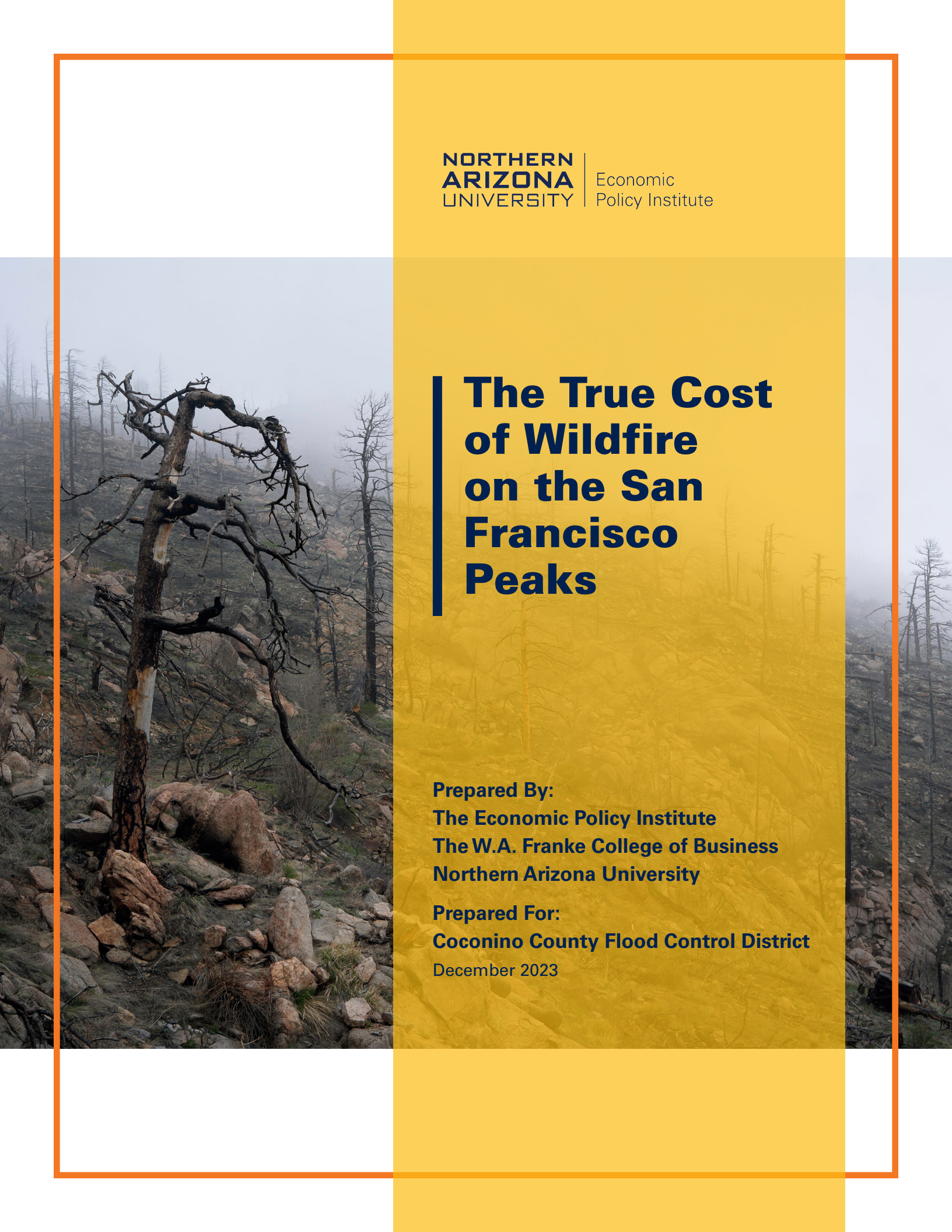




**NORTHERN
ARIZONA
UNIVERSITY**

Economic
Policy Institute

The True Cost of Wildfire on the San Francisco Peaks

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Overview

An active history of wildfire in Flagstaff and its surrounding areas has led agencies and residents to view this natural hazard as their city's largest urban threat. Studies show that climate change has already led to an increase in wildfire season length, wildfire frequency, burned area (USGCRP, 2018), as well as burn severity (Williams, Safford, et al, 2023). According to a UNEP report, catastrophic wildfires are expected to increase globally by 50 percent by the end of the century (UNEP & GRID-Arendal, 2022). Scientific modeling by JE Fuller, a hydrology engineering company with an office in Flagstaff, reveals the Upper Rio de Flag Watershed, east of Highway 180 and into the Kachina Peaks Wilderness on the San Francisco Peaks, is most at risk for catastrophic wildfire, placing Flagstaff and the Highway 180 corridor area at extremely high-risk for post-wildfire flooding.

The true cost of the wildfire is more than the burned forests; closed highways, health warnings from smoke, flooding, and resident displacements are all common occurrences. Long-term recovery issues include post-wildfire flooding, property, and business revenue loss, and impacts to the region's amenity-based economy. In this study, we estimated the cost in two main categories: the immediate costs, which include wildfire suppression and containment, and evacuation coordination; and the induced costs, which include Mexican Spotted Owl habitat loss, structure and content damage, utility damage, loss of property value, business interruption in both wildfire and flooding events, and sales tax loss. In addition, there are also costs associated with the wildfire and post-wildfire flooding that we didn't estimate the value of. These include the environmental cost (e.g., air quality, greenhouse gas emissions and ecosystem disruption), physical and mental health problems, recreational resources loss, and other physical damages (e.g., damage to residential streets and vehicles as a result of the flooding).

This study finds the economic impact of wildfire and post-wildfire flooding on the San Francisco peaks range from \$535,152,529 to \$2,822,207,072 for the lower and upper bound risk respectively.



Methods

The study used a multiple component approach to estimate the total cost of wildfire and post-fire flooding on the San Francisco Peaks. The main basis for this analysis is the wildfire and post-wildfire flooding assessment by JE Fuller Hydrology and Geomorphology, Inc. This assessment provides hypothetical wildfire areas and their corresponding post-wildfire flooding models for two scenarios that are considered the lower and upper bounds of risk for wildfire on the San Francisco Peaks and subsequent flooding. The lower bound of risk model is based on a wildfire that burns only on the watershed above the Fort Valley area, which represents 15.4% of the watershed area studied, and a single, short duration rainstorm. The upper bound of risk model is based on a wildfire burn over the whole upper Rio de Flag Watershed north of Highway 180 and a 6-hour, 100-year rainstorm. Figure 1 and Figure 2 show the flooding areas in each of the two scenarios. One thing needs to be noted is, the costs estimated in this report is based on a one-time post-wildfire flooding. However, repetitive impacts can happen from post-wildfire flooding during the monsoon season, making the total cost more than the estimate here.

The projected economic losses for structure and content, utilities, and business interruption resulting from the flooding events were calculated using Federal Emergency Management Agency (FEMA)'s Hazus 6.0, a nationally standardized risk modeling methodology. It is distributed as free GIS-based desktop software with a collection of inventory databases for every U.S. state and

territory. Hazus model uses inventory information (buildings, infrastructure, and population), hazard extent and intensity data, and damage functions to estimate the impacts of disasters. For its flood model, it calculates physical damage and economic loss due to coastal and/or riverine inundation. Losses are calculated using functions that relate the depth and type of flooding to the degree of damage for various categories of buildings.

