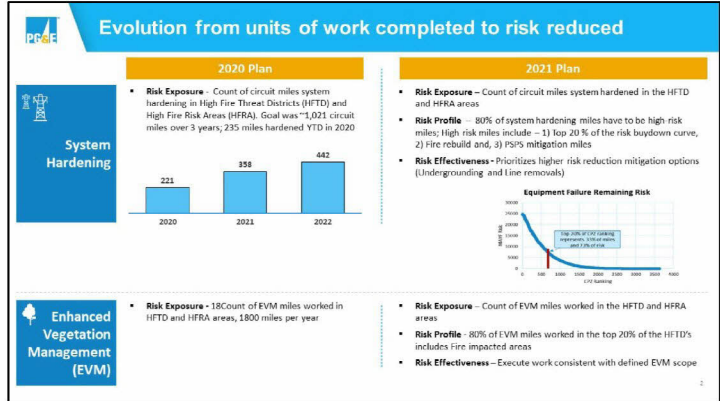


**Risk Models
&
2021 Workplans**

November 17, 2020

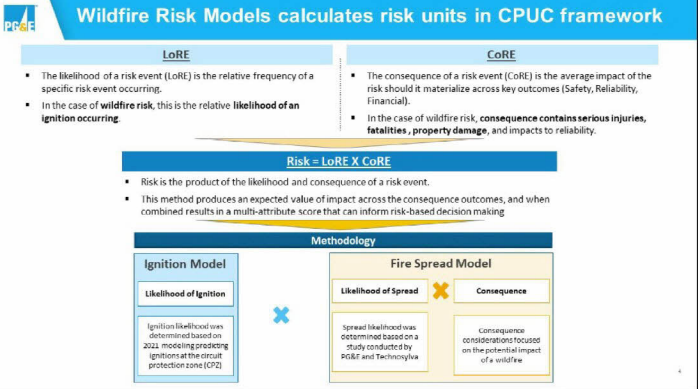


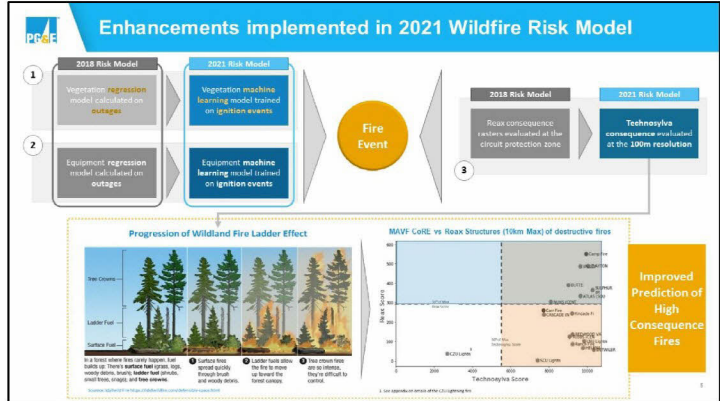
Together, Building
a Better California



Risk Model and Risk Quantification

J. Smith

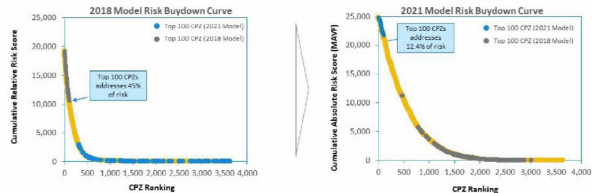






Risk models provide risk buydown curves to guide workplan

The risk buydown curve shows the amount of risk that can be addressed with every subsequent mile or CPZ that is mitigated. This view shows the relative magnitude of potential projects and can compare impacts of programs with varied effectiveness. The visualization helps to highlight the consolidation of risk by mile as you move down the prioritization list.



