Modeling Fire Behavior in Chaparral with HFIRE

Marco Morais

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UCSB Advanced Remote Sensing Group

Discussion Outline

I. Variables Required For Predicting Fire Spread

- temporally static fuels attributes
- temporally static landscape attributes
- temporally dynamic environmental variables
- all vary in space (2D)

II. Issues For Implementing a Fire Behavior Model

- conservation of energy
- fuels as a heat sink
- heat transfer mechanisms
- influence of wind and slope

III. HFire Fire Behavior Model Features

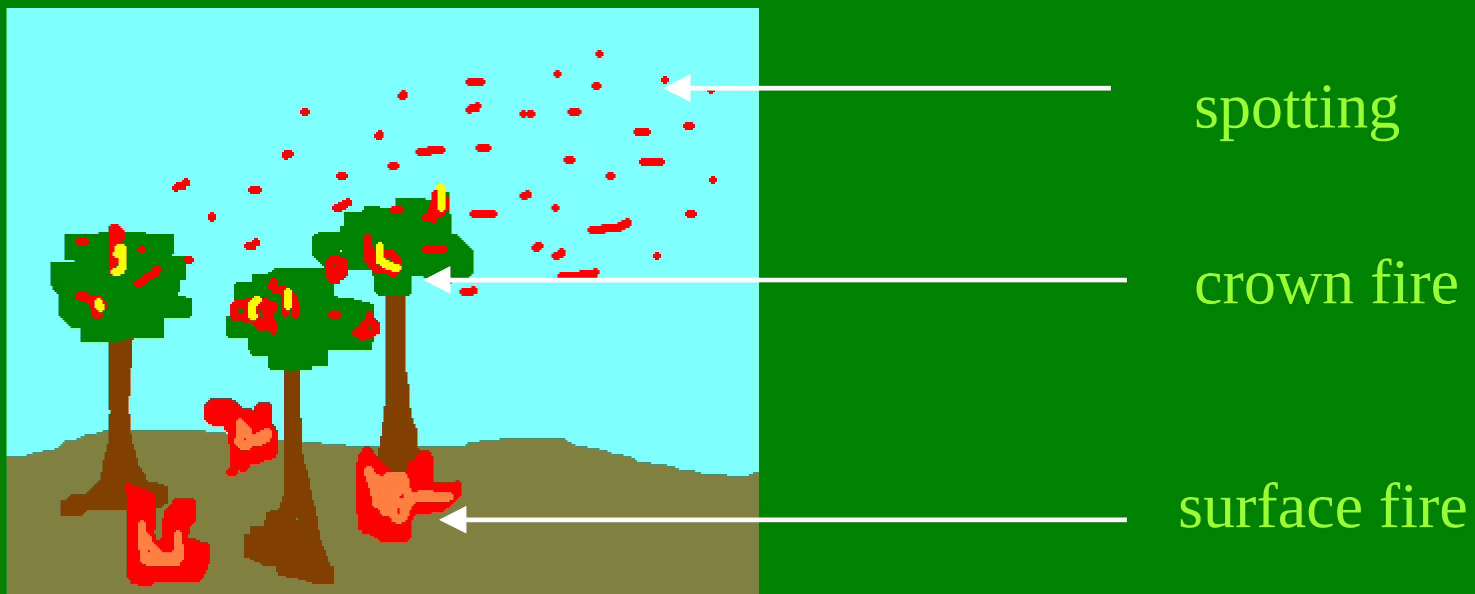
- mechanism for 2D fire spread in HFire
- comparison of model features

IV. Research Questions

- how does HFire perform during hist. fire reconstructions?
- which static variables most influence performance?

Modes of Fire Spread

Chaparral: Crown Fire or Surface Fire Regime?



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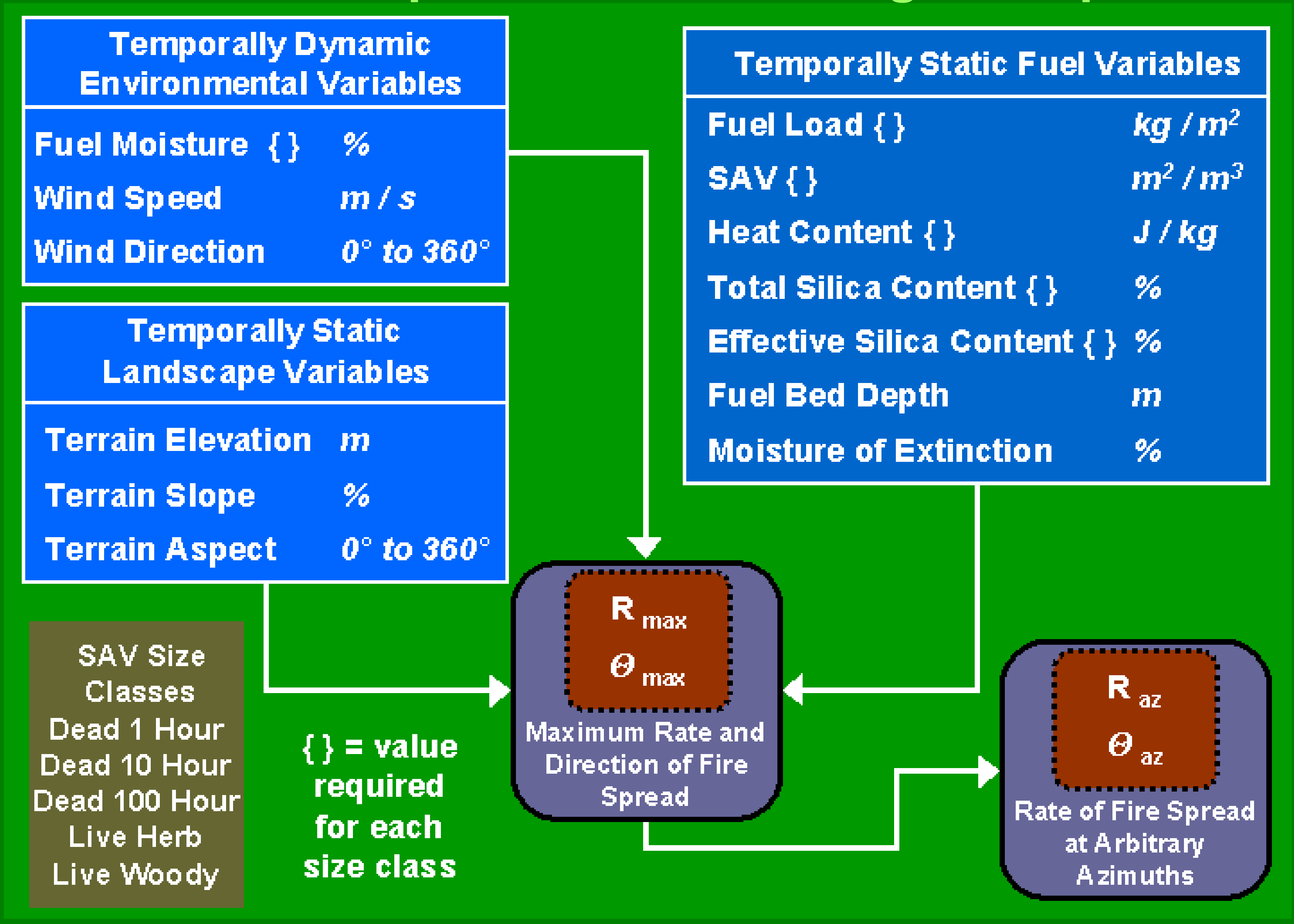
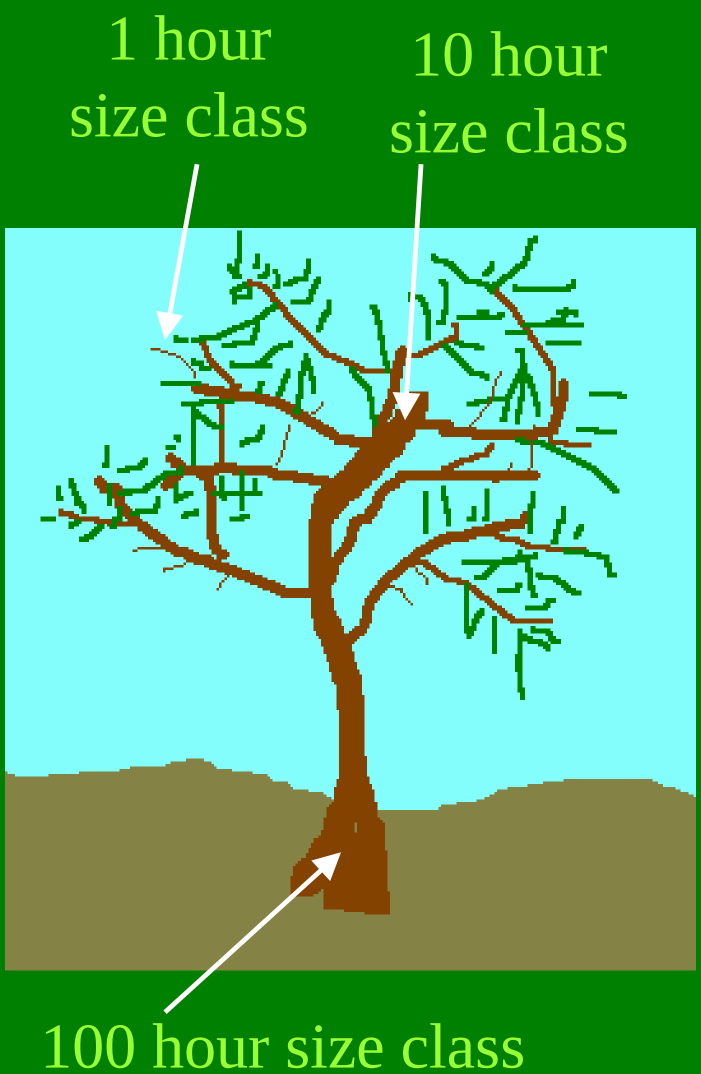
Variables Required For Predicting Fire Spread