For the flood scenarios we looked at in this study, the depth grids files JE Fuller built were used in Hazus 6.0 to generate flood scenarios, which then use census block data to estimate economic losses resulting from the level of flooding. The Hazus 6.0 calculations use replacement costs for determining census block content values. The analysis was done for the upper bound risk scenario and lower bound risk scenario, both using respective depth grid files from JE Fuller. The depth grid files were the only imported data used in the Hazus 6.0 analysis, all other data was from the default census block information for the affected census tracts within Coconino County from the 2020 census. Hazus 6.0 uses damage multipliers from FEMA Benefit-Cost Analysis Re-engineering (BCAR) report (2011), the Federal Insurance and Mitigation Administration (FIMA) FIA credibility-weighted damages, the USACE Chicago District, Galveston District, and Institute for Water Resources to estimate the damage to structures and utilities, and commerce losses resulting from the level of flood inundation at each census block (FEMA, 2022a).

For the other cost components in this study, previous wildfires and post-fire flooding loss were referenced to make the estimate. Data was sourced from the City of Flagstaff, the Coconino County Assessor, and various reports and studies, which are specified in each section of the report.

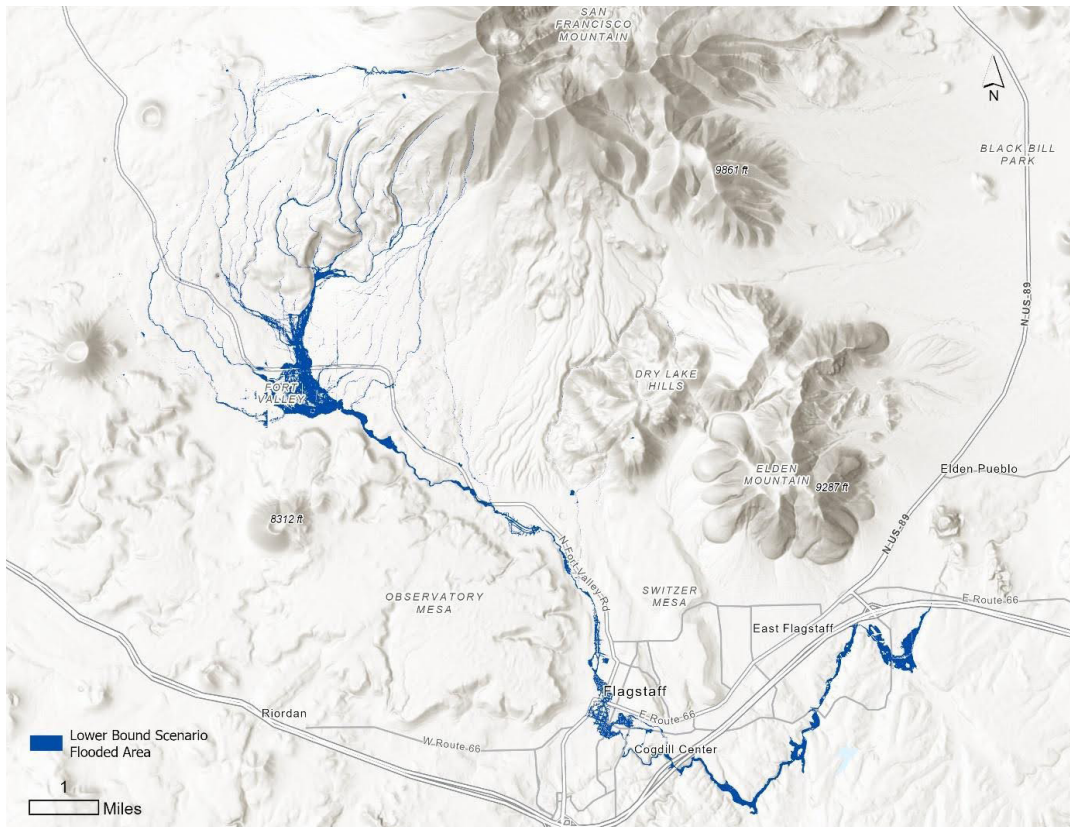


Figure 1.
Lower Bounds
Risk Model
Flooded Area

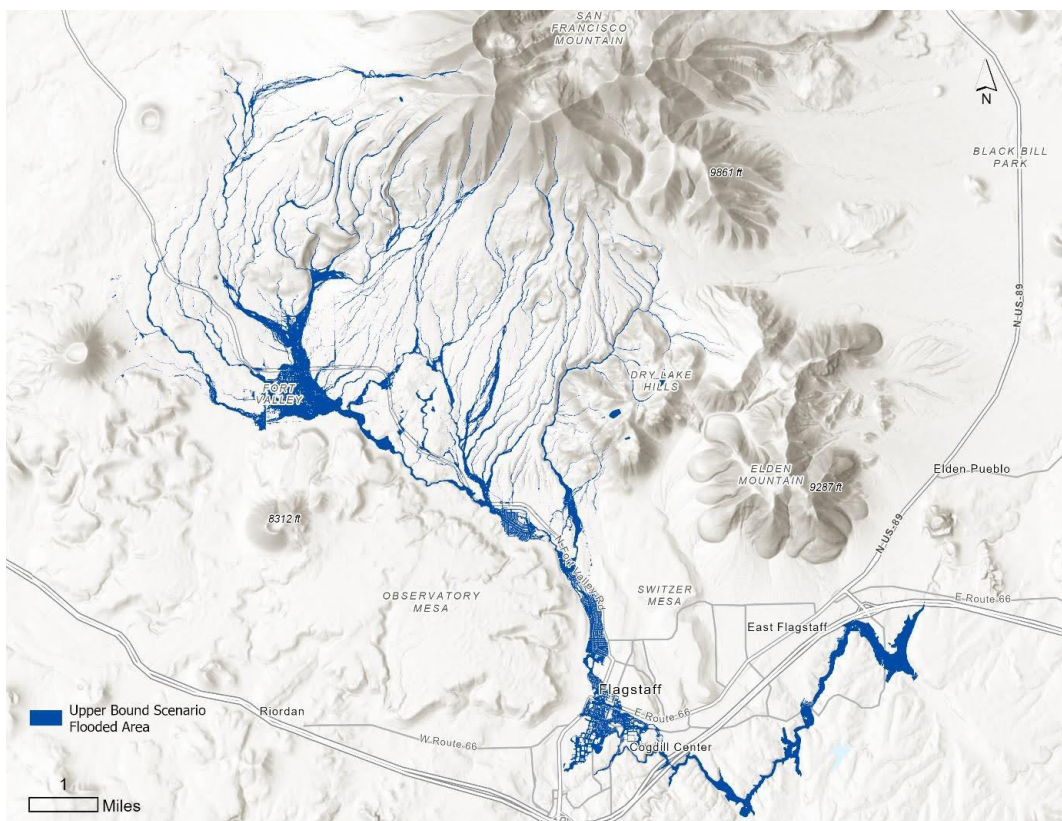


Figure 2.
Upper Bound Risk
Model Flooded Area

Source for Figure 1 & Figure 2: service layer source: Esri, NASA, NGA, USGS, FEMA, County of Yavapai, Esri, HERE, Garmin, SafeGragh, GeoTechnologies, Inc, METI/ NASA, USGS, Bureau of Land Management, EPA, NPS, USDA. The flooded area data source is JE Fuller.

