Watershed Investment Tool 2.0
2020 Annual Updates

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This document provides technical details on the Peaks to People Water Fund Watershed Investment Tool 2020 Annual Updates.

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Purpose

The purpose of this annual update is to refresh the data products in the Watershed Investment Tool (WIT) to reflect to changed conditions on the landscape. These modifications include:

- Updating spatial records of accomplished fuel treatments across all agencies,
- Updating spatial records of planned fuel treatments across all agencies,
- Updating fuels to reflect past fuel treatments and the 2020 wildfires,
- Remodeling fire behavior for current conditions in the WIT, and
- Adjusting burn probability for the 2020 wildfires.

We then report on how these updates change the spatial distribution of wildfire risk to water supplies and priorities for treatment across the full Peaks to People planning area and the Big Thompson Initiative landscape.

Updates

Accomplished fuel treatments

The spatial database of accomplished fuel treatments was updated to include actions through the end of 2020 from most organizations engaged in forest management within the Peaks to People planning area (Table 1; Figure 1). The USDA Forest Service and US Department of Interior (National Park Service and Bureau of Land Management) both report their accomplishments in standardized public databases on a regular basis. There were few federal fuel treatment activities reported in 2020 due to the impacts of COVID-19 on the ability to implement prescribed fire and the significant area impacted by wildfires and related closures in the summer and fall. The Colorado State Forest Service was unable to provide an update of their accomplishments; a state-wide update of their spatial database should be available within the next 12 to 18 months. Larimer County Department of Natural Resources shared an updated version of their forest management activities tracking. Accomplishments from all other organizations were reported in a variety of formats with inconsistent attributes. These were compiled into a layer of "custom" fuel treatment activities and were assigned attributes based on written and verbal descriptions of project activities.

Table 1: Data sources used to describe accomplished fuel treatments.

Organization	Current To	Date Acquired	Contact
USDA Forest Service	12/30/2020	12/30/2020	https://data.fs.usda.gov/geodata/
US Department of Interior	12/15/2020	12/15/2020	https://www.nfpors.gov/
Colorado State Forest Service	12/2017	11/2018; Will have to wait for state update for newer data	Matt Norville (matt.norville@colostate.edu)
Larimer County Department of Natural Resources	12/2020	12/2020	Meegan Flenniken (flennim@co.larimer.co.us)
Peaks to People Water Fund	12/2020	12/2020	Heather Schinkel
Big Thompson Watershed Coalition	NA	No response	Courtney Gutman (courtney.gutman@bigthompson.co)
Coalition for the Poudre River Watershed	1/11/2021	1/11/2021	Jen Kovecses (jenk@poudrewatershed.org)
Big Thompson Conservation District	NA	No response on accomplished	Matt Marshall (matthew.marshall@co.nacdnet.net)
Fort Collins Conservation District	12/22/2020	12/22/2020	Gretchen Reuning (gretchen.reuning@co.nacdnet.net)

