Using IFT-FOFEM: An example of comparing emissions

Overview & Background

Modeling the consumption of fuels and subsequent emissions is an important step in planning for smoke management. Running fuel consumption and emission production in IFTDSS can provide insight into potential emissions generated when a given area burns, as well as gauging the emissions impacts of fuels treatments by modeling consumption using pre and post treatment fuels data. There are two options for modeling fuel consumption and emissions in IFTDSS.

1) FOFEM: First Order Fire Effects Model: A consumption, emission, and fire effects model based on the BurnUp model (Albini 1994), fuel loading, moisture content, region, season, and other variables. IFT-FOFEM can be populated with different inputs for different simulations, and is intended to be used at the stand-level.

2) Consume: A decision-making tool designed to assist planning for prescribed burns and wildfires using realistic fuels data. Consume predicts fuel consumption, pollutant emissions, and heat release based on fuel characteristics, lighting patterns, fuel moistures and other environmental variables. Consume includes separate equations for calculating consumption of activity and natural fuels. Consume may be used to generate consumption and emissions data across the landscape, while Consume for Activity Fuels or Natural fuels may be used to generate information on the stand-level.

This tutorial will focus on predicting consumption and emissions using FOFEM and provides information and step by step instructions on the following:

- Setting up a project
- Selecting and Configuring FOFEM
- Acquiring data to run IFT-FOFEM

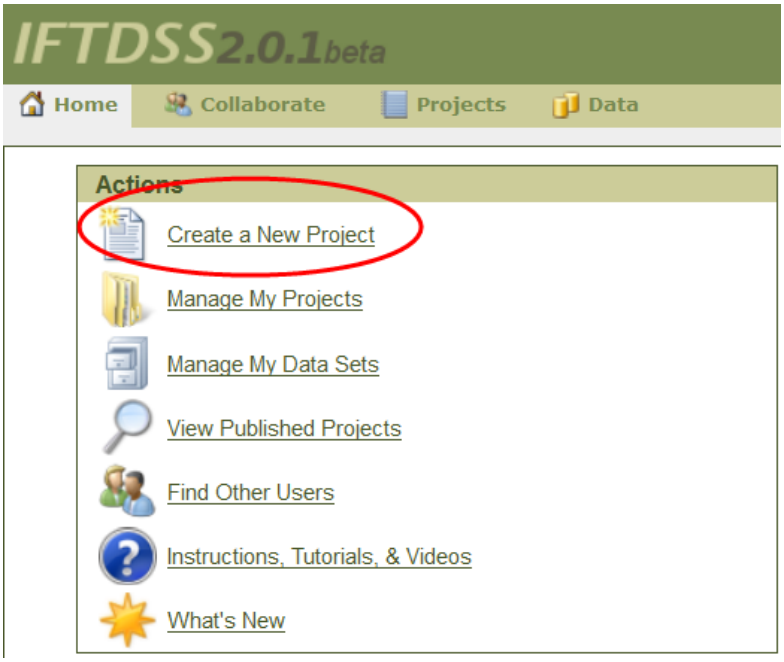
- Populating and running IFT-FOFEM
- Viewing Output and Summary Data
- Re-running and Comparing Runs
- Review and wrap-up

Note
We will begin by setting up a project area for this example, which contains several fuel cover types. To run IFT-FOFEM with more than one fuel type, you must run several simulations within the run, using one fuel type per scenario. This can be done as batch, so that one run produces results for numerous simulations. The results for IFT-FOFEM are displayed in tabular format, and summarized by charts, but not geospatially.

For this tutorial we will run IFT-FOFEM to compare the emissions that may result from consumption of fuel in an untreated stand, with those of a stand treated with prescribed fire.

Setting up the project

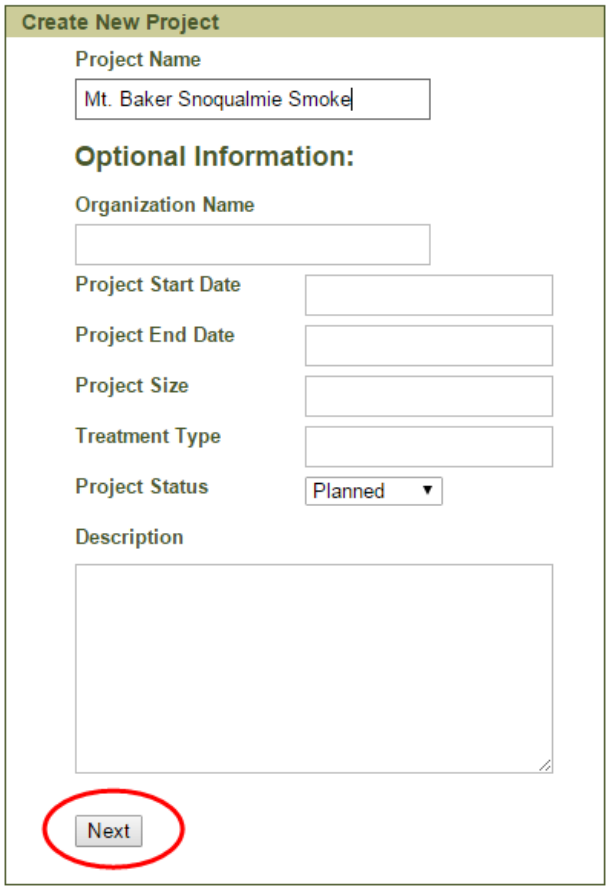
To begin, click **Create a New Project** from the actions menu.



Choose a descriptive project name.

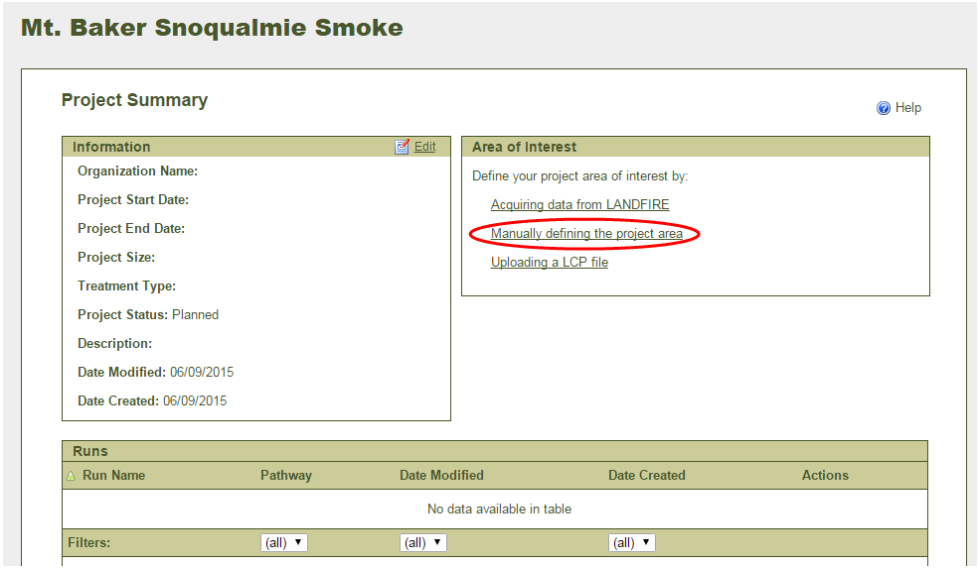
If desired, fill in the optional information.

Choose **Next**.



Upon clicking **Next** you will be taken to the workflow page. Before starting the workflow we will define the project area.

Click the **Projects** tab, at the top of the page, and select the Mt. Baker Snoqualmie Smoke project. In the Area of Interest window, choose to define your project area of interest by **Manually defining the project**.



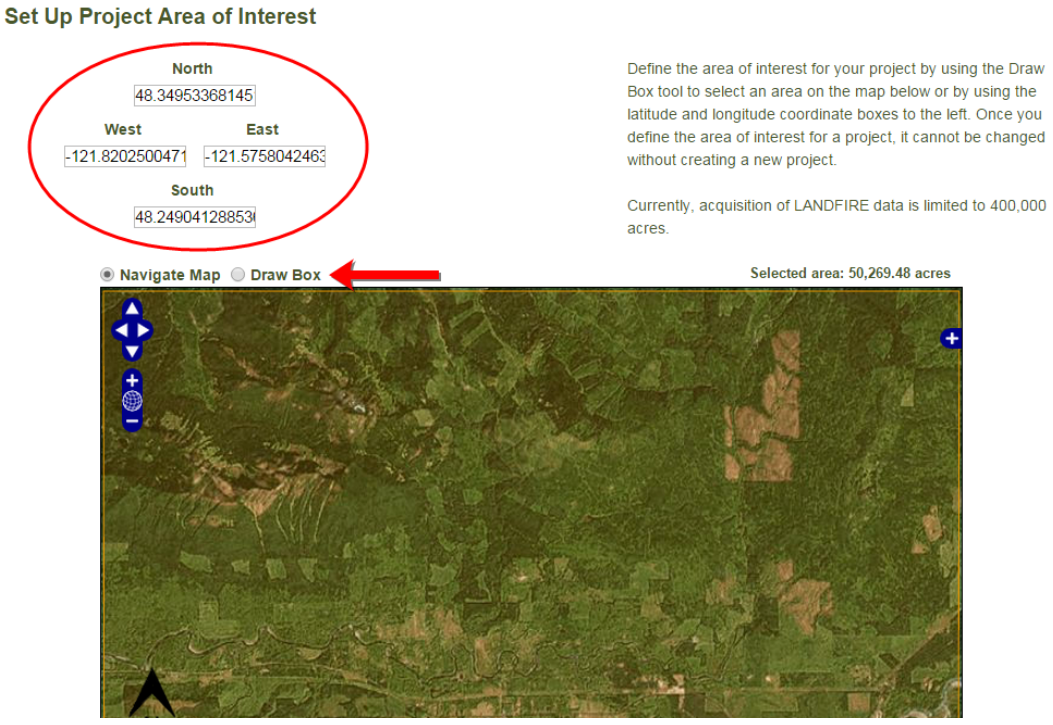
For this example, we will select the following coordinates

