growth in large wildfires, which Dennison et al. (2014) defines as any wildfire exceeding 405 hectares in area burnt (p. 2928). As shown in Figure 1 on page 2, across the Western United States – which according to Hoover and Hanson accounted for more than 93% of national acres burnt due to wildfire in 2020 (p. 2) – nearly all regions have experienced an increase in large wildfires (Dennison et al., 2014, p. 2929).

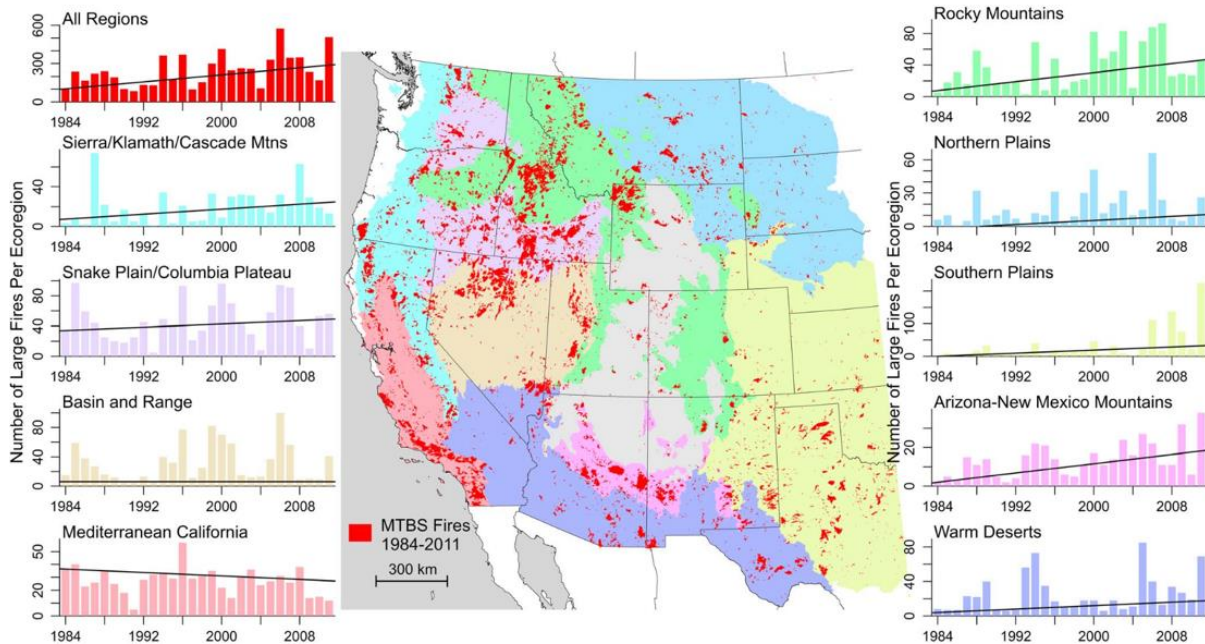


Figure 1: On the left and right, bar graphs indicate the number of large fires which occurred in the given ecoregion since 1984. The central graphic depicts in red the areas affected by wildfire overlaid on a map of the Western US divided into the aforementioned ecoregions. (Dennison et al., 2014, p. 2929).

The driving cause of the increasing range and volatility of wildfire is none other than climate change, warming and desiccating the ecosystem, thereby facilitating fire’s aggressive expansion (Center for Climate and Energy Solutions). Not only is the environment itself more flammable, but with the dry season growing in duration, this dangerous trend will likely continue if left unchecked (Vose et al., 2012, pp. iv-v). The wildfire in Big Sur which scorched over 1000 acres of the California countryside this past January is testament to what Kasakove (2022a) reports is known as the “year-round fire season”. In the face of this seemingly inevitable spread of wildfires, there must exist tools at the public’s disposal to combat this natural disaster and protect their communities and natural surroundings.

