

# **BUSHFIRE THREAT ANALYSIS for Western Australia, final report**



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## **Bushfire Threat Analysis: Western Australia**

**A report for Fire and Emergency Services, Bushfire Protection Branch, Western Australia**

**Prepared by School of Environmental Science, Murdoch University**

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**Final Report, December 2011**

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# Bushfire threat analysis (BFTA) for the State of Western Australia -Final Report-

## PREFACE

This report is an extension of the bushfire threat analysis of Muller (2008) to the whole of Western Australia. The initial approach and general background are described in Muller (2008) where the southwest of Western Australia was analysed. In the current report, we extend and slightly modify Muller's approach and methodology to include additional vegetation types and regions. The approach is based upon AS/NZS 4360 principles (2004).

The report contains the following:

- A bushfire threat analysis (BFTA) model that can be updated annually which provides standardised methods and approaches to characterising overall threat based on fire behaviour, ignition risk, response time, and potential consequences of bushfire.
- Summary of changes relative to Muller (2008)
- Descriptions of all input data
- Bibliography of relevant scientific literature and technical reports.

## SUMMARY

Bushfire threat analysis (BFTA) is an assessment of the comparative risk of damage resulting from bushfires in Western Australia (Muller 2008). It is based upon the principles laid out in Australian Standard AS/NZS 4360 (2004) which defines risk as the likelihood of occurrence of an event (e.g. bushfire) and the consequences of that event.

This analysis has utilised a range of qualitative and quantitative estimates of threat and consequence components to arrive at an overall threat level. It has incorporated the best data available, the published scientific literature, and expert opinion to arrive at the best outcome possible. The document presented builds upon previous work completed for the southwest of Western Australia by Muller (2008). As such, we provide key information necessary for the implementation of the BFTA and describe changes in detail but broader background rationale can be found in Muller (2008).

Overall, bushfire threat can be divided into fire likelihood and consequence of fire in an area. Likelihood of bushfire is partitioned into three components: fire behaviour, likelihood of ignition, and suppression capacity. Consequence of bushfire is characterised by values (infrastructure, homes, indigenous sites, biodiversity, etc) in an area.

### Bushfire Threat

The Risk or Bush Fire Threat is determined using the following risk assessment matrix.

Consequence Class	6: Catastrophic	5: Major	4: Serious	3: Moderate	2: Minor	1: Low
Likelihood Class						
5 Almost Certain	11	10	9	8	7	6
4 Likely	10	9	8	7	6	5
3 Possible	9	8	7	6	5	4
2 Unlikely	8	7	6	5	4	3
1 Rare	7	6	5	4	3	2

Where Likelihood represents a weighted average of the three likelihood measures (2 x fire behaviour + ignition + suppression).

### Final threat values are assigned on a 1-5 scale

Risk Class (Threat)	Likelihood + Consequence
1 Low Risk	2-3
2 Moderate Risk	4-5
3 Significant Risk	6
4 High Risk	7-8
5 Very High Risk	9-11

## THREAT COMPONENTS

### Fire Behaviour

Fire behaviour under 95<sup>th</sup> percentile weather conditions (wind, temperature, relative humidity) was computed for each major vegetation type in Western Australia using published relationships from the scientific literature. Rates of forward spread and fireline intensity were allocated to each of five classes per the AS4360 code. Primary data requirements are Bureau of Meteorology (BOM) data, fire history, and vegetation type.

### Ignition Risk

Ignition risk was based on two primary sources: natural and anthropogenic. Natural ignitions were modelled from the frequency of lightning ignited fires over a 10-year period using the MODIS satellite burned area product. Anthropogenic ignitions were modelled from human population locations (communities) and infrastructure (roads, powerlines, rail).

### Suppression Response

Suppression response was based on travel time from existing fire fighting infrastructure (FESA and DEC stations). Travel time was categorised by travel time by road and vegetation type.

### Values

A series of bushfire consequence data were assembled based on a range of existing societal assets. Broadly, these were classified into human infrastructure (roads, power, rail), habitation (communities, isolated homes), indigenous sites and communities, and biodiversity (rare fauna and flora).

## OUTCOMES

The data products and methods described in this report provide a whole of Western Australia assessment of bushfire threat, a major step forward in aiding government departments and personnel to make decisions in allocating resources to avoid loss of life and property in relation to bushfire.

## Introduction

Management of fire risk is exceptionally complex in places such as Western Australia with such a broad range of fire regimes, vegetation and community types, and varying human values and resources. In particular, fire is not optional – ecosystems are fire-prone and require periodic fire to maintain many species of flora and fauna. Managing this across landscapes, many of which are human-dominated requires extensive information on fire likelihoods as well as the values present.

This report describes the Bush Fire Threat Analysis (BFTA) for the State of Western Australia. The BFTA is an extrapolation of a previous set of models provided for the Southwest of the state by Muller (2008). This document augments the Muller report and describes modifications and improvements to the modelling approaches that were necessary to apply the Muller models to the whole of Western Australia and provides the presented BFTA for the present day.

Organisation of the report reflects the analysis and data inputs. We first provide broad suggestions for future refinements and changes from the previous analysis as well as background information on overall data management. Following that, we detail each key portion of the BFTA explaining data inputs, calculations, and assignment of threat/risk levels.

## Changes from Muller

To accommodate a range of ecosystem types and portions of Western Australia with lower data availability, the following changes were made. Detailed descriptions are provided in the relevant sections of the report

- Ignition likelihood. To better estimate fire frequency (and thus ignition likelihood) in northern regions we used the MODIS burned area product rather than number of fires at the 5km scale based on FESA and DEC records along with hotspot records. This permitted a more consistent treatment across regions with varying levels of record keeping and history.

- Fuel loads and time since fire. Muller employed detailed modelling of biomass accumulation as a function of time since last fire for a number of vegetation types in southwestern Australia as well as rate of spread estimates from the red book (Sneeuwjagt & Peet 2008). In consultation with FESA, the McArthur meter (McArthur 1967) was applied to all southern forest types and look up tables were used to adjust rate of spread by vegetation type (see fire behaviour section for more information). Given the scale of analysis, this level of detail was considered appropriate.

- A number of small changes were made to likelihood and value levels from the original Muller analysis (e.g. ignition likelihood of transmission lines was changed from 4 to 2). These small changes are detailed throughout.

## Recommendations

- Quantify fuel load across the state and time using MODIS net primary productivity. This will greatly improve the Behaviour model as remote sensing estimates of fuel loads are likely more accurate than using flat rates.
- Use BoM weather grids to calculate ROS. This may lead to more reliable ROS calculations than the interpolated layers.
- Consider more detailed analyses of Perth metropolitan region using finer resolution data such as CSIRO urban monitor data and LiDAR flights for fuel/vegetation mapping as well as more detailed infrastructure data from organisations like Western Power (e.g. where power distribution is now located underground).

## Future Steps

This analysis represents a first threat assessment for the whole of Western Australia. Limitations include lack of detailed data for large portions of the state as well as the relative complexity of implementing such an analysis over such a large and heterogeneous area, particularly as it relates to assessing consequences (values) and fire potentials (sparse weather and fuels data). In the future, upgrading of details within input data (e.g. increased detail of power infrastructure to better understand ignition risk and consequence of loss) as well as a more dynamic system allowing for assessment of management options would be desirable. Optimisation approaches such as evaluating trade-offs between allocating resources to homeowner education (ignitability of homes) versus suppression equipment are beginning to be applied in places like Victoria, New South Wales, and California. Calls for the application of such procedures here in Western Australia going forward seem likely, particularly with respect to the peri-urban regions of Perth and the southwest.

## General Methods

The following sections provide key details on software, approach, and data handling needed to repeat the BFTA as presented.

### Data Processing

The approach to data processing mimics that of Muller (2008). The software used was ArcGIS 10 and all models are provided in Model Builder. ArcGIS 10 was used to construct models that take input data, generate a range of intermediate products, and then produce final outputs for each of the four major subcomponents (fire behaviour, ignition risk, suppression, values) and assimilate into a final threat output. Images of all models are provided in appendices of this document. The advantage of this process is that it is transparent and permits the sharing of models and updating of input data every year. The nature of the BFTA, with its diverse data sets, requires heavy processing load of computers which is less efficient in Model Builder and requires substantial computer time. Future work should script the entire BFTA in Python.

All input data were projected to GDA 1994 to ensure consistency across the state. Data were imported into a file geodatabase called 'input' which also holds required tables (e.g. travel time per vegetation class or fire behaviour equation per vegetation type) and a toolbox with all required model builder models. We detail required data inputs in the body of the report.





## INDIVIDUAL MODEL DESCRIPTIONS

### MODEL: Ignition risk

Ignition risk was modelled from infrastructure (anthropogenic ignitions) and MODIS burned area (natural, lightning-caused ignitions). Muller (2008) used MODIS hotspots, FESA fire records, and CALM fire records to estimate fire frequency. However, FESA and DEC fire records are out of date and were therefore disregarded as suggested by FESA (R. Smith, pers comm). Muller's assumption that all hotspots on the same day within 5 km radius represent one fire were found to cause very low fire densities in areas of the Kimberley that are known to burn every year. Instead, we downloaded 10 years (2000-2010) of the MODIS burn area product. For each 500-m pixel, the number of burns was counted and classified using the following table:

Number of fires in 10 years	Likelihood Class
0	1 = rare
1	2 = unlikely
2	3 = possible
3	4 = likely
>=4	5 = almost certain

Areas flagged as burned by the MODIS burned area algorithm that coincided with permanent water bodies according to the Geoscience Australia Water Bodies layer were disregarded as false positives.

*Anthropogenic Ignitions.* Infrastructure was buffered by 500-m and the following likelihood classes were assigned to infrastructure:

Infrastructure Type	Ignition Class
Built up area	4
Roads: Dual Carriageway, Principal Rd, Secondary Rd, Minor Rd	4
Roads: Track	3
Railway: moderate and light use	3
Railway: heavy use (Pilbara)	4
Powerlines: low voltage	3
Powerlines: high voltage transmission	2

We classified railroad into light and heavy use following Muller's approach (2008 report pg 13): Pilbara: 'heavy'; All other: 'light'

We classified 'transmission lines' as 'high voltage carriers' and 'powerlines' as 'low voltage distribution' (this classification is slightly different compared to Muller pages 13 and 70 as the power line data provided did not allow for a 1:1 use of Muller's classes).

**The risk assigned to various infrastructures can easily be modified for specific regions or the entire state.**

## MODEL: Suppression Response Time

Output for the suppression response model relied on two key inputs, location of FESA and DEC fire suppression resources and travel time. For FESA resources, only stations with code: 'BFB' or 'CFRS' or 'Dual-Reg' or 'FESA' 'FRSP' or 'VFRS' or 'VFSU' were selected.

Travel time was calculated for all road infrastructure and vegetation cover types. Roads were derived from Geosciences Australia 250K mapsheets (as described under Input data list). Road travel times were assigned as follows:

Road Type	Travel Time (min per 10 km)
Dual Carriageway	6
Principal Road	6
Secondary Road	8
Minor Road	10
Track	20
All Other	150

The "Travel\_time\_roads" table is provided for reference in the 'input' geodatabase.