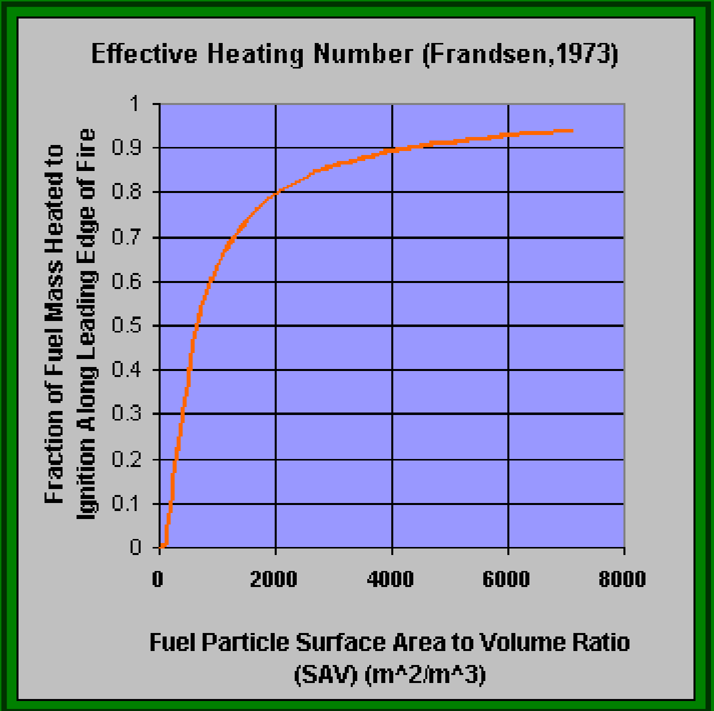


Surface Area to Volume Ratio (SAV)



Size Classes

Dead 1 Hour
Dead 10 Hour
Dead 100 Hour
Live Herb
Live Woody



Fuel Particle Stem Diameter Size Class	Units	Surface-Area-to-Volume (SAV) Ratio	Reference
0 - 0.5 cm	m^2/m^3	2400	Riggan, et al 1988
0.5 - 1.0 cm	m^2/m^3	535	Riggan, et al 1988
1.0 - 2.0 cm	m^2/m^3	265	Riggan, et al 1988
> 2.0 cm	m^2/m^3	90	Riggan, et al 1988
Sclerophytic *Ceanothus* Foliage	m^2/m^3	3100	Riggan, et al 1988
Mesophytic *Ceanothus* Foliage	m^2/m^3	6900	Riggan, et al 1988
Adenostoma fasciculatum Needles	m^2/m^3	6662	Rothermel and Philpot, 1973

Fuel Attributes Measured in Chaparral

Vegetation Related Fuel Properties For Chaparral

Property Name	Measurement	Units	Spatial Variability
Dead 1 Hour Fuels	Stem Diameter < 0.635 cm	Mg/ha	varies spatially
Dead 1 Hour Surface-Area-To-Volume	Estimated	cm2/cm3	constant with species
Dead 1 Hour Fuel Moisture	(Wet-Dry Weight) / Dry Weight	%	varies spatially & temporally (diurnal)
Dead 10 Hour Fuels	Stem Diameter 0.635 - 2.54 cm	Mg/ha	varies spatially
Dead 10 Hour Surface-Area-To-Volume	Estimated	cm2/cm3	constant with species
Dead 10 Hour Fuel Moisture	(Wet-Dry Weight) / Dry Weight	%	varies spatially & temporally (diurnal)
Dead 100 Hour Fuels	Stem Diameter 2.54 - 7.62 cm	Mg/ha	varies spatially
Dead 100 Hour Surface-Area-To-Volume	Estimated	cm2/cm3	constant with species
Dead 100 Hour Fuel Moisture	(Wet-Dry Weight) / Dry Weight	%	varies spatially & temporally (diurnal)
Live Herbaceous Fuels	All, regardless of diameter	Mg/ha	varies spatially
Live Herbaceous Surface-Area-To-Volume	Estimated	cm2/cm3	constant with species
Live Woody Fuels	Stem Diameter < 0.635 cm	Mg/ha	varies spatially
Live Woody Surface-Area-To-Volume	Estimated	cm2/cm3	constant with species
Live Fuel Moisture	(Wet-Dry Weight) / Dry Weight	%	varies spatially & temporally (seasonal)
Fuel Bed Depth	Estimated	m	varies spatially
Heat Content of Dead Fuels	Estimated	kJ/kg	constant with species
Heat Content of Live Fuels	Estimated	kJ/kg	constant with species
Moisture of Extinction of Dead Fuels	(Wet-Dry Weight) / Dry Weight	%	constant with species

Note: The fuel "hour" class corresponds to the fuel diameter and is a direct reference to the amount of time it takes for an idealized cylinder of vegetation of that size to reach equilibrium moisture content (EMC).

Differences Between NFFL and Custom Fuel Models

NFFL 4 Fuel Load Attributes

Dead1 Hour	Dead10 Hour	Dead100 Hour	Live Herb and Woody	Total Fuel Biomass
11.23	8.99	4.51	11.21	35.94

All values shown are in Mg/ha.

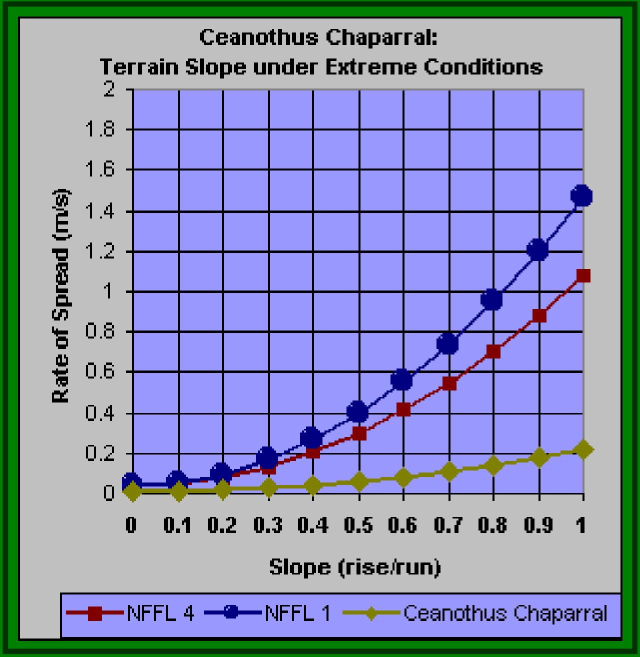
small differences in biomass...

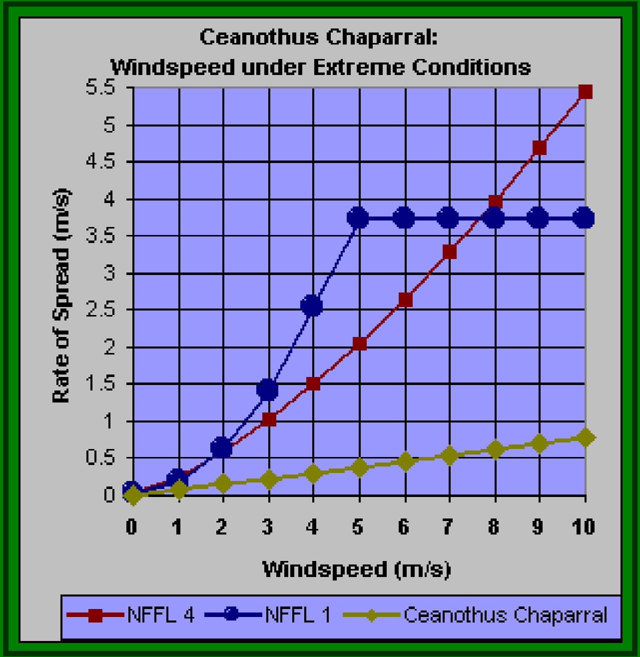
Average Fuel Load for All Stands Dominated By *Ceanothus*-Type Chaparral

Dead1 Hour	Dead10 Hour	Dead100 Hour	Live Herb and Woody	Total Fuel Biomass
7.13	5.60	2.11	17.09	31.93

All values shown are in Mg/ha.
Average reflects field inventory data collected at 5 sites by J Regelbrugge of the USDA Forest Service (1995-1997).
Range of Total Fuel Biomass: 17.90 Mg/ha.

big differences in fire behavior...