Estimated Cost

Table 1 lists the low and high damage estimates that are likely to take place from a wildfire and post-wildfire flood on the San Francisco Peaks for the lower and upper bounds of risk. Financial damages range from \$535,152,529 to \$2,822,207,072. Explanations and calculations for each estimate are found in the following sections.

Table 1. Total Cost Summary

	Low-Risk Scenario	High-Risk Scenario
Wildfire Response/Remediation	\$21,672,000	\$88,064,000
Evacuation Costs	\$22,024,100	\$22,024,100
Mexican Spotted Owl Habitat	\$24,550,000	\$44,190,000
Flood Structure and Content Damage	\$63,060,000	\$550,290,000
Flood Utilities Damage	\$25,555,250	\$52,431,040
Lost Property Value	\$61,484,891	\$126,099,794
Wildfire Business Interruption	\$86,856,500	\$86,856,500
Post-Wildfire Flooding Business Interruption	\$200,740,000	\$1,635,700,000
Long-Term Recovery Cost	\$19,426,360	\$129,645,000
Health Cost	\$9,783,428	\$86,906,638
Total	\$535,152,529	\$2,822,207,072

Source: Estimated by the author. For details see the following sections.

Response and Remediation

A wildfire on the San Francisco Peaks would prompt immediate spending on wildfire suppression and containment, and evacuation coordination. This analysis uses the Schultz Fire in 2010, and Museum Fire in 2019, as a proxy for wildfire scenarios given the similar geography, ecosystems, and scope to the San Francisco Peaks wildfire scenarios. Table 2 shows the expenditures from state, county, city, and federal government agencies on response and remediation costs as a result of the 2010 Schultz Fire.

Table 2. Schultz Fire Response and Remediation Cost by Funding Agency

Funding Agency	Expense
City of Flagstaff	\$5,451,721
Coconino County	\$14,821,116
Arizona Division of Emergency Management (ADEM)	\$1,135,149
Arizona Department of Transportation (ADOT)	\$3,038,074
Fire Department	\$147,100
Federal Emergency Management Agency (FEMA)	\$5,722,000
US Forest Service (USFS)	\$14,395,200
Natural Resource Conservation Service (NRCS)	\$7,650,000
Federal Highway Administration (FHWA)	\$6,200,000
Total	\$44,165,160
Total (2023 dollars)	\$61,443,278

Source: Arizona Rural Policy Institute, 2014, p. 4.

The Museum Fire burned about 2,000 acres and cost \$9 million to control, yields the expenditure of \$4,500 per acre, or \$5,418 in 2023 dollar. For the Schultz Fire, dividing the response and remediation costs by its 15,000 acres burn area yields the expenditure of \$4,096 per acre in 2023 dollar. Following the methodology of the Flagstaff Watershed Protection Project study (Arizona Rural Policy Institute, 2014), given the lower bound acreage of the San Francisco Peaks wildfire is closer to the Museum Fire, and the upper bound acreage is close to the Schultz Fire, we applied the Museum Fire suppression rate to the lower bound estimated acreage, and Schultz Fire suppression rate to the upper bound estimated acreage, provided by JE Fuller – 4,000 acres for the lower bound and 21,500 acres for the upper bound – yields response and remediation costs of \$21,672,000 for the lower bound of risk and \$88,064,000 for the upper bound of risk. These estimates assume that the wildfire and post-wildfire flood scenarios would have a similar intensity to the Schultz Fire and Museum Fire, and similar response strategy and effectiveness.

Evacuation Costs to Households

Evacuation costs to households are another important figure in determining economic impact. Based on survey results from residents in the affected area from the Schultz Fire, on average, evacuees spent three nights away before being allowed to return home, and spent \$356 on evacuation-related costs. Upon the initial flare-up of the Schultz Fire, authorities evacuated more than 700 downwind properties (Ecological Restoration Institute, 2013). These costs include spending on temporary lodging, emergency food, animal-related moving costs, transportation, and more. Given the similarity between the Schultz Peak and the San Francisco Peaks in terms of the direction and distance to Flagstaff, we used the average evacuation cost from the Schultz Fire in 2023 dollar of \$503 and the same number of households being evacuated to estimate the evacuation cost of a wildfire on the San Francisco Peaks, which is \$22,024,100. This evacuation estimate is conservative, as the actual number of homes that would be evacuated would very likely be more than 700, given that the number of homes downwind has been increased since 2010.

Mexican Spotted Owl Habitat

The San Francisco Peaks are homes to the Mexican Spotted Owl (MSO), a threatened owl species with a range across the Southwest U.S. in Arizona, Utah, Colorado, New Mexico, and Texas (USFWS, 2012). Wildland fire has resulted in the greatest loss of critical habitat

relative to other actions (e.g., such as forest management, livestock grazing, recreation, etc.) throughout the U.S. range of the MSO. This has led experts to conclude that presently the largest threat to MSO is the risk of stand-replacing wildfire (Ecological Restoration Institute, 2013).

Within the MSO range, specified areas are designated as Protected Activity Centers (PACs) that are crucial for maintaining a steady MSO population and further species recovery. Each PAC includes 600 acres of land around known MSO sites in their natural habitat.

In order to determine the economic value of MSO habitat loss, this analysis utilizes two methods that were found in the ERI's full cost accounting of the 2010 Schultze Fire. The first is funds spent in conservation efforts. During the 25-year period (1997–2022) the United States Fish and Wildlife Service (USFWS) will have spent at least \$100 million on the “recovery” of the MSO. If we assume the existence of 1,000 PACs based on the literature, then the USFWS is spending, a minimum, of \$100,000 per PAC (Ecological Restoration Institute, 2013, p. 19). The second method is the willingness-to-pay economic analysis of the PACs that MSOs inhabit. A survey of American households was used to determine the value of MSO conservation to the average household in dollar amount, which was then extrapolated to all American households, giving an estimated \$2.6 million/PAC in 1997 dollars (Loomis & Ekstrand, 1997), or \$4.91 million in 2023 dollars.

The lower and upper bound wildfire scenarios in this study both contain PACs, with the lower bound containing 5 PACs and the upper bound containing 9 PACs. Using the PAC valuation from Loomis and Ekstrand, the economic impact for the lower bound of risk scenario is \$24,550,000 and the economic impact for the upper bound is \$44,190,000.

Structure and Content Damage Estimates

The Hazus Flood General Building Stock Module was used to produce assessments of repair and replacement expenses for general building stock, along with the corresponding losses in terms of building contents and business inventory (Table 4).

In the Hazus Flood Model, buildings encompass not only the load-bearing structural system but also architectural, mechanical, and electrical components, as well as building finishes (FEMA, 2022b). To estimate economic losses, the projected percentage of damage for a particular occupancy class, flood depth, and census block was multiplied by the replacement value of that occupancy class (FEMA, 2022b).

Building contents refer to furniture, non-structural equipment, computers, and other supplies that are not integral to the structure. This definition excludes inventory and non-structural elements such as lighting, ceilings, mechanical and electrical equipment, and fixtures (FEMA, 2022b). Building contents losses in the Hazus Flood Model were calculated using damage functions applied in a manner consistent with building losses (FEMA, 2022b). Structure and content damage ranges from \$63,060,000 in the low-risk scenario to \$550,289,000 in the high-risk scenario (Table 3).