## **A STAGNANT INDUSTRY**

In the current arsenal of firefighting technology, one of the most effective tools at suppression and control of large, growing fires is aircraft. Despite their potential for meeting the challenges of a greater-area fire, the current models in deployment at the federal and state level are outdated, refurbished aircraft purchased from a military or civilian application (Iannotta, 2014, p. 2). Given their initial source external to the firefighting sphere, the aircraft themselves often need to undergo cheap patch-up jobs in order to increase their suitability for the new role. According to Wood (2014), the aging aircraft also propose safety concerns not only for the pilots, but for the supporting ground crew and civilians in the surrounding communities.

As such, the industry demands new firefighting aircraft specifically designed for the retardant drop mission, a need which motivated the American Institute for Aeronautics and Astronautics (AIAA) to distribute their request-for-proposal (RFP) for a next-generation firefighting airtanker. The technical project, completed in collaboration with LeeYung Chang, Matteo Harris, Aaron Hyunh, Del Irving, Christopher Kwon, Jason Le, and Andrew Wheatley under the supervision of technical advisor Jesse Quinlan from the Department of Mechanical and Aerospace Engineering, seeks to develop a large airtanker capable of multi-drop and ferry missions in the event of a disaster event as a result of wildfire.

The technical project is tightly coupled with the sociotechnical exploration of the complex system of interconnected actors which facilitate the unequal distribution of federal budget dollars against the funding of firefighting technologies, which if improved would enable the introduction of newer and superior aircraft in favor of the cheaper renovations. The current landscape of design for firefighting aircraft is most aptly characterized as bleak. When thinking of the cutting-edge development of aircraft technology, one's mind immediately gravitates

toward military applications, which is unsurprising considering the current budget for the Department of Defense (DOD) is about \$1.5 trillion (USAspending, n.d.). For reference the Department of Agriculture (USDA) is allocated about a third of this amount (USAspending, n.d.), \$1.01 billions of which has been set aside for investment into wildfire suppression technology (United States Department of Agriculture, 2021, p. 86). When making a further comparison to The Boeing Company's (2021) spending on research and development alone (\$2.5 billion) it is clear there is a dearth in funding which has left the aerial firefighting landscape decades behind commercial and military aviation (p. 62). The reason these values are relevant is that 70% of acreage burned in 2020 was on federal land, indicating that the onus of wildfire suppression falls largely on these federal actors like the Forest Service with the USDA (Hoover & Hanson, 2021, p. 2). As such, understanding how the federal budgeting network interacts in a way which results in this inequity is key for advocating for a better system which promotes investment into technologies which can aid in the battle against wildfires.

## **FEDERAL BUDGETING OF FIREFIGHTING AIRCRAFT: AN EXPLORATION USING ACTOR-NETWORK THEORY**

### **UNDERSTANDING ACTOR-NETWORK THEORY**

In order to characterize the disconnect present in the federal budgetary process, it is first imperative to develop a schematic for the network itself. To do so, a network metaphor as outlined by Law and Callon (1988) which emphasizes the equal dispersion of agency across a network of interconnected actors is adopted. This network itself illustrates a sociotechnical scenario, which Law and Callon define as “a plausible proposal for a revised network of both social and technical roles,” with the key premise that all actors, whether they be human, material, or semiotic, are considered equals (p. 287). Another key concept the authors discuss is the

division of global networks into local networks through the creation of negotiation spaces, which allows for greater autonomy among a smaller sub-network of actors provided there exist sufficient means of communication with the global network at large (Law & Callon, 1988, p. 289). This framework for analyzing scenarios which blur distinctions of agency between the conceptual, the technical, and the human is broadly referred to as Actor-Network Theory (ANT).

Applying the concepts of ANT within the global network of the US government budgetary process, two readily identifiable local networks operate broadly independently of one another, yet are inextricably tied to how tax dollars are distributed. These are the federal agents making decisions regarding budget allocation and the local communities affected by wildfire, each motivated by entirely distinct goals with different levels of understanding on the issues regarding the current technology.