Custom Fuel Models

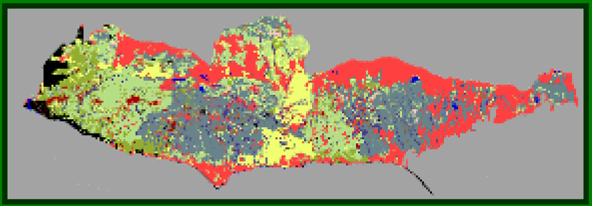
Fuel Model Number	Description	Source	Reference
1	short grass	NFFL	Anderson, 1982
3	tall grass	NFFL	Anderson, 1982
4	chaparral	NFFL	Anderson, 1982
5	brush	NFFL	Anderson, 1982
6	dormant brush	NFFL	Anderson, 1982
7	southern rough	NFFL	Anderson, 1982
9	hardwood litter/riparian	NFFL	Anderson, 1982
15	old Chamise	USFS	Weise and Regelbrugge, 1997
16	Ceanothus	USFS	Weise and Regelbrugge, 1997
17	young Chamise	USFS	Weise and Regelbrugge, 1997
18	sagebrush and buckwheat	USFS	Weise and Regelbrugge, 1997
20	wildland urban interface	UCSB	unpublished
21	SMM coastal sage scrub	UCSB	unpublished
98	water	unburnable	
99	rock/agriculture	unburnable	

Model	D1H	D10H	D100	LH	LW	D1HSAV	LHSAV	LWSAV	FDEPTH	MEX	DHC	LHC
Units	Mg/ha	Mg/ha	Mg/ha	Mg/ha	Mg/ha	1/cm	1/cm	1/cm	cm	%	kJ/kg	kJ/kg
1	1.66	0.00	0.00	0.00	0.00	105.98	0.00	0.00	30.48	12	18608	18608
3	6.75	0.00	0.00	0.00	0.00	45.42	0.00	0.00	76.20	25	18608	18608
4	11.23	8.99	4.51	0.00	11.21	60.56	0.00	45.42	182.88	20	18608	18608
5	2.24	1.12	0.00	0.00	4.48	60.56	0.00	45.42	60.96	20	18608	18608
6	3.36	5.60	4.48	0.00	0.00	52.99	0.00	0.00	76.20	25	18608	18608
7	2.53	4.19	3.36	0.00	0.83	52.99	0.00	46.93	76.20	40	18608	18608
9	6.55	0.92	0.34	0.00	0.00	75.70	0.00	0.00	6.10	25	18608	18608
15	4.48	6.73	2.24	1.12	4.48	19.37	66.61	19.37	91.44	13	23260	23260
16	5.04	10.76	4.04	6.73	6.28	15.14	45.42	15.14	182.88	15	18608	18608
17	2.91	2.24	2.24	4.48	4.48	19.37	66.61	19.37	121.92	20	18608	18608
18	12.33	1.79	0.22	1.68	5.60	19.37	45.42	19.37	91.44	25	21399	21399
20	1.66	4.19	3.36	0.00	0.83	105.98	45.42	46.93	53.34	40	18608	18608
21	5.50	0.70	0.00	1.60	3.00	19.37	45.42	19.37	91.44	25	21399	21399

Input Spatial Data Required for Fire Spread Prediction

Fuel Type

derived from remote sensing (TM/AVIRIS)
important attributes: fuel bed density; fuel bed surface-area-to-volume ratio; fuel bed moisture content
Native Resolution in SMM: 30m



Elevation

derived from Digital Elevation Model (DEM)
establishes adiabatic lapse in temperature and humidity
Native Resolution in SMM: 30m

Slope

derived from Digital Elevation Model (DEM)
influences orientation and eccentricity of predicted fire
used to calculate diurnal fluctuation in dead fuel moisture
Native Resolution in SMM: 30m

Aspect

derived from Digital Elevation Model (DEM)
used to calculate diurnal fluctuation in dead fuel moisture
Native Resolution in SMM: 30m

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Basic Conservation of Energy Relationship

Basic principle.

Rate of Fire Spread = **Heat Received By Fuel Ahead of Fire** / **Heat Required To Ignite the Fuel**

$$R = \frac{q}{Q_{ig}}$$

where

$R = $ *forward rate of spread of the combusting fuel bed, in* $\frac{m}{s}$

$q = $ *energy flux rate received by unignited fuel, in* $\frac{J}{m^2 s}$

$= \sum_{n=1}^{k} q_n$, sum *of the energy flux received due* to *the k heat transfer mechanisms*

$Q_{ig} = $ *energy per unit volume required to raise unignited fuel to ignition, in* $\frac{J}{m^3}$

$= \sum_{n=1}^{v} Q_n$, sum *of bringing all v components of fuel bed* to *ignition*

Evaluating Fuel as a Heat Sink

Fuel Ignition is a Three-Step Process

1. Heat Fuel Particles and Liquid Water to Boiling

$$Q_{step1} = \rho_f c_f (T_{bp} - T_a) + \rho_w c_w (T_{bp} - T_a)$$

2. Enact Phase Change of Liquid Water

$$Q_{step2} = \rho_w l_w$$

3. Raise Dessicated Fuel Particles to Ignition

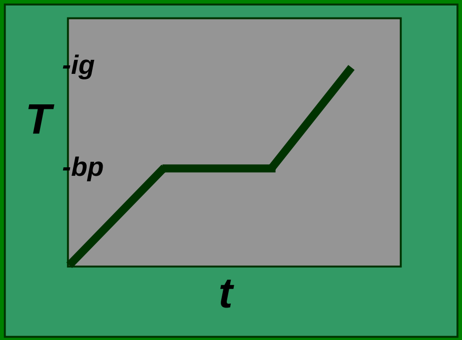
$$Q_{step3} = \rho_f c_f (T_{ig} - T_{bp})$$

$$Q_{ig} = Q_{step1} + Q_{step2} + Q_{step3}$$

Q_{step1} when $T_a \leq T_f < T_{bp}$

Q_{step2} when $T_f = T_{bp}$

Q_{step3} when $T_{bp} < T_f \leq T_{ig}$



Notation

l latent heat, in $\frac{J}{kg}$

ρ density, in $\frac{kg}{m^3}$

c specific heat, in $\frac{J}{kg\,K}$

T temperature, in K

Subscripts

f fuel bed property

w liquid water property

Calculating Q_{ig}

Contribution of Liquid Water

$$h_w = l_w + \int_{T_a}^{T_{bp}} c_w \, dT$$

Assuming mean c_w of 4187 $\frac{J}{kg\,K}$

$$= 2.254 x 10^6 \frac{J}{kg} + 2.930 x 10^5 \frac{J}{kg}$$

$$= 2.547 x 10^6 \frac{J}{kg}$$

Contribution of Fuel

$$c_f = 1110 + 4.86 \left(T_f - 273.15 \right)$$

Source: Dunlap (1912)

$$c_f = 1110 + 4.20 \left(T_f - 273.15 \right)$$

Source: Koch (1969)

$$h_f = \int_{T_a}^{T_{ig}} c_f \, dT$$

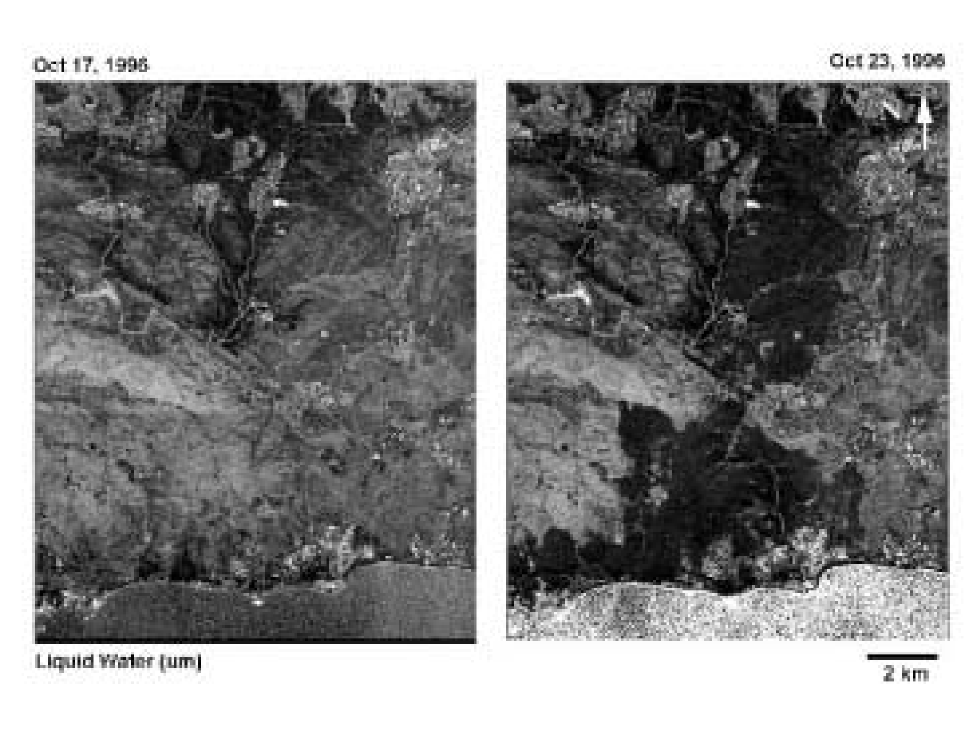
Assuming T_{ig} of 598 K

$$5.781 x 10^5 \frac{J}{kg} (\text{Dunlap}), 5.471 x 10^5 \frac{J}{kg} (\text{Koch})$$

~ 4.5 X less per unit mass in comparison to liquid water!

Putting It All Together

Changes in Liquid Water...



Result in Changes in Heat Sink...