For non-vegetation cover, principally water, travel speeds (time in min to travel 10km) were assigned to water bodies using the FEAT\_CODE field as follows:

'saln_cst_flt': 300 'mangrove_flt': 1200 'watercours': 1200 'sub_to_inund': 2400 'swamp': 6000 'Settling Pond', 'swamp_marine', 'w_body_void', 'reservoir', 'canal', 'lake', 'salt_evapor', 'sew_pond': 600000
---

This classification follows Muller except for 'water bodies void' and 'sewage ponds', which were not found in the Muller report and assigned the highest value (600,000).

Vegetation travel times can be found in the look-up table provided in the 'input' portion of the BFTA geodatabase and follow Muller's approach and classification (pg 15, Muller 2008). Travel time off of roads was modified by slope. Slopes were derived from 90-m SRTM data and assigned a travel time following Muller's approach (page 17). The 'Travel\_time\_slopes' table is provided for reference in the 'input' geodatabase.

To link the pre-European vegetation ('DAFWA\_Pre\_European\_Vegetation.shp') with Muller's travel speeds as specified in the 'Travel\_time\_vegetation' table, 'DAFWA\_Pre\_European\_Vegetation.shp' was first linked with the 'VEGE\_ASSOC' field in 'PreEuropeanVegetation\_attributes.dbf' (this table was provided with an older version of 'DAFWA\_Pre\_European\_Vegetation.shp').

This provided 'DAFWA\_Pre\_European\_Vegetation.shp' with the 'NVIS\_LV2' field that was then used to link the 'Travel\_time\_vegetation' table to get the travel times per vegetation type. The

'Travel\_time\_vegetation' table is provided for reference in the 'input' geodatabase. The feature class of

Below, we describe data sources, classification, manipulation, and methods. We also provide key references used to obtain predictive equations for fire spread in various fuel types.

### **Fire Behaviour Calculations, Model Descriptions, and Literature**

*Fuel Models.* The NVIS level 6 field of the pre-European vegetation map was interpreted to assign vegetation to one of 21 fire models and to reflect extant vegetation types (pastures, etc). This work was carried out by Ana Negreiros in consultation with Ralph Smith (FESA, Bushfire Protection Branch). The table provided was linked to the pre-European vegetation map shape file using the 'SA\_CODE' field.

Each fire model code as provided by FESA was translated into a numeric code for processing within ArcGIS. The table below details each model with its description, code, basic attributes, and key reference from which equations for rate of spread were derived.

Fuel Type	Name	Code	Numeric Code	Default Fuel Load (tons ha <sup>-1</sup> )	Key Inputs	Key Reference	Notes
Northern Australia, grassy understory	Northern Aust Grassland	NA_OG	20	6	Fuel moisture, wind, temp, RH	Sullivan 2010	CSIRO
	North Aust Woodland	NAW	21	8	0.5 * NA_OG	Sullivan 2010	CSIRO
	North Aust Open Forest	NA_OF	22	10	0.3 * NA_OG	Sullivan 2010	CSIRO
Pastures	Pasture/Crop/Natural Grass	Rn	1	4.5	Fuel moisture, wind, temp, RH	Sullivan 2010	Assume 100% curing
	Grazed/Cut Pasture	Rcu	2	4.5	Fuel moisture, wind, temp, RH	Sullivan 2010	Assume 100% curing
	Eaten Out Pasture	Re	3	0.5	Fuel moisture, wind, temp, RH	Sullivan 2010	Assume 100% curing
Hummock Grassland	Spinifex	hg_wind2m	7	10	Fuel load, Profile moisture content, wind	Burrows et al 2009	Assume profile moisture 12%
Shrubland	Woody shrublands	Rsh	6	6	Height, Wind	Catchpole et al 1998	
Mallee Heath	Mallee heath	Rmh	5	5	Litter Moisture, wind, RH, temp	McCaw 1997	Applied Rsh to all Rmh cover types
Woodland	Southern Woodlands	MCAFDI	16	15	FFDI, fuel load	Noble et al 1980	
Plantations	Commercial Plantations	Plntn	19	8	FFDI, fuel load	Noble et al 1980	Same as MCAFDI but with lower fuel load
Low Spread			17	0.2	0.10 * Rsh	NA	0.10 * Rsh
Bare Ground	No Spread	NoSpread	18	0	NA	NA	Water classified as 99

Plantations: plantations were derived from 'FPC\_Plantations' and assigned a separate fire model class as specified above.

All water bodies except for 'subject to inundation' were classified as '99'. The reason for not marking 'subject to inundation' as water is that the BFTA represents a worst case scenario and it is assumed that areas that are not permanently inundated can burn under extreme weather conditions (95<sup>th</sup> percentile).

All areas outside of the Southwest were assumed to be covered by pre-European vegetation. Within the Southwest, Land Monitor data from Landgate showing perennial woody vegetation in 2010 were used to identify extant pre-European woody vegetation. These data were used instead of Muller's 'Vege Mask'. All other areas in the SW were assumed to be grazed/ cut pasture (Rcu, code = 2) for the purpose of fire behaviour modelling.

### Rate of Spread Equations

Vegetation-specific equations for estimating forward rate of spread were based upon empirical studies published in the scientific literature. In the broadest of terms, Western Australia is composed of four major fire-prone vegetation types. Tropical systems with grassy understories but varying in the degree of canopy cover, arid grasslands (spinifex), woody shrublands and mallee throughout Western Australia, and temperate woodlands and forests. Empirical data exist for each of these major vegetation types as well as for human modified grassy vegetation (paddocks/grasslands under varying levels of grazing). Below, the equations and references for each major vegetation type are reported.

An analysis of this type, at the scale of Western Australia, necessarily is relatively coarse with respect to local vegetation conditions. Predictions using detailed empirical data (e.g. fuels data for southern forests varying by canopy closure or species composition; Sneeuwjagt and Peet (Sneeuwjagt & Peet 2008) may be appropriate for district level operations management but is beyond the scope of this analysis where identification of overall threat in a consistent framework is the principal aim.

#### Northern Open Grassland/Woodland/Open Forest (Sullivan 2010)

Northern Australia fuels models were based on the CSIRO fuel models developed by a range of investigators and detailed in Cheney and Sullivan (Cheney & Sullivan 2008) and Sullivan (2010). These vegetation types share a grassy understory with varying levels of overstory structure. Rate of Spread is dominated by the surface fuels with an adjustment term applied to increasing levels of canopy cover to account for diminishing wind. Rates of spread are calibrated on 4.5 tons ha<sup>-1</sup> of surface fuel (see table above for fuel loads used for estimating fireline intensities)

$$\text{RoS Grassland} = \text{phiM} * \text{phiC} * (1.4 + 0.838 * \text{wind} - 5)^{0.844}$$

$$\text{phiM} = \exp(-0.108 * \text{Mf})$$

$$\text{Mf} = 9.58 - 0.205 * \text{temperature} + 0.138 * \text{RH}$$

$$\text{phiC} = 1.12 / (1 + 59.2 * \exp(-0.124 * (\text{Cure} - 50)))$$

$$\text{Set Cure} = 100$$

$$\text{Wind} = \text{kph (95}^{\text{th}} \text{ percentile by station)}$$

$$\text{RH} = \% (95^{\text{th}} \text{ percentile by station)}$$

$$\text{Temp} = \text{degrees C (95}^{\text{th}} \text{ percentile by station)}$$

$$\text{RoS} = \text{kph so multiply by 1000 for m hr}^{-1}$$

Northern Woodland and Open Forest is calculated from Grassland as follows:

Woodland =  $0.5 * \text{Grassland}$ ; Open Forest =  $0.3 * \text{Grassland}$

#### Spinifex/Hummock Grassland (Burrows et al 2009)

Arid grassland rate of spread are based upon the series of papers published by Neil Burrows and others (Burrows et al. 2009). The arid grasslands are the most fuel limited of the fire prone ecosystems in Western Australia. Precipitation in preceding and the current year of consideration exhibit a strong influence on fire potentials.

$$\text{HG\_RoS} = 154.9 * U_2 + 140.6 * \text{FQ} - 228 * \text{PMC} + 1581$$

$$U_2 = \text{wind at 2m height} = (0.8329 + 0.57055 * \text{wind}) / 3.6$$

FQ = fuel quantity tonnes/ha, set at 6 t/ha

PMC = profile moisture content, set to 12%

#### Shrubland (Catchpole et al. 1998)

Catchpole et al (1998) details empirical equations based on a range of experimental and wildfires from across southern Australia and New Zealand. At the timing of writing, it is understood a series of new equations are under development by CSIRO scientists incorporating a range of new data sources.

$$\text{RoS} = 0.801 * U_2^{1.10} * (H^{0.49})$$

H = vegetation height (m). Set to 2m for now in order to get sensible estimates. Parameters reflect mostly Rx fire which largely pertain to more mild conditions (lower FDI/GFDI) which is likely why it underpredicts RoS

$$U_2 = \text{wind at 2m} = 0.71 * \text{wind}$$

RoS is in m/min so multiply by 60 to get m/hr

#### Mallee Heath (McCaw 1997)

These equations are reported for thoroughness but were not used in the BFTA and the shrubland rate of spread equations applied to all mallee-heath vegetation types.

$$\text{RoS} = 0.292 * (U_2^{1.05}) * \exp(-0.11 * \text{Mld}) \text{ \#units are m sec}^{-1}$$

$$U_2 = 0.71 * \text{wind (change to m sec}^{-1} \text{ by dividing by 3.6)}$$

$$\text{Mld} = 0.132 * \text{RH} - 0.168 * \text{temperature} + 6.8 \text{ (\% moisture in deep litter, eqn set for >2 days since last rain and after 12pm)}$$

#### McArthur Fire Danger Index (McArthur 1967; Noble et al. 1980)

This rate of spread prediction is based on extensive empirical data from woodland fires (McArthur 1967). Rate of spread is based on drought index (curing of fuels), current weather, and fuel loads. The Fire Danger Index created by McArthur is still the dominant fire danger system used across southern Australia.

$$\text{RoS} = 0.0012 * F * W$$

Where

F = FFDI (Forest Fire Danger Index)

W = fuel mass ( $\text{t ha}^{-1}$ )

$$\text{FFDI} = 1.25 * D * \exp[(T-H)/30 + 0.0234 * V]$$



D= Drought Factor (supplied by BOM, for 95<sup>th</sup> percentile conditions can almost assume = 10)

T= temperature (supplied by BOM)

H= Relative Humidity

V = wind velocity at 10m height (km hr<sup>-1</sup>)

### Fireline Intensity

In all cases, we derived predicted fireline intensities from the equation:

$$FI = RoS * w * h$$

Where:

FI is fireline intensity in kW m<sup>-1</sup> sec<sup>-1</sup>

RoS is forward rate of spread (m sec<sup>-1</sup>)

h = reaction intensity or heat yield of combustion (18,600 kW kg<sup>-1</sup>)

w = weight of fuel available for combustion (kg m<sup>-2</sup>; typically all fine fuels)

### Fire Weather Data

As the overall goal of the BFTA was to measure threat, we estimated fire potentials under adverse weather conditions. Following standard fire science approaches (as well as Muller), we used 95<sup>th</sup> percentile weather conditions (wind, temperature, relative humidity, drought index) as inputs for predicting forward Rates of Spread and Fireline Intensities (see below for equations). Meteorological data were obtained for all 3-hr weather stations throughout Western Australia from the Bureau of Meteorology (BOM). Drought index data were available from a smaller set of stations throughout Western Australia. Using all years available for each station we extracted the 95<sup>th</sup> percentile conditions. We defined the following times as year as fire seasons for varying regions.

