ASSESSING **HIGH-COST WILDFIRES** IN RELATION TO THE **NATURAL DISTRIBUTION** OF **PONDEROSA PINE** IN THE **11 WESTERN STATES** (2000-2017)

This coarse-resolution assessment suggests that much of the West's wildfire problem traces to the deteriorated condition of its dry ponderosa pine sites.

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A PEER-REVIEWED ANALYSIS.

Editor's Note: *This analysis introduces the occasional publication of peer-reviewed papers in*Wildfire Magazine.While all articles in Wildfire are reviewed and edited, we often seek the more immediate work of professional practitioners and wildfire journalists. The more formal peer-review process has been reserved for science-based journals (such as our sister IAWF publication, the International Journal of Wildland Fire). But often a work of analysis is best suited to reach a mix of practitioners, fire researchers and fire managers, who are the readers of Wildfire. To submit an article to Wildfire for peer-review, please visit our Submittable site.*

INTRODUCTION AND BACKGROUND

In this analysis we introduce a broad-scale long-term overview of the US West's costliest wildfires in relation to the natural distribution of ponderosa pine (Pinus ponderosa). The species is dependent on frequent, low-intensity burning, but in absence of this function, it has become one of the region's most altered ecosystems (U.S. Government Accounting Office, 1999; U.S.D.A. Forest Service, 2000; Arno and Allison-Bunnell, 2002; Fiedler and Arno, 2015). This analysis illuminates the relationship between deteriorated forest conditions over very large scales and the potential for severe, high-cost wildfires. Based on this analysis, we argue that the West's wildfire crisis is fundamentally a forest land management problem and not a fire control failure, as it is more commonly perceived (Williams, 2013).

This analysis also calls for a much-expanded restoration program as a means to establish a more cost-efficient, safer, and more ecologically appropriate wildland fire management strategy in high-risk fire-prone forests.

It has been some 50 years since the first federal wildland fire management agencies began transitioning from a fire control protection model to a fire management protection model (van Wagtendonk, 2007). Concerns for run-away firefighting costs, safety, and ecological damage were the genesis for this change in wildland fire protection policy (Pyne, 1982). In the intervening years, none of these concerns have diminished. In fact, outside of large wilderness areas, where much-expanded fire-use has been restoring natural processes and re-establishing a diverse vegetative mosaic (Teske, et al, 2012), wildfire costs, losses, damages, and dangers have climbed at alarming rates. Since 2000, at least 7 of the 11 western states have suffered their worst wildfires on record (Williams and Hyde, 2009; Williams, 2014). Despite a half-century of movement toward a fire management model, the concept's goals for reigning in costs, improving margins of safety, and restoring ecological integrity have not been realized.

Figure 1: A comparison of a frequent, low intensity fire maintained ponderosa pine forest circa 1897 (left and on the cover), and a ponderosa-pine dominated forest where fire has been long excluded circa 1990s (above).

A number of agency reports, research papers, field studies, staffing documents, and other investigations have observed a relationship between altered forest conditions and the propensity for more severe, stand-replacement wildfires, particularly in the West's dry forest types (USDA Forest Service, 1995; U.S. Government Accounting Office, 1999; USDA Forest Service, 2000; Pyne, 2004; Fiedler and Arno, 2015; Ferguson, 2017). This paper offers a comprehensive, 18-year long-term assessment that shows a widespread pattern confirming these observations across the eleven Western states. The consistency of this pattern and the costs associated with it might encourage a re-evaluation of our over-reliance on firefighting as the principal means for protection and, instead, examine other options that focus on restoring more resilient forest conditions in fire-adapted, fire-dependent ecosystems.

In the US West, perhaps no fire-adapted forest type has been more thoroughly studied than ponderosa pine. At least three generations of scientists have examined the role of frequent, low-intensity fire in maintaining the health and resilience of these dry-site forests (Leopold, 1928; Weaver, 1943; Biswell et al, 1973; Hall, 1976; Covington et al, 1997; Arno, Smith, and Krebs, 1997; and Fiedler and Arno, 2015). Ironically, many of today's worst wildfires are occurring in these heavily altered forests that, a century ago, were among the most benign in terms of potential fire severity.

Following more than a century of high-grade logging, livestock grazing, and the virtual elimination of frequent, low-intensity surface burning, these forests are much changed, in terms of species composition, stand structure, density, and fuel loading (Figure 1). In turn, these changes have predisposed broad landscapes to high-intensity stand-replacement wildfires that often remain uncontrollable until firefighters can capitalize on a change in weather or exploit a break in fuels.

The history, use, ecology, condition, and distribution of the West's dry ponderosa pine forests have relevance in understanding today's wildfire problem. Government officials began inventorying and mapping the nation's forests in the late 1800s. Sargent was among the first in 1884, while subsequent inventories followed in 1897 and 1913 by Mohr and Sudsworth respectively (Little, 1971). These inventories focused on the natural distribution or native range of major tree species. Presence of a particular species was indicated, but abundance or density was not always included. However, early journals and photos from explorers and settlers commonly characterized ponderosa pine forests as open with elevated crowns and grassy understories. The marriage of these early inventories, journals, and photos provides a good idea of the extent and condition of the West's ponderosa pine forests before early logging, grazing, and fire exclusion began to so profoundly change them.

Fiedler and Arno (2015) estimate that roughly 90% of the West's ponderosa pine forests have been cut over. Gordon (2014) notes that these forests were heavily exploited and rapidly depleted in the early- to mid-1900's by timber barons in response to intense demand for lumber, rail ties, mine timbers, and cordwood. Their valley-bottom and foothill sites were easily accessible, hastening their exploitation and removal. During the post-WW II construction boom, old-growth ponderosa pines on higher mountain slopes (also the product of relatively frequent low-intensity fires) were massively harvested, often in large clear-cut logging units. Throughout its range, widespread grazing took out the grasses that once carried low-intensity fire across the forest floor and limited the encroachment of invasive species in ponderosa pine forests. The wholesale elimination of landscape-scale underburning allowed fire-intolerant species to establish and expand their distribution. Ponderosa pine forests that were once described as having 50 or so large trees per acre are, today more commonly described as having upwards of 1,000 spindly ponderosa pine and younger fire-intolerant trees per acre (Gruell et al, 1982; Gruell, 2001). The distribution of ponderosa pine in an open, resilient condition has shrunk to become only a small remnant of its historic extent (Fiedler and Arno, 2015).