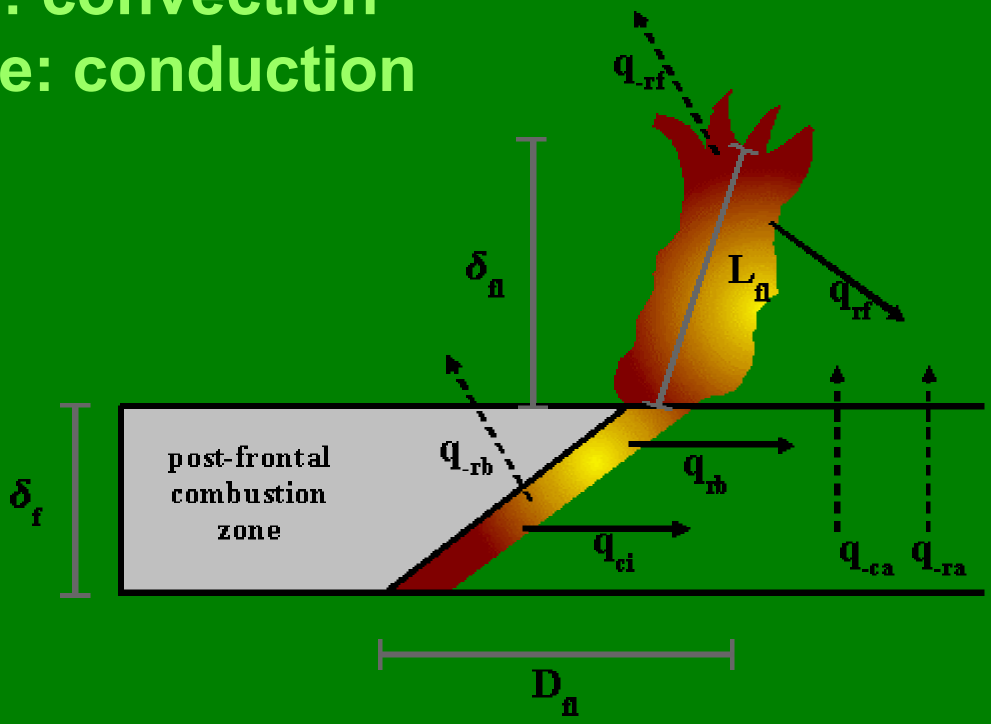
$$R = \frac{q}{Q_{ig}}$$

$$Q_{ig} = \sum_{n=1}^{v} Q_n \text{, sum } of\ bringing\ all\ v\ components\ of\ fuel\ bed \text{ to } ignition$$

Evaluating Energy Flux From Fire Front to Fuel

Modes of Fire Spread Associated with Heat Transfer

- surface fire: radiation
- crown fire: convection
- ground fire: conduction



Heat Transfer Physical Schema for an Idealized Fuel Bed

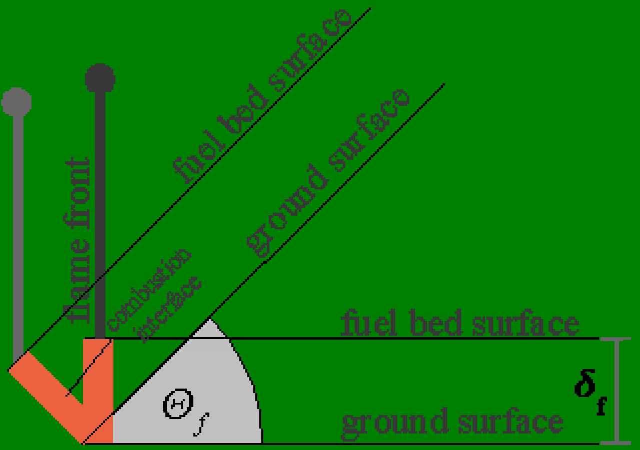
$$R = \frac{q}{Q_{ig}}$$

$$q = \sum_{n=1}^{k} q_n \text{, sum of the energy flux received due to the } k \text{ heat transfer mechanisms}$$

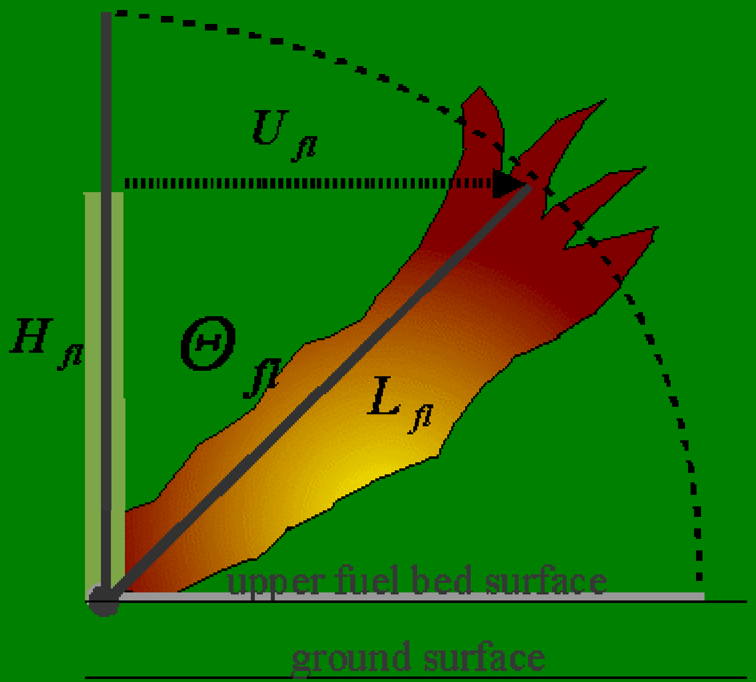
Influence of Wind and Slope on Fire Spread

Geometry

- increase slope = decrease distance flame to unburnt fuel



- increase wind = tilt flame forward



How much flame tilt is due to wind?

$$Fr_{fl} = \left(\frac{U_{fl}^2}{g H_{fl}} \right)^{0.5}$$

$$\Theta_{fl} = \arctan\left(1.22\, Fr_{fl}\right)$$

Source: Albini (1981)

Influence of Wind and Slope on Fire Spread

Other Effects of Wind and Slope

- increased forced convective heat transfer ahead of the fire front
- edaphic properties of fuel due to slope orientation (aspect)
- preferential heating of south-west slopes reduces dead fuel moisture
- increased windspeed speeds loss of moisture in dead fuels

Rule of Thumb

$$R \approx k\,U^{n}$$

- n = 1.51 (Nelson and Adkins, 1988)
- n = 0.5 (Carrier, et al, 1991)
- n = 0.91 (Catchpole, et al, 1998)
- k dependent upon fuel bed properties, esp. depth

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1D Steady-State Prediction of Fire Spread

Rothermel (1972) Fire Spread Equation

- substitutes physical terms in conservation of energy with empirical coefficients
- no-wind and no-slope rate of spread estimates from laboratory fires
- wind coefficient from field observations
- basis of current US fire behavior prediction system
- evidence suggests tends to overpredict fire spread in chaparral

Rate of Fire Spread = **Heat Received By Fuel Ahead of Fire** / **Heat Required To Ignite the Fuel**

$$R = \frac{I_R \, \xi \, (1 + \Phi_w + \Phi_s)}{\rho_f \, \varepsilon \, Q_{ig}}$$

Transforming 1D Predictions to 2D

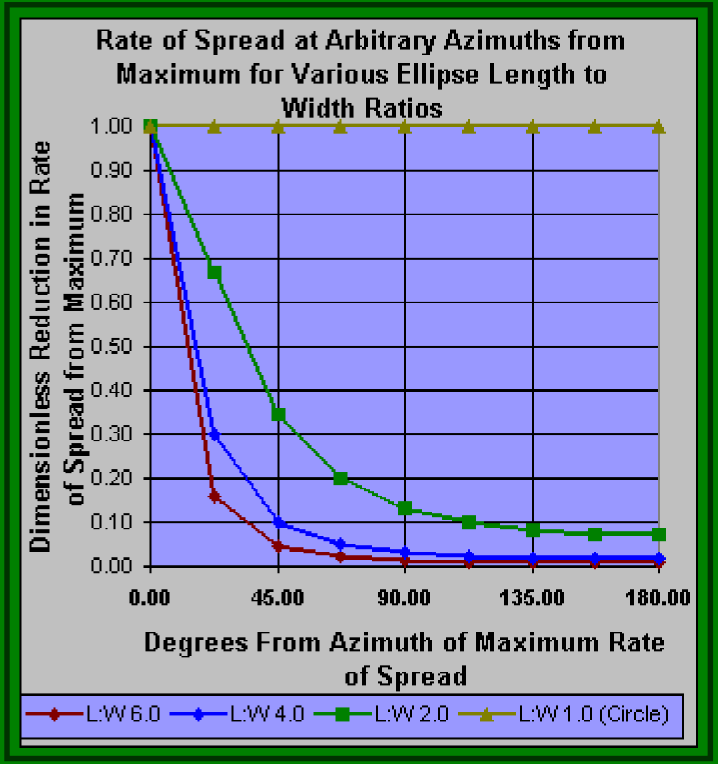
Predicting Rate of Spread in Directions Off-Maximum

- empirical L:W ratios derived for ellipses using midflame windspeed (Anderson, 1983)
- fire containment problem (Albini and Chase, 1980)

$$\frac{L}{W} = 1 + 0.5592\,U_{eff}$$

$$E = \frac{\sqrt{\left(\frac{L}{W}\right)^2 - 1}}{\left(\frac{L}{W}\right)}$$

$$R_\Theta = R_{\max} \frac{(1-\mathrm{E})}{(1-\mathrm{E}\cos\Theta)}$$



Major Flaw: Neglects interaction-contribution of adjacent burning areas (cells).