Region	Fire Season Period	BOM rainfall districts
Kimberley	01 July – 31 December	1,2,3
Southwest	01 November – 30 April	4,5,6,7,11,12,13
Interior, Gascoyne, and Pilbara	All year*	8,9,10

\*Examination of fire danger index (FDI) data from BOM stations led to the conclusion that interior and arid tropical regions were fire prone throughout the year.

Data from BOM stations (as text files) were processed and summarised using the free-to-download statistical software R (R REF). The script that processes these data and also calculates RoS for all vegetation types by station is provided as part of this report as a separate text file.

### Modification of Fire Behaviour Estimates

Ninety-fifth percentile fire behaviour predictions were further modified based upon slope and fuel age within each pixel.

#### Slope Modification (based upon equations Muller report)

Muller's code	Description	Numeric code used in ArcGIS	Equation
Rn	Pasture/ Crop/	1	$95r_n * \text{Exp}(0.069 * \text{slope})$

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	Natural Grasses		
Rcu	Grazed/ cut pasture	2	$95rcu * \text{Exp}(0.069 * \text{slope})$
Re	Eaten out pasture	3	$95re * \text{Exp}(0.069 * \text{slope})$
Rmh	Mallee Heath	5	$95rmh * \text{Exp}(0.069 * \text{slope})$
Rsh	Other Shrubland	6	$95rsh * 1 * \text{Exp}(0.035 * \text{slope})$
	Hummock Grasses		
HG_Wind2m	(soft and hard Spinifex)	7	$95hg\_wind * 154.9 + 140.6 * 6 - 229.1 * 12 * \text{Exp}(0.069 * \text{slope})$
McAFDI	Woodlands	16	$95mcafdi * 16.761 + 10.165 * \text{Exp}(0.069 * \text{slope})$ or $95mcafdi * 11.049 + 7.0807 * \text{Exp}(0.069 * \text{slope})$
LowSpread	Samphire, chenopds	17	$0.1 * 95rsh * 1 * \text{Exp}(0.035 * \text{slope})$
NoSpread	Bare areas	18	0
Plntn	Plantations	19	$95mcafdi * 11.049 + 7.0807 * \text{Exp}(0.069 * \text{slope})$
NA_OG	Northern Australia Grassland	20	$95naog * \text{Exp}(0.069 * \text{slope})$
NA_W	Northern Australia Woodland	21	$95naw * \text{Exp}(0.069 * \text{slope})$
NA_OF	Northern Australia Open Forest	22	$95naof * \text{Exp}(0.069 * \text{slope})$
Water	Water	99	0

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Shrublands	rsh, rmh	0-3 yrs (0.2)	3-6 yrs (0.5)	>6 yrs (1)
Hummock Grasslands	hg_wind2m	0-5 yrs (0.2)	6-10 yrs (0.5)	> 10 yrs (1)
Northern Australia	naog, naw, naof	0-1 yr (0.5)	>1 yr (1)	
Pasture	rcu, re, rn	No adjustment		

The shrubland calculation uses a different slope factor following Muller's approach. The McAFDI (McArthur 1967) model was applied to Southwestern forests and transitional woodlands. The default fuel loads are 15 t/ha and 10 t/ha respectively. To convert McAFDI 95<sup>th</sup> percentile Fire Danger Index into ROS, two conversion equations were used:  $95\%\_FDI * 16.761 + 10.165$  and  $95\%\_FDI * 11.049 + 7.0807$  for 10 and 15 t/ha fuel loads, respectively.

Mueller used specific ROS equations for various forest types in the Southwest. Following the suggestion of Ralph Smith, all forest in the Southwest were modeled using McArthur's (1967) approach.

\*Plantations could not be differentiated by age so a default fuel load of 8 t/ha was assumed. A fuel load of 15 t/ha was used for the South Western forests and 10 t/ha for the transitional woodlands following the suggestion by Ralph Smith.

### Relevant Scientific Literature

A range of important research has been published regarding fire behaviour in relation to fuel and weather conditions. Important background reading includes the books *Flammable Australia* (Bradstock et al. 2002) and *McArthur and Luke* (1978) as well as a more recent report on likely climate change impacts (Williams et al. 2009). A new version of *Flammable Australia* is due out in 2012 with updated materials and references therein. Recent papers by Penman et al (2011) reviewing the efficacy of prescribed burned and Fontaine et al (2012) examining the relationship between fuel age and fire behaviour in managed fires may also be of interest. Finally, work examining fire regimes of various portions of Western Australia (O'Donnell et al. 2011; Parsons & Gosper 2011) and the carbon emissions of fire in Northern Australia (Russell-Smith et al. 2009) may also be of interest going forward. The literature continues to develop rapidly and these papers are but a small subset of what is published, use of these papers as a starting point in a bibliographic database (i.e. google scholar) is strongly recommended for building a more complete reference collection.

### MODEL: Value classes

The value model processes all data available pertinent to negative consequences of being burned in bushfire which includes human infrastructure, homes, indigenous sites and communities, and biodiversity values. The values model is the most complex and computationally intense portion of the BFTA because of the broad range of data types and buffering required for all locations. It is important to allow ample computer time for running this component of the BFTA.

All values were buffered by 500-m except for Bush Subdivisions and Aboriginal\_Heritage\_Sites (which were provide as a buffered dataset),

Four types of building datasets were used:

- Landgate\_Building\_Polygon.shp

- Landgate\_Building\_Point.shp

- FESA\_Buildings\_Pilbara.shp

- Building\_Footprints.shp

All buildings were assigned a value of 3

- ‘Current’ apiary sites were selected(s and)5







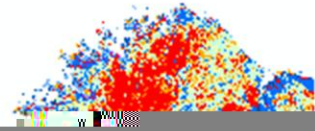








## Ignition Risk



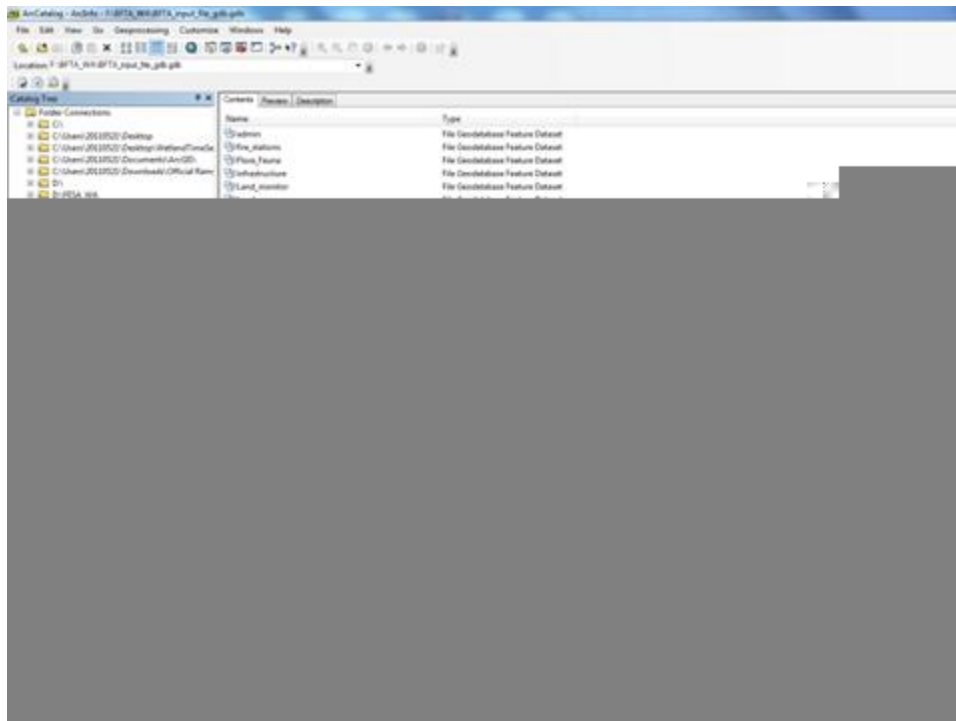