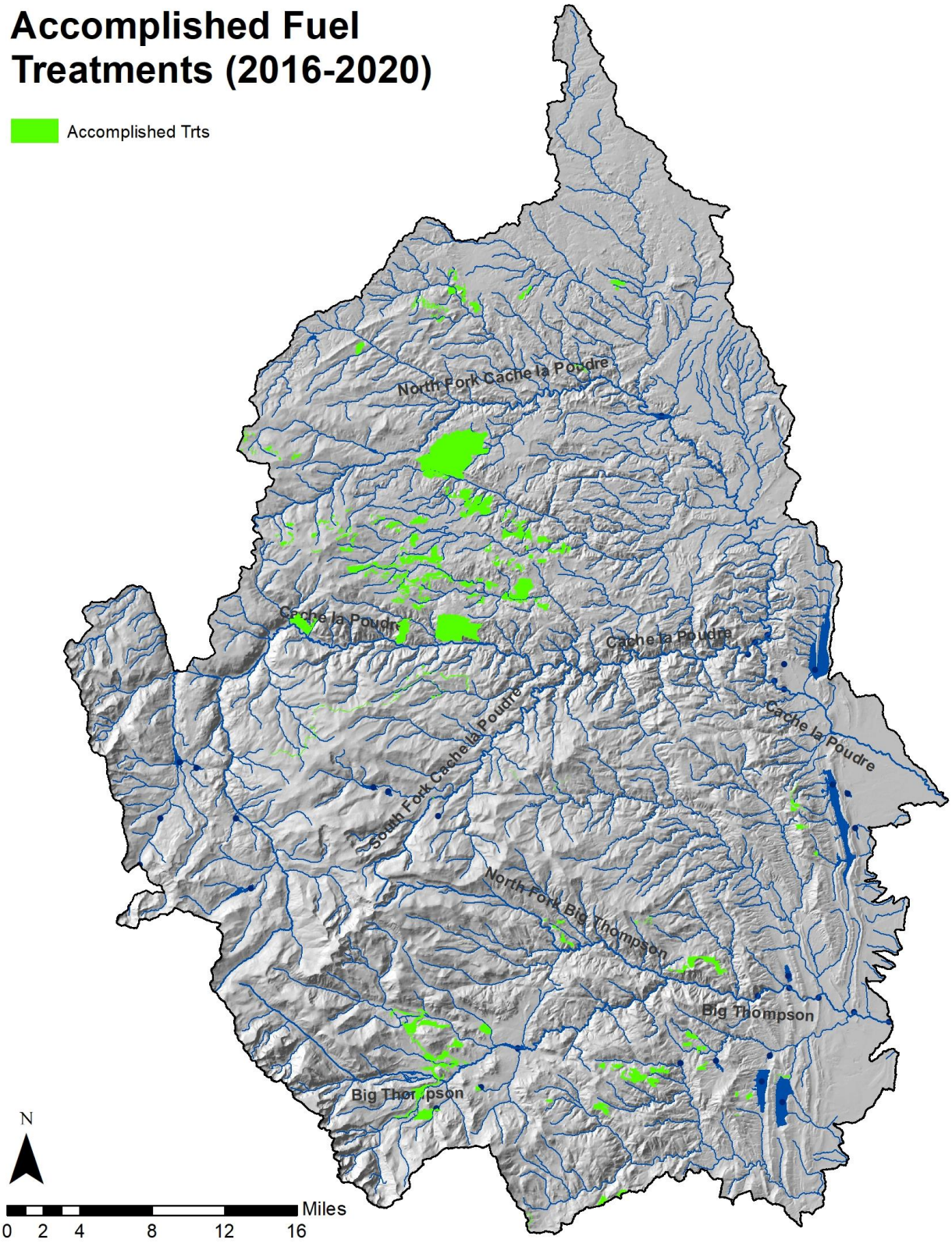

Figure 1: Accomplished fuel treatments 2016-2020 that were used to update fuels in the WIT and are available for retroactive analysis of treatment benefits.

Updating planned fuel treatments

The spatial database of planned fuel treatments was updated for most organizations engaged in forest management within the Peaks to People planning area (Table 2; Figure 2). The USDA Forest Service was unable to share their revised plans because spatial data were not organized and properly attributed to agency standards (Kevin McLaughlin, personal communication). As a stand-in, we revised the previous planned treatment layer to remove areas that have already been accomplished. The Colorado State Forest Service had nothing new to share. Larimer County Department of Natural Resources and the Coalition for the Poudre River Watershed both have several projects identified in various states of planning and secured funding. The Fort Collins and Big Thompson Conservation District contributed a number of projects in the planning phase – it is important to not map these projects in detail or to share the owner information publicly.

Table 2: Data sources used to describe planned fuel treatments.

Organization	Current To	Date Acquired	Contact
USDA Forest Service	?	2016, modified to remove accomplished through 2020	Kevin McLaughlin (kevin.mclaughlin2@usda.gov)
Colorado State Forest Service	NA	Nothing ready to share	Matt Norville (matt.norville@colostate.edu)
Larimer County Department of Natural Resources	~2021-2023	12/2020	Meegan Flenniken (flennim@co.larimer.co.us)
Big Thompson Watershed Coalition	NA	No response	Courtney Gutman (courtney.gutman@bigthompson.co)
Coalition for the Poudre River Watershed	~2021-2023	1/11/2021	Jen Kovecses (jenk@poudrewatershed.org)
Big Thompson Conservation District	~2021	No direct response but any submitted for PPWF assessment are included	Matt Marshall (matthew.marshall@co.nacdnet.net)
Fort Collins Conservation District	~2021-2023	12/22/2020	Gretchen Reuning (gretchen.reuning@co.nacdnet.net)

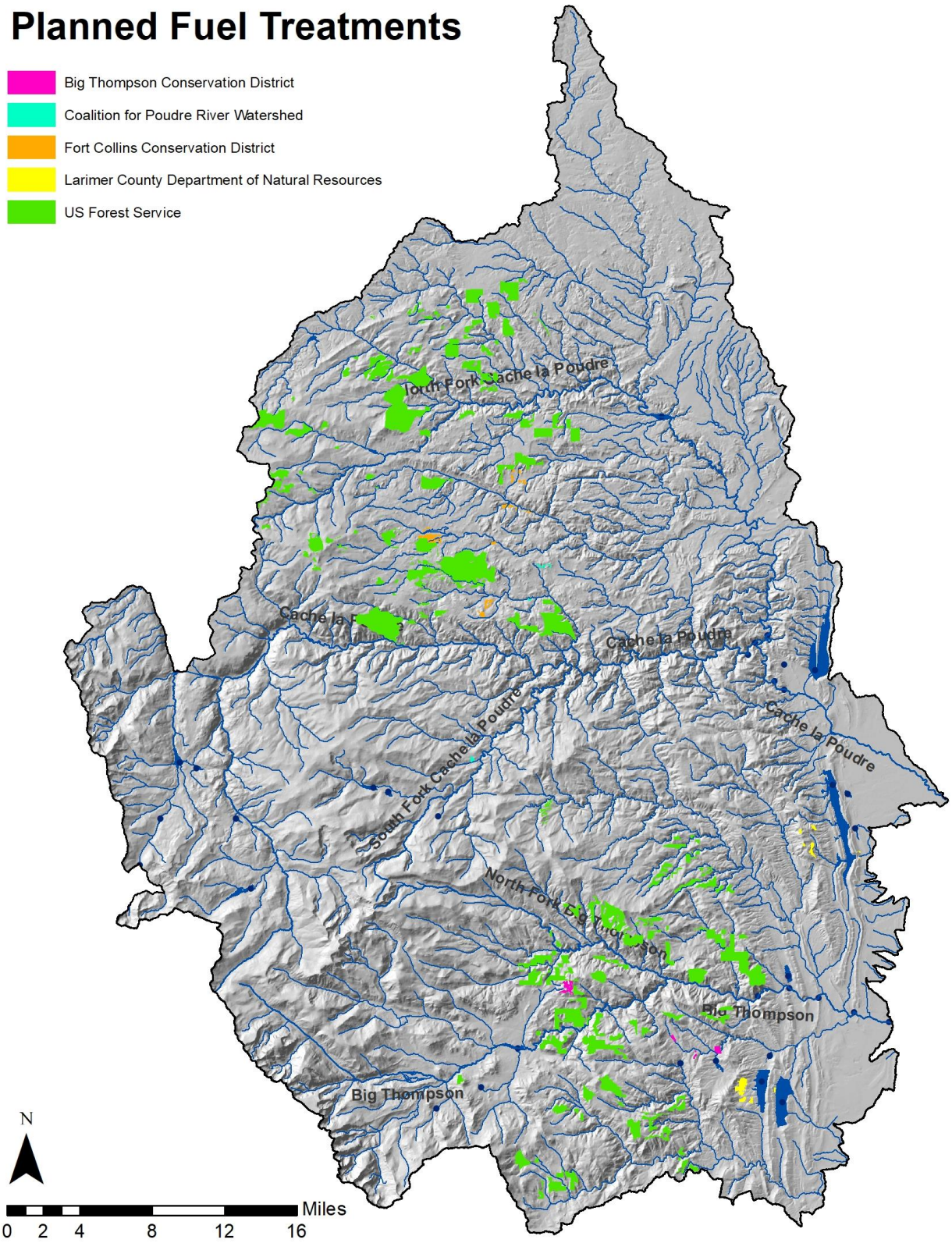

Figure 2: Planned fuel treatments that are available for prospective analysis of treatment benefits.