Although the look of these forests has changed dramatically over the past 150 years, their site characteristics remain relatively warm and dry; made even drier physiologically as a result of many more trees intercepting and transpiring a lesser quantity of available water. Certainly, the onset of climate change has exacerbated the aridity of these sites (Westerling et al, 2006). Together, these changes go a long way in explaining today's wildfire problem in the West.

METHODS

Wildfire occurrence was collected for the eleven Western states and then overlaid onto the natural distribution of ponderosa pine. A $20 million threshold was established to distinguish high-cost incidents (the $20 million threshold was selected somewhat arbitrarily, based on the approximate cost of an extended twenty-one day-long Incident Management Team assignment on a complex wildfire costing roughly $1 million per day).

The green-shaded area in Figure 2 is from Little (1971), which shows the natural distribution of ponderosa pine in the 11 western states. The graduated symbols displayed in Figure 2 represent the reported latitude/longitude of wildfires with reported suppression costs greater than $20 million.

Incident locations and firefighting costs were derived from information reported in SIT-209's (NFAM, 2018) and/or National Incident Coordination Center (NICC) Annual Summaries (NIFC, 2018). This assessment used data from 2000, onward (official NICC annual summaries began in 2000). Reported suppression costs are a compilation of all monies expended in fighting the fire during the effort to control or suppress it. They do not break out firefighting costs to protect private or public values at risk, nor do they reflect any judgments on cost-effectiveness. The reported costs are for suppression only; they do not include private property losses, natural resource damages, or other wildfire-related impacts.

Some named wildfires were made up of two or more incidents, managed as a single incident or multiple incidents that eventually burned together. All dollars are those spent in the year of the fire (they do not account for inflation). The authors acknowledge that these summaries or reports sometimes reflect data that are incomplete or inconsistently collected from year-to-year.

RESULTS AND DISCUSSION

This assessment found that, from 2000 and 2017, there have been 187 wildfires having reported suppression costs greater than $20 million in the eleven Western states. Most of these incidents cost much more than $20 million to control. In all, the total suppression costs, alone, exceeded $8 billion for these 187 incidents.

The true, total costs of wildfires go far beyond the suppression costs reported here; they include private property losses, natural resource damages, as well as environmental degradation, human health effects, infrastructure repairs, adverse impacts to local economies, post-fire rehabilitation, and other long-term costs. They are not accounted for in existing summaries and, therefore, remain largely unknown. Two studies indicate that these un-reported costs, losses, and damages may be 5- to 10-times, or more, greater than reported suppression costs alone (WFLC, 2010; Hessburg, 2017). For example, following the disastrous 2017 fire season, the California insurance commissioner subsequently reported that nearly $12 billion had been submitted in wildfire-related property claims alone (California Department of Insurance, 2018).

The 187 incidents burned over 15 million acres (approximately 23,400 square miles). Among the 187 incidents, 116 (62.03%) occurred within the natural distribution of ponderosa pine, as mapped by Little (1971). These 116 incidents burned over 9.7 million acres (64.7% of the total) and cost over $5 billion to control (64.3% of the total).

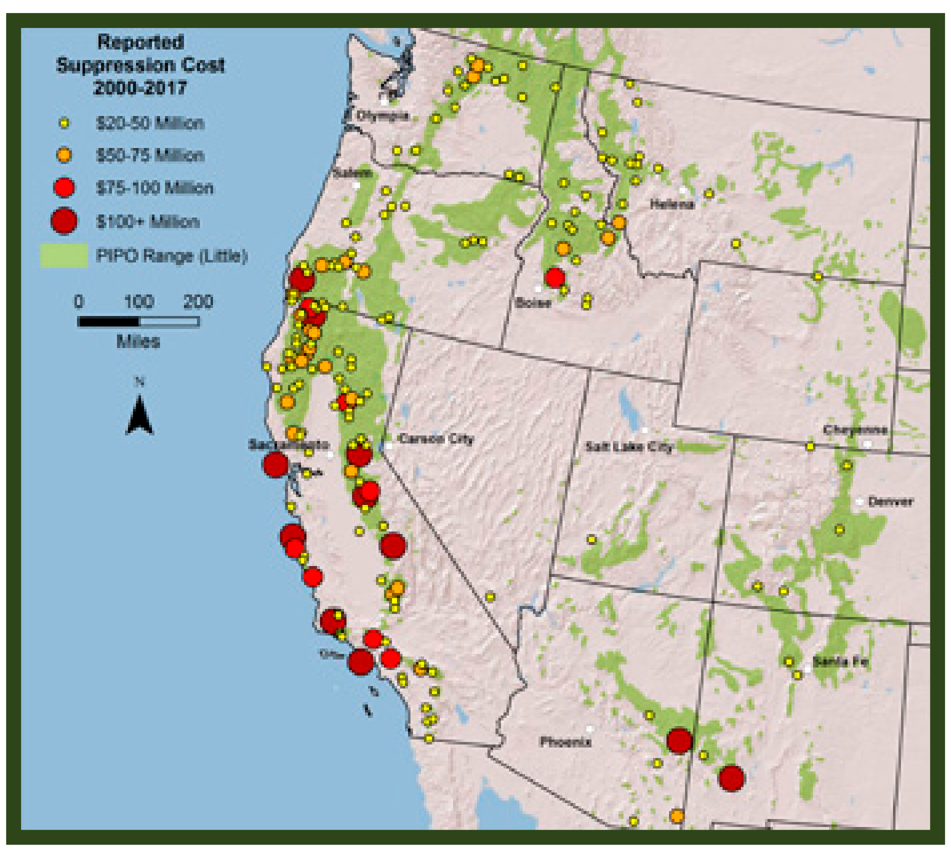

Figure 2: Reported locations of high-cost wildfires in relation to the natural distribution of ponderosa pine in the 11 Western states (2000-2017).

California had the greatest number of reported high-cost incidents; 97 out of the 187 (52%). Of these 97 incidents, 59 were within Little's natural range of ponderosa pine (60.82%).

Of the West's ten wildfires with highest reported suppression costs, seven were located in California, including the 132,000 acre Soberanes Fire (2016), the nation's most expensive wildfire on record with a reported suppression cost of $262.5 million.