North: 48.34953368145102

South: 48.24904128853667

West: -121.8202500471653

East: -121.57580424635472



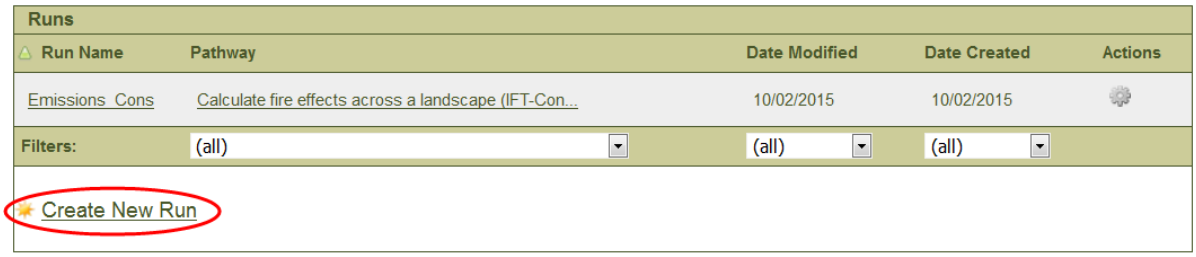
Note
You may also define your area of interest by selecting the **Draw Box** option and drawing your area of interest.

When finished, click **Next** at the bottom of the page, this will return you to the project summary page.

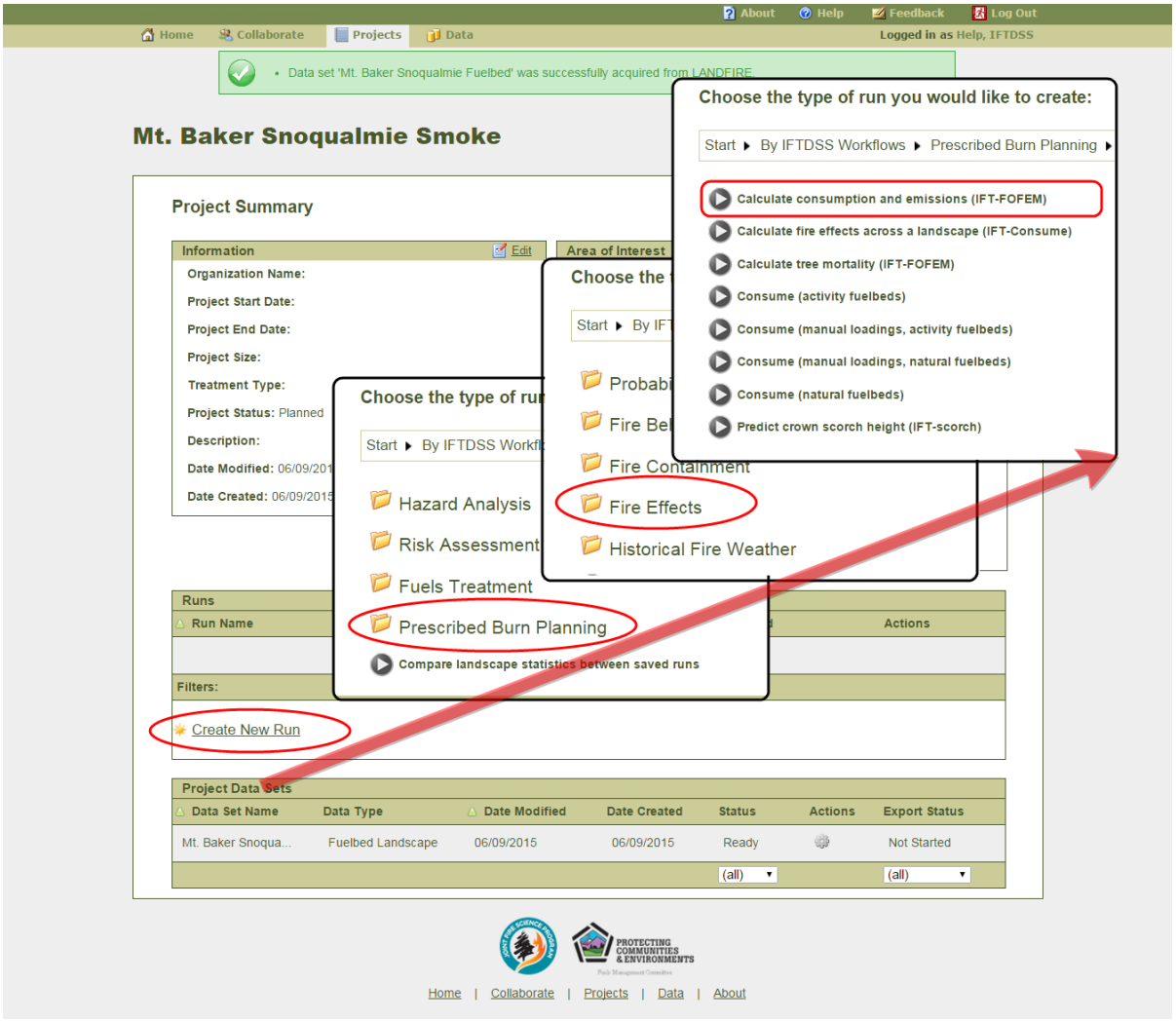
Note
While there are multiple stands and fuel types in a project area of this size, we will focus on comparing differing fuels in one stand to keep this tutorial brief. However, you may choose to represent multiple stands or multiple fuel types when running IFT-FOFEM.

Selecting and Configuring IFT-FOFEM from the IFTDSS workflows

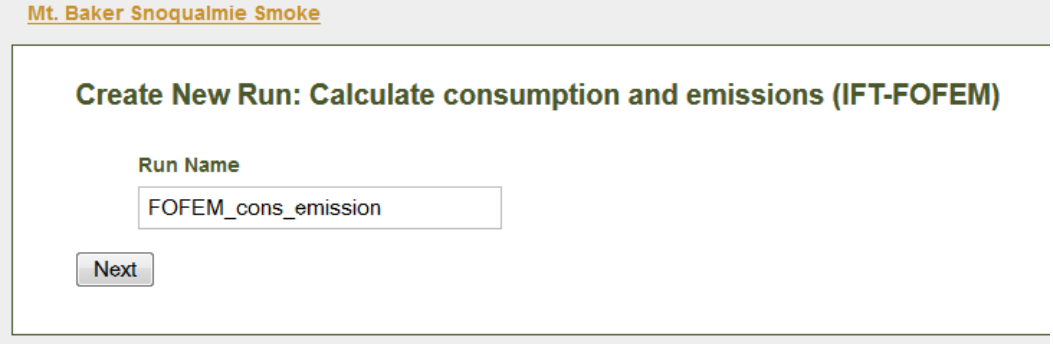
Select **Create New Run**from the **Project Summary** page



From the **Create New Run** menu, Select **Prescribed Burn Planning, Fire Effects, Calculate consumption and emissions (IFT-FOFEM)**.



Name your Run, ensure the coordinates are corrects, and click **Next.**

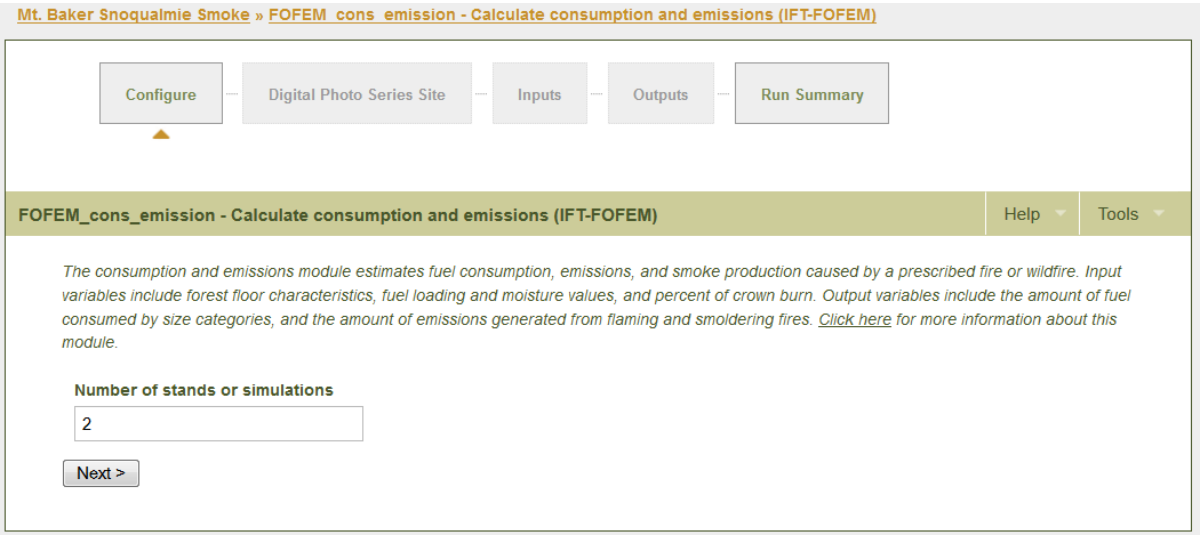


Next you will be prompted to configure the IFT-FOFEM run with the number of simulations.

