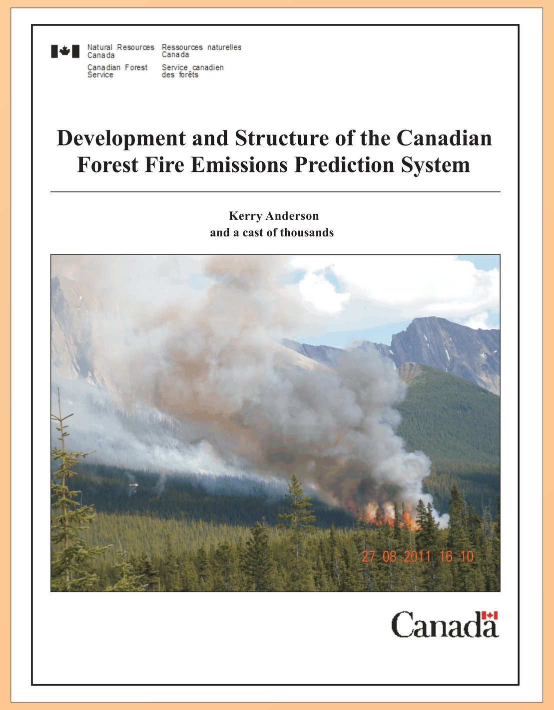

The Canadian Forest Fire Emissions Prediction System CFFEPS

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INTRODUCTION

The Canadian Forest Fire Emissions Prediction System, or CFFEPS, is a model being developed to predict emissions and smoke plume development.

The objective of the system is to provide estimates of smoke and particulate matter (PM2.5) concentrations for inclusion in the BlueSky Framework and used for smoke forecasting for Canada.

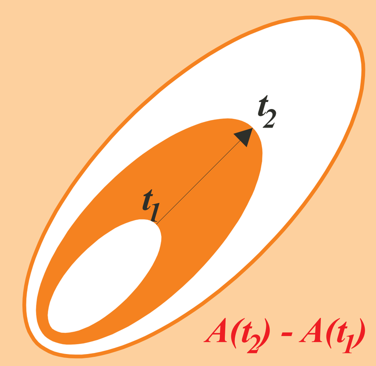
As a Canadian model, CFFEPS uses the Canadian Forest Fire Danger Rating System (CFFDRS), including the FWI and FBP systems.

The model also uses elements from CONSUME 3.0 developed by the US Forest Service.

This poster describes the methodology and the inputs used in the Canadian Forest Fire Emissions Prediction System (CFFPES).

FIRE GROWTH

Many of the calculations in the CFFEPS model depend on fire size. To determine this, the model uses a simple elliptical fire growth model to predict the area burned. Fuel type and wind direction are held constant.



The fire-growth model uses components of the CFFDRS to drive it:

The **Fine Fuel Moisture Code** (FFMC) is diurnally adjusted over time using the technique developed by Lawson et al. (1996).

The **Rate of Spread** (ROS) is calculated over the course of the day and from this the area growth.

The **Surface** and the **Total Fuel Consumption** (SFC and TFC) are then calculated for the area burned to estimate the amount of smoke emissions.

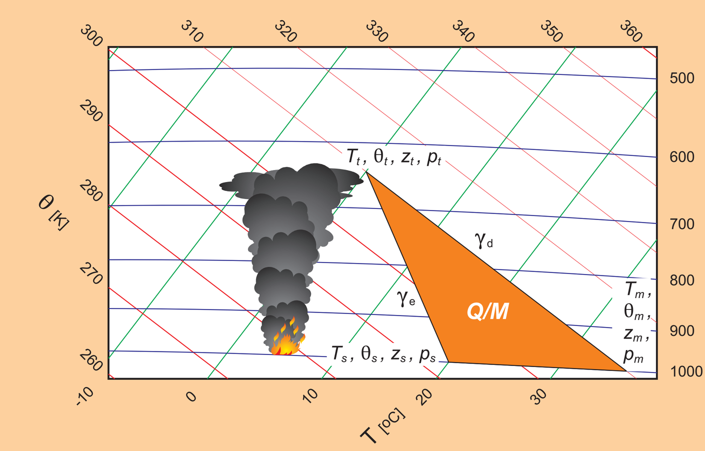
Elapsed time (hours)	Time Of Day	FFMC	ROS	HFI	TFC (kg/m2)	CFB (%)	Forward Spread Distance (km)	Area (ha)	Perimeter (km)
0.00	1400	88.2	6.3	5767	3.05	31	0.1	1.0	0.4
0.25	1415	88.4	6.6	6035	3.05	35	0.2	3.4	0.7
0.50	1430	88.6	6.8	6314	3.10	38	0.3	7.3	1.0
0.75	1445	88.8	7.1	6604	3.10	42	0.4	13.0	1.3
1.00	1500	88.9	7.3	6906	3.15	45	0.5	20.6	1.7
1.25	1515	89.1	7.5	7140	3.17	47	0.6	30.3	2.0
1.50	1530	89.2	7.7	7381	3.20	50	0.7	42.2	2.4
1.75	1545	89.3	8.0	7629	3.18	52	0.9	56.6	2.8
2.00	1600	89.5	8.2	7884	3.20	55	1.0	73.5	3.1
2.25	1615	89.6	8.4	8149	3.23	57	1.1	93.2	3.5
2.50	1630	89.8	8.6	8421	3.26	59	1.2	115.9	3.9
2.75	1645	89.9	8.9	8701	3.26	61	1.4	141.8	4.4
3.00	1700	90.0	9.1	8988	3.29	63	1.5	171.2	4.8
3.25	1715	89.9	8.9	8684	3.25	61	1.6	204.0	5.2
3.50	1730	89.8	8.6	8388	3.25	59	1.8	238.6	5.7
3.75	1745	89.6	8.4	8101	3.21	57	1.9	274.7	6.1
4.00	1800	89.5	8.1	7821	3.22	54	2.0	312.2	6.5
4.25	1815	89.3	7.9	7550	3.19	52	2.1	351.0	6.9
4.50	1830	89.2	7.7	7287	3.15	49	2.2	390.8	7.2
4.75	1845	89.0	7.4	7032	3.17	46	2.4	431.4	7.6
5.00	1900	88.9	7.2	6784	3.14	44	2.5	472.8	8.0
5.25	1915	88.5	6.8	6248	3.06	37	2.6	514.4	8.3
5.50	1930	88.2	6.3	5750	3.04	31	2.7	554.8	8.6
5.75	1945	87.9	5.9	5288	2.99	24	2.8	594.0	8.9
6.00	2000	87.5	5.6	4860	2.89	17	2.9	631.9	9.2