Will be true even assuming perfect fit between ellipse and fire.

2D Fire Spread As Implemented in HFire

Raster Model of Fire Spread

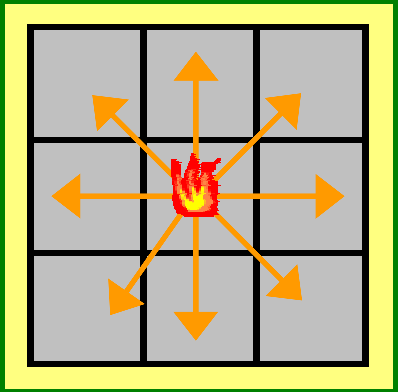
1. Efficient

- adaptive time step: time increments more slowly during rapid fire spread and more rapidly during slow fire spread

2. Free of Distortiom

- unlike event-driven simulation fire spreads in nonuniform distance increments between cell centers

All Cells Nbr
to i,j



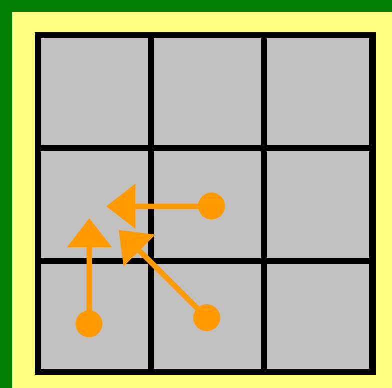
$$t_n = \frac{\Delta d}{R_{\max}}$$

2D Fire Spread As Implemented in HFire

Finding Distance Travelled During Timestep

- t_n = size of current timestep (sec)
- R_{max} = maximum rate of spread (meters/sec)
- Θ_{max} = direction of max rate of spread (°)
- L / W = length to width ratio of fire spread ellipse
- Θ = direction of fire spread into cell 2,1 from nbr
- d_{xyz} = dist. btwn nbr and cell 2,1 (meters)
- R_{Θ} = rate of fire spread from nbr (meters)

Fire Converging on Cell 2,1



$$d_{\Theta} = R_{\Theta} * t_n$$

Case	Source Cell Index	Dest. Cell Index	Source Elevation	Dest. Elevation	Cellsize (Δ d)	t_n	R_{max}	θ_{max}	L/W	θ	d_{xyz}	R_{θ}	d_{θ}	d_{θ} / d_{xyz}
Units			m	m	m	s	m/s				m	m/s	m	
1	2,2	2,1	200	220	30	20	1.00	0.0	2.0	270.0	36.06	0.13	2.60	0.07
2	3,2	2,1	200	220	30	20	1.50	0.0	2.0	315.0	46.90	0.53	10.50	0.22
3	3,1	2,1	200	220	30	20	0.75	0.0	2.0	0.0	36.06	0.75	15.00	0.42

Cell Contact Fire Spread Algorithm Used By HFire

Cell States

- Unburnable
- No Fire In Cell
- Fire in Cell, Fuel Not Consumed
- Fuel in Cell Consumed By Fire

Array of Cell States, t_0

Cell Distances

Fire Not Burning into Current Cell — 0.0

Fire From Neighboring Cell(s) Burning into Current Cell

Fire Arrived at a Current Cell Center — 1.0

0.0	0.0	0.0
0.0	1.0	0.0
0.8	1.0	0.0

Array of Distances, t_0

Array of Cell States, t_1

0.3	0.1	0.0
0.6	1.0	0.0
1.0	1.0	0.0

Array of Distances, t_1

Array of Cell States, t_2

0.9	0.6	0.0
1.0	1.0	0.0
1.0	1.0	0.0

Array of Distances, t_2

Comparison of Fire Behavior Model Features

Model Name	FARSITE	HFire	PhysFire
Acronym	Fire Area Simulator	Highly Optimized Tolerance Fire Spread Model	Physical Fire Spread Model
Model Type[1]	semi-empirical	semi-empirical	physical
Fire Spread Mechanism[2]	wave phenomena, Huygens' Principle	contact-based approach	heat accumulation, all cells have fixed ignition temperature
Rate of Spread, Maximum Direction	Rothermel (1972)	Rothermel (1972)	energy balance
Rate of Spread, Directions Off Maximum	elliptical growth described using a pair of differential equations	rate of spread in directions off-maximum fit to an ellipse	equations balanced in two-dimensions
Fire Perimeter Stored As…	fire growth stored as x,y coordinates (vector)	cell state is binary function: consumed by fire (yes/no)	fuel temperature at any x,y point available via interpolation from control volume centerpoints
Incrementing Time	adaptive timestep	adaptive timestep	fixed timestep
Wind Direction and Speed	hourly point-source or 2D data	hourly point-source or 2D data	hourly point-source or 2D data
Dead Fuel Moisture	diurnal values interpolated from daily max and min according to Rothermel (1986)	hourly point-source or 2D data	hourly point-source or 2D data
Live Fuel Moisture	single value per fuel type	single value all fuel types	single value all fuel types
Can Be Run Stochastically	no	yes	no

1. Classification system developed by Weber (1991) describes fire spread model types as fully empirical, semi-empirical, or physical.
2. A range of fire spread mechanisms, Huygens' Principle, cell contact, and heat accumulation, were identified in French, et. al. (1990).

FARSITE vs HFIRE Feature Comparison

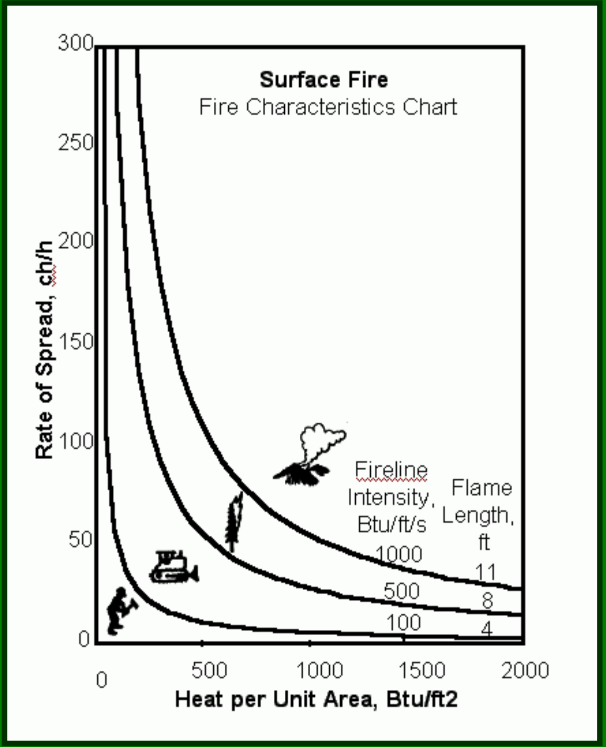
FARSITE Features Not Present in HFire

- concept of distance and perimeter resolution
- fire acceleration (McAlpine and Wakimoto, 1991)
- dead fuel moisture is interpolated from daily max and min temp and humdity (Rothermel, et al., 1986)
- windspeed reduction calculated differently in forested areas vs. non-forested areas
- spotting (Albini, 1979)
- treatment of areas with canopy cover > 0
- correction to Anderson (1983) ellipse s.t. no wind and no slope ros produces circular fire shape

FARSITE vs HFIRE Feature Comparison

HFire Features Not Present in FARSITE

- log wndspd reduction (Albini and Baughman, 1979); midflame windspeed taken at 2X fuel bed depth
- rate of spread adjustment replaced with…
  1. rate of spread threshold (~5 ch/hr = 0.3 m/s)
  2. incomplete consumption: resolution dependent
- original unmodified Anderson (1983) single ellipse



HFire vs. Cellular Automata (CA) Model Comparison

Event Based CA Model

- rules applied to individual cells
- rules produce complex behavior

  Box, PW. 2000. Garage band science and dynamic spatial models. Journal of Geographical Information Systems. 2:1. 49-54.
- cell-to-cell percolation
- simulation clock advances in increments equal to cell with shortest time of arrival to the fire front

HFire Model

- fire spread decoupled from underlying data representation: fire spreads in nonuniform distance increments from cell center to cell center

  avoid distortion problems cited by French, et. al. (1990)
- simulation clock advances in discrete nonuniform units of time

  adaptive timestep: time increments fastest when fire spread is slow

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Research Questions

Influence of the Following on Fire Behavior Predictions...