For this example we will compare the emissions generated by untreated and treated fuels during a hypothetical summer fire in northwestern Washington. Specifically, we will compare emissions from two **simulations**, one using the original fuel loadings, and one in which a prior prescribed fire treatment had reduced duff, 100 hr, and coarse woody debris loadings by 50%, and litter, 1, and 10 hour fuel loadings by 75%.

Under the **number of simulations**, enter **2**. While we evaluate two simulations here, users may enter many different simulations.

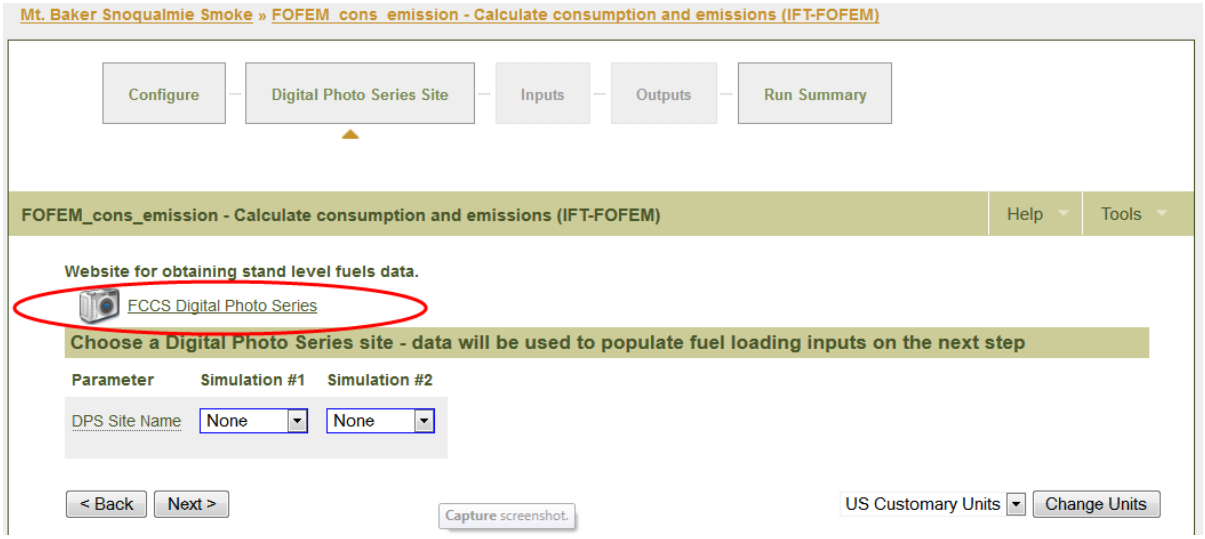
When finished, click **Next** to proceed.



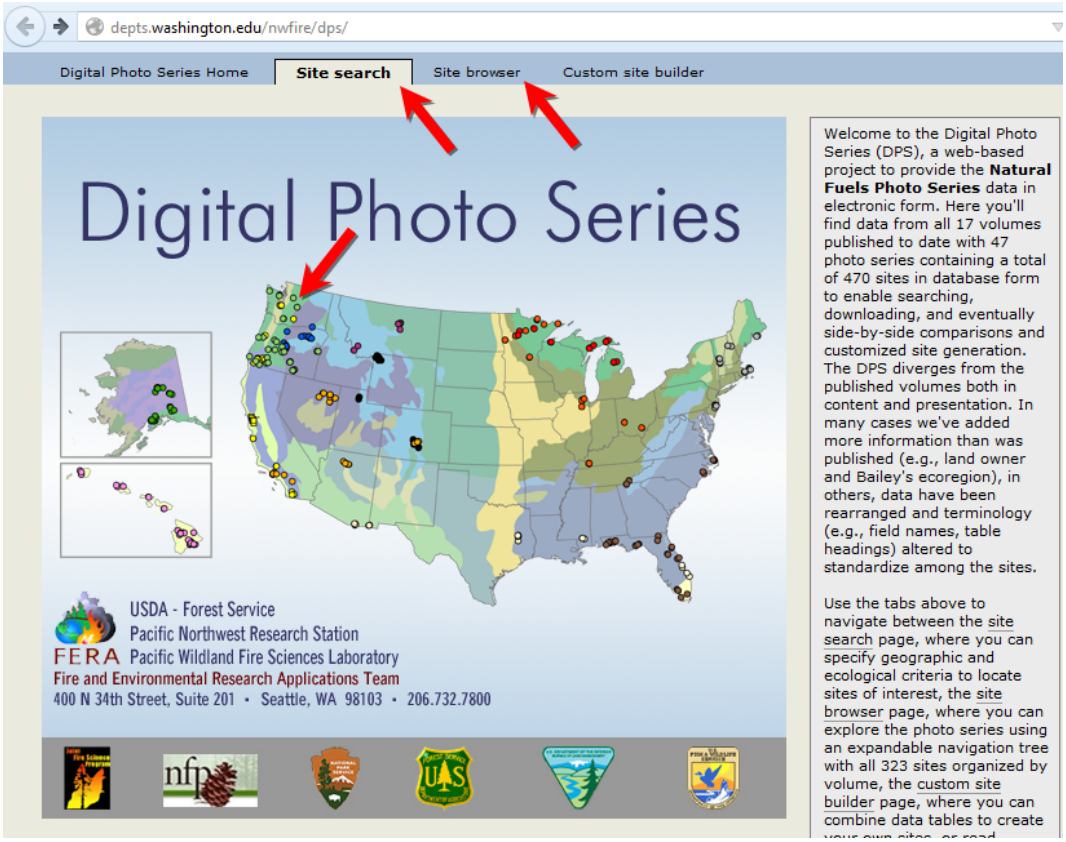
Acquiring data to run IFT-FOFEM

Next, you will be prompted to choose an **FCCS Digital Photo Series (DPS)** from which fuel loading will be drawn. If you have your own data, you may leave these blank and continue with the workflow, populating the fuel loadings without the DPS. For this example we will select a DPS.

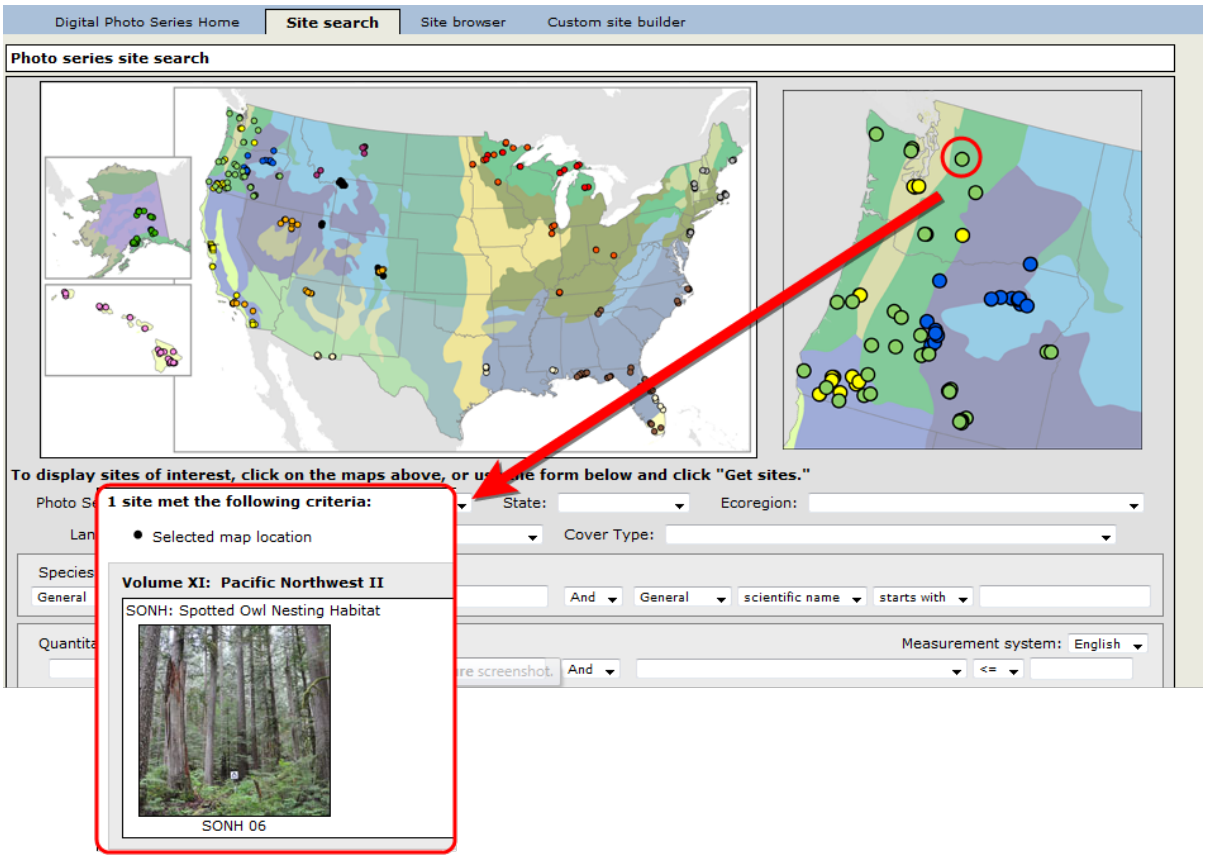
First, click on the **FCCS Digital Photo Series** option (circled in red) to see which DPS are available