Adjusting fuels

Past fuel treatments

Past fuel treatments (Table 1; Figure 1) were used to update fuels as described in the WIT technical user guide. The only change was to include fuel treatments that occurred since the last update.

Describing fire extent and severity

Because the large size of the 2020 wildfires, we modified the process to update fuels data to better reflect the spatial variability in fire effects within the fire extents. First, we acquired the final Burned Area Reflectance Classification (BARC) maps generated by the USDA Forest Service for the Cameron Peak and East Troublesome Fires. Their methods for burn severity mapping can be found at https://fsapps.nwcg.gov/baer/home. Suitable post-fire Landsat imagery was not immediately available for the fires due to the timing of satellite passes and snowfall, so these maps were generated with similar imagery collected by the European Space Agency's Sentinel Satellite Program (https://sentinel.esa.int/web/sentinel/home). We resampled and reprojected the burn severity rasters to match the resolution and alignment of the LANDFIRE data products used in the WIT. Then, we mosaiced them into a single raster representing all wildfire activity to include in the update (Figure 3). The raster is classified as: 1 – unburned/very low severity, 2 – low severity, 3 – moderate severity, and 4 – high severity. The area burned by watershed and severity is presented in Table 3.

Table 3: Area (ac) burned by watershed and severity. The Upper Laramie is diverted into the Cache la Poudre watershed.

Watershed	Unburned / Very Low	Low	Moderate	High		Total
Big Thompson	10,791	42,069	17,075	343		70,277
Cache la Poudre	30,107	49,269	47,931	10,416		137,724
Upper Laramie	699	1,643	1,842	1,496		5,679

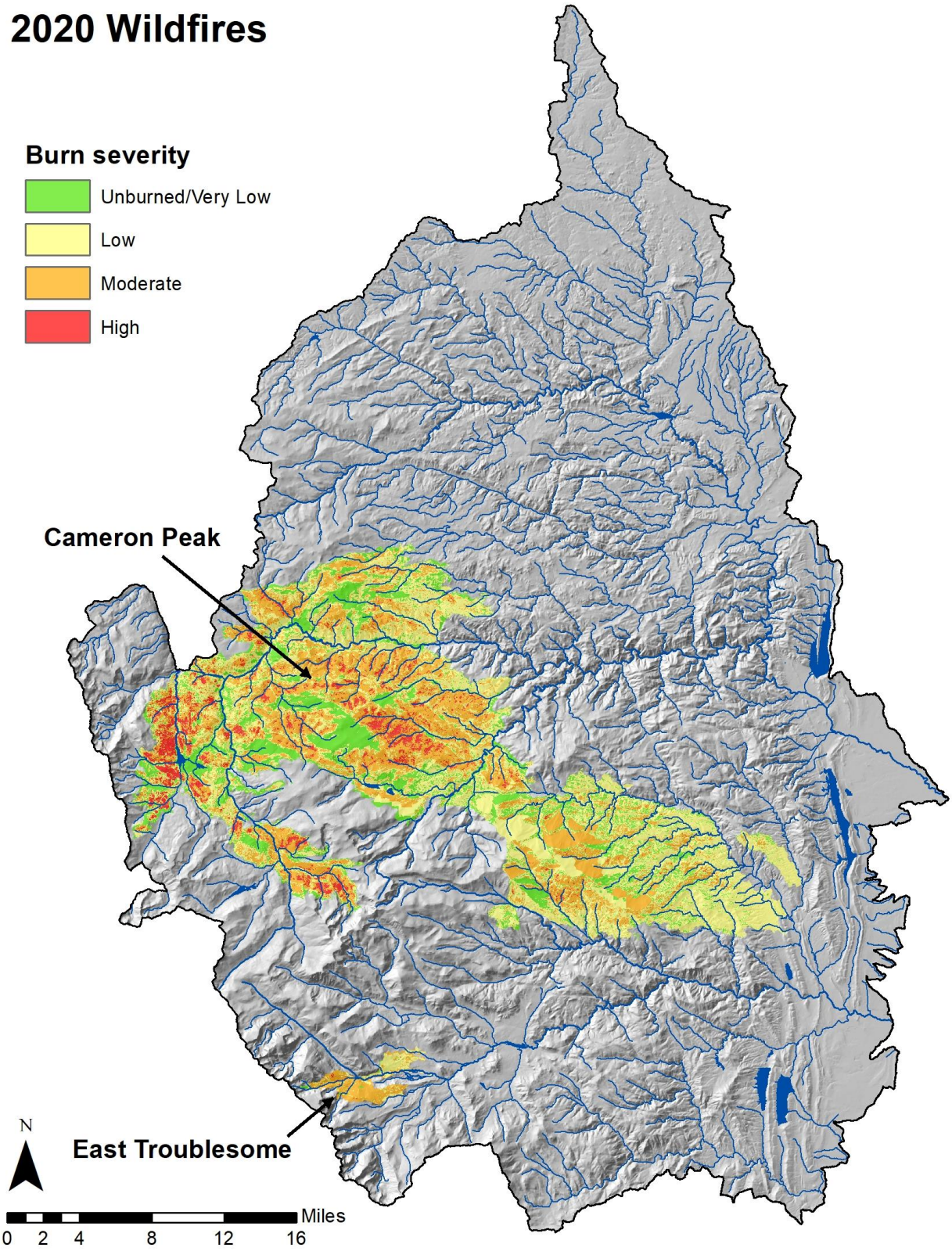

Figure 3: Map of burn severity from the Cameron Peak and East Troublesome Fires.