### **LOCAL NETWORK ANALYSIS: THE FEDERAL GOVERNMENT**

Considering first the federal level, already at the foundational steps of fiscal planning, ambiguity of the actors involved is introduced. The official website of the government of the United States, USA.gov (2021), when describing its own budget allocation writes that the various executive agencies (including the USDA, DOD, etc.) “create budget requests,” which the Office of Management and Budget (OMB) “refers to... as it develops the *President’s* budget proposal.” Not to mention, the President – not the OMB – is responsible for the final submission of the budget. Thus, questions begin to emerge: To what extent are the formal budget requests drafted by these federal agencies merely a formality of the bureaucratic process? What role does OMB actually play in affecting the nation’s budget, beside drafting it according to political aspirations of the president? As the agency critically placed between the president and

organizations, like the Forest Service, seeking to make a case for their own budgetary plans, is it providing a sufficient avenue for negotiation between the two parties?

From vague beginnings, the president's proposal lumbers through the legislative process. Both houses of Congress formulate a resolution (essentially a revised budget scheme) via appropriations committees, comprised of subcommittees concerned with specific facets of the budget which align with the agencies receiving funding (USA.gov, 2021). Appropriations bills are drafted, debated by the Senate and House of Representatives, revised, agreed upon, sent to the president for approval, and either a new budget is enacted or the nation's government shuts down. Thus, a major political motivation of the process reveals itself: pass a budget, or face the impending political catastrophe of shutdown. Nevertheless, an equally powerful motivation is avoiding the perception of political weakness by stubbornly sticking to policies which earned a candidate election, especially considering the ever-imminent next election cycle.

In the last and historically longest U.S. shutdown from the end of 2018 into late January of 2019, the extent to which politicians will go to maintain the semblance of honesty was laid bare. Former president Donald Trump was determined to secure funding for the border wall, a key policy initiative around which his political base unified, so much so that he eventually declared a state of emergency to acquire his own discretionary funds for its completion (Baker, 2019). In opposition, Democratic leaders like then newly-reelected Speaker of the House Nancy Pelosi and Senate minority leader Chuck Schumer were staunchly opposed to the inclusion of such measures in the budget allocation, claiming the president's motivations were based in fear rather than evidence (Gray, 2019). All the while, federal employees performing critical duties were furloughed as their wages cannot be subsidized during the shutdown. California National Park rangers left without pay due to the freeze in government spending, returned post-shutdown

to find Joshua Tree a vandalized, trash-ridden nightmare (Gammon, 2019). Such destruction only represents a fraction of the potential damage caused by a shutdown, and the negative media coverage of the politicians enabling this standstill means every individual congressmen's alignment will be scrutinized come time for reelection, and they themselves are fully aware of this. Trump himself faced an annual high disapproval rating of 59% in January of 2019 as reported by Gallup (2021), and given the Pew Research Center's (2020) data that the economy was the issue most Americans considered as very important in motivating their vote in the 2020 election, it is clear that conduct during surrounding a shutdown is an integral issue informing the decisions of eligible voters.

As such, within the local federal budgetary network, political aspirations of reelection and shutdown avoidance can readily trump the earnest pursuit of federal agencies, like the Forest Service, to seek additional funding, as for the development of aerial firefighting technologies. Though OMB refers their plans to the president and congressional subcommittees are organized around agency lines, how relevant are these steps in the shadow of a publicized feud between political leaders eager to be the beneficiary of press coverage while tarnishing the reputation of their adversaries?

## **LOCAL NETWORK ANALYSIS: FIRE-PRONE COMMUNITIES**

Thus far, in analyzing the federal local network, interaction with the local community network has been purely based on elections and popular opinion, with the media existing by proxy as a negotiation space for the two spheres. This coverage, however, is limited by popularity, recency, that which will earn the outlet the most clicks. In applying a similar approach as when dissecting the federal system, the motivations of the actors external to the federal government, and how these motivations inform their actions, is elucidated.