Fuels Attribute Data

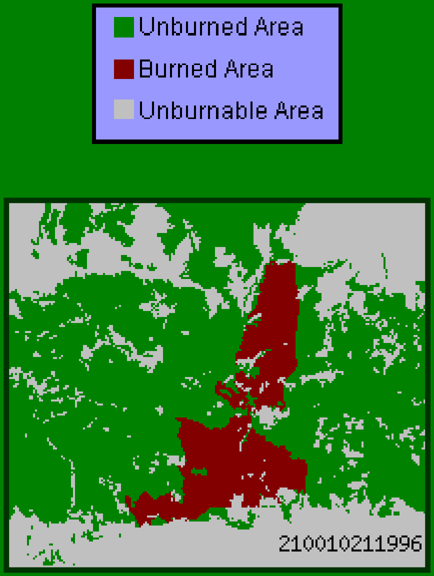
- quality = aspatial stylized fuel models
- quality != spatial resolution
- fuels = physical properties only {load; SAV}
- fuels != chemical properties {moisture; heat content}

Spatial Resolution of Input Spatial Data

- all spatial data input as rasters
- spatial resolution = cell size
- spatial data inputs {fuels; elevation; slope; aspect}

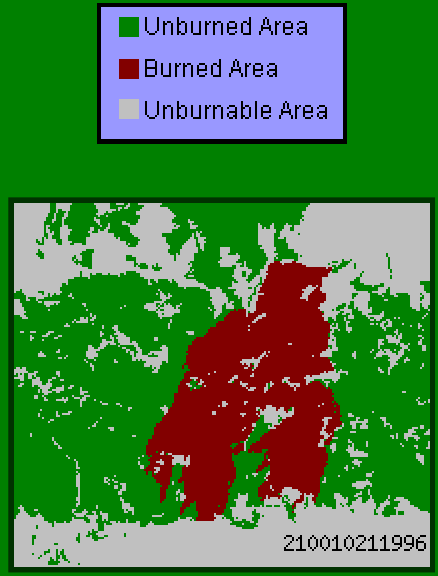
Retrospective Analysis

Compare predicted fire behavior to observed fire spread during historical events.



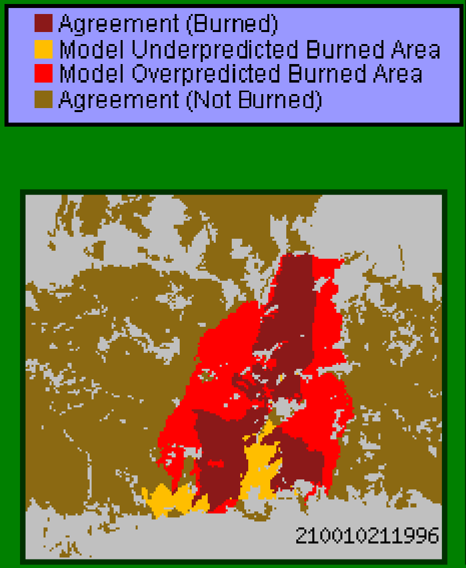
Historical Fire Spread

2100 Hours



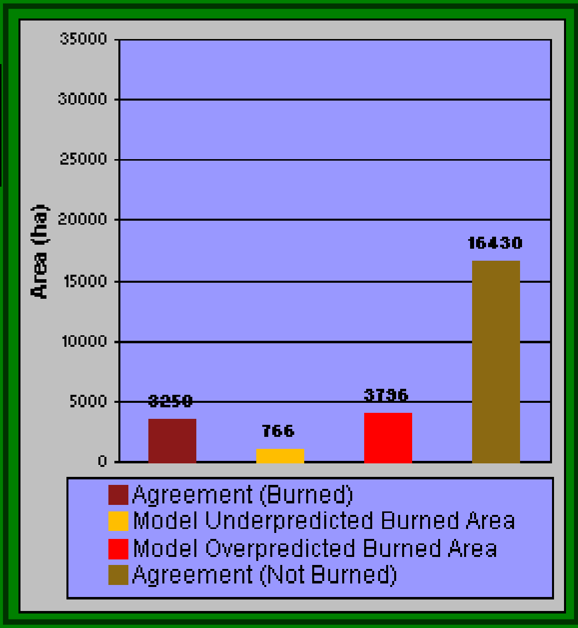
Predicted Fire Spread

2100 Hours



Comparison of Historical and Predicted Fire Spread

2100 Hours

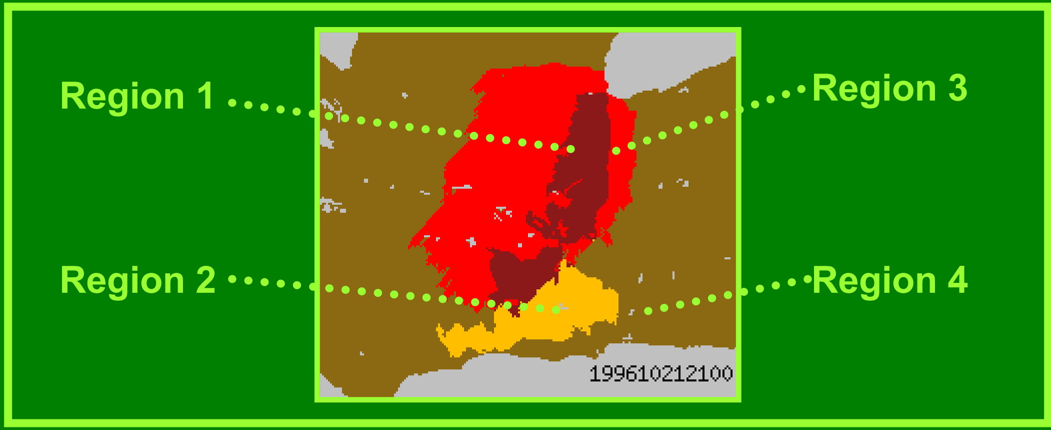


Correlation Table

2100 Hours

Repeat hour-by-hour for every combination of fire behavior model and historical event.

Accuracy of Observed and Predicted Fire Spread



Region 1 (R1): Agreement btwn Obs. & Pred. (burn)
Region 2 (R2): Underprediction
Region 3 (R3): Overprediction
Region 4 (R4): Agreement btwn Obs. & Pred. (unburn)

Three statistics used to assess accuracy...

1. Jacards Coefficient (C_J)

$$C_J = \frac{R_1}{(R_1 + R_2 + R_3)}$$

2. Areal Association (C_A)

$$C_A = \frac{R_1 + R_4}{R_1 + R_2 + R_3 + R_4}$$

3. Kappa (Κ)

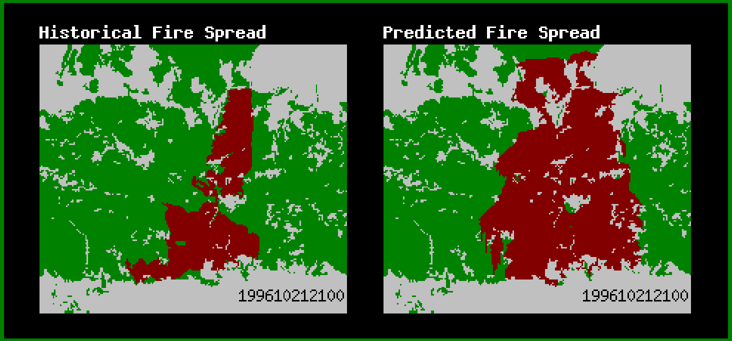
$$\kappa = \frac{(P_1 + P_4) - (E_1 + E_4)}{1 - (E_1 + E_4)}$$

Fire Spread Under Extreme Conditions

Overall Best Accuracy

- C_A = 0.7336 K = 0.3960

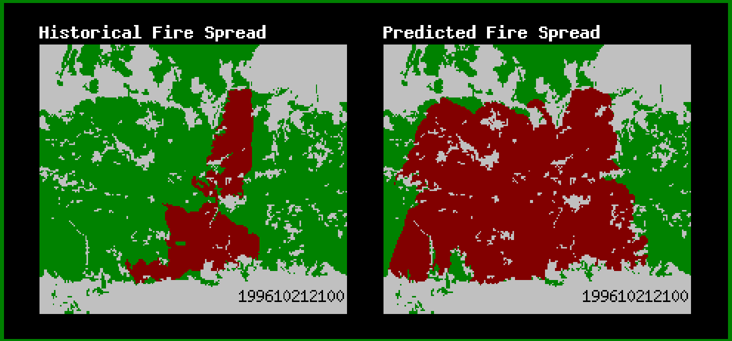
1996 Calabasas Fire
HFire Predicted Fire Spread
Parameters:
NFFL Fuels
Malibu RAWS
100 meter Cellsize
Best Estimate Live Fuel Moisture
Marco Morais 2/20/2001



Accuracy of Unburned Areas Important

- C_A = 0.5345 K = 0.2069

1996 Calabasas Fire
FARSITE Predicted Fire Spread
Parameters:
NFFL Fuels
Malibu RAWS
100 meter Cellsize
Best Estimate Live Fuel Moisture
Marco Morais 2/20/2001