CONCLUSIONS

Although very large wildfires typically burn across a variety of forest types, many of them are concentrated in forests that, today, are burning at intensities well beyond those experienced historically. The preponderance of high-intensity, stand-replacement wildfires occurring in ponderosa pine ecosystems is a significant departure from historical patterns. The prevalence of high-cost incidents within the mapped natural distribution of ponderosa pine infers an important pattern: 150-years of change on these sites have predisposed present day forests to most of today's highest cost wildfires.

Because these forests also tend to occupy valley-bottoms and foothills, where people, property, and other high values are often most concentrated, wildfires in these areas almost always result in high losses and damages. Throughout much of the West, homeowners who locate in wildland-urban interface settings are not required to reduce fuel hazards or comply with Firewise standards (NFPA, 2018) as a requisite for wildfire protection or as an incentive for insurance coverage. Consequently, the protection of private property in these areas typically carry inordinately high costs. Compounding the situation is the fact that protecting private property often occurs at the expense of public values (e.g. damage to watersheds, critical habitat, air quality, others).

In broad terms, the results of this assessment point to a serious and urgent forest land management crisis. In Arizona, alone, between 1990 and 2010, Swetnam (2012) estimated that nearly 20 percent of Arizona's forests burned over with near-complete mortality. Despite the commonly held view that today's worst wildfires are considered either "accidents of nature," a result of poor management decisions, or due to a lack of firefighting effort, this assessment helps support the analysis that much of today's wildfire problem traces to vulnerable forest conditions on dry sites. In this context, uncharacteristically severe wildfires in these altered forests are among the least natural of the natural disasters that, today, confront those living in the US West.

Nearly two-thirds of all western wildfires with reported suppression costs exceeding $20 million occurred within the natural distribution of ponderosa pine. These wildfires burned almost two-thirds of the total acreage documented in this assessment and accounted for close to two-thirds of the assessment's reported suppression expenditures. The proportions involved are perhaps a "bad-news – good news" story. The bad news is that these forests, over a century of exploitation and neglect, have devolved into a condition that makes them highly susceptible to severe, high-intensity burning. However, the good news is that their ecology holds the key to their resilience and, in turn, our ability to better protect them and provide for our own safety. At appropriate fire intensities and fire return intervals, and at meaningful scales, ponderosa pine can be maintained in a resilient, sustainable condition. This observation is consistent with the findings of wildland fire scientists stretching back to the late 1920's.

NEXT STEPS

The high suppression costs, as well as the unaccounted losses and damages reflected in this assessment may change the calculus of how alternative wildfire protection models (including greater investments in fuel hazard mitigation) are evaluated. It is unclear that there exists a threshold where high suppression costs, coupled with high wildfire-related losses and damages, might combine to challenge the efficacy of "staying the course" and prompt a change in the protection strategy for the West's dry forests (Williams, 2014). Certainly, a more complete accounting of the true and total wildfire costs would better reflect the realities involved and help support a more accurate analysis of future protection options.

The very large size of many incidents described in this analysis is not lost within the scale of Little's map, but a more detailed, site-specific analysis would better support land management decisions.

Although this paper focuses on the relationship between high-cost wildfires and the natural distribution of altered ponderosa pine forests, an overlay of high-cost wildfire perimeters onto LANDFIRE data (Rollins, 2009) may more precisely frame the relationship between vegetation type, condition, and wildfire potential. An integration of more precise fire and vegetative data may also provide an ecological basis for evaluating wildfire protection options. This understanding will be especially critical in the West's fire-prone ponderosa pine forests where safe, cost-effective protection depends so much on more resilient conditions.

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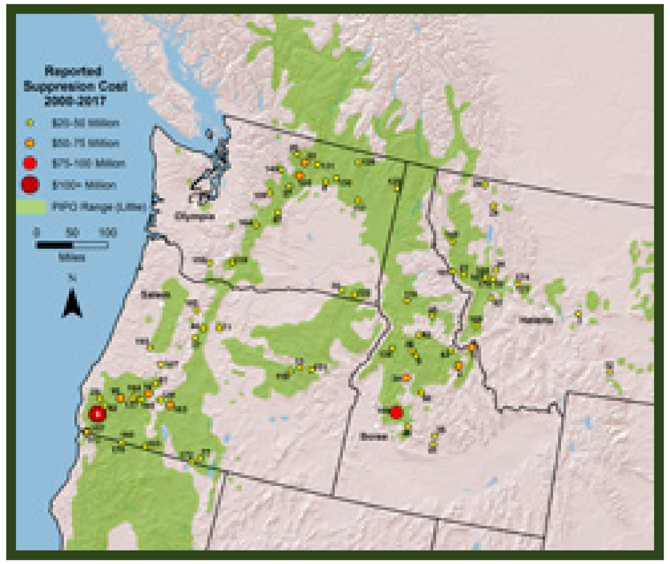
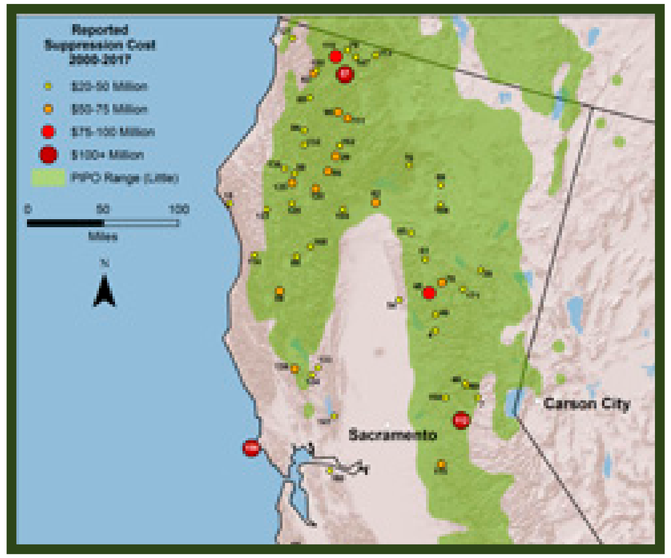
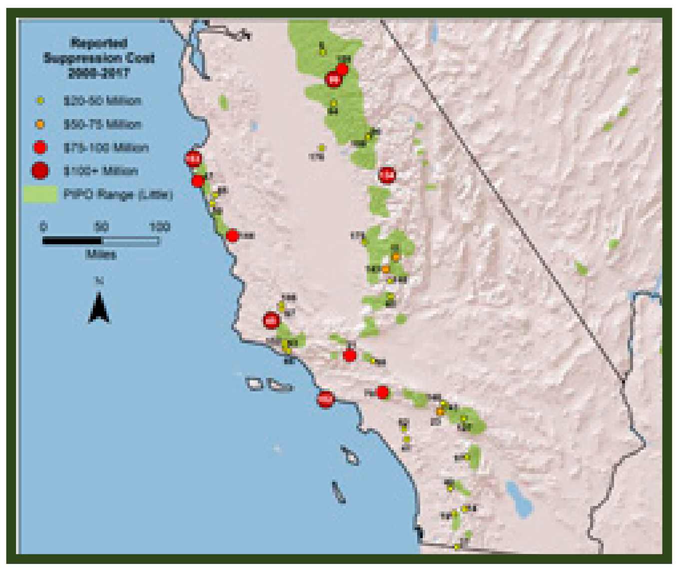
The authors take full responsibility for any mistakes or omissions that may have occurred in summarizing the data.