Effects on fuels

Wildfire effects on fuels and fire behavior were accounted for by first adjusting canopy and surface fuels by burn severity level and then by modeling crown fire activity (Scott and Reinhardt 2001) in FlamMap (Finney et al. 2015) from the modified fuels. We used equivalent methods to those used to update fuels to reflect past fuel treatments and to estimate the effects of hypothetical future fuel treatments (see WIT 2.0 Technical User Guide).

The canopy adjustment factors are presented in Table 4 with the fuel treatment effects for comparison. The logic for adjusting canopy bulk density and canopy cover stems from the common vegetation burn severity categories based on percent mortality: low – 0 to 30%, moderate – 30 to 80%, and high – 80 to 100%. We assumed that canopy bulk density and canopy cover would be reduced proportional to mortality and we used the mid-points of the vegetation mortality ranges to represent each category; for example, the midpoint of moderate severity is 55% mortality, which converts to a proportional adjustment multiplier of 0.45. Canopy base height and canopy height are assumed to increase with severity.

Table 4: Proportional adjustment factors used to estimate treatment and fire effects on canopy variables. CBD = canopy bulk density. CBH = canopy base height. CC = canopy cover. CH = canopy height.

	Adjustment factor			
Treatment	**CBD**	**CBH**	**CC**	**CH**
Thin	0.60	1.20	0.70	1.20
Rx Fire	0.92	1.09	0.95	1.13
Complete	0.50	1.20	0.75	1.20
Low Severity Wildfire	0.85	1.10	0.85	1.10
Moderate Severity Wildfire	0.45	1.25	0.45	1.25
High Severity Wildfire	0.10	1.50	0.10	1.50

The fire behavior fuel model transitions are specified by severity level in Table 5. The low and moderate severity levels are assigned the same effects as prescribed fire in which we assume that the fire behavior fuel model is changed to the least extreme model by fuel model category (e.g., grass, timber understory, timber litter). Like previous representations of high severity fire effects in LANDFIRE, we assumed that burnable fuels would transition to an unburnable state in the short term. After the initial recovery period, we plan to transition fuels in high severity burned areas to the least extreme model by fuel model category. When these wildfires are accounted for in a LANDFIRE update, we will revert to their logic for representing the longer-term recovery. An update to LANDFIRE is expected within one to two years.

Table 5: Fire behavior fuel model changes by surface fuel management type and wildfire severity using standard codes from Scott and Burgan (2005). Changes are highlighted in bold, red type.

Code	FBFM40	Manage	Rx Fire	Rearrange	Low Severity Wildfire	Moderate Severity Wildfire	High Severity Wildfire
NB1	91	91	91	91	91	91	91
NB2	92	92	92	92	92	92	92
NB3	93	93	93	93	93	93	93
NB4	94	94	94	94	94	94	94
NB5	95	95	95	95	95	95	95
NB6	96	96	96	96	96	96	96
NB7	97	97	97	97	97	97	97
NB8	98	98	98	98	98	98	98
NB9	99	99	99	99	99	99	99
GR1	101	101	101	**201**	101	101	**99**
GR2	102	102	**101**	**201**	**101**	**101**	**99**
GR3	103	103	**101**	**201**	**101**	**101**	**99**
GR4	104	104	**101**	**201**	**101**	**101**	**99**
GR5	105	105	**101**	**201**	**101**	**101**	**99**
GR6	106	106	**101**	**201**	**101**	**101**	**99**
GR7	107	107	**101**	**201**	**101**	**101**	**99**
GR8	108	108	**101**	**201**	**101**	**101**	**99**
GR9	109	109	**101**	**201**	**101**	**101**	**99**
GS1	121	121	121	**201**	121	121	**99**
GS2	122	122	**121**	**201**	**121**	**121**	**99**
GS3	123	123	**121**	**201**	**121**	**121**	**99**
GS4	124	124	**121**	**201**	**121**	**121**	**99**
SH1	141	141	141	**201**	141	141	**99**
SH2	142	142	**141**	**201**	**141**	**141**	**99**
SH3	143	143	**141**	**201**	**141**	**141**	**99**
SH4	144	144	**141**	**201**	**141**	**141**	**99**
SH5	145	145	**141**	**201**	**141**	**141**	**99**
SH6	146	146	**141**	**201**	**141**	**141**	**99**
SH7	147	147	**141**	**201**	**141**	**141**	**99**
SH8	148	148	**141**	**201**	**141**	**141**	**99**
SH9	149	149	**141**	**201**	**141**	**141**	**99**
TU1	161	161	161	**201**	161	161	**99**
TU2	162	162	**161**	**201**	**161**	**161**	**99**
TU3	163	163	**161**	**201**	**161**	**161**	**99**
TU4	164	164	**161**	**201**	**161**	**161**	**99**
TU5	165	165	**161**	**201**	**161**	**161**	**99**
TL1	181	181	181	**201**	181	181	**99**
TL2	182	182	**181**	**201**	**181**	**181**	**99**
TL3	183	183	**181**	**201**	**181**	**181**	**99**
TL4	184	184	**181**	**201**	**181**	**181**	**99**
TL5	185	185	**181**	**201**	**181**	**181**	**99**
TL6	186	186	**181**	**201**	**181**	**181**	**99**
TL7	187	187	**181**	**201**	**181**	**181**	**99**
TL8	188	188	**181**	**201**	**181**	**181**	**99**
TL9	189	189	**181**	**201**	**181**	**181**	**99**
SB1	201	201	201	201	201	201	**99**
SB2	202	**201**	**201**	**201**	**201**	**201**	**99**
SB3	203	**201**	**201**	**201**	**201**	**201**	**99**
SB4	204	**201**	**201**	**201**	**201**	**201**	**99**

Effects on fire behavior

Crown fire activity (CFA) is used as a proxy for burn severity in the WIT water supply impact analysis and several co-benefit analyses. Figure 4 shows CFA for 2016 fuel conditions and for the updated fuel conditions at the end of 2020. Fuel treatments had some localized effects, but the most dramatic changes were from the 2020 wildfires. Much of the area burned was altered from potential passive or active crown fire to surface fire. Areas burned at high severity were assumed to be unburnable in the short term.