Fire Spread Under Extreme Conditions

1996 Calabasas Fire (Santa Monica Mountains)

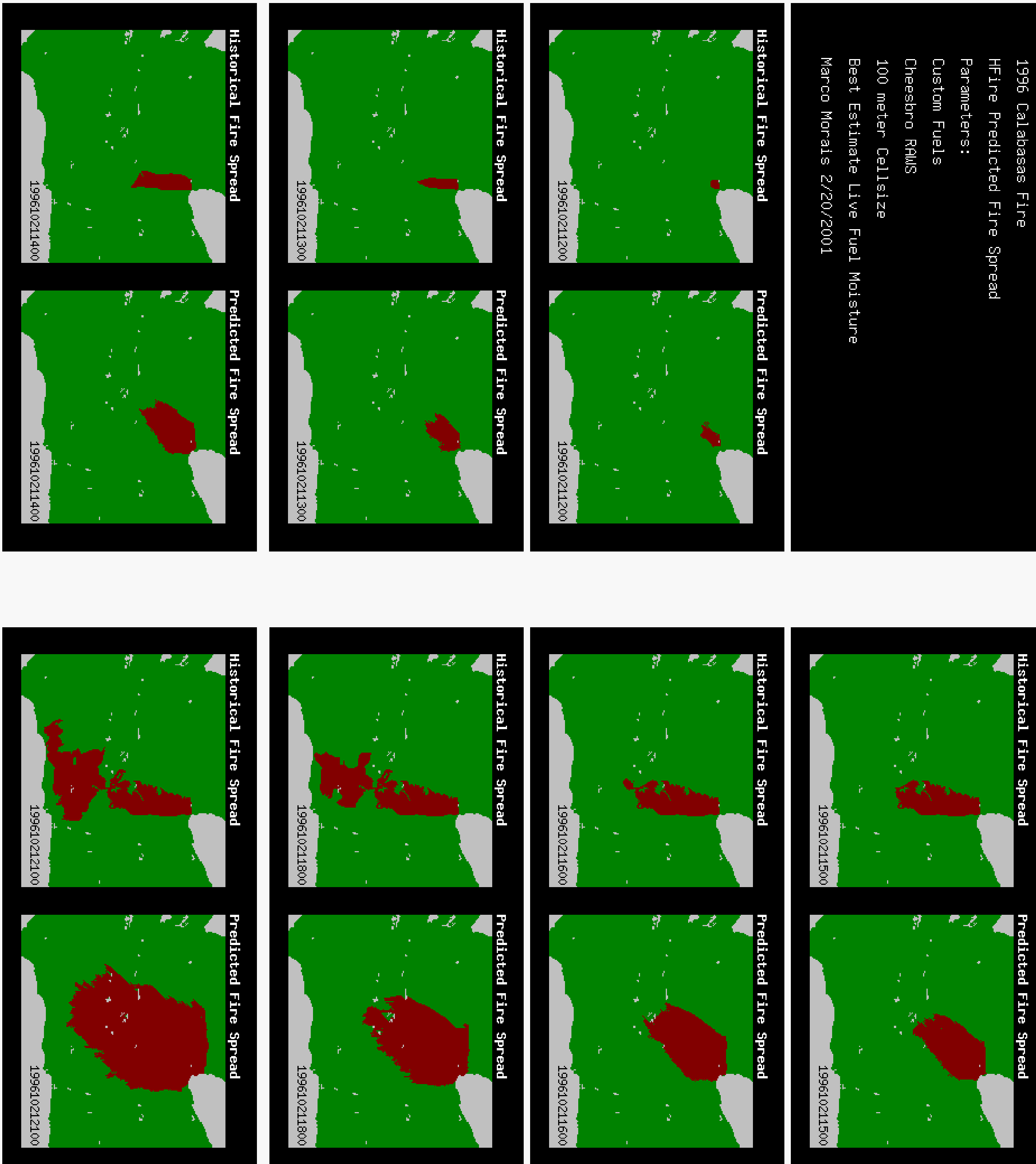
- duration as active fire: 10/21 1100 to 10/22 0600
- size: approx. 5159 hectares
- character: Santa Ana wind-driven event
- sim duration: 10/21 1100 to 10/21 2100 (10 hours)

Duration of 1996 Calabasas Simulation: 10/21 1100 to 10/21 2100 (10 hours)				*kappa*	*Jacard's*	*areal association*
FuelsUsed	Data Resolution	Weather Data	Fire Behavior Model	κ	C_J	C_A
cust	30m	che	HFIRE	0.1859	0.2051	0.6879
cust	30m	che	FARSITE	0.2066	0.2177	0.6938
cust	100m	che	HFIRE	0.2244	0.2226	0.7348
cust	100m	che	FARSITE	0.2271	0.2334	0.6804
cust	30m	mal	HFIRE	0.1838	0.2160	0.5774
cust	30m	mal	FARSITE	0.1763	0.2144	0.5364
cust	100m	mal	HFIRE	0.2328	0.2417	0.6419
cust	100m	mal	FARSITE	0.1779	0.2160	0.5292
nffl	30m	che	HFIRE	0.2963	0.3107	0.6332
nffl	30m	che	FARSITE	0.3331	0.3312	0.6745
nffl	100m	che	HFIRE	0.3284	0.3291	0.6646
nffl	100m	che	FARSITE	0.3145	0.3209	0.6516
nffl	30m	mal	HFIRE	0.3709	0.3554	0.7007
nffl	30m	mal	FARSITE	0.3265	0.3283	0.6618
nffl	100m	mal	HFIRE	0.3960	0.3685	0.7336
nffl	100m	mal	FARSITE	0.2069	0.2616	0.5345

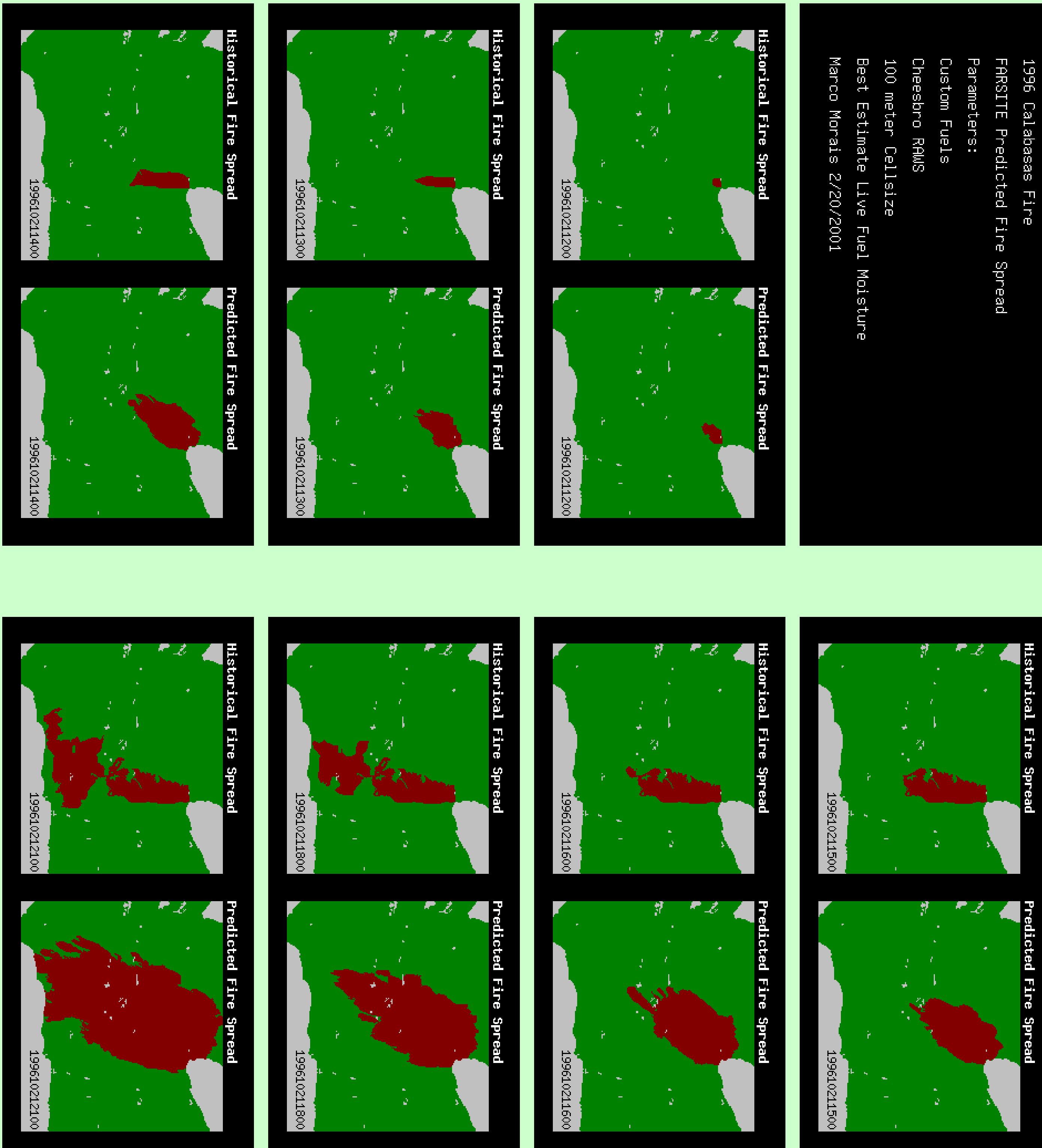
Summary Statistics

	kappa	*Jacard's*	*areal association*
MaxFARS	0.3331	0.3312	0.6938
MinFARS	0.1763	0.2144	0.5292
RngFARS	0.1568	0.1168	0.1646
AvgFARS	0.2461	0.2654	0.6203
SdevFARS	0.0673	0.0531	0.0730
MaxHFire	0.3960	0.3685	0.7348
MinHFire	0.1838	0.2051	0.5774
RngHFire	0.2122	0.1634	0.1574
AvgHFire	0.2773	0.2811	0.6718
SdevHFire	0.0825	0.0669	0.0538

Good Accuracy: HFire Model



Good Accuracy: FARSITE Model



Fire Spread Under Moderate Conditions

1998 Ogilvy Fire (Ventura County)

- duration as active fire: 10/16 1500 to 10/23 0800
- size: approx. 1714 hectares
- character: relatively moderate for late fall wildfire
- sim duration: 10/16 1500 to 10/22 1700 (146 hours)