Table 3. Structure and Content Costs for Both Risk Scenarios

Capital Stock	Lower Bound Costs	Upper Bound Costs
Building Loss	\$25,075,000	\$132,699,000
Contents Loss	\$34,800,000	\$399,737,000
Inventory Loss	\$3,185,000	\$17,853,000
Total Capital Stock Loss	\$63,060,000	\$550,289,000

Source: Hazus model, using inputs provided by JE Fuller.

Loss of Property Value

After a wildfire and flood event, one major cost for the region would be the loss in property values. Residents and businesses would feel the impact of this loss. Many factors could contribute to the loss in property value, from direct flood damage and compromised infrastructure to aesthetic changes in scenery from wildfire and market uncertainty. Determining the loss of property value requires first defining which properties are affected, then determining the total market value of all affected properties, and finally applying an estimated drop in value attributable to wildfire and post-wildfire flood to all affected properties.

In order to determine the value of all affected properties, the JE Fuller flood models were mapped alongside the County Assessor's Office's records of property information, including property's full cash value.

Total Current FCV (Full Cash Value) is the total value of all land and improvement models. This number is synonymous with market value. The property value data is sourced from the County Assessor's office, where the government exempt accounts may not contain model data due to the lack of need to apply a value - government properties do not pay property taxes. Since the government properties and NAU buildings will not be put on the market, the property value loss is not applied to those properties. We will only estimate the property value loss of the residential and commercial buildings.

According to records provided by the Coconino County Assessor's Office, the full cash value of all affected properties (government properties not included) is \$917,684,946 for the lower bound of risk and \$1,882,086,471 for the upper bound (Table 4).

*Table 4. Asset at Risk in both Scenarios **

	Lower Bound Scenario		Upper Bound Scenario	
	Number of Parcels Affected	Full Cash Value	Number of Parcels Affected	Full Cash Value
Residential	1,017	\$656,565,028	1,998	\$1,341,575,029
Commercial & Other Facilities	267	\$187,681,767	434	\$437,432,095
Vacant	316	\$73,438,151	401	\$103,079,347
Non-Taxable	7	-	13	-
Total	1,607	\$917,684,946	2,846	\$1,882,086,471

Source: EPI sorted based on data from Country Assessor Office, ESRI ArcGIS, and JE Fuller.

* Government properties are not included.

Figure 3 shows the parcels affected by flooding in the lower bound scenario. Some of the non-taxable parcels are quite large in size. Figure 4, with a closer look of the affected parcels, shows only the taxable parcels that are included in the estimate. Figure 5 and Figure 6 show the parcels affected and the taxable parcels affected in the upper bound risk scenario.