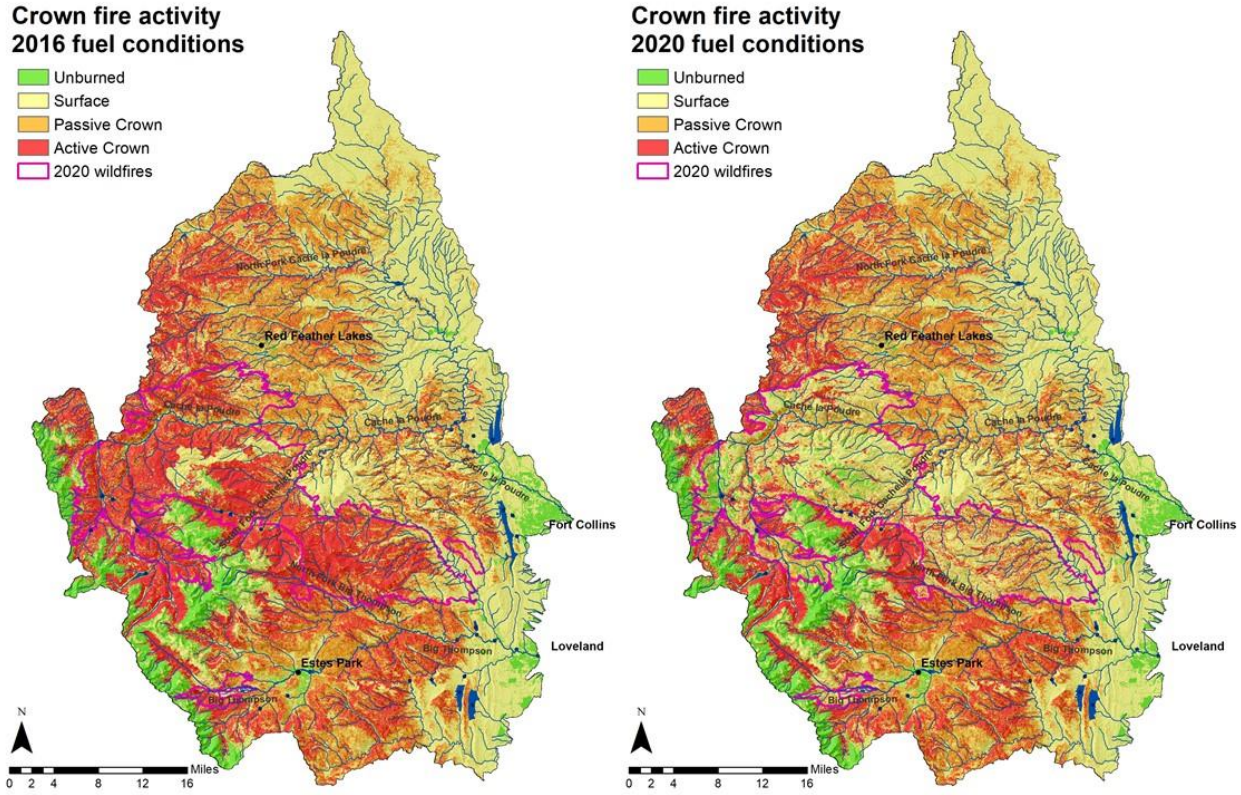

Figure 4: Crown fire activity modeled for 2016 fuel conditions (LEFT) and crown fire activity adjusted for recent fuel treatments and the 2020 wildfires (RIGHT).

Adjusting burn probability

The burn probability used in the WIT comes from the National FSim Modeling Effort (Short et al. 2020). These products have been updated on a four-year schedule, so it is possible that we will not see an update that reflects the recent fires until 2024. Re-modeling burn probability for the Peaks to People focal area is beyond the scope and budget of our current agreement, so we pursued an approximate representation of the effects drawing from a fuel treatment effectiveness study in Oregon (Thompson et al. 2013). Thompson et al. (2013) found that combined thinning and burning treatments could reduce burn probability as modeled with FSim an average of 36.25% within the areas treated and 23.37% within the treated areas and the surrounding 2-mile buffer. The declining reduction in burn probability effects with increasing extent reflects that treatments provide less shadowing effect as you move away from the treatment. The Thompson et al. (2013) burn probability effects should be viewed as approximate given that the 2020 wildfires had different effects on the fuels and differed in their extent and spatial configuration than the fuel treatments analyzed in Oregon.

We applied the mean effects from Thompson et al. (2013) in two steps. Burn probability within the fire extents were reduced uniformly by 36.25%. Then, we calculated what the buffer area reduction factor should be to reduce the total burn probability in the burned area and buffer by 23.37% and applied this to the buffer area. Given that much of the Cameron Peak Fire burned in areas with low predicted burn probability, the adjusted burn probability does not differ dramatically from the original. This means that there should not be a major shift in treatment priorities.