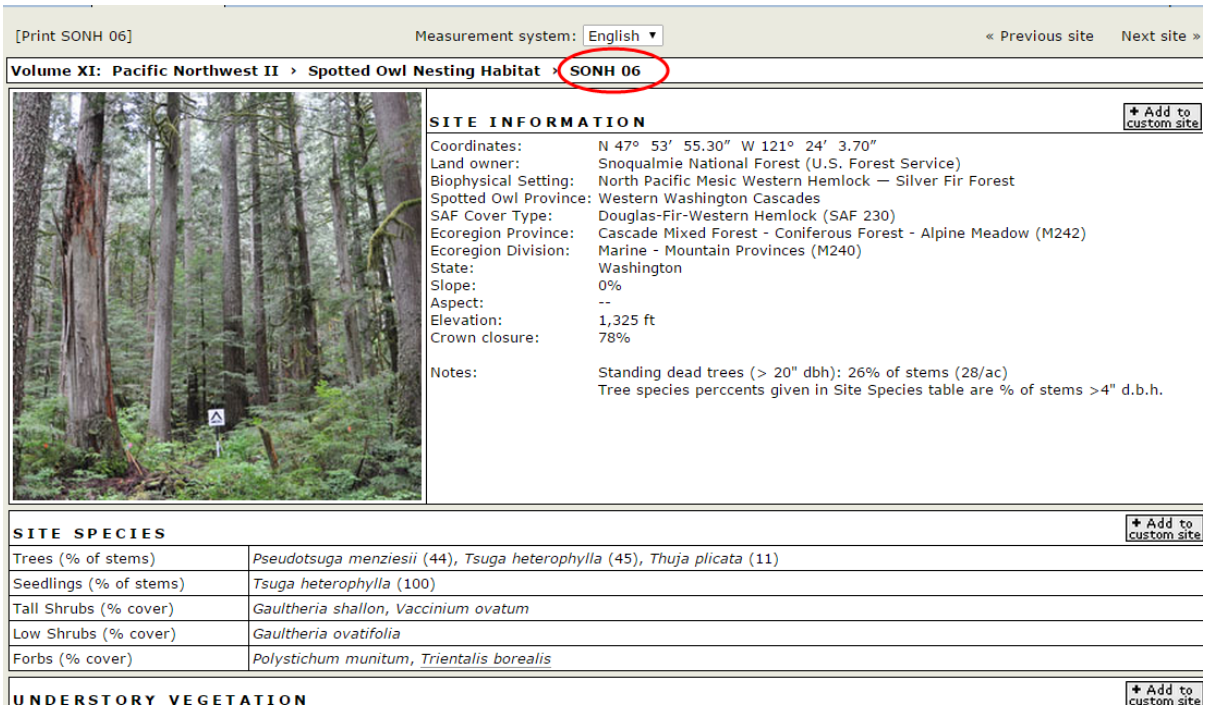
This will take you to a new page in your browser - the **Digital Photo Series** home page. Here, you may search for a specific site or browse for your site to obtain fuel loading data. You may also click on the sites indicated on the map.



Selecting **Site Search** brings up a national map with fuels sampling sites. For this example we will select the closest point to our stand (circled in red). Once a point is clicked upon, corresponding sites will appear at the bottom of the page.

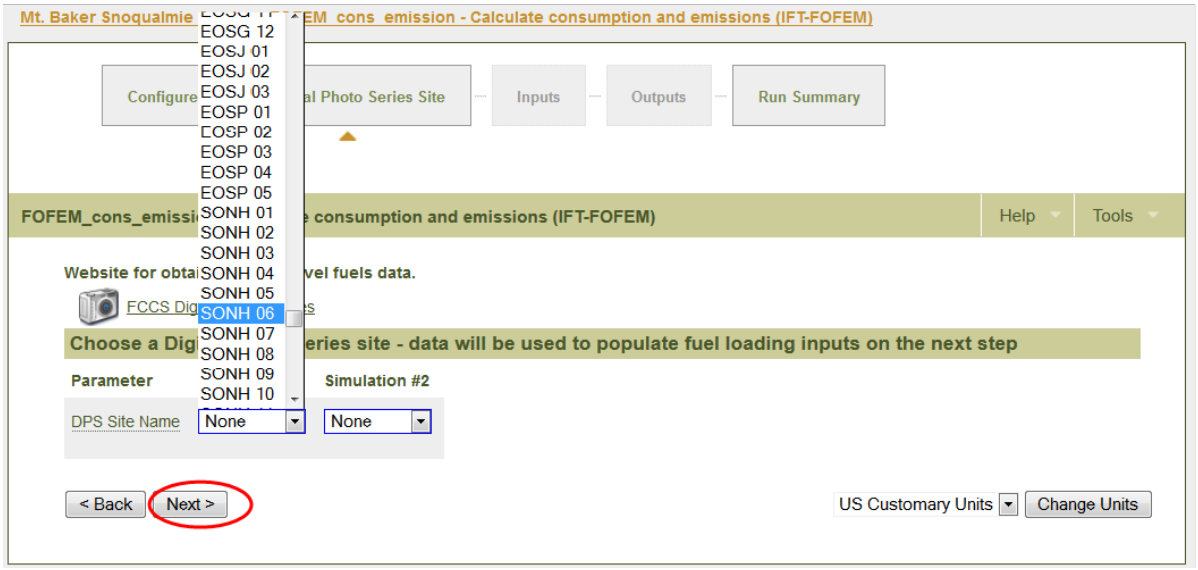


Clicking on the image of the site brings up the DPS number (circled in red), site information and fuel loading details.



Review the image, site information, and fuel loading data for your chosen site. If it matches your stand, note the **DPS number** and return to the IFTDSS Digital Photo Series page. In this example we will use the DPS **SONH 6**, a site dominated by Douglas fir, hemlock, and cedar.

Select the IFTDSS Digital Photo Series number from the dropdown menu for IFTDSS simulation 1. We will leave simulation 2 blank and input the changes in fuel loading manually in the next step. You may close the browser window containing the DPS website, it will no longer be needed. Select **Next** at the bottom of the page.


Mt. Baker Snoqualmie
EM_cons_emission - Calculate consumption and emissions (IFT-FOFEM)
Configure
al Photo Series Site
Inputs
Outputs
Run Summary
EOSG 12
EOSJ 01
EOSJ 02
EOSJ 03
EOSP 01
EOSP 02
EOSP 03
EOSP 04
EOSP 05
SONH 01
SONH 02
SONH 03
SONH 04
SONH 05
SONH 06
SONH 07
SONH 08
SONH 09
SONH 10
FOFEM_cons_emissi
e consumption and emissions (IFT-FOFEM)
Help
Tools
Website for obta
vel fuels data.
FCCS Dig
es
Choose a Dig
eries site - data will be used to populate fuel loading inputs on the next step
Parameter
Simulation #2
DPS Site Name
None
None
< Back
Next >
US Customary Units
Change Units

Populating and running IFT-FOFEM

For each scenario, environmental conditions, moisture, and fuel loading inputs are needed to run IFT-FOFEM. In the example below we will begin with the default fuel data acquired previously for simulation one, and reduce the fuel loadings in scenario two as per our post-prescribed fire loadings outlined earlier. Inputs needed to run FOFEM for emissions are summarized in the table below.

Input	Purpose
Environmental Inputs	
Region	Algorithm selection for shrub and duff consumption
Season	Predictive variable for herb and shrub consumption
Fuel category	Algorithm selection for duff calculation
Cover group	Algorithm selection for herb, shrub, and duff consumption
Percent of crown burn	Determines quantity of foliage consumed
Fuel Moisture	
Duff moisture method	Input to specify the degree of consumption
10 hr woody fuel moisture	
1000 hr woody fuel moisture	
Duff moisture	
Above Ground Fuels	
Crown foliage fuel loading	Input for calculating above ground fuel consumption
Crown branch fuel loading	
Shrub fuel loading	
Herbaceous fuel loading	
Woody Fuel Loading	

Input	Purpose
1 hr woody fuel loading	Input for calculating woody fuel consumption
10 hr woody fuel loading	
100 hr woody fuel loading	
1000 hr sound woody fuel loading 3-6 in.	
1000 hr sound woody fuel loading 6-9 in.	
1000 hr sound woody fuel loading 9-20 in.	
1000 hr sound woody fuel loading 20+ in.	
1000 hr rotten woody fuel loading 3-6 in.	
1000 hr rotten woody fuel loading 6-9 in.	
1000 hr rotten woody fuel loading 9-20 in.	
1000 hr rotten woody fuel loading 20+ in.	
Ground Fuels	
Litter fuel loading	Input for calculating ground fuel consumption
Duff fuel loading	
Duff depth	