System Hardening Risk Buydown curves highlight the significant shift of where the top 100 CPZ's are between the two models

System Hardening

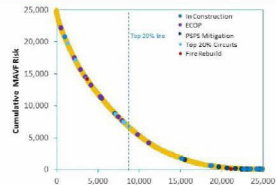


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The team proposes a "No Regrets" plan for approaching initial wildfire scope

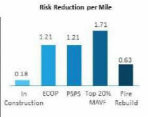
- Included Scope**
- All projects in the top 20% CPZ
 - Any ECOP projects in the top 20% CPZ's
 - All PSPS Mitigation Projects
 - All Fire Rebuild Projects

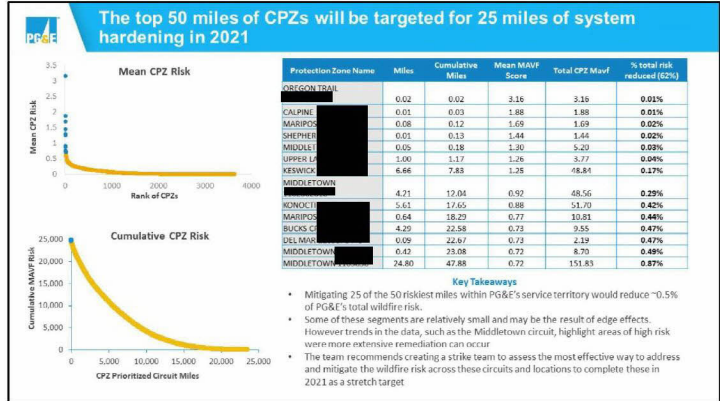


The "No Regrets" plan is an initial scope of work for the 2023 wildfire season that targets in the highest risk locations for either experienced or predicated fire risk. This scope of work will allow for the system hardening execution teams to remain fully utilized while confirmation of the remaining workplan is underway.

The system hardening team is requesting approval to move forward with this initial scope of work from the wildfire governance team.

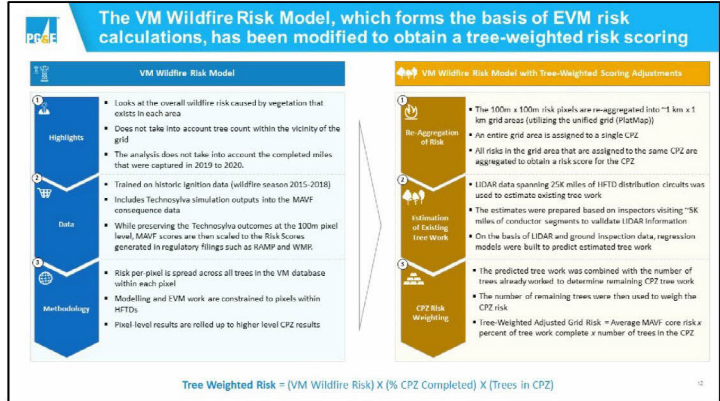
	CPZ Prioritized Circuit Miles		High Risk Area		Expected Case
	Miles	Projects Risk Reduction ¹	Miles		
In Construction	41.17	77	7.62	5.11	
ECOP (In Estimating)	55.94	17	68.05	49.04	
PSPS Mitigation	14.47	12	17.45	14.47	
Top 20% MAVI CPZ	41.32	8	70.58	41.42	
Fire Rebuild	12.7	2	8.12	12.7	