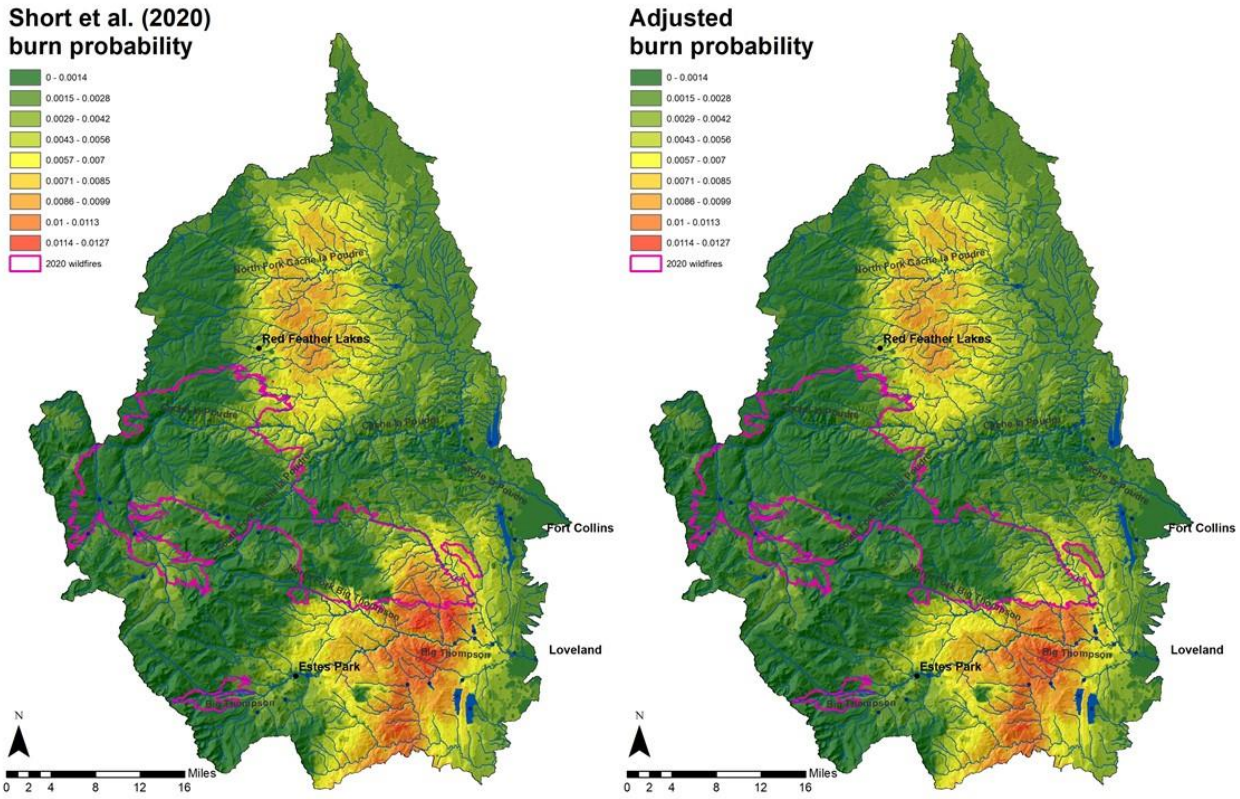

Figure 5: Original burn probability included in WIT 2.0 (LEFT) and burn probability adjusted for the 2020 wildfires (RIGHT).

Risk assessment and fuel treatment prioritization results

Wildfire risk to water supplies

Our updates to the landscape fuel conditions and burn probability lowered wildfire risk to water supplies. Table 6 compares the total risk before and after the updates for the full planning area and the Big Thompson Initiative focus area. Across both watersheds, there was a 22.3% reduction in risk. Much of this came from the extensive burning in the Cache la Poudre Watershed and diverted section of the Upper Laramie Watershed (Table 3; Figure 6). The less extensive burning in the Big Thompson Watershed resulted in an 8% reduction in risk – most of this was concentrated in the north-central portion of the watershed. An important caveat with the total risk estimates is that they are premised on burn probability that has been calibrated to historical fire activity (~1992-2015). Adding the 2020 wildfires to the calibration data would bump the average burn probability for the landscape up. Therefore, it is likely that risk estimates will increase with the next iteration of the National FSim products.

Table 6: Total wildfire risk to water supplies (USD) before and after the updates to account for recent fires and fuel treatments.

Extent	Before	After	% Change
Full	10,079,317	7,831,594	-22.3
C-BT	1,911,904	1,759,269	-8.0