APPENDIX A.



APPENDIX B.



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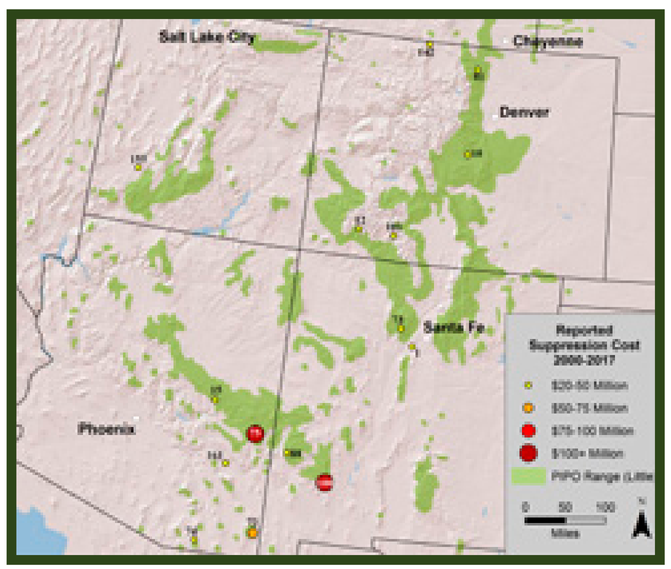

APPENDIX D.

APPENDICES

APPENDIX A. Distribution of high suppression cost wildfires and their relationship to the native range of ponderosa in the states of Oregon, Washington, and Montana (2000-2017). Wildfire numbers in all Appendices correspond to those numbered in Appendix E.

APPENDIX B. Distribution of high suppression cost wildfires and their relationship to the native range of ponderosa pine in North Zone, California (2000-2017).

APPENDIX C. Distribution of high suppression cost wildfires and their relationship to the native range of ponderosa pine in South Zone, California (2000-2017).

APPENDIX D. Distribution of high suppression cost wildfires and their relationship to the native range of ponderosa pine in Nevada, Colorado, New Mexico, and Arizona (2000-2017).

APPENDIX E. A summary of all wildfires with reported suppression costs greater than $20 million in the eleven western states (2000-2017). This asseessment can also be found online at wildfiremagazine.org/article/high-cost-wildfires-in-ponderosa/.

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Appendix E - *Summary of all wildfires with reported suppression costs greater than $20 million in the 11 Western states. (2000-2017)*