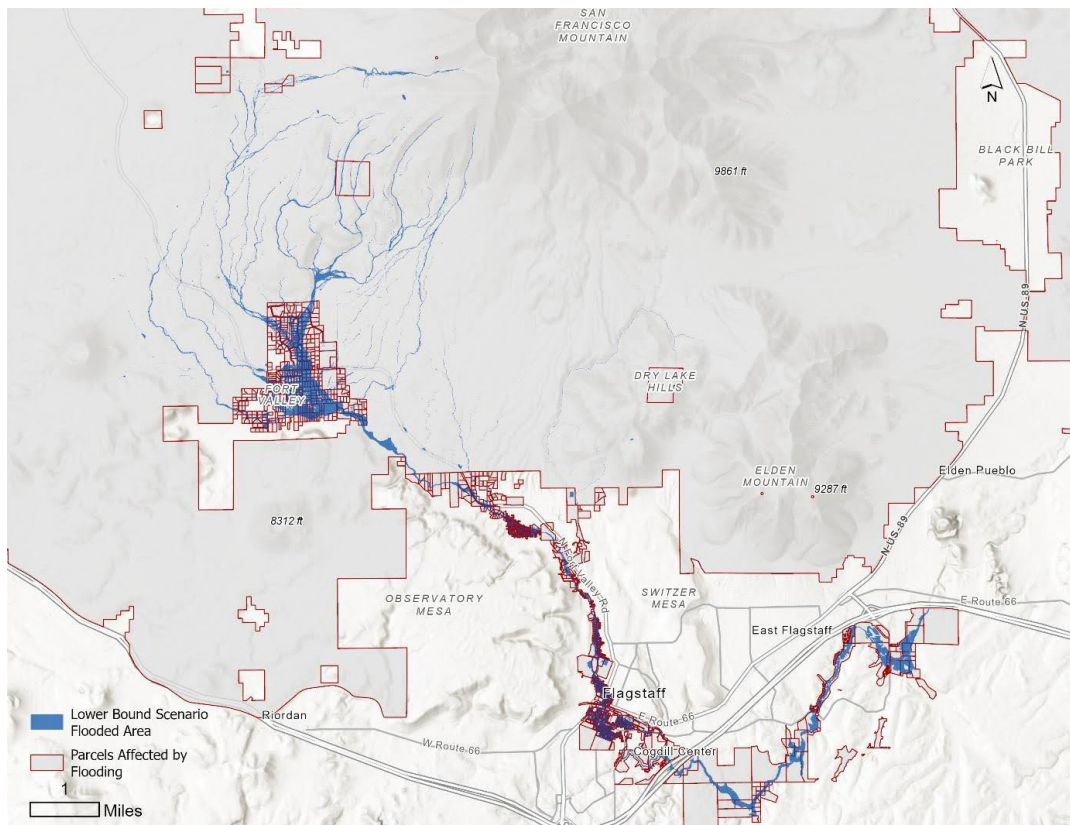


Figure 3.
Lower Bound
Scenario -
Parcels Affected
by Flooding

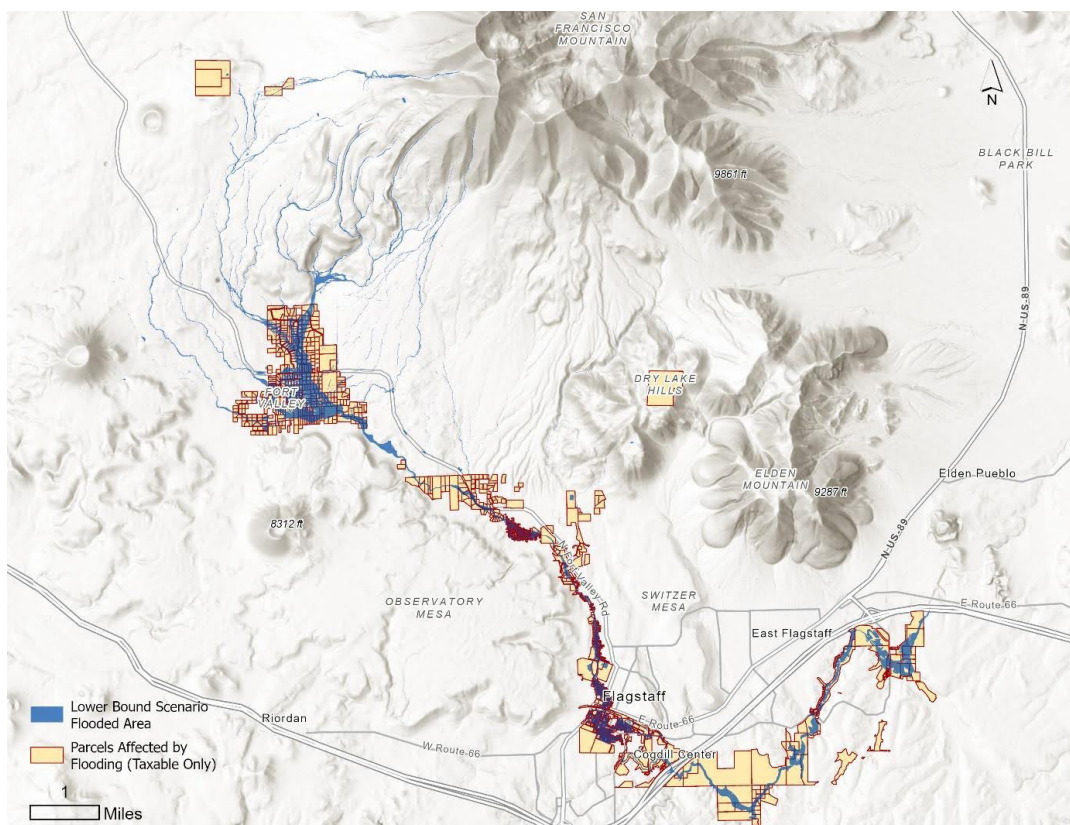


Figure 4.
Lower Bound
Scenario -
Taxable Parcels
Affected by
Flooding

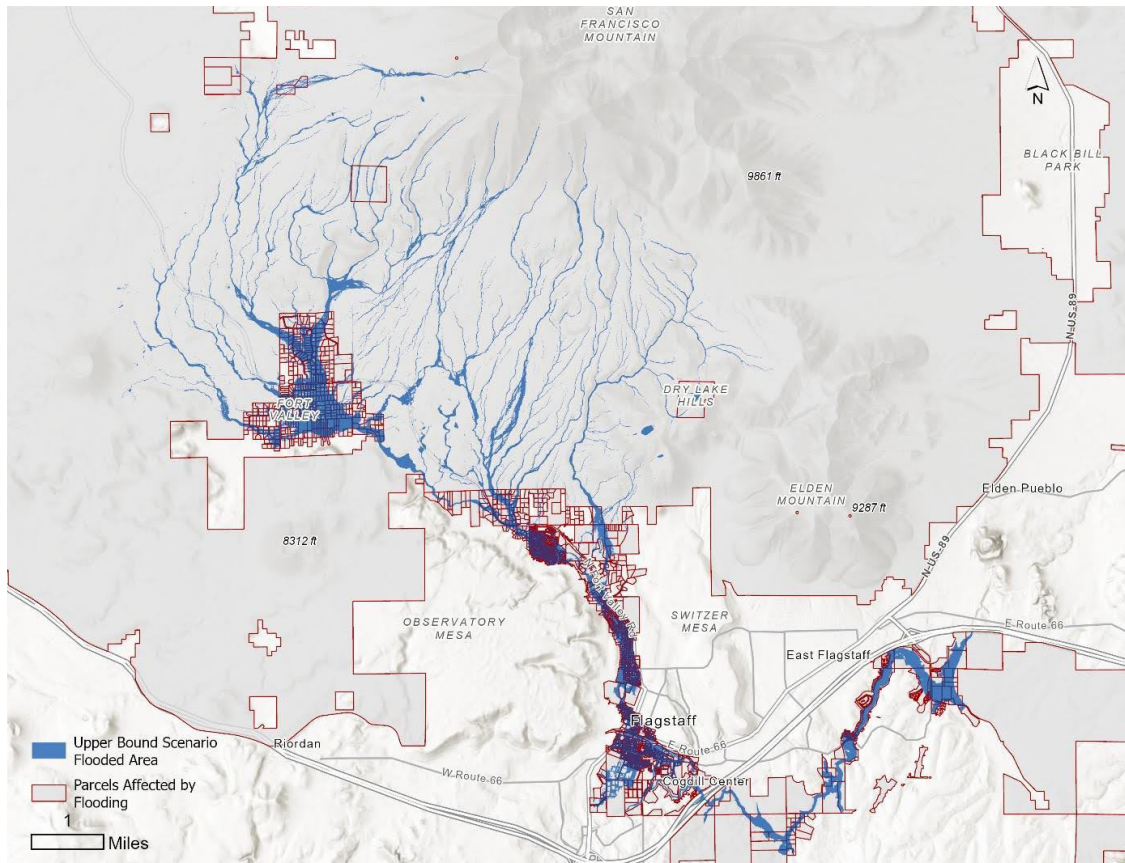


Figure 5. Upper Bound Scenario - Parcels Affected by Flooding

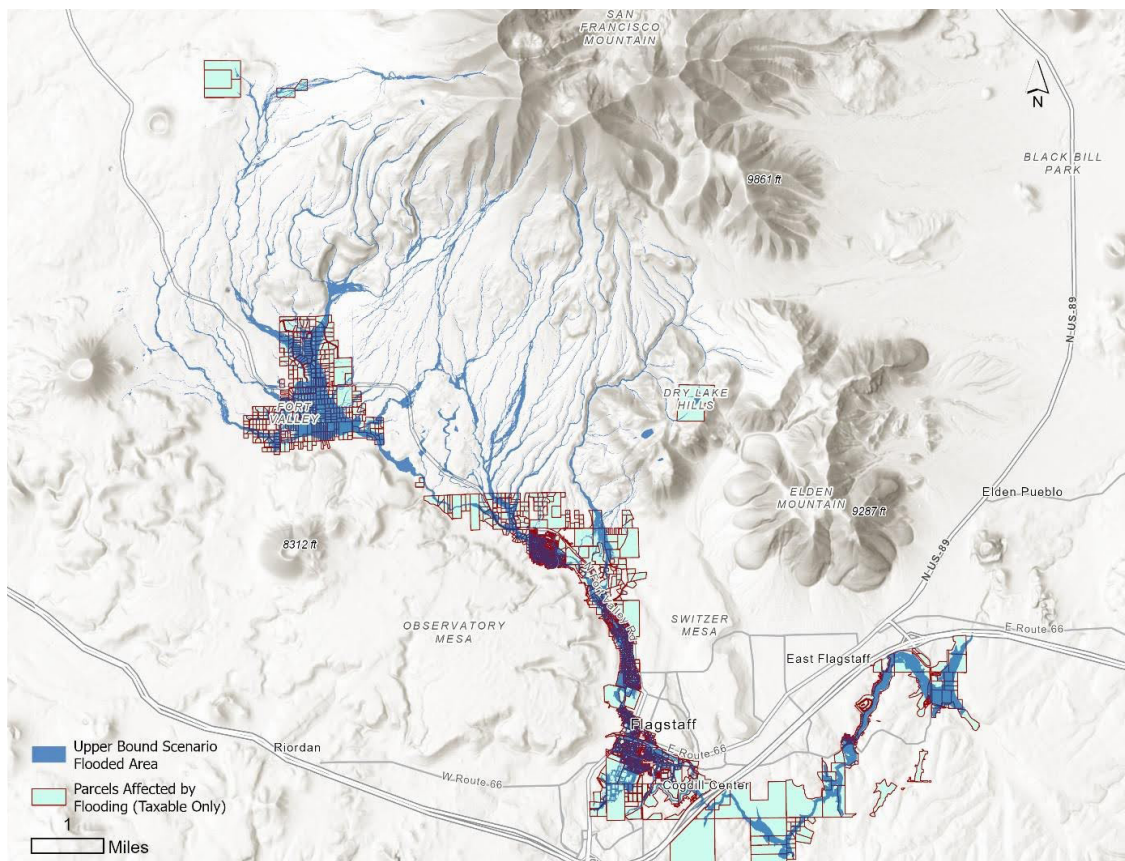


Figure 6. Upper Bound Scenario - Taxable Parcels Affected by Flooding

Source for Figures 4 through 6: service layer source: Esri, NASA, NGA, USGS, FEMA, County of Yavapai, Esri, HERE, Garmin, SafeGragh, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA. The flooded area data source is JE Fuller; the parcel data source is Coconino County Assessor Office.