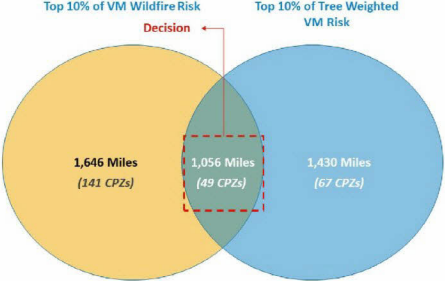
Enhanced Vegetation Management





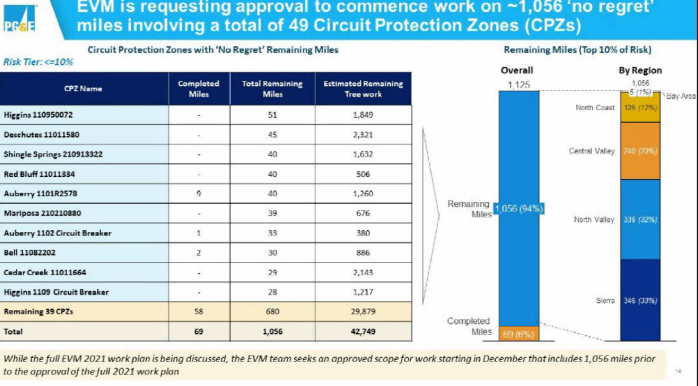


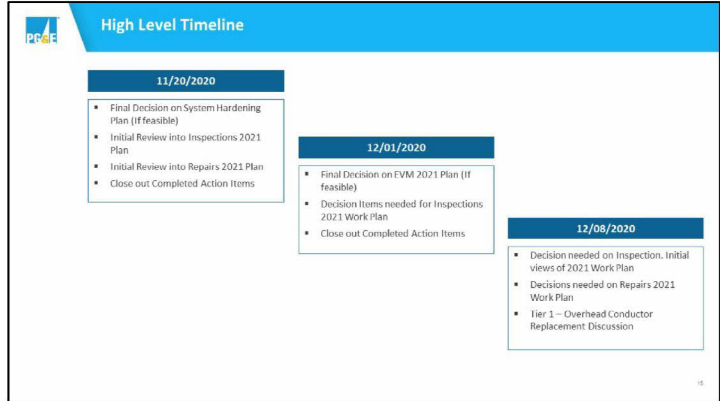
A "no regrets" approach of tackling the CPZs identified as high risk by both models is proposed for adoption to operationalize work



49 CPZs and 1,056 miles were common across the VM Wildfire risk ranking and the Tree Weighted risk ranking. Both models highlight these areas as high impact, and should be prioritized for EVM work.

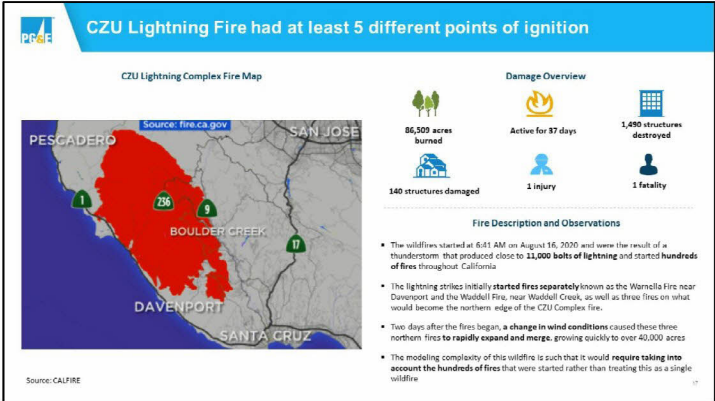
Note: CPZs indicated are based on the draft 2021 EVM Plan targeting 2,295 miles.

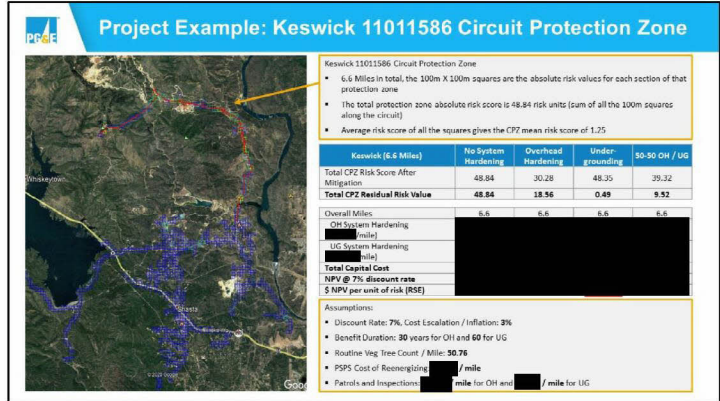




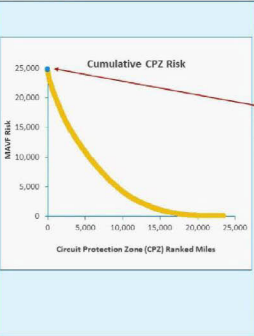
Appendix

11/20/2014





The top 50 riskiest miles represent 4.9% of the system risk.