## APPENDIX 2: IMAGES OF ArcGIS Model Builder Structures for Bushfire Threat Analysis

### Data Structure

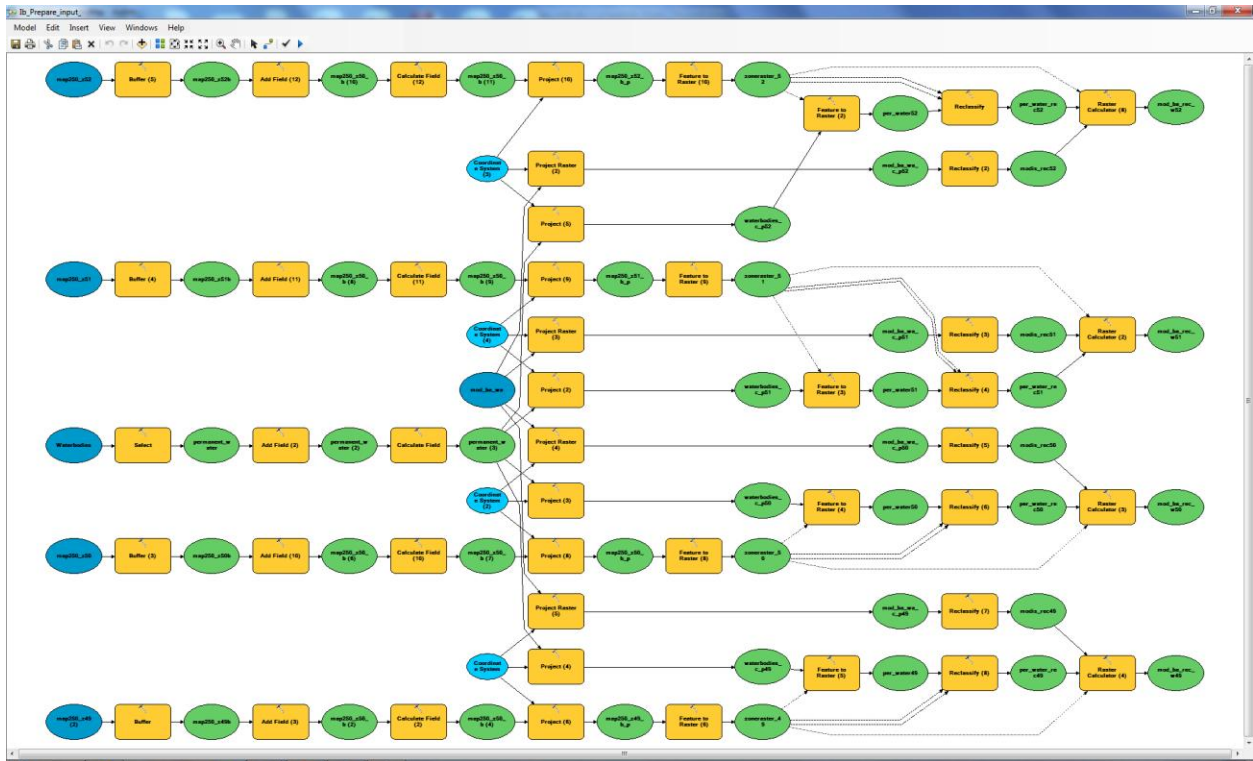




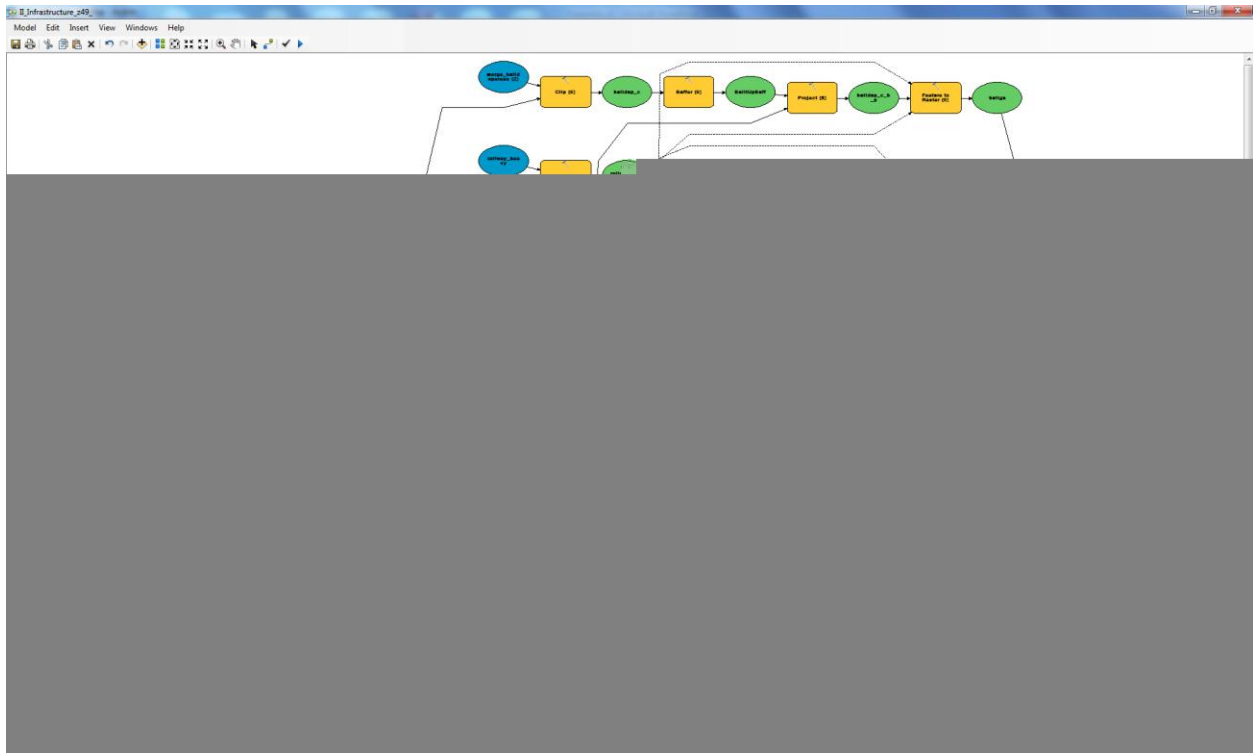




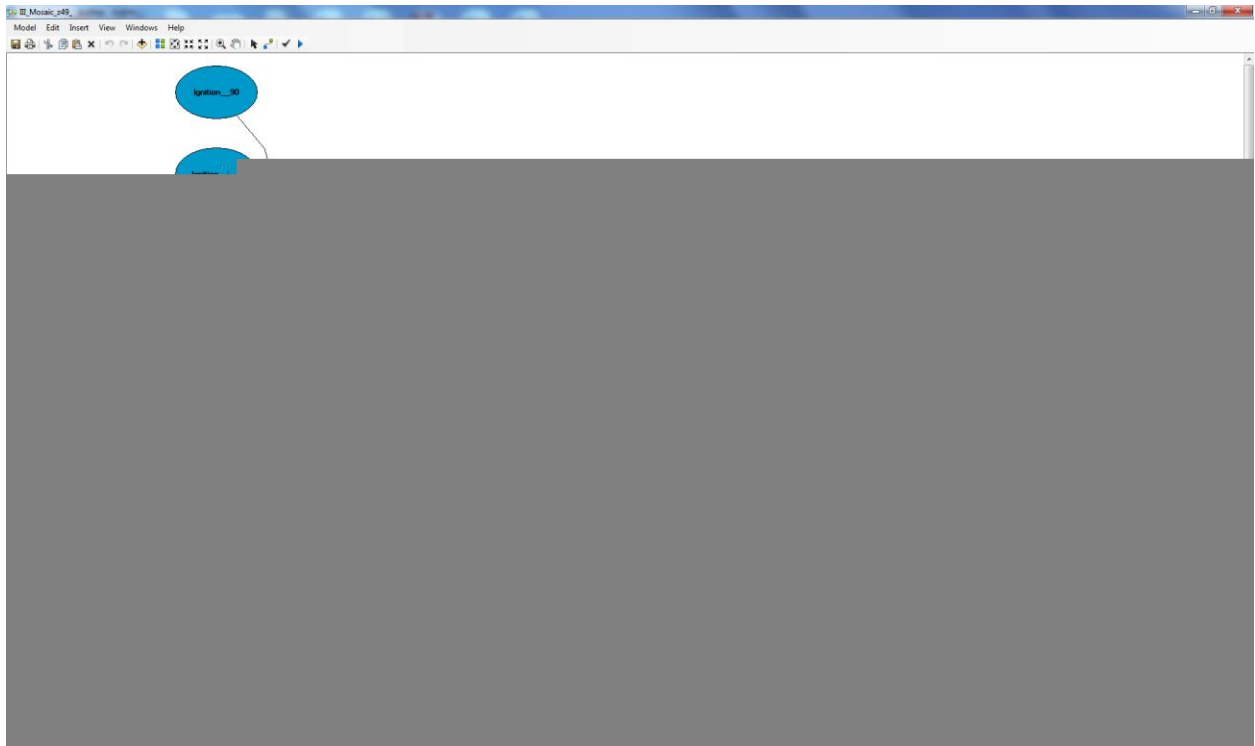
## IGNITION: Level 1b



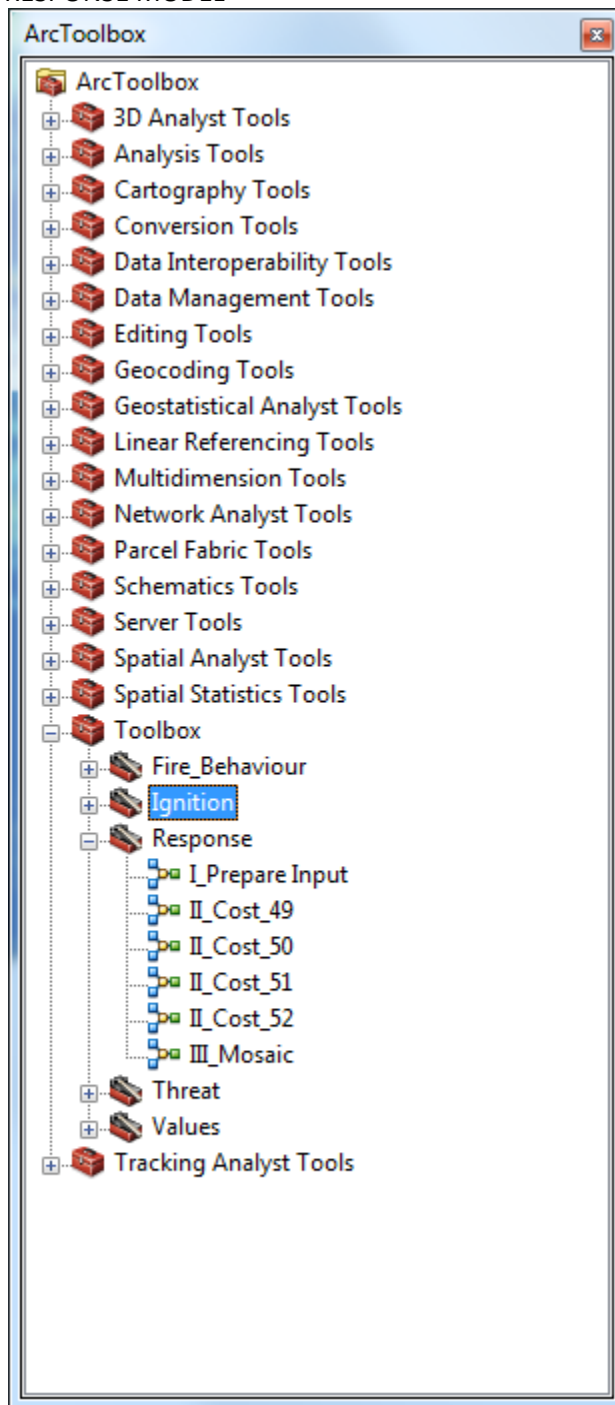