For many residents, home equity is a major portion of net worth and the same is true of many businesses. The impact of flooding on government assets is also important, impacting the ability to acquire new assets and provide services. After the wildfire and the flooding, residents, businesses, and governments would feel these impacts and losses throughout the city. Multiple factors, ranging from water damage to the loss of a forested backdrop, would depress the existing property market. The resulting loss in property owners' personal wealth would be staggering. Because Flagstaff's property values include a premium based on intangibles such as natural beauty and access to adjacent forest land, all parcels in the city would likely see some loss of property value. In the study of the impact of the Schultz Fire the overall percentage of loss is conservatively assumed as 6.7% (Ecological Restoration Institute, 2013, p. 6). The rate was calculated using the drop experienced by homeowners in the neighborhoods north of Flagstaff affected by the 2010 Schultz Fire floods. It is an average built both on properties inundated and damaged, and those in the region that lost value due to intangible commodities such as degraded views and buyer uncertainty.

Decreases within all city properties are very likely. However, to provide a more conservative comparison, impacts are only calculated on the smaller footprint that will be inundated in the lower and upper bounds scenarios' flooded areas. According to records supplied by the Coconino County Assessor's Office (2018), as shown in Section 3.4, the aggregate full cash value (FCV) for properties in is \$917,684,946 in the lower bound scenario, and \$1,882,086,471 in the upper bound scenario. Using the property value decline rate of 6.7% with the combined market value of all affected properties in each scenario, we can estimate the total loss in property values is \$61,484,891 in the lower bound of risk and \$126,099,794 in the upper bound.

Utilities Damage Estimates

The Hazus Flood Utility Systems Module was used to assess the direct physical damage and economic losses incurred by specific utility system components as a result of flooding. The flooding depth for each Utility System Component was calculated using a geoprocessing tool called the extract value to point. This tool utilized the flood depth grid specific to the Study Region scenario, along with the latitude and longitude coordinates of each Utility System Component (FEMA, 2022b). By comparing the flooding depth at the location of the Utility System Component to the height of critical equipment components listed in the inventory, an estimation of the damage was determined. Hazus determined that the wastewater facilities were the only water systems that would be significantly damaged. Utilities damages range from \$25,555,250 to \$52,341,040.

Business Interruption – Wildfire Event

One category of losses as a result of a wildfire event is business revenue loss. A wildfire may significantly reduce spending in the city through deterring citizens from spending, especially if the wildfire is an immediate threat to the city and causes evacuations. Furthermore, since Flagstaff is a tourist destination, a fire event would adversely affect visitor volume. According to a presentation from the Sedona Chamber of Commerce and Tourism Bureau, \$7.6 million in visitor spending was lost during the 10 days of the Slide Fire. After the wildfire when the press was concentrating on stories about the Slide Fire the official Sedona Visitor Center saw a 40% reduction in visitors in June and July. The Chamber estimates that reduced tourism resulted in \$3.4 million in lost tax revenues during June and July and an overall loss of \$100 million dollars in total visitor spending over the period May to July. Visitor volumes for Sedona returned to normal by the end of August 2014, four months after the wildfire. According to flagstaffprospector.com, the accommodation and food services industry generates an annual revenue of \$349,965,000.

Using the Sedona case as an analogy, a wildfire could well cause three months of visitor decline by 40%. That means the tourism industry would lose 40% of a quarter of the annual revenue, which is \$34,996,500. Considering the wildfire season and the tourism peak season overlap, businesses would lose more than a quarter of their annual revenue. This number is just the direct business revenue loss in the tourism industry, which doesn't count its ripple effects, e.g., lost revenue from their upstream industries, and the lost jobs and those employees' purchasing power. Thus, this estimate is very conservative.

For both the lower and upper bound scenarios, the sales tax rate on all lost sales would be 9.181%, broken down as 5.6% sales tax for the state of Arizona, 1.3% for Coconino County, and 2.281% for the City of Flagstaff (AZDOR, 2023). Additionally, Flagstaff has an additional 2% tax on all Bed, Board, and Beverage (BBB) sales. The \$34,996,500 revenue loss in accommodation and food services industry were all subject to the City's BBB tax. The tax loss is shown in Table 5.

Table 5. Sales Tax Loss Due to Wildfire Event

Government Organization	Sales Tax Loss (Low-Risk)	Sales Tax Loss (High-Risk)
State of Arizona	\$1,959,804	\$1,959,804
Coconino County	\$454,955	\$454,955
City of Flagstaff (with BBB)	\$1,498,200	\$1,498,200
Total	\$3,912,959	\$3,912,959

Source: Calculated by the author based on business revenue loss due to wildfire event.

Another catastrophic business revenue loss is from the businesses within the wildfire's burn area. In both wildfire scenarios, there is a high probability of major damage to Arizona Snowbowl, a very large business for the Flagstaff economy. A comparable case is the Sierra-at-Tahoe resort in California, which was heavily damaged by the 221,835-acre Caldor Fire in August 2021. Buildup of timber at the base of many ski areas—such as existed below Sierra-at-Tahoe—is especially threatening because fire spreads quickly uphill. It is the first ski resort to suffer a direct hit from one of the increasingly common large wildfires ravaging the West. Forestry researchers fear it won't be the last (Whittaker, M., 2022). The Caldor Fire burned through 80 percent of Sierra-at-Tahoe's 2,000 skiable acres (Hansman H., 2023). Its season-long closure following the Caldor Fire devastated not just its own business, but nearby restaurants and ski rental shops. After the wildfire, Sierra spent almost its entire 75th anniversary season closed with the exception of one weekend in April.

For this analysis, we assume that a stand-replacing fire on the San Francisco Peaks will shut down Arizona Snowbowl for a year, which could be best scenario according to the Sierra-at-Tahoe case. Based on this assumption, total loss in business activity can be calculated by utilizing the total economic impact of Arizona Snowbowl. The Economic Policy Institute estimates Arizona Snowbowl's economic impact at \$69.18 million in 2023 dollars (Economic Policy Institute, 2019). This figure includes economic output from skier expenditures (both on and off the mountain), payroll, operations, projects, and tax revenue, and estimates the total impact of Arizona Snowbowl on the local and state economy. Using the assumption that wildfire would disrupt business activity for a year, all of the economic impact from Arizona Snowbowl for the year would be lost, translating to a loss of \$69.18 million at both risk levels. This number doesn't include the rebuild cost of Snowbowl. Most of the visitors to Snow Bowl are during the winter season, but there

might be some overlap with the reduced visitors described above after the wildfire event. To be conservative, we only include three quarters of the total loss for Snow Bowl, which is \$51.86 million. Adding this to the \$34,996,500 of other tourism businesses loss, that makes the total business interruption loss due to the fire event \$86,856,500.

Business Interruption – Flood Event

The interruption of business activity is another impactful economic loss as a result of the flood event. For this study, business interruption costs include four categories.