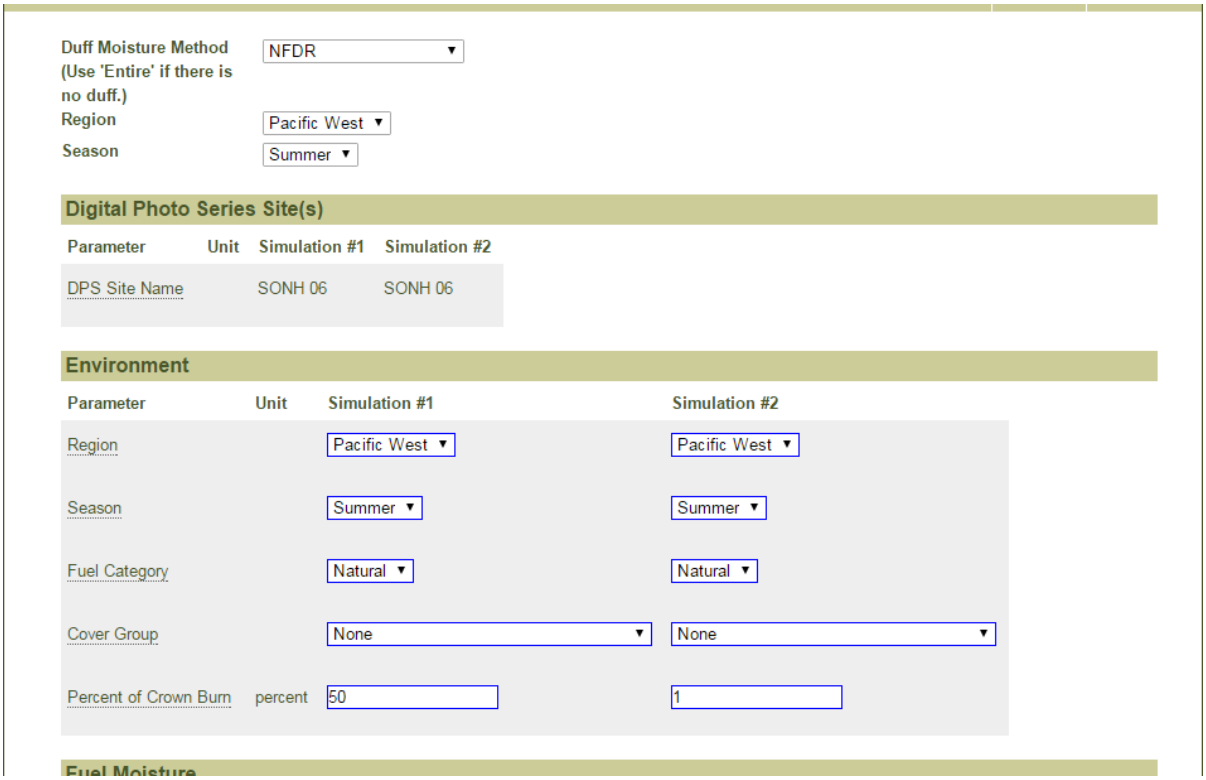
Environmental inputs

To ensure the correct consumption equations are used, information on environmental inputs must be provided. For both simulations in this example, set the **region** to **Pacific West** and the **Season** to **summer**, to evaluate the results of a fire ignited over the summer. Because the area in question is natural, rather than activity fuels, set the **Fuel category** to **Natural**.

The Cover Group[1] determines the equations used by the run to calculate fire effects. '**None**' was chosen for this example as none of the choices adequately described the example area.

The percent of crown burn expected from a fire will likely need to come from experience, or local expertise. For this hypothetical example, we will assume a fire burning through the untreated simulation will result in **50% crown burn**, while the percent crown burn resulting from the post-treatment simulation 2 is set to **1%**.

Note
The value for Percent of Crown Burn must be between 1 and 100



[1]When you select a cover group in the consumption and emissions module (IFT-FOFEM), that determines the equations the module uses to calculate fire effects. These equations are based on cover types; for example, Pocosin (PC) or Ponderosa (PN). IFTDSS uses FOFEM desktop's batch mode functionality; IFTDSS does not have the direct links to the SAF/SFM, NVCS, or FCC cover classifications that are present in FOFEM desktop. In IFTDSS, you select a cover group directly based on the broad general cover groups. In FOFEM desktop, you select a SAF/SFM, NVCS, or FCC cover type, which is then mapped to a cover group. If your desired cover type does not fit into one of the cover groups provided, select "none" to use the general consumption algorithms.

Fuel moisture inputs

For this example we will set the moisture parameters equal for both simulations, since we are primarily concerned with the emission differences resulting from the fuels. Duff moisture method, in part, determines the equations used by FOFEM. Choices for duff moisture methods include **Entire**, **Lower**, **NFDR**, **Adj_NFDR**. For this example we'll assume duff moisture was calculated using the National Fire Danger Rating method, so we will select **NFDR** for **Duff Moisture Method**.

To represent extremely dry conditions we will set the **10-hr Woody Fuel Moisture** to **3%** and the **1000-hr Woody Fuel Moisture** and **Duff Fuel Moisture** to **11%**, for both simulations.

Fuel Moisture

Parameter	Unit	Simulation #1	Simulation #2
Duff Mositure Method		NFDR	NFDR
10-hr Woody Fuel Moisture	percent	3	3
1000-hr Woody Fuel Moisture	percent	11	11
Duff Fuel Moisture	percent	11	11

Note
Duff moisture method, in part, determines the equations used by FOFEM. For more information on duff moisture methods and FOFEM consult Reinhardt et al. 1997.

Above Ground Inputs

For above ground fuel loading, simulation 1 has been automatically filled by IFTDSS based upon the selection of Digital Photo Series Site **SONH 6**. We will assume the same crown foliage, branch, and herbaceous loading for both simulations, and half the shrub loading on the post-treatment simulation 2.

Above Ground Fuels

Parameter	Unit	Simulation #1	Simulation #2
Crown Foliage Fuel Loading	tons/ac	0.0080	0.0080
Crown Branch Fuel Loading	tons/ac	0.00	0.00
Shrub Fuel Loading	tons/ac	0.46	0.23
Herbaceous Fuel Loading	tons/ac	0.0200	0.0200

Woody Fuel Inputs

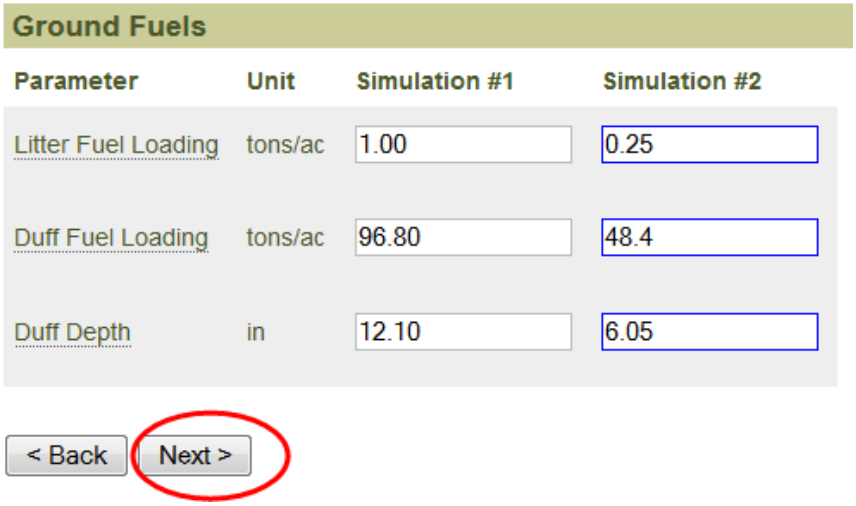
Woody fuel loadings for simulation 1 have been automatically filled by IFTDSS based upon the selection of Digital Photo Series Site **SONH 6**. For simulation 2, we'll assume 75% reduction of simulation 1 loading for 1 and 10-hr fuels, and 50% reduction for all other fuels loadings; this will represent post prescribed burn conditions in Simulation 2.

Woody Fuels

Parameter	Unit	Simulation #1	Simulation #2
1-hr Woody Fuel Loading	tons/ac	0.60	0.15
10-hr Woody Fuel Loading	tons/ac	1.90	0.475
100-hr Woody Fuel Loading	tons/ac	3.30	1.65
1000-hr Sound Woody Fuel Loading 3-6 in.	tons/ac	0.78	0.39
1000-hr Sound Woody Fuel Loading 6-9 in.	tons/ac	0.52	0.26
1000-hr Sound Woody Fuel Loading 9-20 in.	tons/ac	5.60	2.80
1000-hr Sound Woody Fuel Loading 20+ in.	tons/ac	4.10	2.05
1000-hr Rotten Woody Fuel Loading 3-6 in.	tons/ac	5.04	2.52
1000-hr Rotten Woody Fuel Loading 6-9 in.	tons/ac	3.36	1.68
1000-hr Rotten Woody Fuel Loading 9-20 in.	tons/ac	29.80	14.9
1000-hr Rotten Woody Fuel Loading 20+ in.	tons/ac	52.80	26.4

Ground Fuel Inputs

Ground fuel loadings for simulation 1 have been automatically filled by IFTDSS based upon the selection of Digital Photo Series Site SONH 6. For simulation 2, we'll assume 75% reduction of litter loadings and a 50% reduction of duff loading and depth to represent post prescribed burn conditions. When these selections are made, click **Next**.

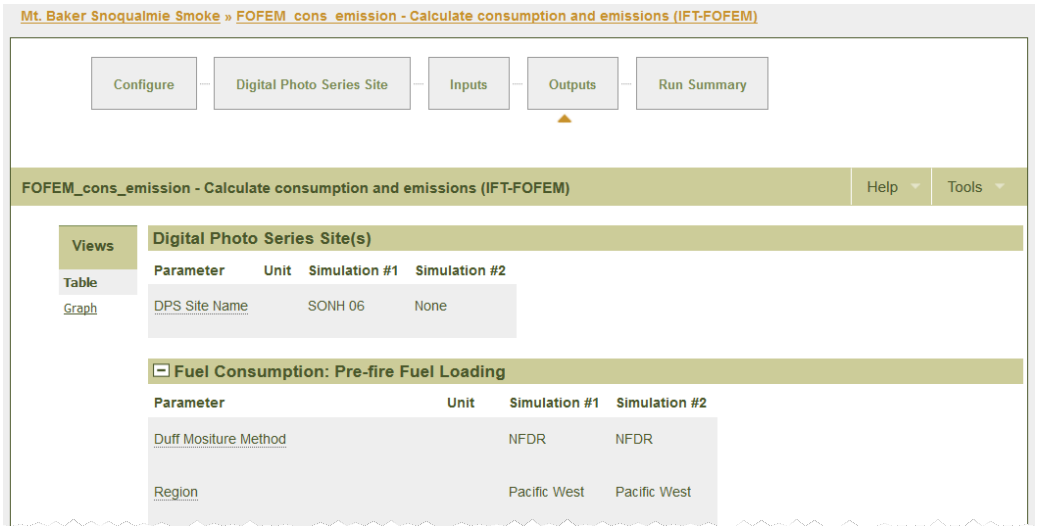

Ground Fuels
Parameter
Unit
Simulation #1
Simulation #2
Litter Fuel Loading
tons/ac
1.00
0.25
Duff Fuel Loading
tons/ac
96.80
48.4
Duff Depth
in
12.10
6.05
< Back
Next >