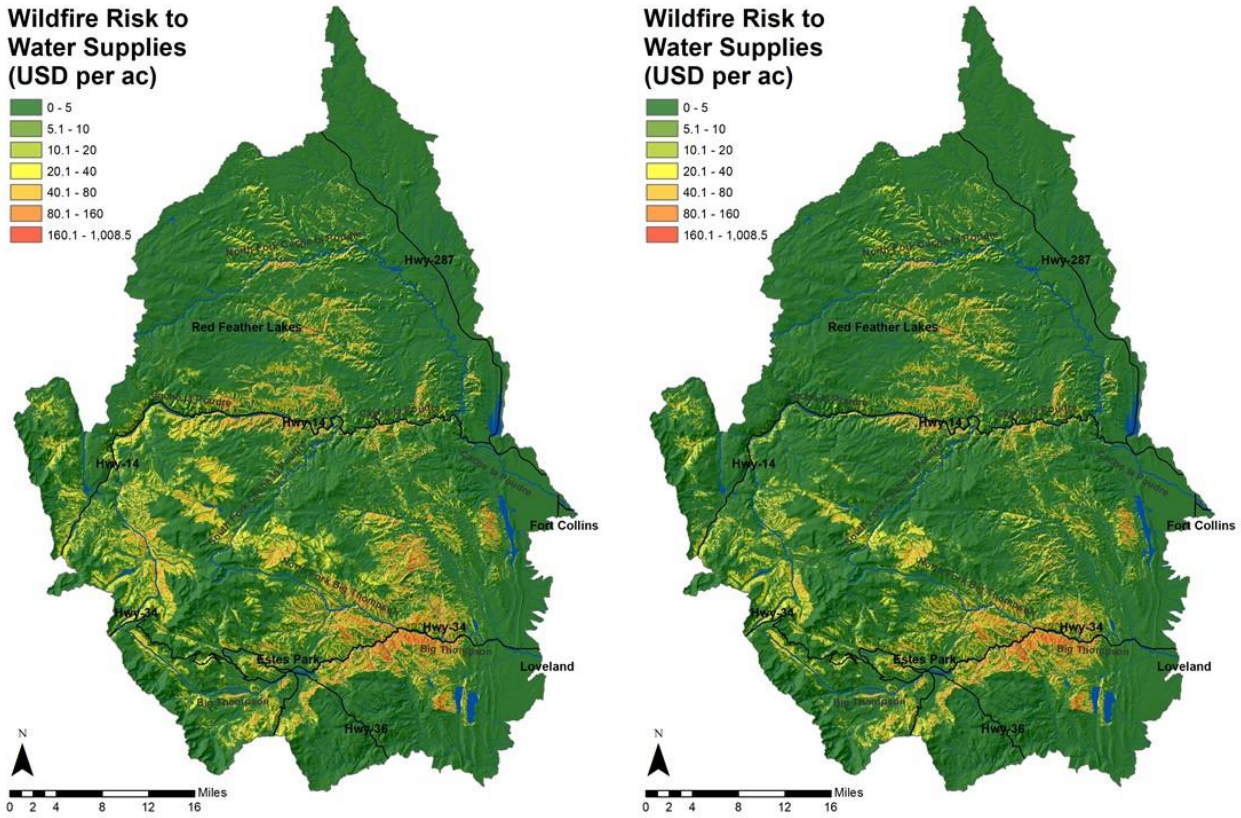

Figure 6: Wildfire risk to water supplies for the full Peaks to People planning area before (LEFT) and after the 2020 updates (RIGHT).

Fuel treatment priorities for full planning area

For the full planning area, we maintained the current risk reduction goals to define priority levels (Table 7). There are slight shifts in priority away from areas that burned in the Cameron Peak Fire and the East Troublesome Fire. The most prominent changes are in the Upper Poudre.

Table 7: Mapping of subjective priority levels to percent risk reduction goals.

Priority	Percent Reduction (%)
Highest	10
Higher	25
High	50

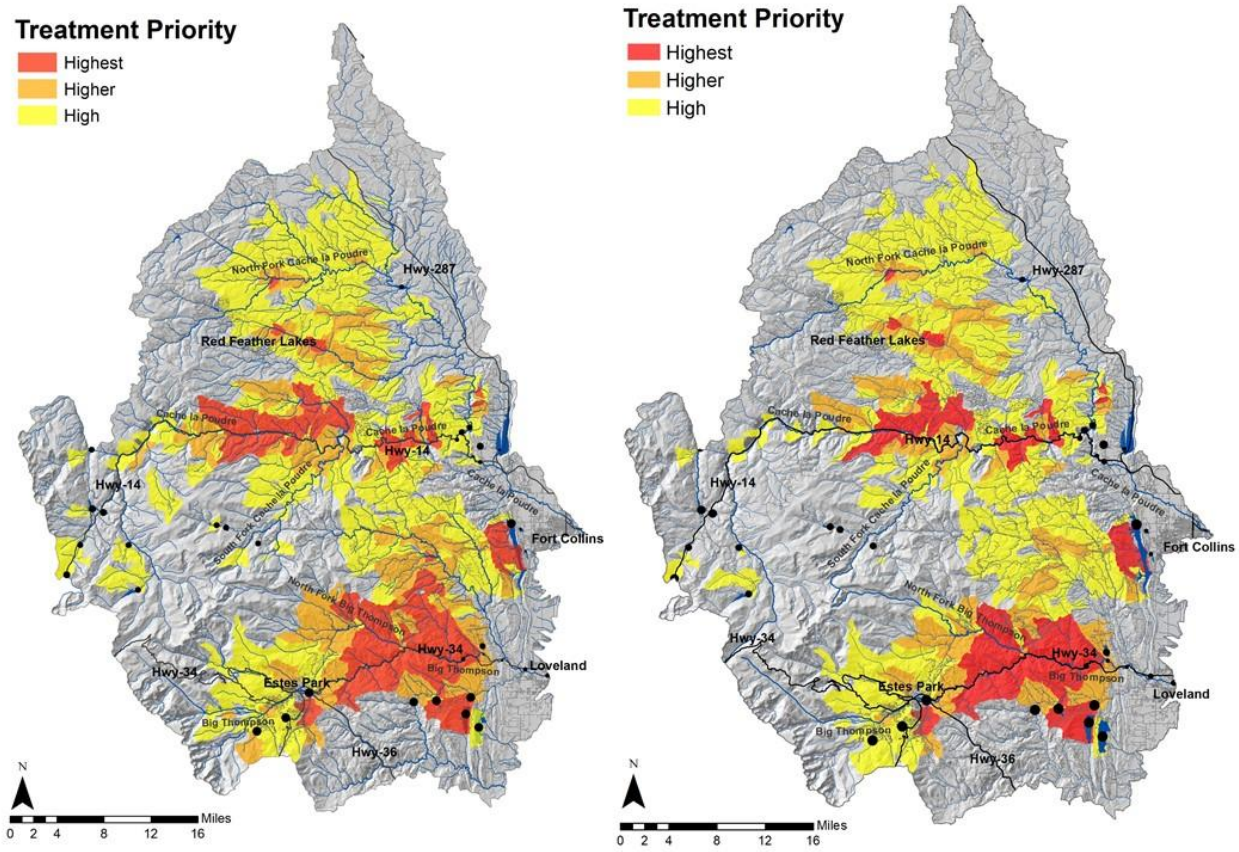

Figure 7: Treatment priorities for the full Peaks to People planning area before (LEFT) and after the 2020 updates (RIGHT). Priority levels (highest, higher, and high) are based on goals of 10, 25, and 50% risk reduction.