A key concept discussed by Jolivet and Heiskanen (2010) in their exploration of the Cap Eole wind farm project using ANT was *framing*, how a group of actors can form a “common world” through which a mutually desired outcome can be attained (p. 6748). For towns in areas at risk to wildfire, where safety and adequate protective measures are of paramount importance, the desire to achieve maximum preparedness in the event of a large fire creates such a collective scenario. As an example, from this localized, safety-oriented framing of wildfire preparedness, one key area of concern is the establishment and maintenance of evacuation routes. Considering the devastation caused by events such as the 2018 Camp Fire in Paradise, California, where 85 individuals were killed, many of whom caught in traffic, such an emphasis on exit strategy is not unfounded (Carlton, 2021). Having experienced such tragedy, it became imperative for community members to ensure they rebuilt smarter, and having established evacuation procedure keep it safe from any external threat.

One such externality is the introduction of development projects in at-risk communities which might increase road congestion, or otherwise unpredictably affect evacuation traffic patterns. Carlton (2021), reporting from Colorado Springs, details the successful efforts of a local citizens’ group in lobbying against the development of an apartment complex titled Garden of the Gods, slated for construction close to a gridlocked intersection during a previous local wildfire occurrence. Kasakove (2022b), reporting from Middletown, California, discusses a very similar community-led effort to halt a luxury development in Guenoc Valley, which had the potential of introducing some 4000 new people to an area connected via a single two-lane road. When recalling her interview with the lawyer frontrunning the successful lawsuit against the developers, he summed up their collective approach against the development proposal plainly: “prevention is better than mitigation” (Kasakove, 2022b).

In some ways, this behavior on the part of local communities to restrict development projects constitutes an overflow, a term which Jolivet and Heiskanen (2010) used to describe actions taken which seemingly contradict the expected behavior of an actor (p. 6748). New development is good and often essential, especially considering the high cost of living in the West pushing low-income residents into rural and suburban area (Kasakove, 2022b). By halting such projects which might provide relief for the population crisis, these communities are acting outside of the expectations of the developers, representing an overflow in their predictions. Crucially, this overflow is brought on by the collective framing of the community of the critical importance of evacuation management, and thus the sacrifice to expansion incurred is communally shared. In contrast, something like raising tax dollars for improvements to firefighting aircraft, which Tonarelli (2021) shows already as having been met with backlash at the state level, represents an individual sacrifice. With politicians obsessed with reelection, media outlets concerned with viewership, and communities focused on the safety of their populations, the global network is dispersed with motivations and approaches which either circumvent or inhibit the development of firefighting technologies.

### **ANALYZING THE SHORTCOMINGS WITHIN THE ACTOR NETWORK**

Figure 2 on page 9 depicts the global network concerned with federal budgeting of firefighting technology, comprised of two local networks at the communal and the federal level.