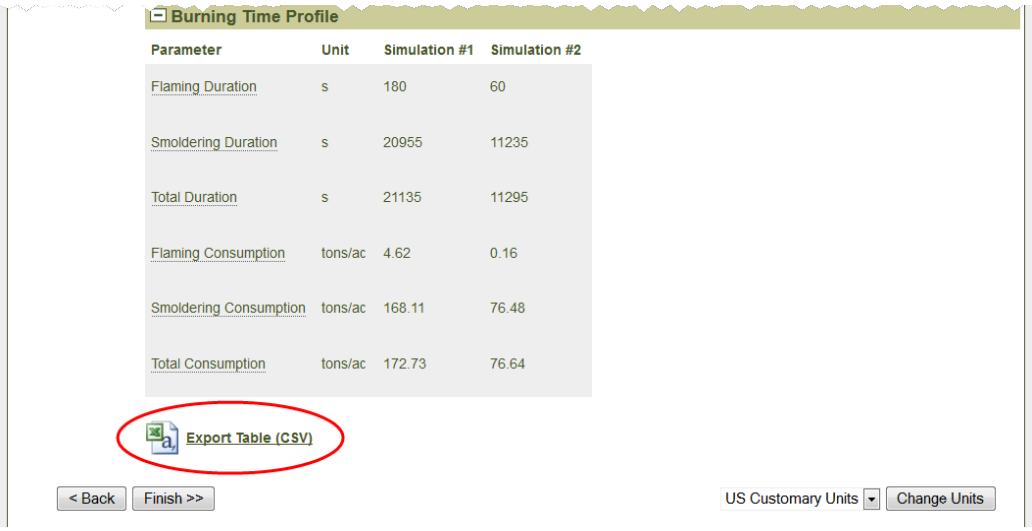
Viewing output and summary data

Emission outputs are listed in the table below. For details on all the outputs provided by IFT-FOFEM, consult the IFT-FOFEM outputs topic.

Emissions Outputs
Carbon dioxide (CO_2)generated during flaming and smoldering combustion phases.
Carbon monoxide(CO) generated during flaming and smoldering combustion phases.
Methane (CH_4) generated during flaming and smoldering combustion phases.
Nitrogen oxides (NO_x)generated during flaming and smoldering combustion phases.
Particulate matter 10 (PM_{10}) Carbon dioxide generated during flaming and smoldering combustion phases.
Particulate matter 2.5 ($PM_{2.5}$) generated during flaming and smoldering combustion phases.
Sulfur dioxide (SO_2) generated during flaming and smoldering combustion phases.

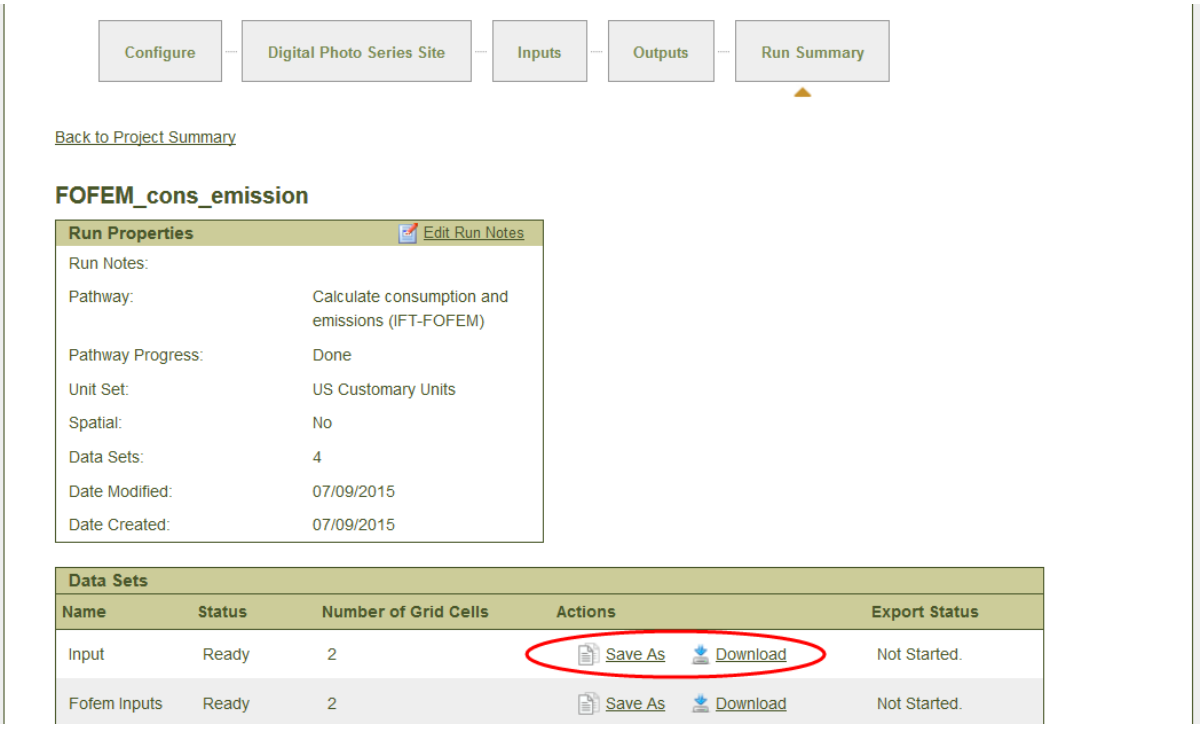
When the model is finished running, you can view the outputs as a table or export them to an Excel Spreadsheet as a CSV file.





Click finish to proceed to the **Run Summary** page.

On the summaries page you may choose to save the data from your model run, with other IFTDSS data files.



Scrolling down, there is also the option of saving the project run data as a CSV table, or downloading comparison charts for each parameter.

Downloadable Files

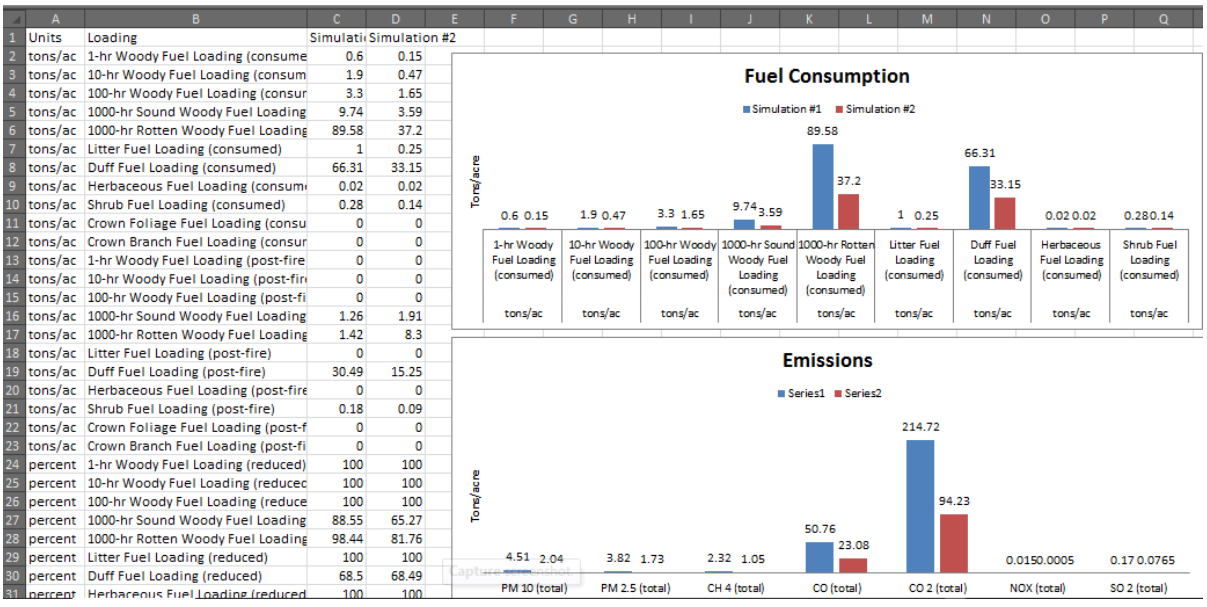
Show 10 entries Search:

Name	Type	Actions
fofem_table	Excel CSV	Download
chart.fofem_c.fuels.duffMoistureMethod	Chart	Download
chart.fofem_c.fuels.region	Chart	Download
chart.fofem_c.fuels.season	Chart	Download
chart.fofem_c.fuels.category	Chart	Download
chart.fofem_c.fuels.coverGroup	Chart	Download
chart.fofem_c.fuels.prefire.woody1hr	Chart	Download
chart.fofem_c.fuels.prefire.woody10hr	Chart	Download
chart.fofem_c.fuels.prefire.woody100hr	Chart	Download
chart.fofem_c.fuels.prefire.woody1kSound3	Chart	Download

(all)