- Business Income – loss of revenue for businesses
- Relocation – cost to temporarily or permanently relocate business operations
- Rental Income – cost to property owners of losing rental income
- Wage Loss – loss to employees of their wages

These business interruption costs were calculated using FEMA’s Hazus software. Hazus estimates these losses using the flood inundation levels from the JE Fuller flood models and loss estimation functions based on census block information.

Through the Hazus software, total business interruption costs for the lower bound of risk are estimated at \$200,740,000 and \$1,635,700,000 for the upper bound (Table 6).

Table 6. Business Interruption Costs

Business Interruption Category	Low-Risk Scenario Costs	High-Risk Scenario Costs
Business Income	\$45,310,000	\$407,860,000
Relocation	\$30,210,000	\$164,230,000
Rental Income	\$13,780,000	\$48,310,000
Wage	\$111,440,000	\$1,015,310,000
Total	\$200,740,000	\$1,635,700,000

Source: Hazus model, using inputs provided by JE Fuller.

The business interruption due to the flood event results in business revenue loss, which includes the loss of potential sales tax revenue for Flagstaff, Coconino County, and Arizona. Business income loss for each scenario is shown in Table 6 - the lower bound of risk suffered a business income loss of \$45,310,000 and the upper bound suffered a loss of \$407,860,000. For each of these scenarios, the sales tax rate on all lost sales would be 9.181%, broken down as 5.6% sales tax for the state of Arizona, 1.3% for Coconino County, and 2.281% for the City of Flagstaff (AZDOR, 2023). Additionally, Flagstaff has an additional 2% tax on all Bed, Board, and Beverage (BBB) sales. Using the monthly sales tax data acquired from the city and using 2019 as a baseline year, it is estimated that approximately 23% of sales during the summer months when a flood event would occur would be subject to this additional 2% BBB tax, which roughly equates to an additional 0.46% sales tax loss for Flagstaff (City of Flagstaff, 2023).

With these sales tax rates, we can determine the loss to each of these government organizations of the loss in business income. Sales tax loss for each level of government is broken down in the table below for each scenario.

Table 7. Sales Tax Loss Due to Flood Event

Government Organization	Sales Tax Loss (Low-Risk)	Sales Tax Loss (High-Risk)
State of Arizona	\$2,537,360	\$22,840,160
Coconino County	\$589,030	\$5,302,180
City of Flagstaff (with BBB)	\$1,241,947	\$11,179,443
Total	\$4,368,337	\$39,321,783

Source: Calculated by the author based on business revenue loss due to flood event.

Long Term Recovery Cost

It's a long road to clean up and restore the area. Recovering the forest includes long-term flood mitigation infrastructure to be built on federal land and within communities to make sure the area is resilient to future fires, to reduce the repetitive impacts from post-wildfire flooding, to bring businesses, e.g., the skii area back to operation, to protect lives and properties, and to help property values to recover.

The flood mitigation cost of the Schultz Fire, the Museum Fire, and the Pipeline Fire are referenced to estimate the flood mitigation cost after a wildfire on the San Francisco Peaks happens.

A series of floodwater mitigation projects were completed after the Schultz Fire, to recover the post-wildfire ecosystem, reclaim, repair, and replant the forest. In total, the Schultz flood mitigation projects cost a reported \$31.462 million, or \$35,737,010 in 2023 dollar. Divided by the burned area of 15,000 acres, the per acre flood mitigation cost is \$2,382.47.

For the Museum Fire, according to the Coconino County Flood Control District, from 2019 to 2023, a total of \$9,713,188 have been spent on various flood mitigation projects, e.g., communication and flood alert system, debris removal, alluvial fan stabilization, etc., funded by various sources. Divided by the 2,000 acres of the burned areas, the per acre flood mitigation cost is \$4,856.59.

In terms of the Pipeline Fire, the estimated cost of the construction projects and funding to date is \$130 million. At 26,532 acres of burned area, that puts a per acre cost at approximately \$4,900. If all the money is available for all the projects identified as necessary for Pipeline Fire flood mitigation, the cost would be \$150 million to \$160 million. The per acre cost for doing all the work that Coconino Flood Control District would like to do would be between \$5,635 and \$6,030.

Since the Museum Fire and the Pipeline Fire are closer in date and we have the recovery cost available, the estimate for this study is based on those numbers. Using the \$4,856.59 as the lower bound estimated per acre cost, and \$6,030 per acre as the upper bound estimated cost, to multiply the burned area in the hypothetical San Francisco Peaks wildfire - 4,000 acres for the lower bound and 21,500 acres for the upper bound, we estimate that the recovery cost is \$19,426,360 for the lower bound scenario, and \$129,645,000 for the upper bound scenario.

Health Cost

Although human health impacts from wildfire smoke are typically ignored in estimates of monetized damages, A research by Richardson, Leslie A. et al (2012) found out a cost of illness estimate is \$9.50 per exposed person per day, using the primary data from the largest wildfire in Los Angeles County's modern history. However, theory and empirical research consistently find that this measure largely underestimates the true economic cost of health effects from exposure to a pollutant in that it ignores the cost of defensive actions taken as well as disutility. In the same study, the defensive behavior method is applied to calculate the willingness to pay for a reduction in one wildfire smoke induced symptom day, which is estimated to be \$84.42 per exposed person per day. We used the two numbers as the lower bound and upper bound health costs estimates for the hypothetical San Francisco Peaks wildfire, which is \$12.74 and \$113.17 in 2023 dollar. A 10-day fire which affect the City of Flagstaff's population of 76,793 will cost a total of \$9,783,428 as the lower bound health cost, and \$86,906,638 as the upper bound health cost.

Other Costs (Uncalculated)

There are other potentially significant costs that was not estimated in this report due to the constraint in data availability. These costs include the following.

- Decrease in outdoor recreation.

The San Francisco Peaks are home to many trails and areas used for hiking, mountain biking, climbing, hunting, camping and many other activities. It has been shown that wildfire significantly decreases the demand for outdoor recreation in an area from these groups over a long time period – mountain bikers' demand effectively drops to zero trips per year from 6.2 trips on average, and hikers' trips per year drops from 2.8 to 0.95 (Hesseln et al., 2003). Participating in these activities has a measurable benefit to those engaging in them, which Hesseln et al. estimate at about \$130 of benefit per hiking trip and \$150 of benefit per mountain biking trip. The loss of this personal benefit, as well as loss to the local economy of tourist spending, would undoubtedly take place. Further research is required to determine the visitation to the San Francisco Peaks for each of these activities to calculate the true cost of the decrease in outdoor recreation.

- Decrease to the railroad and the disruption to supply chain.

The railroad constitutes a vital artery for Flagstaff's economy, with a substantial volume of trains traversing the city daily. According to McClure (2021), an average of 74 trains pass through within a single day, signifying a continuous flow of goods to and from the city. Furthermore, the threat of flooding poses a substantial risk to this essential transport corridor. A potential inundation could render the railroad inoperative for several days, disrupting the supply chains and inflicting notable economic repercussions. Although the precise economic value due to the interruption of railroad operation through Flagstaff remains uncertain, the sheer volume of railroad traffic underscores the significant economic stake held in maintaining an operational railroad system.

- Impact to visitation to the Grand Canyon.