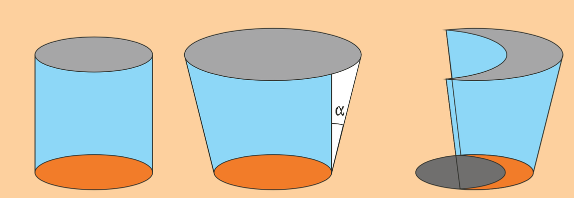
Fire behaviour produces the energy that drives the plume rise model, Diurnal calculations and accumulated area growth are used to capture the development of the plume over time.

PLUME RISE

A thermodynamic solution to plume rise can be solved using a tephigram. The tephigram is a thermodynamic diagram where energy spent per unit mass is proportional to area on the diagram.

$$Q/M = q = -c_p \oint T \; d \ln \theta = -c_p \, \Sigma_{tephi}$$

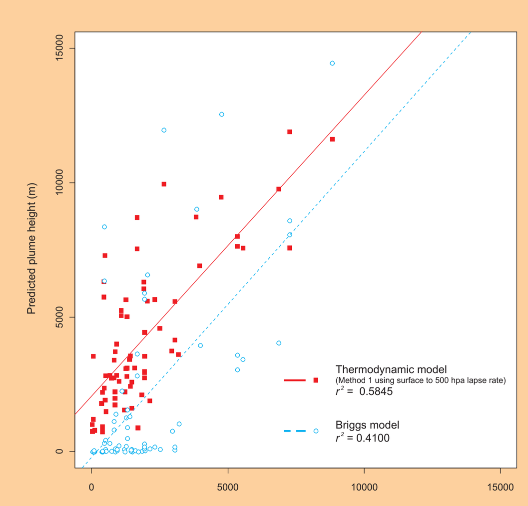




Entrainment can be captured by the shape of the plume

Energy Balance

A simple energy balance for the fire was constructed to estimate the energy into the plume.



Results indicate that the model can predict up to 66% of the variation of the plume rise.
(up to r^2 = 0.6664 depending on modeling decisions)

EMISSIONS

The CFFEPS model uses fuel consumption as calculated by the FBP system.

Surface Fuel Consumption (SFC) represents fuel consumption as the fire burns into the forest floor. The bulk density of the forest floor increases with depth, which have an impact on emissions.

Crown Fuel Consumption (CFC) represents the burning of needles and thin branches above ground.

Total Fuel Consumption (TFC) represents the sum of the surface and the crown fuel consumption.

Reduction factors per fuel type

Fuel (duration)		Flaming (Instantaneous)	Smouldering (2 hours)	Residual (6 hours)
Ground	Litter (0-2 cm)	0.95	0.05	0
	Upper duff (2-5 cm)	0.10	0.70	0.20
	Lower duff (5-8 cm)	0	0.20	0.80
Canopy		0.85	0.05	0
Slash		0.70	0.15	0.15
Grass		0.95	0.05	0

The emission factors of pollutants used in CFFEPS are based on CFFDRS fuels and average emission factors used in CONSUME.

Emission factors (g/kg) of pollutants

	PM	PM10	PM2.5	CO	CO2	CH4	NMHC
Flaming	11.5	7.5	6.5	45	1261	1.5	2.5
Smouldering	17	12	9.5	104.5	1142.5	5.5	5
Residual	17	12	9.5	104.5	1142.5	5.5	5