Showing 1 to 10 of 91 entries First Previous 1 2 3 4 5 Next Last

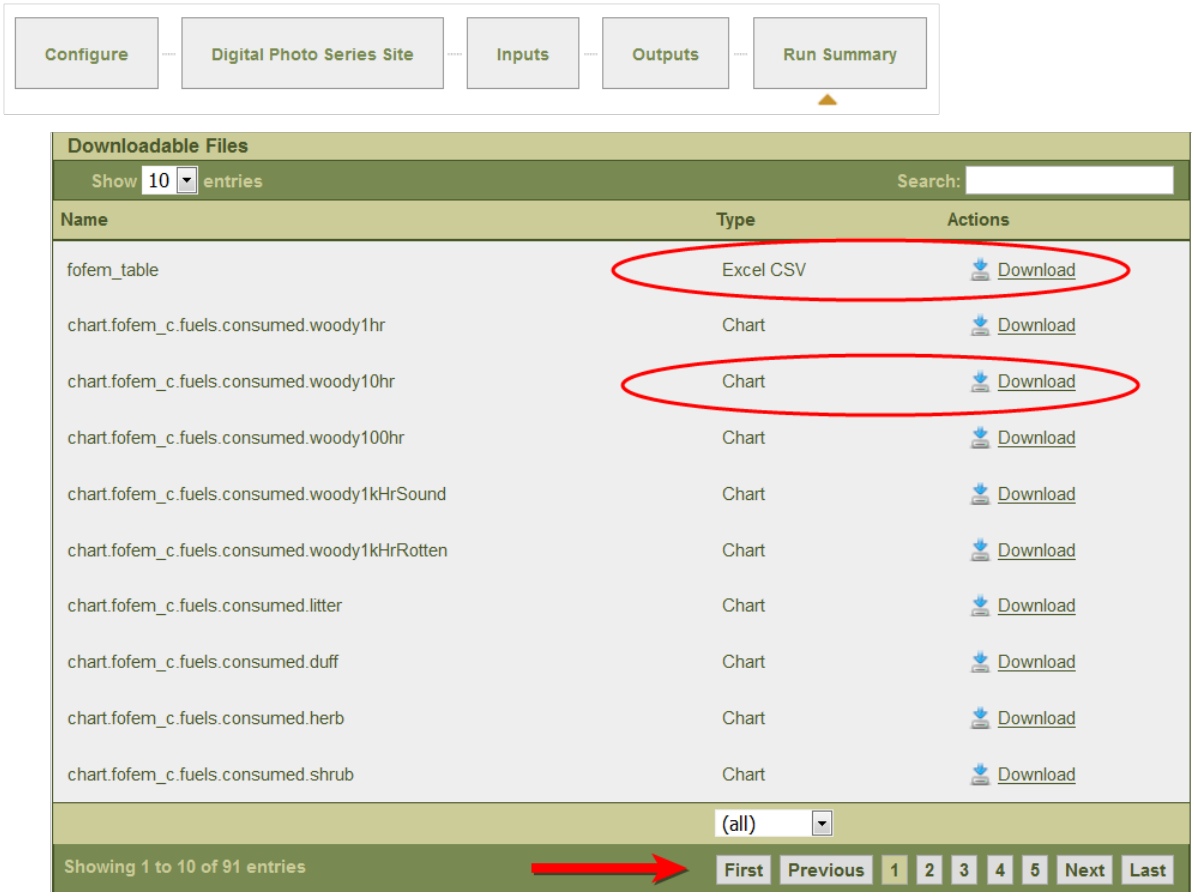
Saving a CSV table of the data allows for further analysis, or graphical representation.

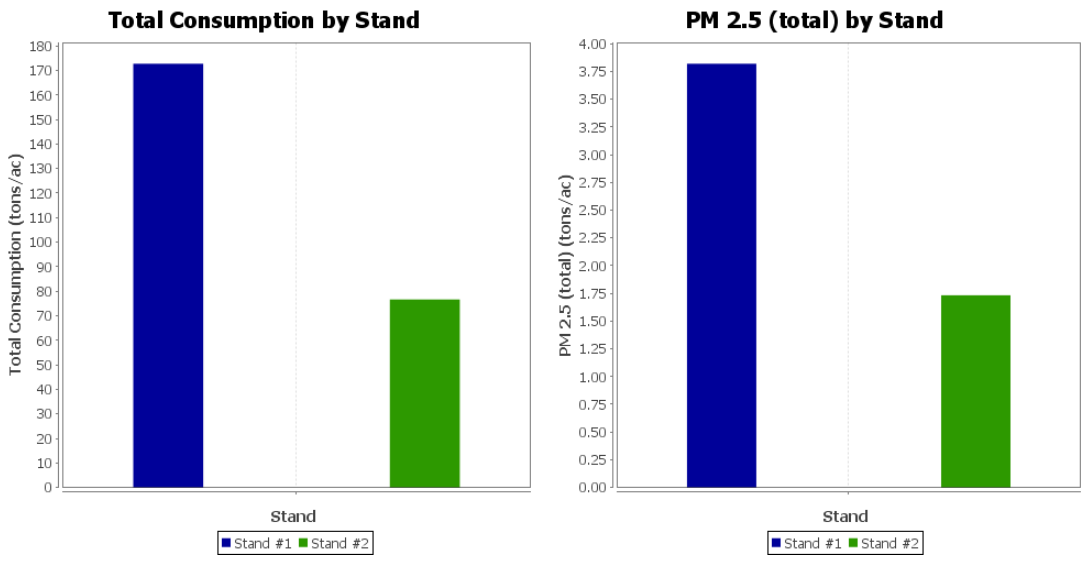


	A	B	C	D
1	Units	Loading	Simulati	Simulation #2
2	tons/ac	1-hr Woody Fuel Loading (consume	0.6	0.15
3	tons/ac	10-hr Woody Fuel Loading (consum	1.9	0.47
4	tons/ac	100-hr Woody Fuel Loading (consur	3.3	1.65
5	tons/ac	1000-hr Sound Woody Fuel Loading	9.74	3.59
6	tons/ac	1000-hr Rotten Woody Fuel Loading	89.58	37.2
7	tons/ac	Litter Fuel Loading (consumed)	1	0.25
8	tons/ac	Duff Fuel Loading (consumed)	66.31	33.15
9	tons/ac	Herbaceous Fuel Loading (consum	0.02	0.02
10	tons/ac	Shrub Fuel Loading (consumed)	0.28	0.14
11	tons/ac	Crown Foliage Fuel Loading (consu	0	0
12	tons/ac	Crown Branch Fuel Loading (consur	0	0
13	tons/ac	1-hr Woody Fuel Loading (post-fire	0	0
14	tons/ac	10-hr Woody Fuel Loading (post-fir	0	0
15	tons/ac	100-hr Woody Fuel Loading (post-fi	0	0
16	tons/ac	1000-hr Sound Woody Fuel Loading	1.26	1.91
17	tons/ac	1000-hr Rotten Woody Fuel Loading	1.42	8.3
18	tons/ac	Litter Fuel Loading (post-fire)	0	0
19	tons/ac	Duff Fuel Loading (post-fire)	30.49	15.25
20	tons/ac	Herbaceous Fuel Loading (post-fire	0	0
21	tons/ac	Shrub Fuel Loading (post-fire)	0.18	0.09
22	tons/ac	Crown Foliage Fuel Loading (post-f	0	0
23	tons/ac	Crown Branch Fuel Loading (post-fi	0	0
24	percent	1-hr Woody Fuel Loading (reduced)	100	100
25	percent	10-hr Woody Fuel Loading (reducec	100	100
26	percent	100-hr Woody Fuel Loading (reduce	100	100
27	percent	1000-hr Sound Woody Fuel Loading	88.55	65.27
28	percent	1000-hr Rotten Woody Fuel Loading	98.44	81.76
29	percent	Litter Fuel Loading (reduced)	100	100
30	percent	Duff Fuel Loading (reduced)	68.5	68.49
31	percent	Herbaceous Fuel Loading (reduced	100	100

For a quick graphic comparing specific parameters from each scenarios, you may find the IFTDSS-generated charts useful. These FOFEM output charts can be

downloaded in IFTDSS on the Run Summary page under Downloads. Note on the images below the word stand is used in place of simulation, but these are describing the same thing.





Note
There may be several pages of downloadable data. If you don't see your output of interest, check the other pages.

From the outputs generated, we can demonstrate the degree of emission reduction that would take place in the prescribed fire-treated scenario, represented by simulation 2, relative to the untreated scenario, represented by simulation 1.

In this example we compared two scenarios in one Run. But what if we needed to use numerous simulations to describe different fuel types across a large area? Using simulations to describe many different stands AND different treatment scenarios can become confusing. In such a circumstance it is better to use the simulations as stands, one for each fuel type. Then, run the simulations under pre-treatment specifications, save the outputs, and re-run the simulations under the post-treatment specifications. An outline of how to do this, is described in the next section.

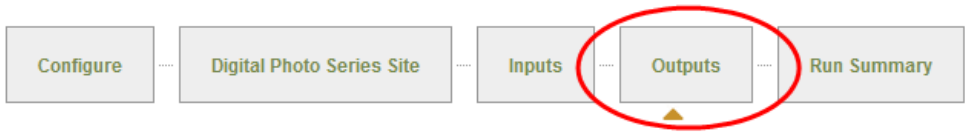
Comparing Runs

One of the strengths of IFTDSS is the ability to save run inputs and results to be compared against different fuel treatment outcomes, weather conditions, moisture conditions, etc. Here we will outline the steps needed to re-run different parameters in a run while not losing data.

When re-running parameters it is critical that you save copies of your run inputs and outputs before re-running, as they will be automatically be overridden when the new outputs are generated.