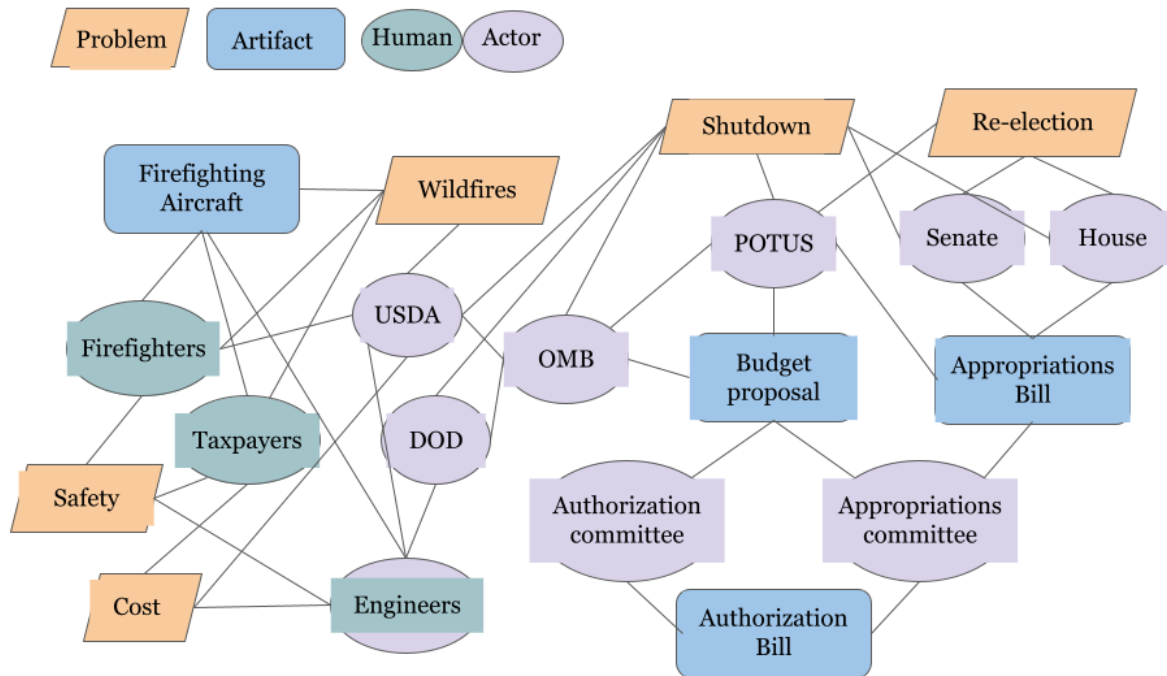


Figure 2: Actor-network for aerial firefighting funding. Purple agents are those within the federal local network, while green agents are those within the communal local network. They are still, however, related to government actors within the larger global network, often connected via artifacts (blue rounded rectangle) and semiotic motivations (orange parallelogram). (Damm, 2022).

The engineers responsible for designing the next-generation firefighting aircraft finds themselves caught in this web of contradicting motivations. There is no negotiation space in which the engineer can tangibly express the potential of firefighting aircraft to mitigate the risk of dangerous wildfires for communities like Colorado Springs, which are instead planning for their inevitable encroachment upon their towns and homes. For the politically ambitious, investing in a modernized aerial arsenal against wildfires does not provide the prospect of popularity, especially considering the need for extensive and expensive upgrades. Despite the aforementioned increasing trend in area burned by wildfire, the cost of suppressing a wildfire per acre burned has shown no significant change (Lueck & Yoder, 2016, p. 8). For the technology to become more modernized and specialized to the firefighting application, this value would

necessarily have to go up. Arguing for such an increase in spending toward an issue of little national news appeal is unrewarding in the political sphere, despite the onus of wildfire suppression falling largely on national shoulders. For communities entrenched in other local battles to secure themselves for the next wildfire, spending increases, regardless of their motivation, appear merely as another tax hike in the stream of other fiscal problems affecting the average American. Even if development of the next firefighting aircraft were outsourced to a private company, as is frequently the case, the economic determination to save money halts any potential for complete overhaul or rapid improvement. As economists Lueck and Yoder illuminate, the only valid economic reason for increasing investment in wildfire suppression is “whenever an additional dollar of suppression expenditures avoids at least a dollar of wildfire damages” – nothing but cold, hard dollars and cents (p. 13).

### **AN IMPROVED FIREFIGHTING ARSENAL**

Despite a lack of desire to forfeit the requisite cash, with the modern technologies present in other aviation industries and sectors, aerial firefighting can become a more effective tool in the fight against wildfire. There is certainly room for improvement in the current landscape of strategies used. Though curbing further development plans secures evacuation paths for current inhabitants, the already existing infrastructure is left behind and still at the mercy of the wildfire. Hoover and Hanson (2021) reported in 2020 alone 17,904 structures burned due to wildfire, 54% of which were residential (p. 2). As such, the potential for individual sacrifice is ubiquitously high when faced with this natural disaster. By crafting technology at the level current civilian and military counterparts occupy, our chances of rapidly targeting and suppressing a wildfire to prevent any such destruction at all increases – but the cost is certainly steep. Sacrifices need to be

made in other areas of funding, but the money is certainly there – all one needs to do is check the DOD for its cutting-edge technology.

Future work in this field can potentially focus on the ability to attract engineers to positions of public service, and creating excitement among engineers to work on projects of public good. Moreover, an often-overlooked subgroup of the local community are the firefighters on the ground, who find themselves at risk when a wildfire prevention effort includes the use of outdated, refurbished technology. How informed they are to the status of the technology they are collaborating with is unclear, as is whether or not engineering, to them, is a possible avenue for improvement.

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