WILDFIRE NUMBER	RANGE	YEAR	START DATE	STATE	INCIDENT ID	INCIDENT NAME	LAT	LONG	ACRES	REPORTED SUPPRESSION COST
0	PIPO	2000	07/14/2000	ID	ID-PAF-008	BURGDORF JUNCTION	45.16	-115.53	64,496	$23,484,252
1		2000	05/05/2000	NM	NM-BAP-0009	CERRO GRANDE	35.51	-106.24	47,650	$32,449,962
2		2000	07/10/2000	ID	ID-SCF-P46044	CLEAR CREEK COMPLEX	45.14	-114.27	216,961	$71,500,000
3		2000	08/16/2000	MT	MT-CES-103	MAUDLOW/TOSTON	46.6	-111.10	81,687	$23,150,000
4	PIPO	2000	08/17/2000	CA	CA-PNF-848	STORRIE	39.55	-121.20	46,280	$22,703,120
5		2000	07/31/2000	MT	MT-BRF-11445	VALLEY COMPLEX	45.55	-114.00	292,070	$61,986,078
6	PIPO	2001	09/05/2001	CA	CA-TCU-06632	DARBY	38.15	-120.37	14,280	$21,476,122
7	PIPO	2001	08/25/2001	CA	CA-ENF-12745	STAR	39.04	-120.47	16,761	$28,200,000
8	PIPO	2001	08/13/2001	WA	WA-COA-132	VIRGINIA LAKE COMPLEX	48.22	-119.28	74,243	$25,200,000
9	PIPO	2002	07/13/2002	OR	OR-SIF-003	BISCUIT (FORMERLY FLORENCE)	42.41	-123.87	499,570	$152,658,738
10	PIPO	2002	06/08/2002	CO	CO-PSF-404	HAYMAN	39.05	-105.43	137,760	$39,200,000
11	PIPO	2002	07/21/2002	CA	CA-SQF-1888	MCNALLY	35.92	-118.47	150,696	$55,587,000
12	PIPO	2002	06/09/2002	CO	CO-SJF-26804	MISSIONARY RIDGE	37.50	-107.75	70,485	$40,700,000
13	PIPO	2002	07/12/2002	OR	OR-MAF-103	MONUMENT-MALHEUR COMPLEX	44.40	-118.71	44,062	$30,761,594
14		2002	07/29/2002	CA	CA-MVU-05658	PINES	33.07	-116.59	61,690	$24,976,052
15	PIPO	2002	06/18/2002	AZ	AZ-FTA-251	RODEO/CHEDISKI COMPLEX	34.10	-110.43	468,638	$48,737,663
16	PIPO	2002	07/12/2002	OR	OR-UPF-069	TILLER COMPLEX	43.10	-122.67	68,775	$58,917,923
17	PIPO	2003	08/19/2003	OR	OR-DEF-848	B & B COMPLEX	44.44	-121.83	90,769	$41,198,000
18		2003	09/03/2003	CA	CA-HUU-004435	CANOE/HONEYDEW	40.17	-124.13	24,882	$33,900,000
19		2003	10/25/2003	CA	CA-CNF-003056	CEDAR	32.99	-116.73	273,246	$32,616,213
20	PIPO	2003	06/29/2003	WA	WA-OWF-199	FAWN PEAK COMPLEX	48.62	-120.33	81,343	$39,790,496
21	PIPO	2003	08/09/2003	MT	MT-LNF-000264	FISH CREEK COMPLEX	46.98	-114.65	36,956	$27,000,000
22		2003	08/06/2003	MT	MT-LNF-00332	MINERAL-PRIMM	47.01	-113.76	25,202	$22,907,000
23	PIPO	2003	10/25/2003	CA	CA-BDF-10329	OLD/GRAND PRIX/PADUA COMPLEX	34.18	-117.27	161,175	$55,107,829
24		2003	07/23/2003	MT	MT-FNF-000048	ROBERT	48.48	-114.15	57,570	$30,744,892
25	PIPO	2003	07/07/2003	ID	ID-NPF-000014	SLIMS COMPLEX	46.03	-115.30	14,473	$22,000,000
26		2003	07/16/2003	MT	MT-FNF-036	WEDGE CANYON	48.88	-114.55	53,315	$34,000,000
27	PIPO	2004	06/26/2004	WA	WA-OWF-271	POT PEAK/SISI RIDGE COMPLEX	47.94	-120.31	47,170	$27,739,172
28	PIPO	2005	07/21/2005	OR	OR-SIF-11	BLOSSOM COMPLEX	42.73	-123.94	15,600	$28,424,301
29	PIPO	2006	07/23/2006	CA	CA-SHF-001693	BAR COMPLEX	40.89	-123.01	100,414	$61,331,547
30	PIPO	2006	08/21/2006	OR	OR-UMF-000411	COLUMBIA COMPLEX	46.14	-118.04	109,422	$35,400,000
31		2006	09/04/2006	CA	CA-LPF-2023	DAY	34.60	-118.80	162,702	$78,000,000
32		2006	08/22/2006	MT	MT-GNF-000047	DERBY FIRE	45.53	-109.93	223,570	$23,000,000
33	PIPO	2006	07/24/2006	WA	WA-OWF-398	TRIPOD COMPLEX	48.50	-120.04	113,011	$68,175,390
34		2007	07/17/2007	ID	ID-BOF-000635	CASCADE COMPLEX	44.67	-115.69	302,376	$53,240,816
35		2007	08/16/2007	ID	ID-STF-002132	CASTLE ROCK	43.64	-114.56	48,520	$25,000,000
36	PIPO	2007	07/07/2007	ID	ID-PAF-007071	EAST ZONE COMPLEX	45.25	-115.68	300,022	$33,000,000
37		2007	10/21/2007	CA	CA-MVU-010427	HARRIS	32.59	-116.58	90,440	$21,000,000
38		2007	08/03/2007	MT	MT-FHA-115	JOCKO LAKES	47.20	-113.73	36,388	$31,423,766
39	PIPO	2007	09/03/2007	CA	CA-PNF-000670	MOONLIGHT	40.22	-120.85	64,997	$34,000,000
40		2007	10/23/2007	CA	CA-MVU-10643	POOMACHA	33.28	-116.87	49,410	$20,658,000
41		2007	10/21/2007	CA	CA-ORC-68555	SANTIAGO	33.75	-117.67	28,400	$21,650,000
42		2007	07/31/2007	MT	MT-LNF-211	SAWMILL COMPLEX	46.61	-113.70	68,500	$20,864,000
43		2007	10/22/2007	CA	CA-BDF-10570	SLIDE	34.28	-117.22	12,759	$27,147,745
44	PIPO	2007	07/12/2007	OR	OR-WSA-073	WSA LIGHTNING COMPLEX	44.68	-121.67	13,077	$20,988,400
45		2007	07/04/2007	CA	CA-LPF-001087	ZACA / ZACA TWO	34.78	-120.09	240,207	$122,533,385
46	PIPO	2008	06/21/2008	CA	CA-TNF-1011	AMERICAN RIVER COMPLEX	39.14	-120.67	20,541	$23,950,980
47		2008	06/21/2008	CA	CA-LPF-1649	BASIN COMPLEX	36.21	-121.74	162,818	$78,096,079
48	PIPO	2008	06/21/2008	CA	CA-BTU-007660	BTU LIGHTNING COMPLEX	39.88	-121.40	64,995	$94,825,683
49	PIPO	2008	06/21/2008	CA	CA-PNF-000539	CANYON COMPLEX	39.70	-121.25	47,680	$45,501,474
50		2008	09/27/2008	CA	CA-LPF-002754	CHALK	35.99	-121.43	16,269	$24,042,000
51	PIPO	2008	06/21/2008	CA	CA-LNF-2713	CUB COMPLEX	40.18	-121.56	19,718	$21,000,000
52		2008	11/15/2008	CA	CA-ORC-075221	FREEWAY COMPLEX	33.87	-117.74	30,305	$24,328,779
53		2008	07/01/2008	CA	CA-LPF-1778	GAP	34.49	-119.78	9,443	$20,970,000
54		2008	06/11/2008	CA	CA-BTU-007089	HUMBOLDT	39.74	-121.74	23,344	$20,568,690
55		2008	06/08/2008	CA	CA-LPF-1491	INDIANS	36.10	-121.42	76,554	$42,500,000
56	PIPO	2008	06/21/2008	CA	CA-SHF-1057	IRON & ALPS COMPLEXES	40.73	-123.05	105,805	$73,974,917
57	PIPO	2008	06/21/2008	CA	CA-KNF-3393	KLAMATH THEATER	41.66	-123.19	192,038	$126,086,065
58	PIPO	2008	06/20/2008	CA	CA-SHF-1041	LIME COMPLEX	40.53	-123.45	99,585	$59,329,698
59	PIPO	2008	06/20/2008	CA	CA-MEU-004608	MEU LIGHTNING COMPLEX	39.51	-123.21	54,819	$66,000,000
60	PIPO	2008	06/28/2008	CA	CA-SQF-001356	PIUTE	35.43	-118.40	37,026	$25,000,000
61	PIPO	2008	08/17/2008	OR	OR-UPF-008209	RATTLE	43.33	-122.54	19,775	$21,057,784
62	PIPO	2008	06/21/2008	CA	CA-SHU-004727	SHU LIGHTNING COMPLEX	40.57	-122.36	86,500	$56,438,391
63	PIPO	2008	06/21/2008	CA	CA-KNF-002975	SISKIYOU / BLUE 2 COMPLEX	41.59	-123.58	82,186	$65,692,836