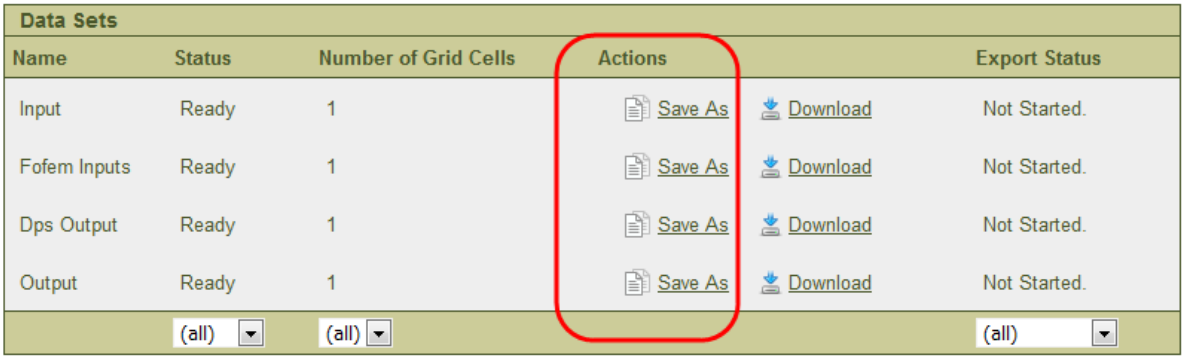
Saving Run Inputs and Outputs

Once you have completed an initial run, record and export all the data you wish to compare from the **Outputs** page.

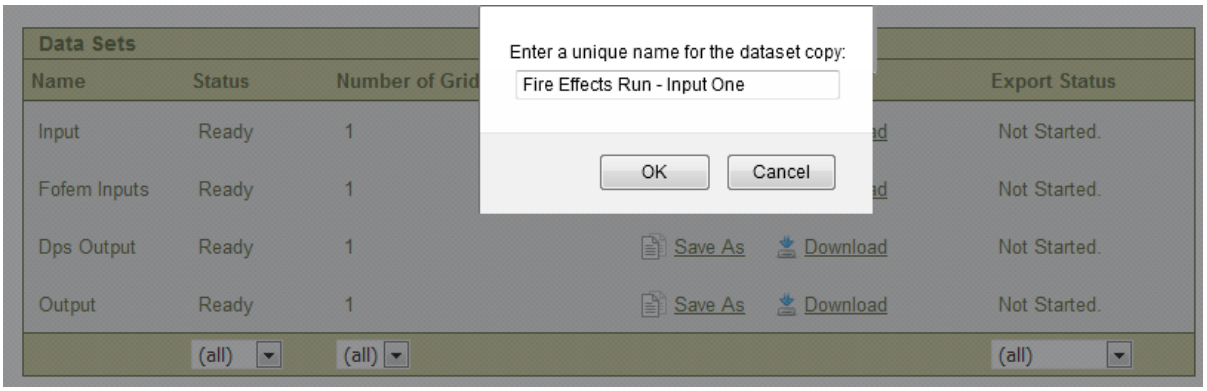


Next, proceed to the **Run Summary** page and save all the inputs and outputs for that run in case they are needed for future use.

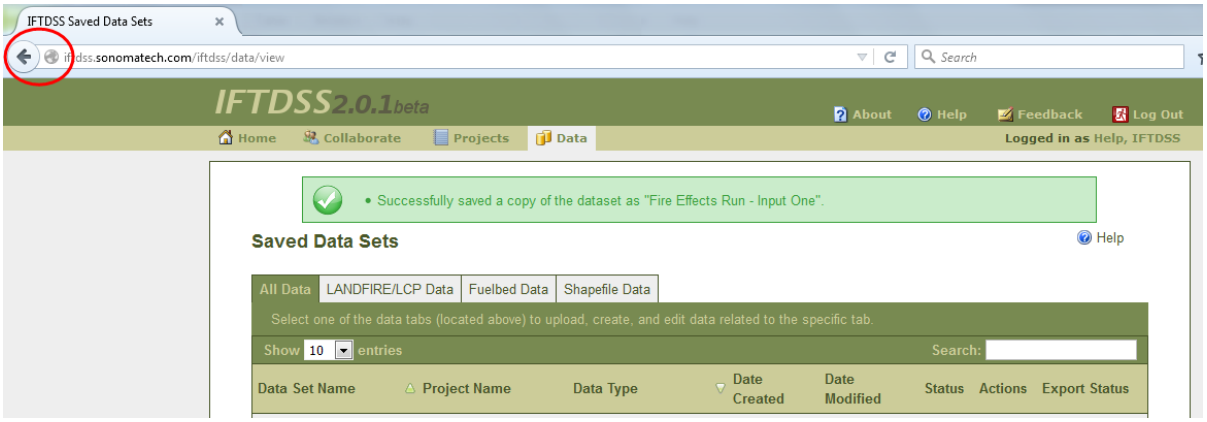
From the run summary page, ensure to save both the Inputs and the Outputs from the Run Data set section.



Be sure to save each set of inputs and outputs with a name that will be easy to recognize later.



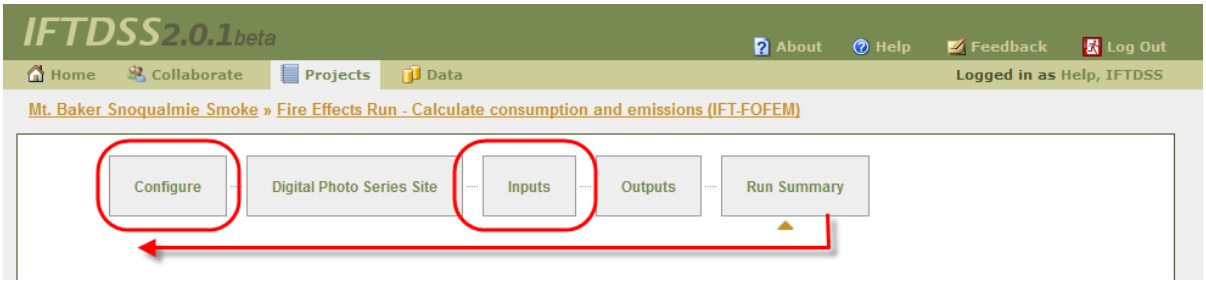
When the first data set is saved you will automatically be taken the Data Sets page. Use your browser back button to navigate back to the Run Summary page and continue saving each data set.



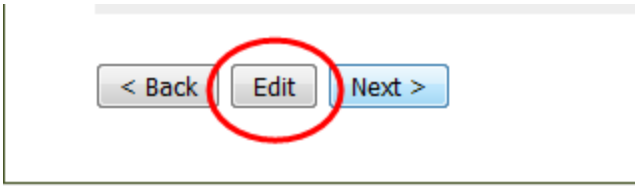
Ensure that all data sets from the run are saved.

Re-run and Save

Once all the inputs and data are saved from the initial run, you may use the top progress bar to navigate back to the desired stage in the run that requires alteration.



To start editing data click the **Edit** button at the bottom of the page.

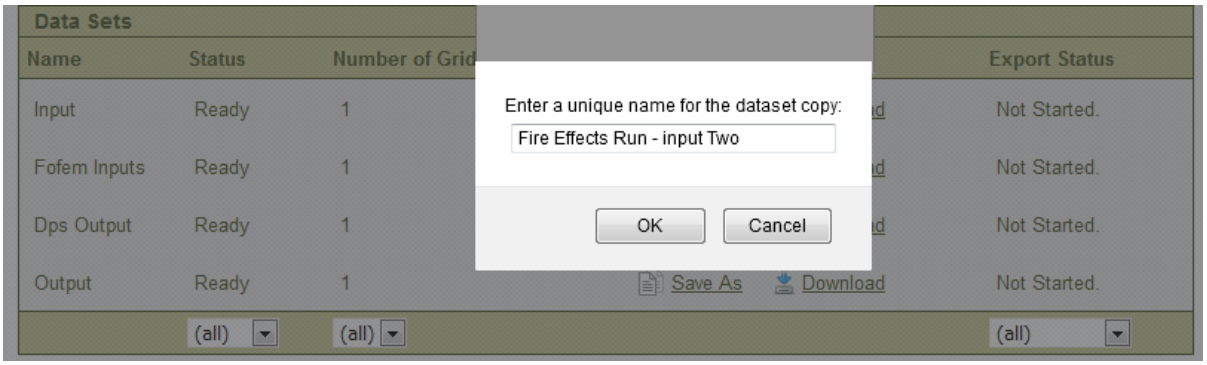


Once the alterations are made, click **Next** and proceed through the remainder of the Run until you are again at the **Outputs** page.

Like before, you can record or export all the outputs of interest and make your comparisons.

To save these inputs and outputs for future use, proceed to the **Run Summary** page and

save your altered inputs and outputs using a name that will be easily recognized.


Data Sets
Name
Status
Number of Grid
Export Status
Input
Ready
1
Not Started.
Fofem Inputs
Ready
1
Not Started.
Dps Output
Ready
1
Not Started.
Output
Ready
1
Save As
Download
Not Started.
(all)
(all)
(all)
Enter a unique name for the dataset copy:
Fire Effects Run - input Two
OK
Cancel

Review

In this tutorial we walked through the steps needed to predict consumption and emissions using IFT-FOFEM. The tutorial provided information and step by step instructions on:

- Setting up a project
- Selecting and Configuring FOFEM
- Acquiring data to run IFT-FOFEM
- Populating and running IFT-FOFEM
- Viewing Output and Summary Data
- Re-running and Comparing Runs

Additional Help

To navigate to additional tutorials in the IFTDSS online help content,

1. Click the **Help** button.
2. Then select **Getting Started (Tutorials and Videos)** from the side menu.

On that page, you'll find links to tutorials and videos on such topics as hazard analysis, prescribed burn planning, fuels treatment, spatial analysis across a landscape, and many more.