## IGNITION: Level II



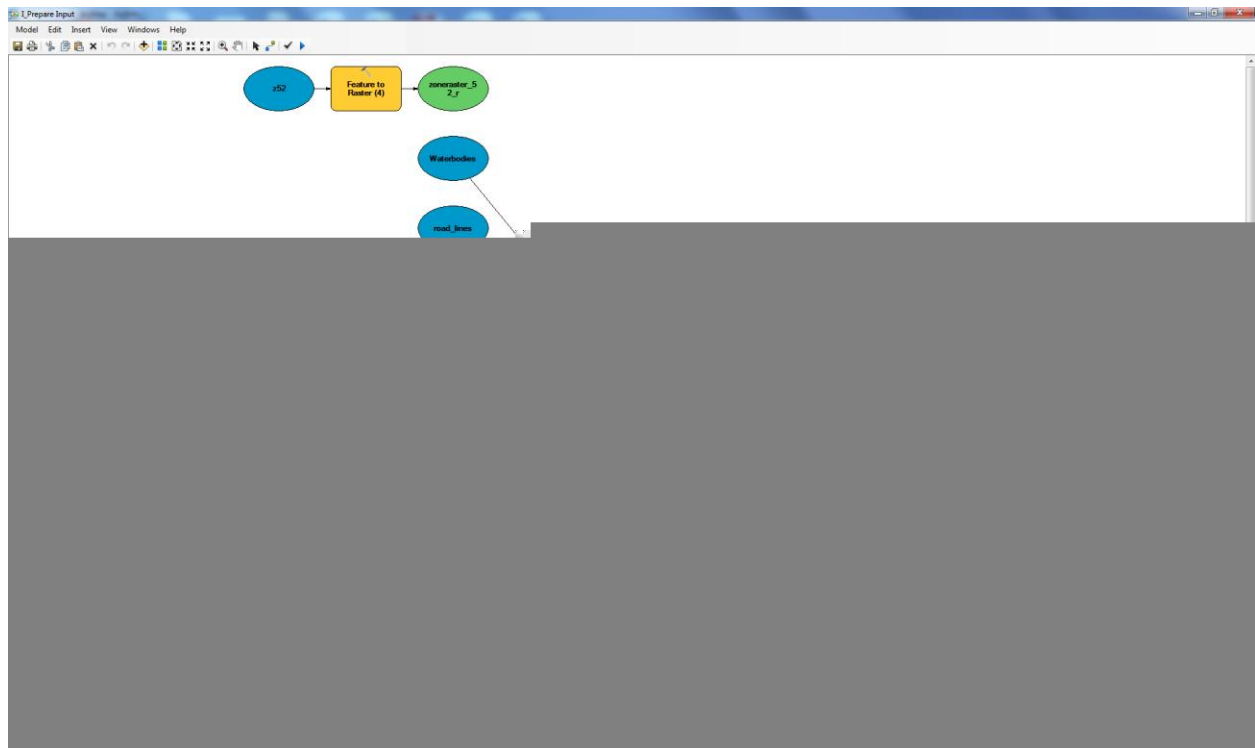
## IGNITION: Level III



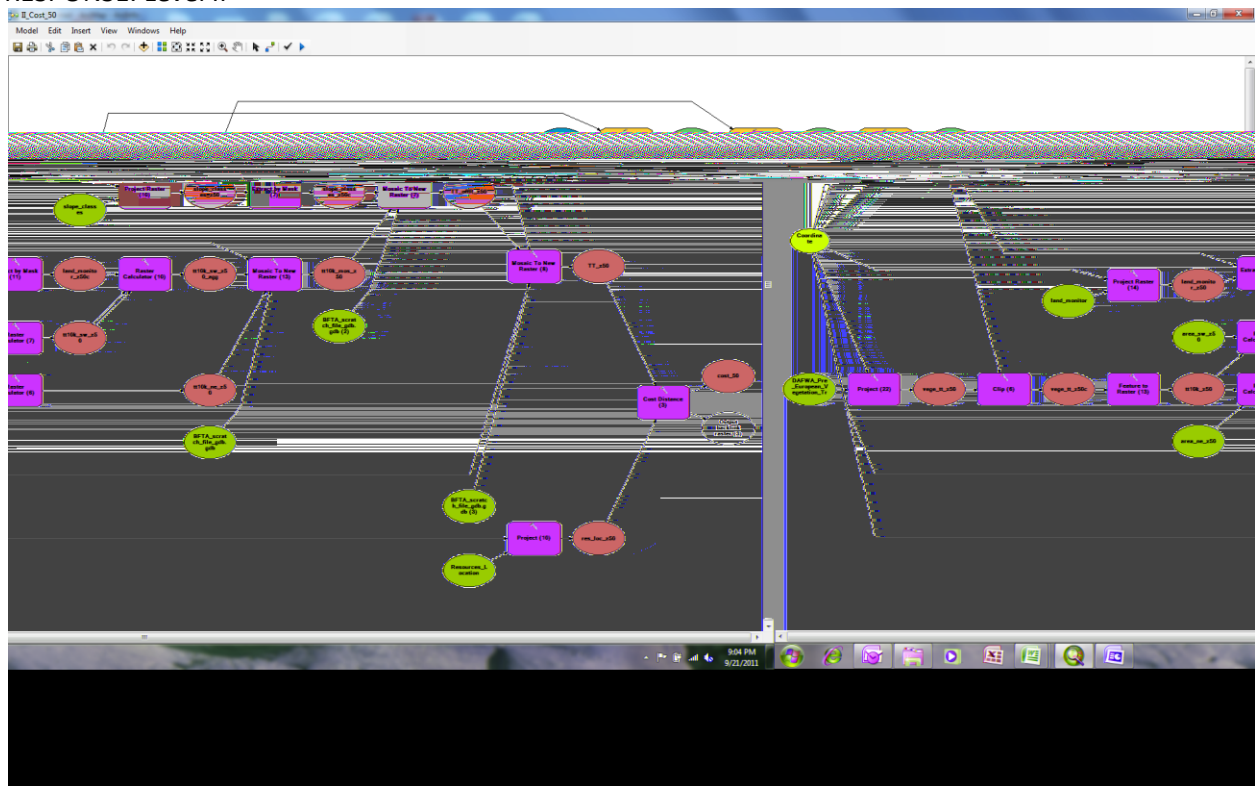
## RESPONSE MODEL



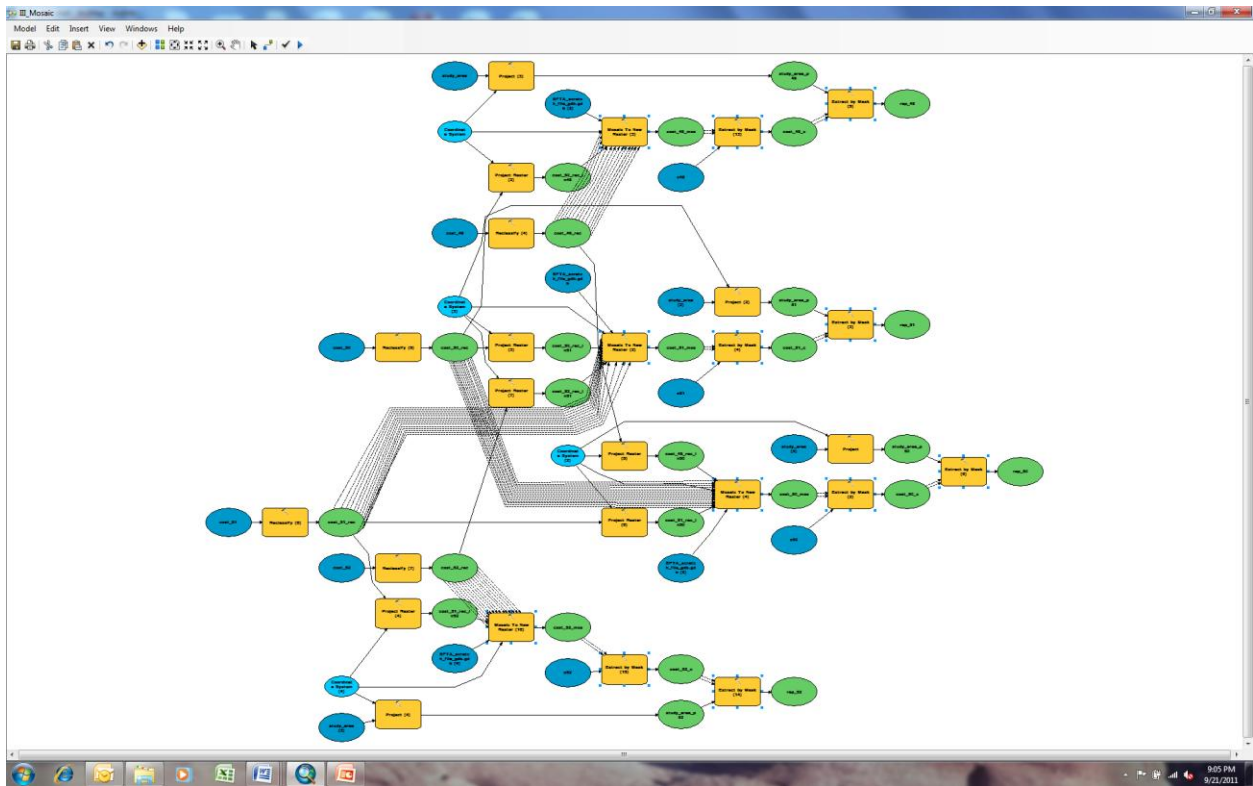
## RESPONSE: Level I



RESPONSE: Level II

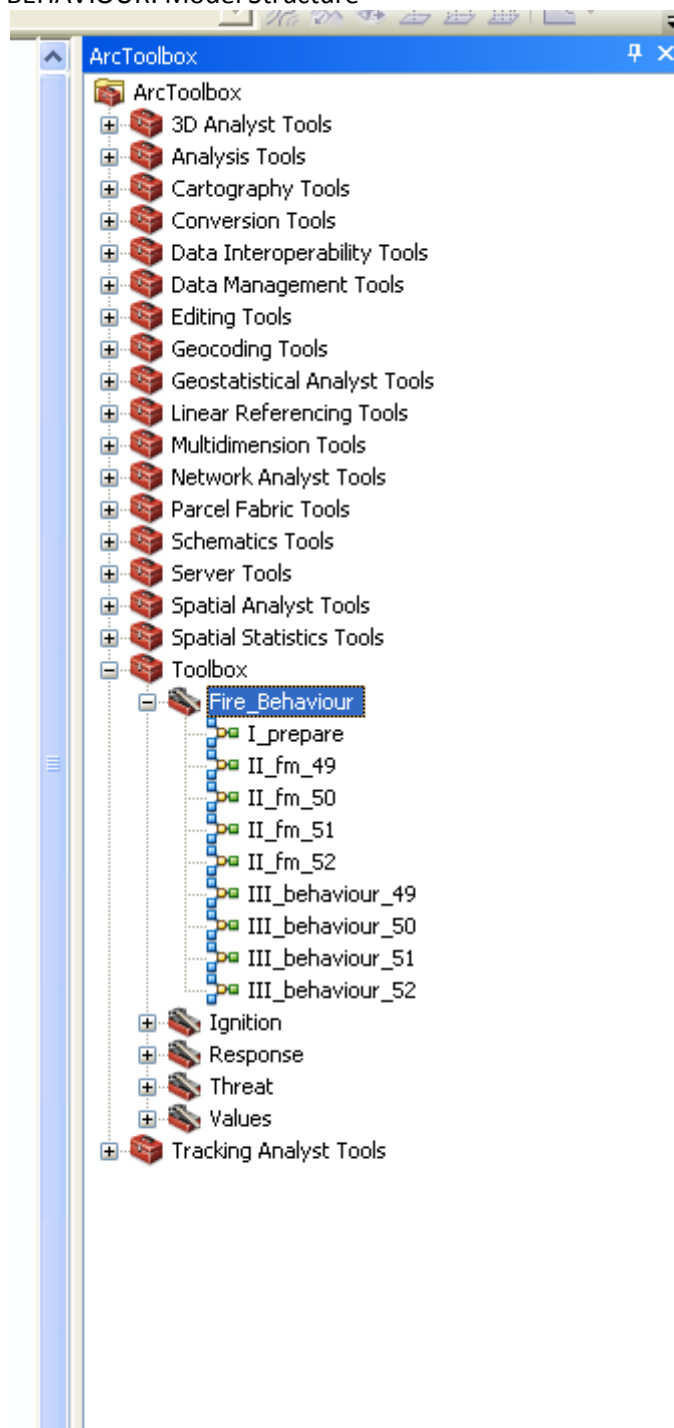


## RESPONSE: Level III

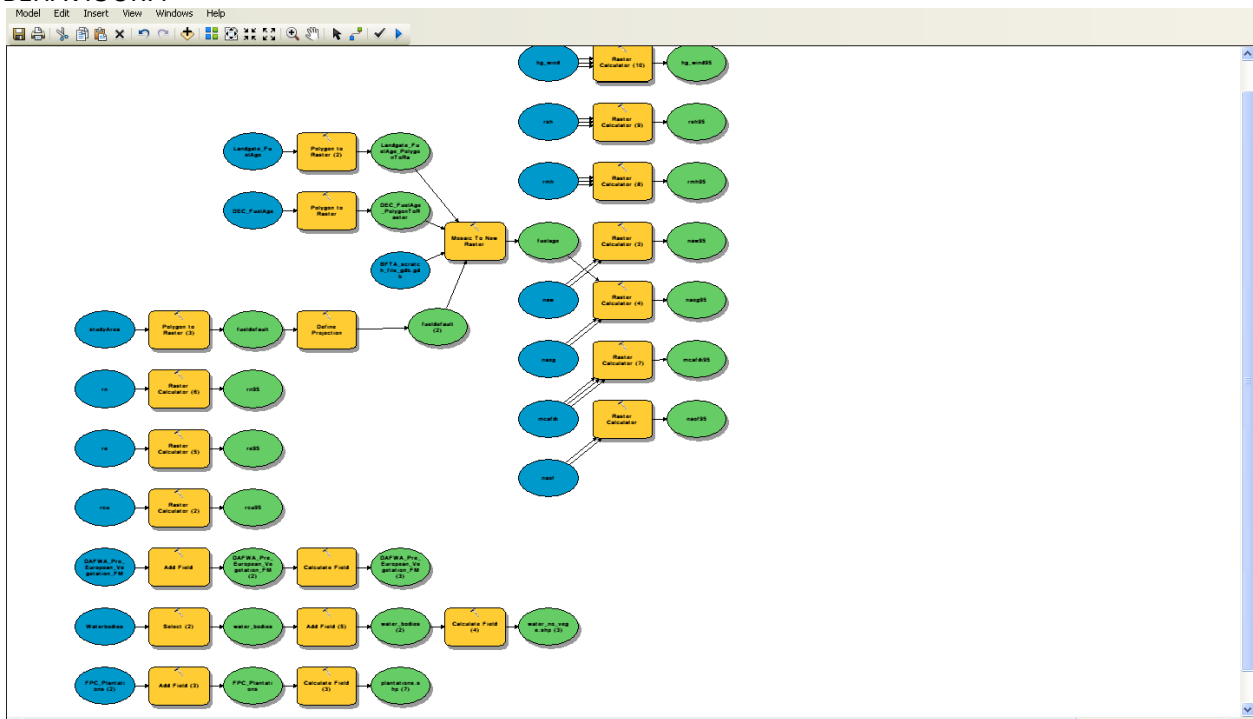