Legend and Summary of Assessments

Data Source		Obtained directly from SIT209 Database
		Obtained from NICC Annual Summary Report
Ponderosa Range	PIPO	Reported fire location - IN Ponderosa Pine Range (Little, 1971)
		Reported fire location - NOT IN Ponderosa Pine Range

ALL FIRES	
Total Reported Suppression Cost	$8,052,345,713
Total Burned Acres	15,092,281
PONDEROSA FIRES	
Total Reported Suppression Cost	$5,179,497,094
Total Burned Acres	9,768,916

WILDFIRE NUMBER	RANGE	YEAR	START DATE	STATE	INCIDENT ID	INCIDENT NAME	LAT	LONG	ACRES	REPORTED SUPPRESSION COST
64	PIPO	2008	07/25/2008	CA	CA-MMU-009779	TELEGRAPH	37.57	-120.00	34,091	$38,350,000
65	PIPO	2008	06/20/2008	CA	CA-SRF-1126	UKONOM-SOUTH COMPLEX	41.35	-123.54	58,871	$23,581,000
66		2009	05/05/2009	CA	CA-LPF-1479	JESUSITA	34.47	-119.72	8,733	$20,002,000
67		2009	08/08/2009	CA	CA-LPF-002631	LA BREA	34.95	-119.98	89,489	$35,120,000
68		2009	08/12/2009	CA	CA-CZU-007246	LOCKHEED	37.14	-122.19	7,817	$30,788,744
69	PIPO	2009	08/01/2009	CA	CA-SHU-5594	SHU LIGHTNING	40.90	-121.62	17,623	$31,653,934
70		2009	08/26/2009	CA	CA-ANF-003622	STATION	34.25	-118.19	160,577	$95,510,000
71		2011	08/24/2011	OR	OR-WSA-000108	HIGH CASCADES	44.77	-121.23	108,154	$28,294,465
72	PIPO	2011	05/08/2011	AZ	AZ-CNF-011047	HORSESHOE 2	31.82	-109.21	222,954	$52,000,000
73	PIPO	2011	06/26/2011	NM	NM-N6S-000451-N	LAS CONCHAS	35.81	-106.54	156,593	$48,385,000
74		2011	06/12/2011	AZ	AZ-COP-001102	MONUMENT	31.55	-110.42	30,526	$20,411,500
75	PIPO	2011	05/29/2011	AZ	AZ-ASF-110152-1	WALLOW	33.60	-109.45	538,049	$109,000,000
76	PIPO	2012	08/18/2012	CA	CA-SHF-002744	BAGLEY	41.00	-122.08	46,011	$37,063,416
77	PIPO	2012	08/06/2012	OR	OR-FWF-120680	BARRY POINT	42.11	-120.80	93,071	$23,247,235
78	PIPO	2012	07/29/2012	CA	CA-PNF-1001	CHIPS	40.01	-121.28	75,431	$53,300,000
79	PIPO	2012	08/05/2012	CA	CA-KNF-5659	FORT COMPLEX	41.89	-123.25	23,658	$26,747,381
80		2012	07/27/2012	ID	ID-SCF-012151	HALSTEAD	44.45	-115.17	181,948	$26,413,932
81	PIPO	2012	06/09/2012	CO	CO-LRX-329	HIGH PARK	40.59	-105.40	87,284	$38,400,000
82		2012	08/27/2012	ID	ID-NPF-00531	MCGUIRE COMPLEX	45.60	-115.56	43,621	$24,741,628
83	PIPO	2012	07/30/2012	ID	ID-SCF-12190	MUSTANG COMPLEX	45.42	-114.59	341,488	$38,323,413
84	PIPO	2012	08/18/2012	CA	CA-MNF-001446	NORTH PASS	39.87	-123.13	41,983	$30,493,184
85	PIPO	2012	08/18/2012	CA	CA-TGU-6696	PONDEROSA	40.39	-121.82	27,676	$33,051,301
86		2012	08/03/2012	ID	ID-BOF-000628	TRINITY RIDGE	43.71	-115.37	146,832	$41,228,912
87	PIPO	2012	09/09/2012	WA	WA-OWF-000559	WENATCHEE COMPLEX	47.37	-120.45	56,478	$32,394,876
88	PIPO	2012	05/16/2012	NM	NM-GNF-000143	WHITEWATER-BALDY	33.34	-108.71	297,845	$23,000,000
89	PIPO	2013	08/10/2013	CA	CA-TNF-001562	AMERICAN	39.12	-120.65	27,440	$27,310,674
90	PIPO	2013	07/22/2013	CA	CA-SNF-1732	ASPEN	37.28	-119.32	22,992	$32,289,100
91		2013	08/07/2013	ID	ID-TFD-000337	BEAVER CREEK	43.46	-114.55	111,490	$26,500,000
92	PIPO	2013	07/26/2013	OR	OR-712S-133-14	BIG WINDY COMPLEX	42.61	-123.76	26,725	$36,489,789