Protection Zone Name	Miles	Cumulative Miles	Mean MAUP Score	Total CPZ MAUP	% total risk reduced (52%)
OREGON TRAIL	0.02	0.02	3.16	3.16	0.01%
CALPINE	0.01	0.03	1.88	1.88	0.01%
MARIPOSA	0.08	0.12	1.69	1.69	0.02%
SHEPHERD	0.01	0.13	1.44	1.44	0.02%
MIDDLE	0.05	0.18	1.30	3.20	0.03%
UPPER LA	1.00	1.17	1.26	3.77	0.04%
KEWICHO	6.66	7.83	1.25	48.84	0.17%
MONOCT	4.71	12.04	0.92	48.56	0.23%
MONOCT	5.61	17.65	0.88	51.70	0.42%
MARIPOSA	0.64	18.29	0.77	10.81	0.44%
BUCKS CO	4.29	22.58	0.72	7.55	0.47%
SILVER	0.09	22.67	0.72	4.38	0.47%
MIDDLETOW	0.42	23.08	0.72	8.70	0.48%
MIDDLETOW	24.80	47.88	0.72	151.83	0.87%

Key Takeaways

- Mitigating 25 of the 50 riskiest miles within PG&E's service territory would reduce ~0.5% of PG&E's total wildfire risk.
- Reason it is only 0.5% is because this is across all circuits in HFTD's (~25000 miles).
- On each project a more granular risk spend efficiency calculation can and will be performed on an NPV basis once the project is fully scoped similar to what is shown on the Keswick 11011586 circuit protection zone.

2021 Dx Model

In the effort to prioritize circuits, 2021 Dx Model continues advancement of risk model capabilities compared to earlier models

	PRIORITIZATION DETAILS	RISK EQUATION
<p>Methodology</p> <ul style="list-style-type: none"> Make ignition predictions at a scale of 100m x 100m "pixels" along the Dx grid Rolls-up pixels to Circuit Protection Zones For each pixel, assign risk score based upon the product of: <ol style="list-style-type: none"> (1) Likelihood of ignition (2) Effect of a potential ignition <p>Scope</p> <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Tier 3 <input checked="" type="checkbox"/> Tier 2 <p>Risk Components</p> <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Likelihood: via ignition prediction (Max Entropy) <input checked="" type="checkbox"/> Effect: via : <ol style="list-style-type: none"> (1) Ignition spread (Technolyva) (2) Ignition consequence (Technolyva) 	<ul style="list-style-type: none"> Make ignition predictions at a scale of 100m x 100m "pixels" along the Dx grid Rolls-up pixels to Circuit Protection Zones For each pixel, assign risk score based upon the product of: <ol style="list-style-type: none"> (1) Likelihood of ignition (2) Effect of a potential ignition <p><input checked="" type="checkbox"/> Tier 3</p> <p><input checked="" type="checkbox"/> Tier 2</p> <p><input checked="" type="checkbox"/> Likelihood: via ignition prediction (Max Entropy)</p> <p><input checked="" type="checkbox"/> Effect: via :</p> <ol style="list-style-type: none"> (1) Ignition spread (Technolyva) (2) Ignition consequence (Technolyva) 	<div style="border: 1px solid #ADD8E6; padding: 10px; text-align: center; margin-bottom: 10px;"> <p>Wildfire risk=</p> <p>LoIte X CoIte (Ignition Spread X Consequence)</p> </div> <p><u>Ignition likelihood:</u> The likelihood of ignition in 100m x 100m pixels</p> <p><u>Ignition spread:</u> The likelihood of ignition spread in 100m x 100m pixels</p> <p><u>Consequence:</u> The Consequence score is the effect on structures and natural resources in 100m x 100m pixels</p>

2021 Dx Model (EVM Model)
LoRE Ignition likelihood calculation

IGNITION LIKELIHOOD

Wildfire Risk = LoRE * CoRE (Ignition Spread * Consequence)

Scoring methodology
Ignition likelihood (LoRE) was determined based on a probability analysis predicting ignitions in 100m pixels. The model was trained on ignitions limited to fires season events and CPUC reportable ignitions from 2015 to 2018:

1 Variables importance ranking

Variable	Permutation Importance
temperature	23.3
200-hour-fuelvols	24.1
water-availability-avg	23.4
wind-current-direction	4
rho	4.2
precipitation-avg	3.1
humidity	2.9
precip-forecast-avg	2.4
burn-index-avg	2.3
altitude	2.0
temperature-avg	1.4
wind-direction-avg	1
total-precip-avg	0.8
tree-height-avg	0.8
2000-hour-fuelvols	0.4
energy-release-avg	0.4

2 Model Type
Maximum Entropy: The principle of maximum entropy states that the probability distribution which best represents the current state of knowledge is the one with the largest entropy, in the context of precisely stated prior data