The symbiotic relationship between Flagstaff and the Grand Canyon's tourism sector could face significant strain amidst the unfolding ecological crisis. Wildfires, followed by consequential flooding, not only pose a direct threat to accessibility to the Grand Canyon but cast a long pall over the region's image as a desirable tourist destination. The mere dissemination of news regarding natural disasters in the area could foster a climate of apprehension among potential visitors, inducing a hesitation to make the journey to the Grand Canyon. This phenomenon isn't merely transient; the lingering apprehension could extend well into the future, long after the initial calamity has been mitigated.

The ripple effects on local businesses, especially those heavily reliant on the seasonal influx of tourists, could be pronounced, ushering in a period of economic hardship. Restoring the tarnished image and rekindling the allure of the Grand Canyon as a safe and majestic haven for tourists may necessitate a concerted effort encompassing strategic communication, infrastructure restoration, and community engagement to assuage fears and reestablish the region's status as a premier tourist destination.

- Damage to I-40 and interrupted connectivity.

The unfolding catastrophe, born from wildfires and exacerbated by subsequent flooding, threatens to unleash a torrent of challenges upon the lifeblood of Flagstaff's transportation network - the Interstate 40 (I-40). The anticipated flooding could render sections of the I-40 impassable, severing the city's connectivity with the broader region and beyond. The abrupt halt of traffic, even for a transient period, could reverberate through the supply chains, inducing a cascade of delays and economic losses. Moreover, the prospect of repeated flooding events, as mentioned earlier, paints a narrative of lingering vulnerability and the imperative for enduring solutions to safeguard this critical infrastructure. The disruption could also divert traffic to alternative routes, which may not be equipped to handle the sudden influx, thereby exacerbating congestion, wear-and-tear, and safety concerns on these detour paths.

Conclusion

In this study, the potential damages as a result of a wildfire event on the San Francisco Peaks and the post-fire flooding event range from \$535,152,529 to \$2,822,207,072. However, there are many economic costs that have not been accounted for due to data availability issues, making the estimate very conservative.

Another thing to be noted is, the analysis presented in this report revolves around the impacts stemming from a singular flood event wherein wildfires incite subsequent flooding within the city bounds. It's imperative to cast light upon a potentially more distressing scenario — the predisposition towards recurrent events. The wildfire, besides inflicting immediate damages, could result in long-term vulnerability by denuding the vegetative cover that ordinarily serves as a natural bulwark against flooding. Consequently, the loss of the vegetation could render Flagstaff susceptible to repeated flooding episodes, each with its own suite of damaging repercussions. This cyclical calamity not only amplifies the physical damages but could also entrench a prolonged economic downturn, eroding the resilience of the city over time. The prospect of repeat events, thus, unfurls a layer of complexity and accentuates the urgency for robust preventative measures and adaptive strategies to safeguard the city's future against a backdrop of escalating wildfire and flooding risks.

References

- Arizona Department of Revenue (AZDOR). (2023). *Tax Rate Table*.
<https://azdor.gov/transaction-privilege-tax/tax-rate-table>.
- Arizona Rural Policy Institute. (2014, October). *Flagstaff Watershed Protection Project Cost Avoidance Study*. Northern Arizona University.
<https://flagstaffwatershedprotection.org/wp-content/uploads/2014/10/Final-FWPP-Cost-Avoidance-October-27.pdf>.
- City of Flagstaff. (2023). *Monthly Sales Tax Statistics*.
<https://www.flagstaff.az.gov/2769/Monthly-Tax-Revenue-Statistics>.
- Ecological Restoration Institute. (2013, May). *A Full Cost Accounting of the 2010 Schultz Fire*. Northern Arizona University.
<https://in.nau.edu/wp-content/uploads/sites/212/SchultzFire-CostAccounting-2013.pdf>.
- Economic Policy Institute. (2019). *The Economic Contribution of Arizona Snowbowl on the Economy of Flagstaff, Coconino County, and the State of Arizona*. Northern Arizona University.
- Hansman H. Lessons Learned from Calif.'s Caldor Fire, and How to Prevent the Next Big One: Why Sierra-at-Tahoe sustained so much damage, and what ski resorts can do to prepare for the next big wildfire. Ski. Retrieved from <https://www.skimag.com/ski-resort-life/west-coast/lessons-learned-from-caldor-fire-sierra-at-tahoe/>
- Hesseln, H., Loomis, J. B., González-Cabán, A., & Alexander, S. (2003). Wildfire effects on hiking and biking demand in New Mexico: a travel cost study. *Journal of Environmental Management*, 69(4), 359-368.
- Loomis, J., & Ekstrand, E. (1997). Economic Benefits of Critical Habitat for the Mexican Spotted Owl: A Scope Test Using a Multiple-Bounded Contingent Valuation Survey. *Journal of Agricultural and Resource Economics*, 22(2), 356-366.
<http://www.jstor.org/stable/40986954>.
- McClure, M. (2021, April 1). *Train Town: A railroad economy and its impacts*. Retrieved from JackCentral.org: https://www.jackcentral.org/features/train-town-a-railroad-economy-and-its-impacts/article_86d5b478-9319-11eb-8f0c-3f70ed7d6e30.html#:~:text=Wilemon%20also%20said%20as%20of,Winslow%2C%20per%20a%20BNSF%20report
- Richardson, Leslie A.; Champ, Patricia A.; Loomis, John B. 2012. The hidden cost of wildfires: Economic valuation of health effects of wildfire smoke exposure in southern California. *Journal of Forest Economics*. 18: 14-35.
- The Federal Emergency Management Agency (FEMA). (2022a, July). *Hazus Flood Technical Manual: Hazus 5.1*. Retrieved from FEMA.gov:
https://www.fema.gov/sites/default/files/documents/fema_hazus-flood-model-technical-manual-5-1.pdf

References

- The Federal Emergency Management Agency (FEMA). (2022b, November). *Hazus Inventory Technical Manual: Hazus 6.0*. Retrieved from FEMA.gov: https://www.fema.gov/sites/default/files/documents/fema_hazus-inventory-technical-manual-6.pdf.
- UNEP and GRID-Arendal. (2022). Spreading like Wildfire: The Rising Threat of Extraordinary Landscape Fires. Retrieved from UNEP.org: <https://www.unep.org/resources/report/spreading-wildfire-rising-threat-extraordinary-landscape-fires>
- US Fish and Wildlife Service (USFWS). (2012, September). *Mexican Spotted Owl Recovery Plan, First Revision*. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd475767.pdf.
- USGCRP (U.S. Global Change Research Program). (2018). Impacts, risks, and adaptation in the United States: Fourth National Climate Assessment, volume II. Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.). <https://nca2018.globalchange.gov/downloads>. doi:10.7930/NCA4.2018.
- Williams, Safford, H. D., Enstice, N., Steel, Z. L., & Paulson, A. K. (2023). High-severity burned area and proportion exceed historic conditions in Sierra Nevada, California, and adjacent ranges. *Ecosphere.*, 14(1). <https://doi.org/10.1002/ecs2.4397>.
- Whittaker, M. (2022, Mar 19). Ski resorts threatened by wildfires prepare to defend and rebuild; after sierra-at-tahoe lost equipment and a ski lift, resorts in the west prepare for another potentially destructive fire season. *Wall Street Journal* (Online) Retrieved from <https://libproxy.nau.edu/login?url=https://www.proquest.com/newspapers/ski-resorts-threatened-wildfires-prepare-defend/docview/2640524556/se-2>.