93		2013	07/01/2013	NV	NV-HTF-500068	CARPENTER 1	36.20	-115.70	27,883	$20,183,000
94	PIPO	2013	08/10/2013	CA	CA-SRF-1486	CORRAL COMPLEX	41.04	-123.49	12,503	$36,666,073
95	PIPO	2013	07/26/2013	OR	OR-732-05314	DOUGLAS COMPLEX	42.86	-123.38	48,679	$55,000,000
96	PIPO	2013	08/31/2013	CA	CA-KNF-005949	FORKS COMPLEX/SALMON RIVER COMPLEX/BUTLER FIRE	41.30	-123.14	37,246	$59,806,008
97		2013	07/15/2013	CA	CA-BDF-10080	MOUNTAIN	33.70	-116.73	27,531	$25,856,300
98		2013	05/30/2013	CA	CA-ANF-2297	POWERHOUSE	34.60	-118.44	30,274	$27,321,000
99	PIPO	2013	08/17/2013	CA	CA-STF-002857	RIM	37.86	-120.09	257,314	$127,350,000
100	PIPO	2013	06/07/2013	NM	NM-GNF-000230	SILVER	32.89	-107.81	138,546	$143,000,000
101		2013	06/05/2013	CO	CO-SJF-000285	WEST FORK COMPLEX	37.46	-106.94	109,615	$31,261,047
102	PIPO	2013	07/26/2013	OR	OR-UPF-130132	WHISKEY COMPLEX	42.94	-122.82	17,891	$22,128,577
103	PIPO	2014	07/30/2014	OR	OR-711S-161-15	BEAVER COMPLEX	42.05	-122.35	35,302	$22,220,837
104	PIPO	2014	07/11/2014	CA	CA-SHU-006248	BULLY	40.42	-122.73	12,661	$23,865,759
105	PIPO	2014	07/14/2014	WA	WA-NES-000534	CARLTON COMPLEX	48.21	-120.10	256,108	$68,800,000
106		2014	07/15/2014	WA	WA-OWF-000356	CHIWAUKUM COMPLEX	47.71	-120.83	13,895	$28,516,174
107		2014	08/11/2014	OR	OR-WIF-140274	DECEPTION COMPLEX	43.74	-122.57	6,033	$28,450,000
108	PIPO	2014	07/31/2014	CA	CA-LNF-003502	EILER	40.72	-121.56	32,416	$26,334,929
109	PIPO	2014	07/28/2014	CA	CA-SNF-001619	FRENCH	37.27	-119.33	13,838	$21,600,000
110	PIPO	2014	08/14/2014	CA	CA-KNF-005956	HAPPY CAMP COMPLEX	41.80	-123.37	134,056	$88,214,725
111	PIPO	2014	08/03/2014	CA	CA-KNF-005564	JULY COMPLEX	41.27	-123.00	50,042	$50,295,981
112	PIPO	2014	09/13/2014	CA	CA-ENF-023461	KING	38.79	-120.60	97,717	$119,000,000
113	PIPO	2014	07/30/2014	CA	CA-KNF-005497	KNF BEAVER	41.92	-122.88	32,496	$27,128,721
114	PIPO	2014	07/30/2014	CA	CA-MEU-007202	LODGE COMPLEX	39.77	-123.65	12,536	$41,500,000
115	PIPO	2015	09/09/2015	CA	CA-AEU-024918	BUTTE	38.34	-120.70	70,868	$74,720,784
116	PIPO	2015	08/12/2015	OR	OR-MAF-015192	CANYON CREEK COMPLEX	44.28	-118.96	110,261	$31,453,602
117	PIPO	2015	08/14/2015	WA	WA-SPA-000046	CARPENTER ROAD	48.00	-118.20	63,972	$22,650,000
118	PIPO	2015	08/10/2015	ID	ID-NCF-000720	CLEARWATER/MUNICIPAL/ MOTORWAY/NORTH COMPLEX	46.22	-116.13	83,243	$41,527,637
119	PIPO	2015	08/10/2015	WA	WA-YAA-000157	COUGAR CREEK	46.13	-121.37	53,534	$23,500,000
120	PIPO	2015	07/31/2015	CA	CA-SHF-002067	FORK COMPLEX	40.54	-123.14	36,499	$51,700,000
121		2015	07/31/2015	CA	CA-SRF-001488	GASQUET COMPLEX	41.85	-123.97	30,361	$42,548,342
122	PIPO	2015	08/13/2015	OR	OR-UMF-000947	GRIZZLY BEAR COMPLEX	46.11	-117.68	83,148	$20,968,610
123	PIPO	2015	07/30/2015	CA	CA-HUU-005606	HUMBOLDT COMPLEX	40.22	-123.66	4,883	$30,560,608
124		2015	08/09/2015	CA	CA-LNU-007410	JERUSALEM	38.83	-122.53	25,118	$25,000,000
125	PIPO	2015	08/18/2015	WA	WA-COF-001302	KANIKSU COMPLEX	48.42	-117.14	26,125	$26,343,033
126	PIPO	2015	08/11/2015	WA	WA-COF-001264	KETTLE COMPLEX	48.76	-118.46	76,512	$37,557,251