Duration of 1998 Ogilvy Fire Simulation: 10/16 1500 to 10/20 0800 (89 hours)			*kappa*	*Jacard's*	*areal association*
FuelsUsed	Data Resolution	Fire Behavior	κ	C_J	C_A
cust	30m	HFIRE	0.0701	0.0564	0.6512
cust	30m	FARSITE	0.0371	0.0394	0.4908
cust	100m	HFIRE	0.1826	0.1192	0.8461
cust	100m	FARSITE	0.0368	0.0392	0.4884
nffl	30m	HFIRE	0.0019	0.0218	0.0636
nffl	30m	FARSITE	0.0001	0.0209	0.0228
nffl	100m	HFIRE	0.0043	0.0230	0.1129
nffl	100m	FARSITE	0.0000	0.0209	0.0209

Summary Statistics

	kappa	*Jacard's*	*areal association*
MaxFARS	0.0371	0.0394	0.4908
MinFARS	0.0000	0.0209	0.0209
RngFARS	0.0371	0.0185	0.4699
AvgFARS	0.0185	0.0301	0.2558
SdevFARS	0.0213	0.0106	0.2701
MaxHFire	0.1826	0.1192	0.8461
MinHFire	0.0019	0.0218	0.0636
RngHFire	0.1807	0.0974	0.7825
AvgHFire	0.0647	0.0551	0.4184
SdevHFire	0.0847	0.0457	0.3900

Accuracy: HFire Model

1998 Ogilvy Fire

HFire Predicted Fire Spread

Parameters:

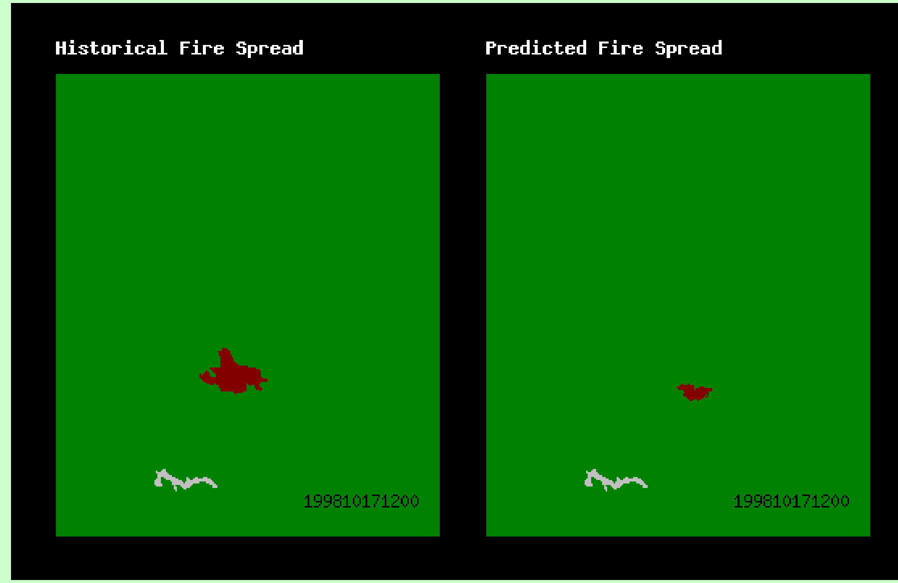
Custom Fuels

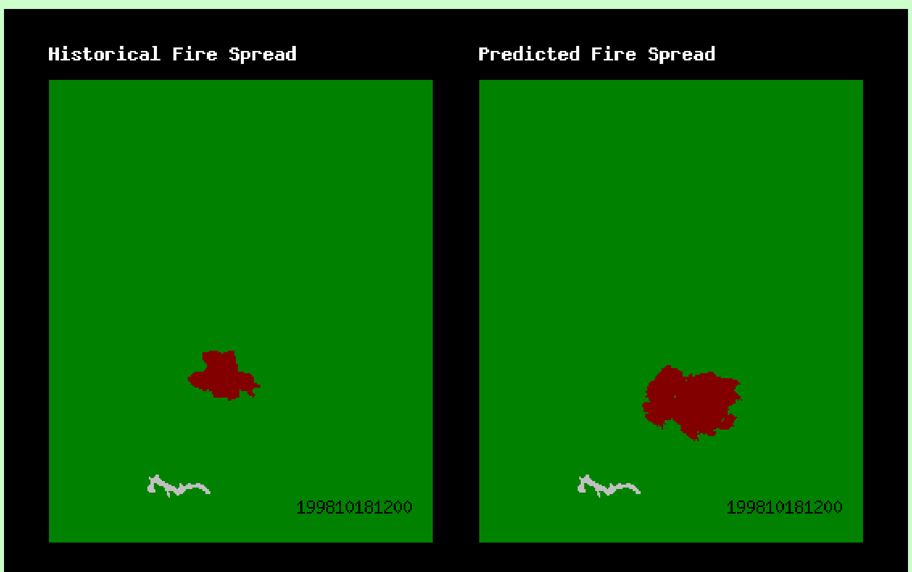
Los Prietos RAWS

100 meter Cellsize

Best Estimate Live Fuel Moisture

Marco Morais 2/20/2001





Accuracy: FARSITE Model

1998 Ogilvy Fire

FARSITE Predicted Fire Spread

Parameters:

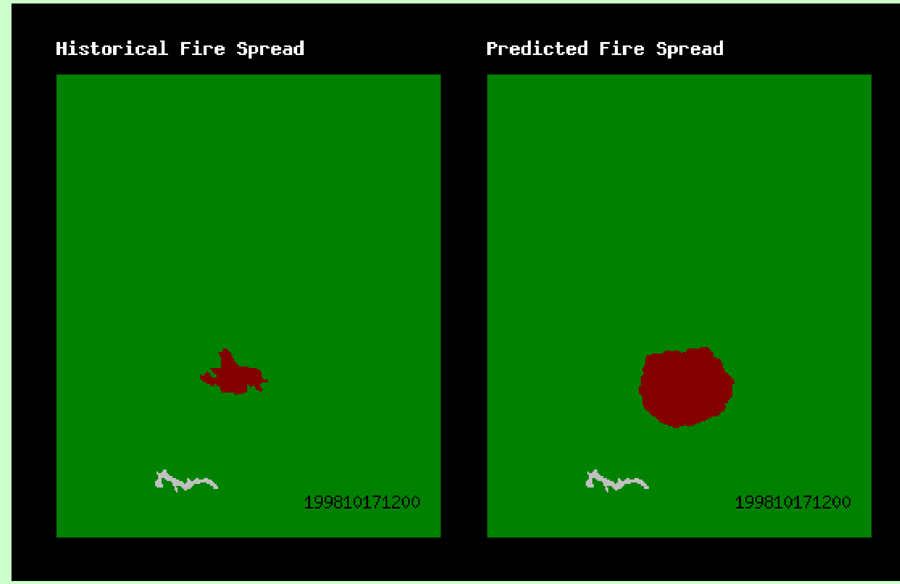
Custom Fuels

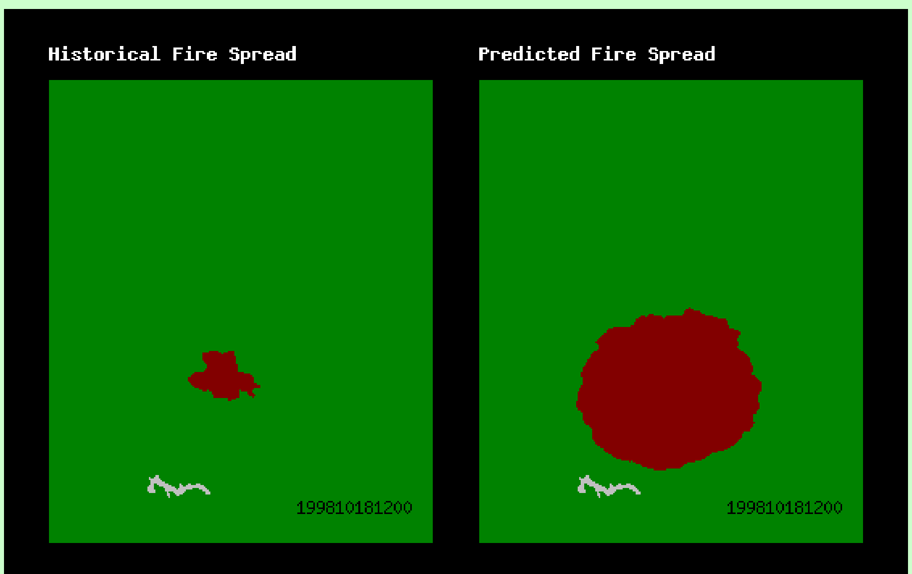
Los Prietos RAWS

100 meter Cellsize

Best Estimate Live Fuel Moisture

Marco Morais 2/20/2001





Summary

Conclusions

- both models showed little sensitivity to fuels under extreme environmental conditions
- NFFL fuels produced very large overprediction errors under moderate environmental conditions
- extinction based upon fire behavior superior to rate of spread adjustment factors
- HFire far more efficient in comparison to vector-based fire spread (FARSITE) without distortion problems

Future Work

- improved measures of accuracy (spatial & temporal)
- testing with more fires
- sensitivity to dynamic environmental variables
- incorporate more physical principles

Discussion Outline

I. Variables Required For Predicting Fire Spread

II. Issues For Implementing a Fire Behavior Model

III. HFire Fire Behavior Model Features

IV. Research Questions