Fuel treatment priorities for the Big Thompson Initiative

Several quantitative targets were established for the Big Thompson Initiative before the 2020 wildfire season. In the short-term, the impacts of these fires on the watershed are expected be negative, but the fuels reduction should benefit long-term risk. As noted in Table 6, we estimate a reduction in long-term risk amounting to $152,635. The previous target risk reduction goal for the Big Thompson Initiative was $1,013,309. The remaining $860K of risk reduction is roughly equivalent to aiming to reduce 49% of the remaining risk (compared to 53% for the original assessment). This translates to lower forest management costs and fewer acres in need of treatment to reach the goal (Table 8).

The new percent risk reduction targets are presented in Table 9 and the associated spatial priorities are shown in Figure 8. The general patterns are the same with a few localized changes. The two catchments within Rocky Mountain National Park that were affected by the East Troublesome Fire are no longer priorities. The same goes for catchments in the north-central portion of the watershed that were affected by the Cameron Peak Fire. Several catchments that were not burned in 2020 were also removed from the priority map in response to lowering the risk reduction goal. These areas no longer require treatment to

reach the risk reduction target. The key performance metrics for the Big Thompson Initiative priority areas are presented in Table 10.

Table 8: Program-level summary metrics from the priority level areas before and after the 2020 updates.

Condition	Percent of Total Risk Reduction	Percent of Maximum Feasible Risk Reduction	Risk Reduction ($)	Budget	Treated area (ac)
Before updates	10	17.0	191,288	3,036,852	2,119
	25	42.6	477,976	16,253,005	10,673
	53	90.2	1,013,309	91,508,831	37,309
After updates	10	17.1	176,115	2,702,160	1,964
	25	42.6	439,817	14,567,458	9,461
	49	83.5	862,042	66,596,781	28,133

Table 9: Mapping of subjective priority levels to percent risk reduction goals for the original and revised assessments.

Priority	Original Percent Reduction (%)	Revised Risk Reduction (%)
Highest	10	10
Higher	25	25
High	53	49

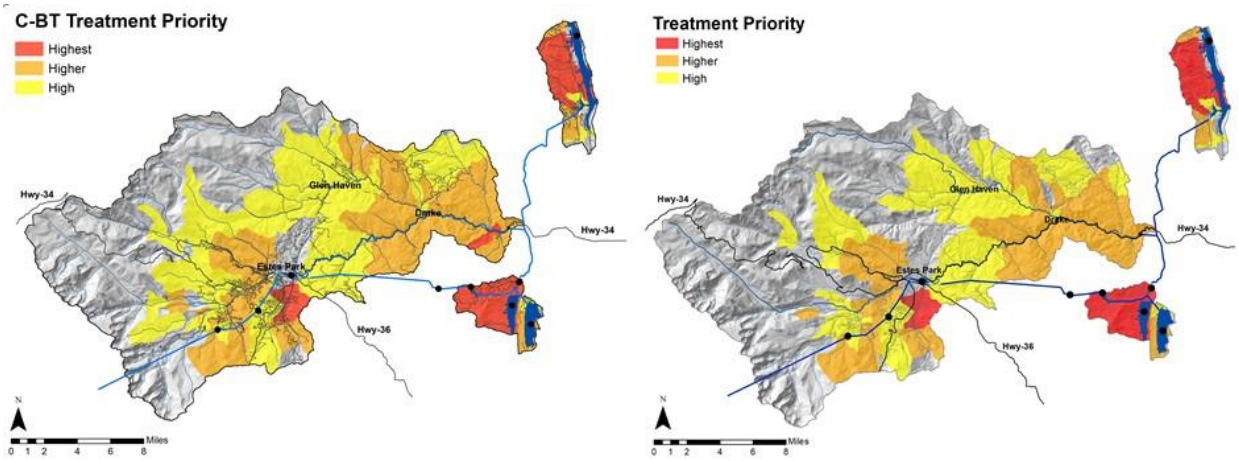

Figure 8: Treatment priorities for the Big Thompson Initiative planning area before (LEFT) and after the 2020 updates (RIGHT). Priority levels (highest, higher, and high) are based on goals of 10, 25, and 53% risk reduction for the original plan and goals of 10, 25, and 49% risk reduction for the revised plan.

Table 10: Key performance indicators for the Big Thompson Initiative priority treatment areas.

Outcomes Tracker Name	**Value**
Fuels Reduction/Forest Restoration (acres)	28,133
Conditional reduction in erosion (metric tons)	1,194,214
Expected reduction in erosion (metric tons)	179,896
Conditional reduction in sediment delivered to streams (metric tons)	614,416
Expected reduction in sediment delivered to streams (metric tons)	93,683
Conditional reduction in sediment delivered to water supplies (metric tons)	544,875
Expected reduction in sediment delivered to water supplies (metric tons)	83,345
Conditional reduction in sediment costs to water supplies ($)	8,348,065
Expected reduction in sediment costs to water supplies ($)	861,653
Active Crown Fire Reduced (ac)	21,974
Parks and open space protected from wildfire (acres)	2,101
Crucial wildlife habitat protected from wildfire (acres)	17,096
Homes within influence zone of treatments (homes) – duplicates removed	13,449
Trails protected from wildfire (miles)	233
Conditional reduction in home loss (homes)	894
Expected reduction in home loss (homes)	59
Conditional reduction in home loss ($)	293,047,693
Expected reduction in home loss ($)	19,198,549

References

Short KC, Finney MA, Vogler KC, Scott JH, Gilbertson-Day JW, Grenfell IC (2020) Spatial datasets of probabilistic wildfire risk components for the United States (270m). 2nd edition. USDA Forest Service Research Data Archive. (Fort Collins, CO, USA) doi:10.2737/RDS-2016-0034-2

Thompson MP, Vaillant NM, Haas JR, Gebert KM, Stockmann KD (2013) Quantifying the potential impacts of fuel treatments on wildfire suppression costs. *Journal of Forestry* **111**, 49–58. doi:10.5849/jof.12-027