Appendix E - Summary of all wildfires with reported suppression costs greater than $20 million in the 11 Western states. (2000-2017)

WILDFIRE NUMBER	RANGE	YEAR	START DATE	STATE	INCIDENT ID	INCIDENT NAME	LAT	LONG	ACRES	REPORTED SUPPRESSION COST
127	PIPO	2015	06/17/2015	CA	CA-BDF-007894	LAKE	34.16	-116.90	31,359	$30,000,000
128	PIPO	2015	07/30/2015	CA	CA-SRF-001433	MAD RIVER COMPLEX	40.34	-123.38	37,462	$33,350,510
129		2015	08/01/2015	OR	OR-RSF-000836	NATIONAL CREEK COMPLEX	43.04	-122.28	20,960	$21,100,000
130	PIPO	2015	08/13/2015	WA	WA-COA-000157	NORTH STAR	48.34	-119.00	218,138	$45,000,000
131	PIPO	2015	08/14/2015	WA	WA-NES-001203	OKANOGAN COMPLEX	48.52	-119.66	145,282	$46,296,090
132	PIPO	2015	07/30/2015	CA	CA-SHF-002066	RIVER COMPLEX	40.91	-123.44	77,081	$32,678,783
133		2015	07/29/2015	CA	CA-LNU-006984	ROCKY	38.91	-122.49	69,438	$46,100,000
134	PIPO	2015	07/31/2015	CA	CA-SNF-001746	ROUGH	36.87	-118.90	151,623	$120,930,243
135	PIPO	2015	07/30/2015	CA	CA-SRF-001476	ROUTE COMPLEX	40.64	-123.59	35,675	$25,275,680
136	PIPO	2015	08/01/2015	CA	CA-SHF-002108	SOUTH COMPLEX	40.62	-123.45	29,416	$31,770,000
137	PIPO	2015	07/30/2015	OR	OR-732S-000090	STOUTS CREEK	42.92	-123.05	26,452	$38,000,000
138	PIPO	2015	08/12/2015	ID	ID-PAF-000192	TEPEE SPRINGS	45.21	-116.25	95,709	$31,540,000
139	PIPO	2015	09/12/2015	CA	CA-LNU-008670	VALLEY	38.84	-122.76	76,067	$56,220,000
140	PIPO	2015	06/29/2015	WA	WA-OWF-000287	WOLVERINE	48.23	-120.67	72,123	$35,000,000
141		2015	07/22/2015	CA	CA-LNU-006678	WRAGG	38.51	-122.13	8,051	$21,655,500
142		2016	06/19/2016	CO	CO-RTF-000088	BEAVER CREEK	40.95	-106.61	38,380	$31,000,000
143		2016	08/16/2016	CA	CA-SQF-002595	CEDAR	35.74	-118.58	29,322	$58,446,000
144		2016	08/13/2016	CA	CA-SLU-008948	CHIMNEY	35.67	-121.00	46,344	$78,300,000
145	PIPO	2016	07/31/2016	MT	MT-LNF-005092	COPPER KING	47.60	-115.18	28,553	$26,467,287
146		2016	06/23/2016	CA	CA-CND-001415	ERSKINE	35.61	-118.47	48,019	$23,000,000
147	PIPO	2016	08/27/2016	CA	CA-KNF-007501	GAP	41.85	-123.12	33,867	$29,700,000
148		2016	08/07/2016	CA	CA-BDF-010205	PILOT	34.29	-117.25	8,110	$25,000,000
149	PIPO	2016	07/18/2016	ID	ID-BOF-000539	PIONEER	43.95	-115.76	188,404	$90,000,000
150	PIPO	2016	06/07/2016	CA	CA-KNF-004500	PONY	41.62	-123.56	2,860	$20,500,000
151	PIPO	2016	07/31/2016	OR	OR-WWF-000582	RAIL	44.41	-118.38	41,706	$34,900,000
152		2016	08/18/2016	CA	CA-LPF-002809	REY	34.55	-119.81	32,606	$29,910,000
153		2016	07/22/2016	CA	CA-BEU-003422	SOBERANES	36.46	-121.90	132,127	$262,500,000
154	PIPO	2016	06/28/2016	CA	CA-NEU-015200	TRAILHEAD	38.96	-120.86	5,646	$25,782,000
155		2017	06/17/2017	UT	UT-SWS-000218	BRIANHEAD	38	-113	71,675	$36,600,000
156		2017	10/09/2017	CA	CA-LNU-010104	CENTRAL LNU COMPLEX	38	-123	110,720	$102,000,000
157	PIPO	2017	07/12/2017	OR	OR-RSF-000326	CHETCO BAR	42	-124	191,125	$72,000,000
158	PIPO	2017	07/16/2017	CA	CA-MMU-014474	DETWILER	38	-120	81,826	$90,000,000
159		2017	09/02/2017	OR	OR-CGF-000493	EAGLE CREEK	46	-122	48,831	$20,251,700
160	PIPO	2017	08/15/2017	CA	CA-KNF-006098	ECLIPSE COMPLEX	42	-123	78,698	$46,006,691
161		2017	06/07/2017	AZ	AZ-CNF-000467	FRYE	33	-110	48,443	$20,000,000
162	PIPO	2017	08/30/2017	CA	CA-SHF-001770	HELENA	41	-123	18,316	$30,640,000
163	PIPO	2017	08/13/2017	OR	OR-RSF-000636	HIGH CASCADES COMPLEX	43	-122	27,476	$65,000,000
164	PIPO	2017	08/11/2017	WA	WA-OWF-000361	JOLLY MOUNTAIN	47	-121	36,808	$24,400,000
165		2017	08/10/2017	OR	OR-WIF-170191	JONES	44	-123	10,114	$22,075,117
166	PIPO	2017	07/15/2017	MT	MT-FHA-000105	LIBERTY	47	-114	28,694	$20,600,000
167	PIPO	2017	07/15/2017	MT	MT-LNF-001288	LOLO PEAK	47	-114	53,902	$48,500,000
168	PIPO	2017	10/09/2017	CA	CA-MEU-012169	MENDOCINO LAKE COMPLEX	40	-123	38,730	$25,000,000
169	PIPO	2017	07/14/2017	MT	MT-BDF-002217	MEYERS	46	-114	62,034	$32,800,000
170	PIPO	2017	08/14/2017	OR	OR-RSF-000647	MILLER COMPLEX	42	-123	39,716	$38,924,000
171	PIPO	2017	07/29/2017	CA	CA-PNF-001043	MINERVA 5	40	-121	4,310	$20,500,000
172		2017	07/24/2017	CA	CA-MDF-000671	MODOC JULY COMPLEX	42	-121	83,120	$35,200,000
173	PIPO	2017	07/25/2017	CA	CA-SRF-000741	ORLEANS COMPLEX	42	-124	27,276	$44,000,000
174		2017	07/14/2017	MT	MT-HLF-000146	PARK CREEK	47	-113	18,000	$20,050,123
175		2017	08/29/2017	CA	CA-SQF-002385	PIER	36	-119	36,556	$38,760,000
176		2017	08/29/2017	CA	CA-SNF-001743	RAILROAD	37	-120	12,407	$21,500,000
177		2017	07/24/2017	MT	MT-LNF-001464	RICE RIDGE	47	-113	160,187	$49,251,000
178	PIPO	2017	08/13/2017	CA	CA-KNF-006081	SALMON AUGUST COMPLEX	41	-123	65,889	$39,805,700
179	PIPO	2017	07/24/2017	MT	MT-LNF-001463	SAPPHIRE COMPLEX	47	-114	43,733	$35,406,736
180		2017	10/09/2017	CA	CA-LNU-010105	SOUTHERN LNU COMPLEX	38	-122	51,624	$48,509,895
181		2017	07/16/2017	MT	MT-LNF-001336	SUNRISE	47	-115	26,310	$31,700,000
182		2017	12/04/2017	CA	CA-VNC-103156	THOMAS	34	-119	270,000	$123,836,000
183		2017	07/09/2017	MT	MT-MCD-000163	TONGUE RIVER COMPLEX	45	-107	32,965	$26,500,000
184	PIPO	2017	08/11/2017	OR	OR-UPF-000406	UMPQUA NORTH COMPLEX	43	-123	43,158	$42,890,561
185		2017	07/23/2017	OR	OR-WIF-170123	WHITEWATER	45	-122	14,451	$39,702,783
186		2017	07/08/2017	CA	CA-LNF-001770	WHITTIER	35	-120	18,430	$38,500,000