Model Results
Top 10 feeders with the highest predicted count of vegetation caused ignitions:

Feeder name	Predicted count
GARBERVILLE 1103	0.000336
FRUITLAND 1142	0.000333
FRUITLAND 1141	0.000274
GARBERVILLE 1102	0.000285
BEN LOMOND 0401	0.000245
BEN LOMOND 1101	0.00024
GARBERVILLE 1101	0.000216
HOOPA 1101	0.000216
FELTON 0401	0.000215
PARADISE 1106	0.000204

Model Statistics and Performance

- Predicted annual HFTD ignitions (average): 100
- Observed total HFTD ignitions (2015-2018): 401
- ROC-AUC: 0.737 (in-sample)
- ROC-AUC: 0.716 (out-of-sample)

PGE

2021 Dx Model (Conductor Model) LoRE Ignition likelihood calculation

IGNITION LIKELIHOOD

Wildfire Risk = **LoRE** * **LoRS** (Ignition Spread * Consequence)

Scoring methodology

Ignition likelihood (LoRE) is calculated using classification model that identifies the likelihood of at least one ignition per year at a given 100m by 100m pixel location. More specifically, the Conductor Failure models the conditional probability that a reportable ignition will occur within a given pixel location:

1 Variables importance ranking

Variable	Permutation Importance
Non-burnable area	32.8
Daily precipitation, mean	25.8
Conductor material: ACSS	9.7
Estimated conductor age	8.9
Max tree height	6.2
Reliability Program splice	4.5
Vapor pressure deficit, mean	4.0
Conductor size 2	3.4
Conductor size 4	1.6
100 hour fuel, mean	1.5
Max temperature, mean	1.0
Wind speed, mean	0.9
Local topography	0.2
Conductor size 6	0.1
Conductor material: AI	~0
Conductor material: Oo	~0

Model Results

Top 10 feeders with the highest probability of ignition led by asset failure:

Feeder name	Mean Ignition Probability
CRESTA 1101	.001
PARADISE 1105	0.00098
BIG BASIN 1101	0.000911
APPLEMILL 1104	0.00086
CAMP EVERES 1104	0.00079
PARADISE 1103	0.00072
CURTIS 1105	0.00070
PARADISE 1104	0.00067
CEDAR CREEK 1101	0.00065
PARADISE 1109	0.00064

Model Statistics and Performance

- Predicted annual HFTD ignitions (average): **60**
- Observed total HFTD ignitions (2015-2018): **242**
- ROC-AUC - 0.76 (in-sample)
- ROC-AUC - 0.74 (out-of-sample)

2021 Dx Model – Technosylva Modeling and CoRE Calculation

IGNITION SPREAD

Wildfire Risk = Likeli • CoRE = Ignition Spread • Consequence

Ignition Spread Calculation Concept

- Ignition points were selected within a 200m buffer around PG&E's assets, creating a grid of 100m squares, (~254,000)
- For each point on the grid pick a date from the worst weather dates (452)
- Simulate a fire and let it burn for 8 hours using underlying fuel and weather conditions.
- Simulation results were aggregated including acres burned, flame length, rate of spread, buildings destroyed, and fire volume.
- Pixels were then averaged across CPZs to create consequence scores for CPZs.

Destructive fire probability

A destructive fire probability is calculated at each of the 255k HFTD locations by taking a ratio of number of simulations that met the following criteria

1) Acres burnt* >= 300 Or 3) FBI >= 3
2) Building destroyed* >= 50 Or 3) FBI >= 3
3) Fire behavior index (FBI) >= 2

* Acres burnt and building destroyed are at the end of the 8 hrs simulation

CONSEQUENCES

Wildfire Risk = Likeli • CoRE = Ignition Spread • Consequence

Scoring methodology

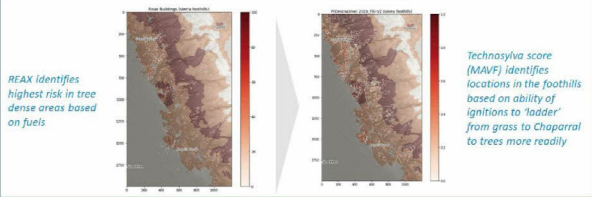
Within PG&E, the Meteorology team is working with Technosylva to create fire spread simulation for every 100 x 100m pixel within HFTD regions. By leveraging the Technosylva fire spread modeling outputs and historical Red Flag Warning shapefiles, consequence model are developed to distinguish the consequence within the HFTD tranche at 100m x 100m grid level. The steps implemented included:

- 1) **Calculate RFW and Fire Size Probabilities**
Technosylva and (Red Flag Warning) RFW shape files from National Weather Service to be used to calculate the Probability of the fire size given an ignition, and the probability of RFW at 100m pixel level
- 2) **Calculate pre-calibrated MAVF CoRE**
Combining the fire size probabilities and RFW probabilities calculated in Step 1 with MAVF CoRE values at tranche, the MAVF CoRE values at 100m Tranche Level are calculated.
- 3) **Calibrate MAVF CoRE w.r.t Ignition Driver**
Calibrate the CoRE by matching uncalibrated Risk per event to the weighted average CoRE from the wildfire bovine model. By applying uniform calibration factor across all pixels, this method preserves the relative consequence difference between 100m pixels

Redacted for Privilege



Evaluating Wildfire Consequence (REAX vs. Technosylva)



Key Insights

- While densely forested areas have the fuels to support a catastrophic fire, it is **more difficult for an ignition to propagate** to the tree-tops where the fuel resides.
- Foothill regions have an even higher wildfire consequence due to the more readily available fuel ladder to tree-tops.
- Wildfire risk and vegetation ignitions are **not highly correlated**.
- In many areas of highest wildfire risk the probability of ignition is low. Therefore, **mitigations to reduce the probability of an ignition may have a marginal impact on reducing overall wildfire risk.**
- Vegetation ignitions are still highly correlated with trees and fuels.
- Conductor ignitions are correlated with conductor type and age.

Risk Model Action Items					
Workstream	Action Item	Description	Responsible Party	Resolution	Date
risk model	risk model contributors	provide a detailed description of the top model contributors		Complete - Targeted for inclusion in open source release	11/13/2020

Vegetation Model - Contributors Description		Conductor Model - Contributors Description	
Variable	Description	Variable	Description
Tree height	Maximum tree height, in meters, for each 100m x 100m pixel area along the distribution grid	Nonflammable area	land cover description similar to imperviousness that includes surfaces that typically don't ignite when a spark occurs
100-hour fuel	The dead fuel moisture data from GRDMET	Daily precipitation, mean	The average daily precipitation from the GRDMET dataset
Vapor pressure deficit	The average vapor pressure deficit from the GRDMET dataset	Conductor material, acsr	Aluminum conductor steel-reinforced
Windy-summer-day-pct	Percentage of days that have high frequency of gusts	Estimated conductor age	Number of years since the installation year
WU	High fuel/moisture district	Max tree height	Maximum tree height, in meters, for each 100m x 100m pixel area along the distribution grid
Precipitation	The average daily precipitation from the GRDMET dataset	Reliability Program score	Score with more than three nulls per phase
Impervious	Impervious ground cover (i.e. non-flammable)	Vapor pressure deficit, mean	The average vapor pressure deficit from the GRDMET dataset
Specific humidity	The average specific humidity from the GRDMET dataset	Conductor size 2	Conductor size 2
Burn index	An derived variable based off of the geographical and topographical aspects of a location	Conductor size 4	Conductor size 4
Wind max	The maximum wind velocity a height of 10 meters from the RealTime Mesoscale Analysis (RTMA) dataset at a resolution of 2.5km	100-hour fuel, mean	The dead fuel moisture data from GRDMET
Temperature	The average temperature from the GRDMET dataset	Max temperature, mean	The average maximum temperature from the GRDMET dataset
Windy-summer-day-pct	Percentage of days that have a high percentage of days with high average wind speed	Wind speed, mean	The average wind velocity a height of 10 meters from the RealTime Mesoscale Analysis (RTMA) dataset at a resolution of 2.5km
Local topography	The topographic position index (TPI) was extracted from a USGS digital elevation model (DEM) at 100-meter resolution	Local topography	The topographic position index (TPI) was extracted from a USGS digital elevation model (DEM) at 100-meter resolution
1000-hour fuel	The dead fuel moisture data from GRDMET		
Energy release	Average release of energy from fuels		