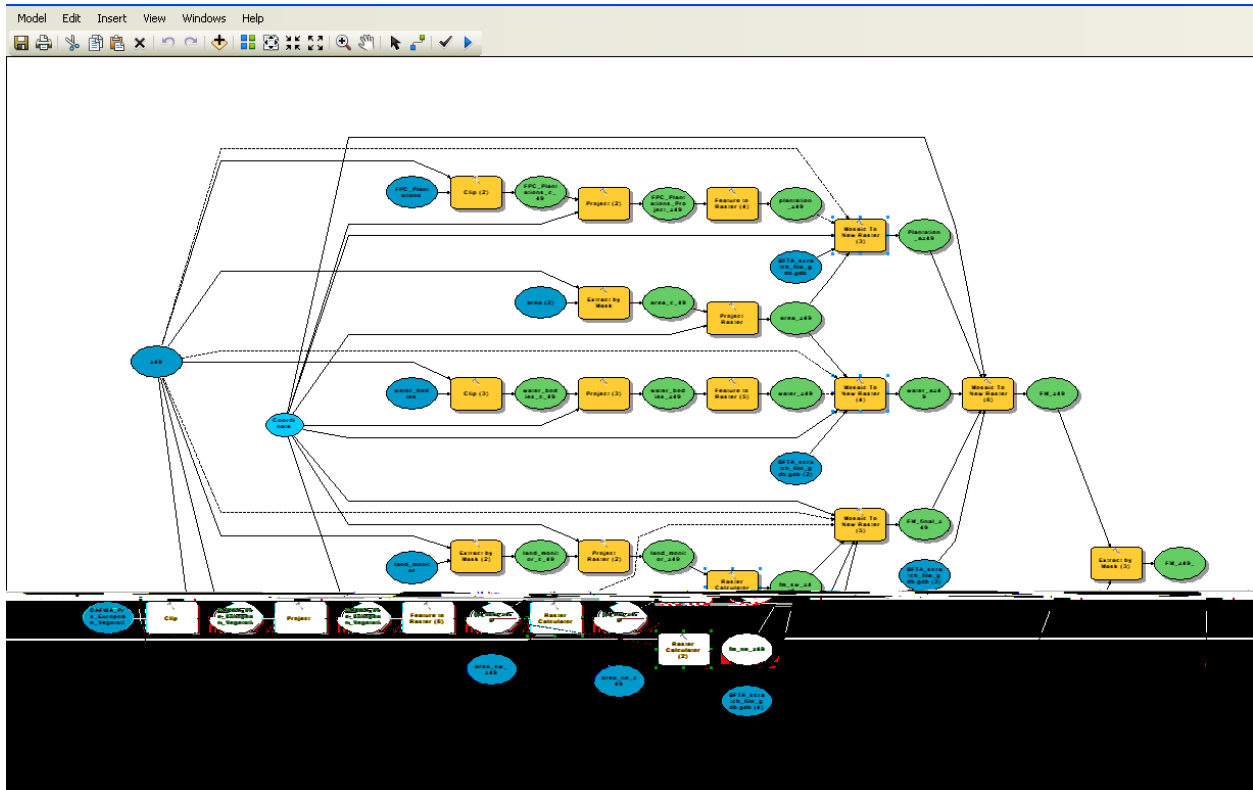
## BEHAVIOUR: Model Structure



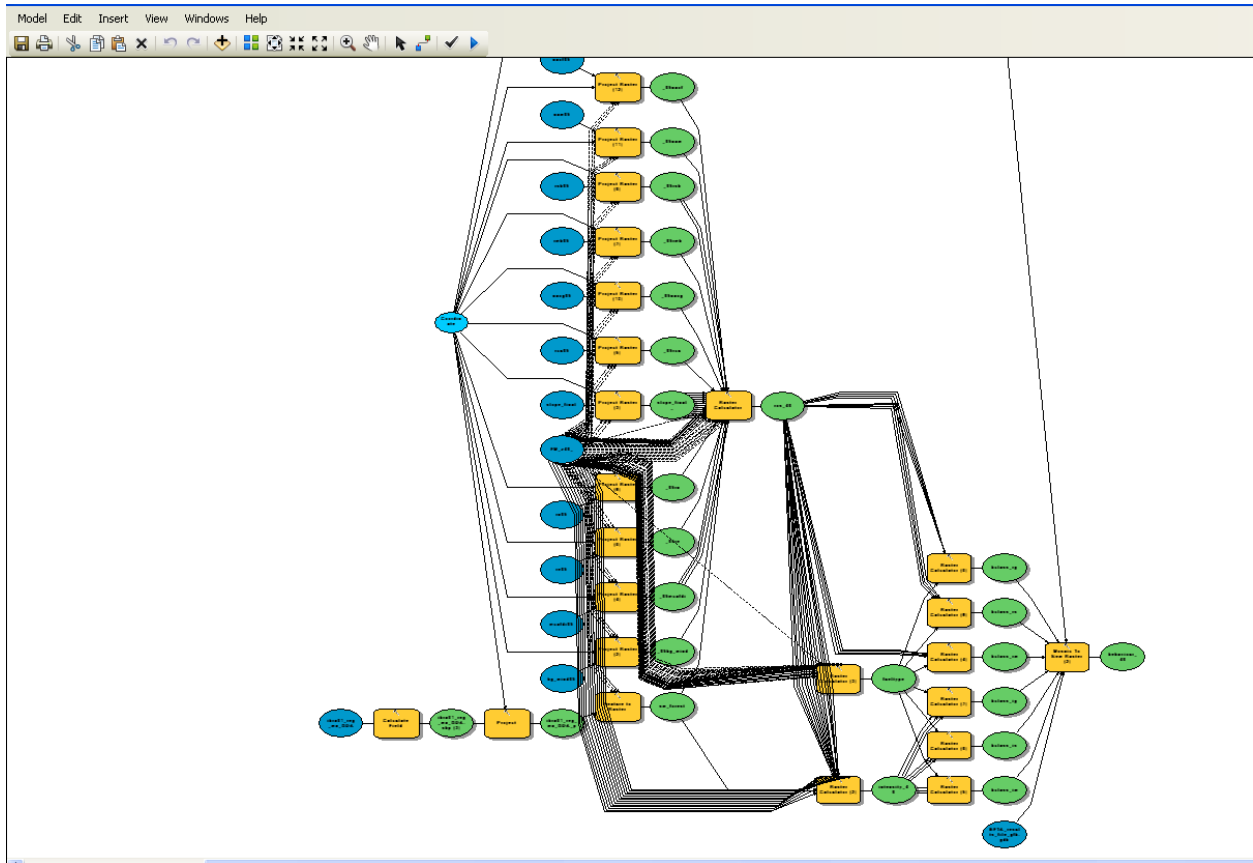
## BEHAVIOUR: I



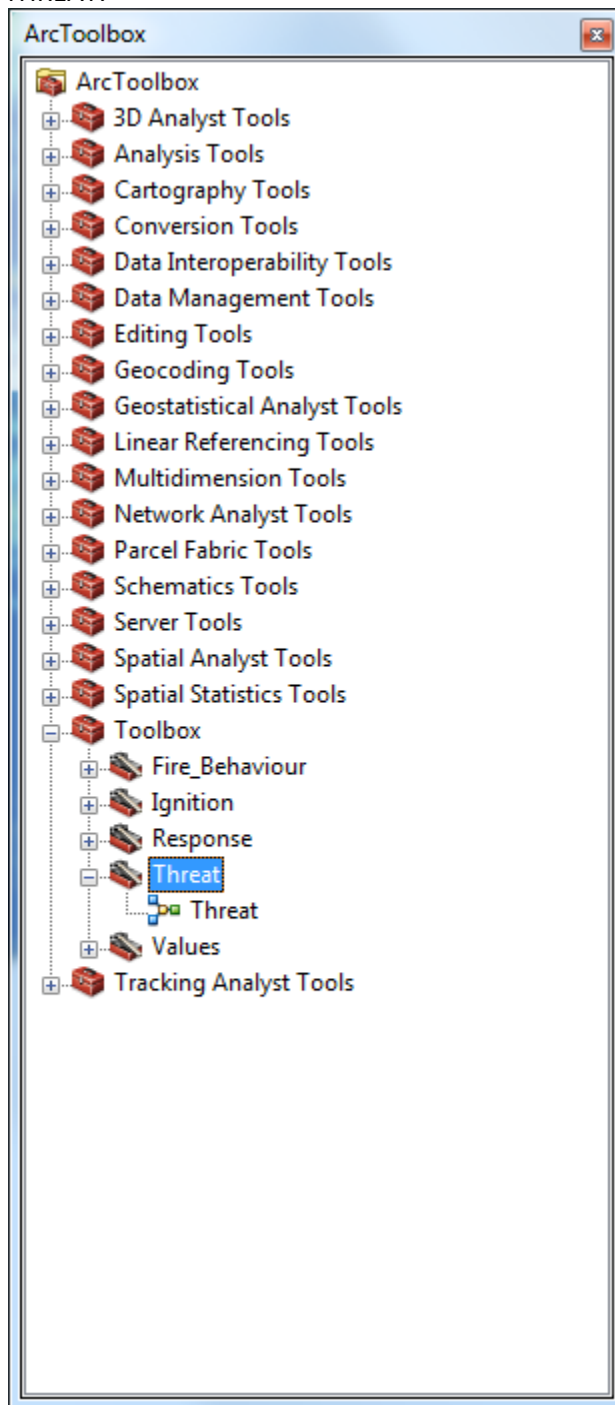
## BEHAVIOUR: II



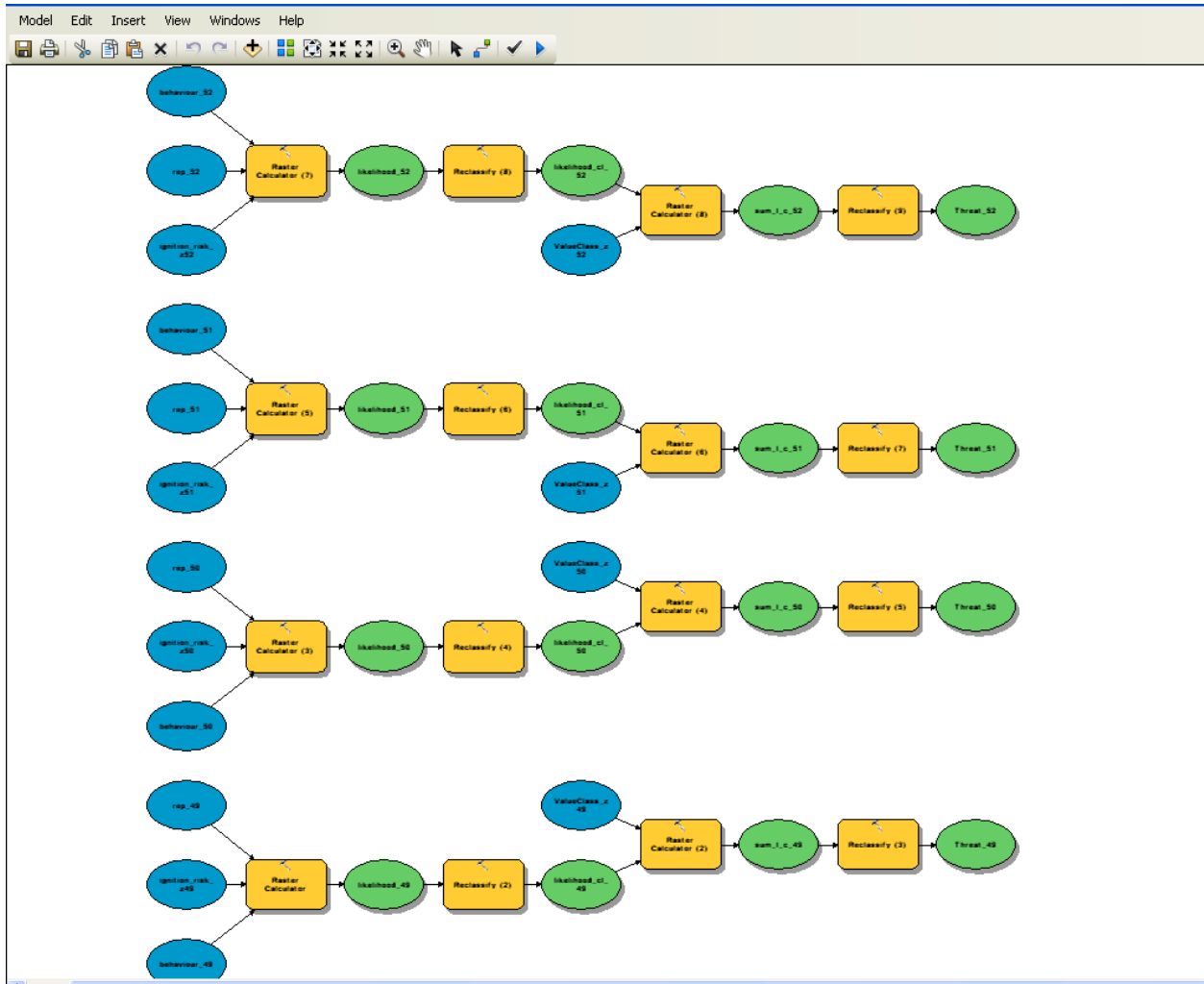
### BEHAVIOUR: III



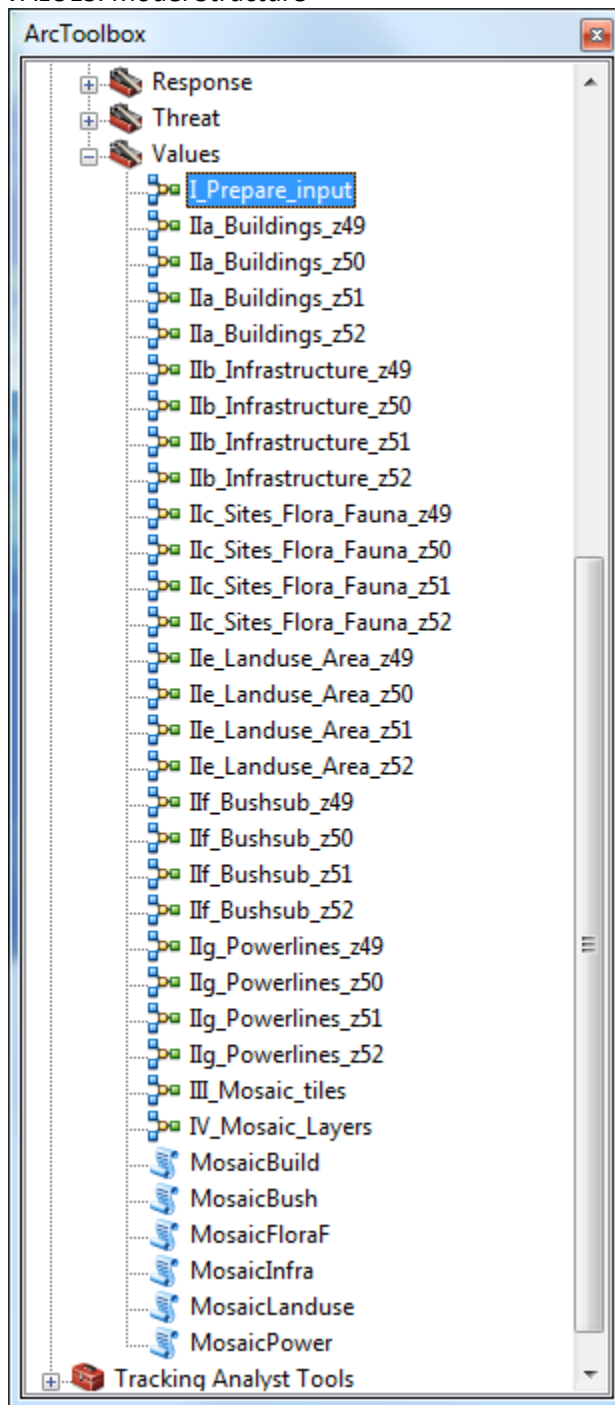
THREAT:



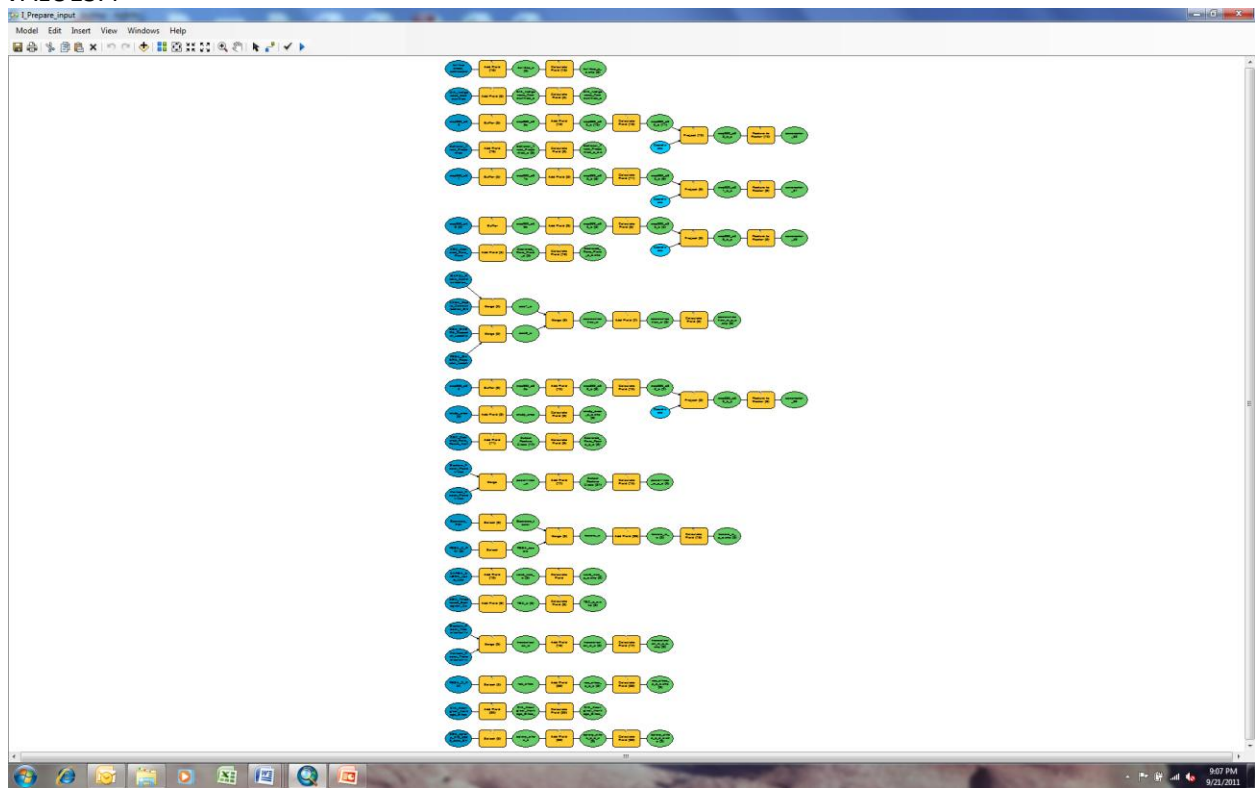
## THREAT: Model



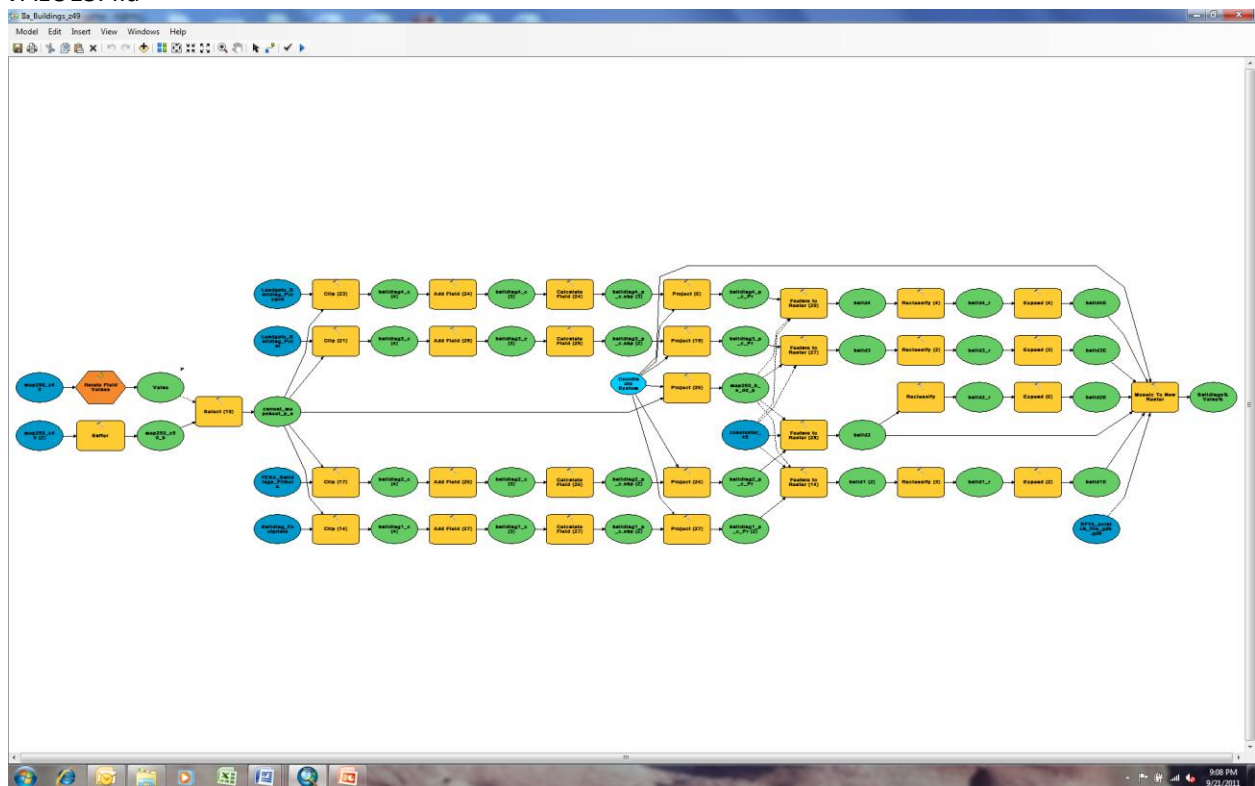
VALUES: Model Structure



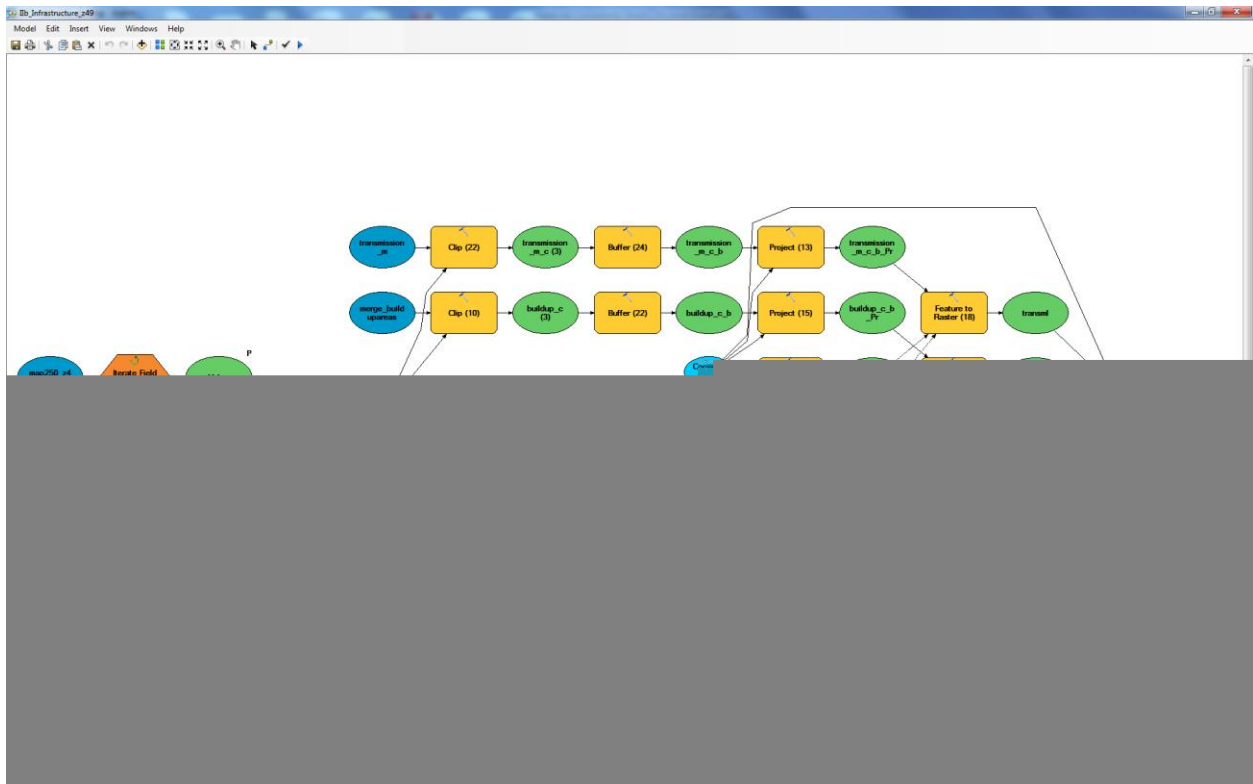
VALUES: I



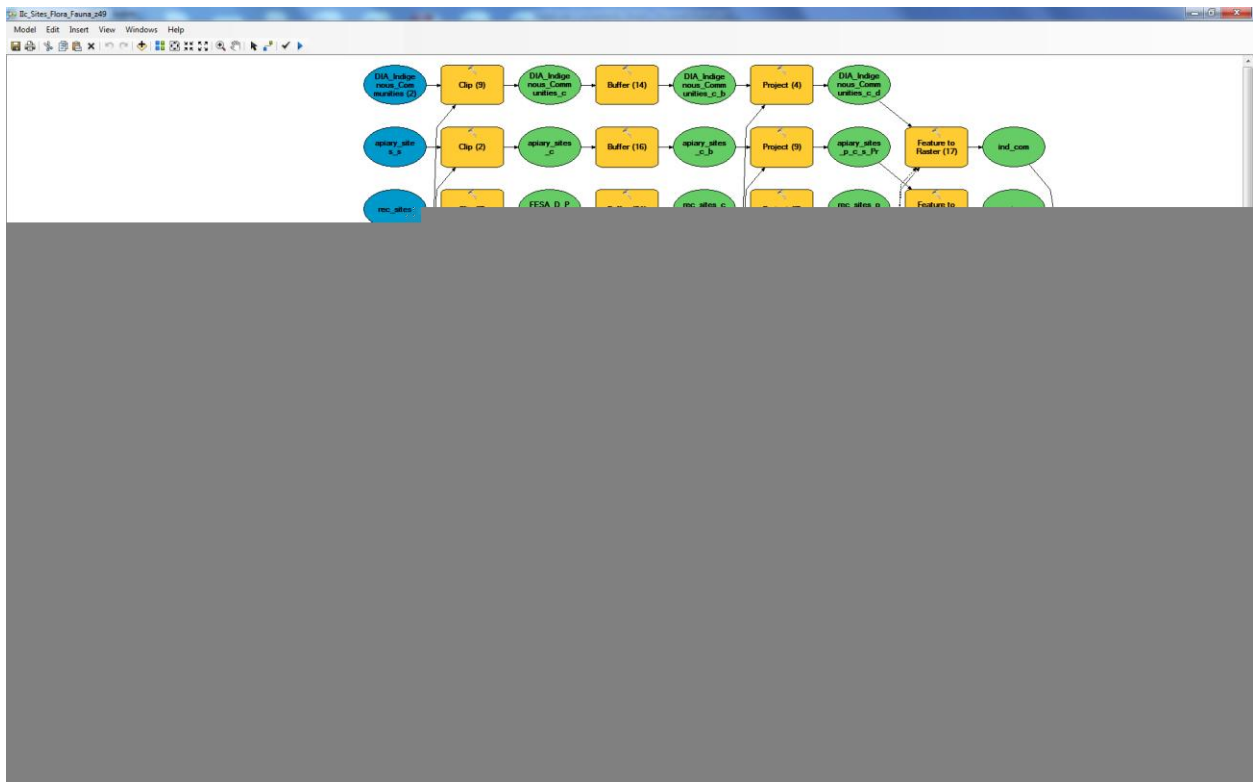
VALUES: Iia



## VALUES: I1b

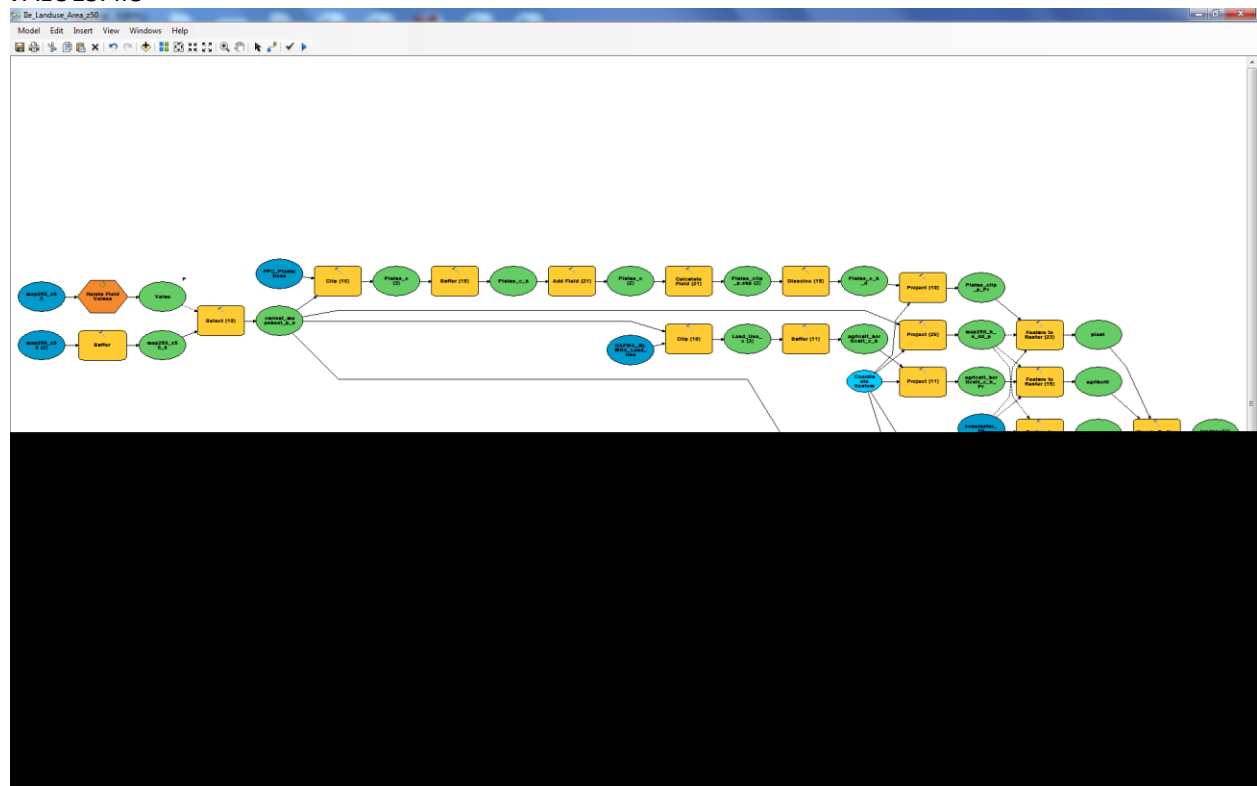


## VALUES: I1c

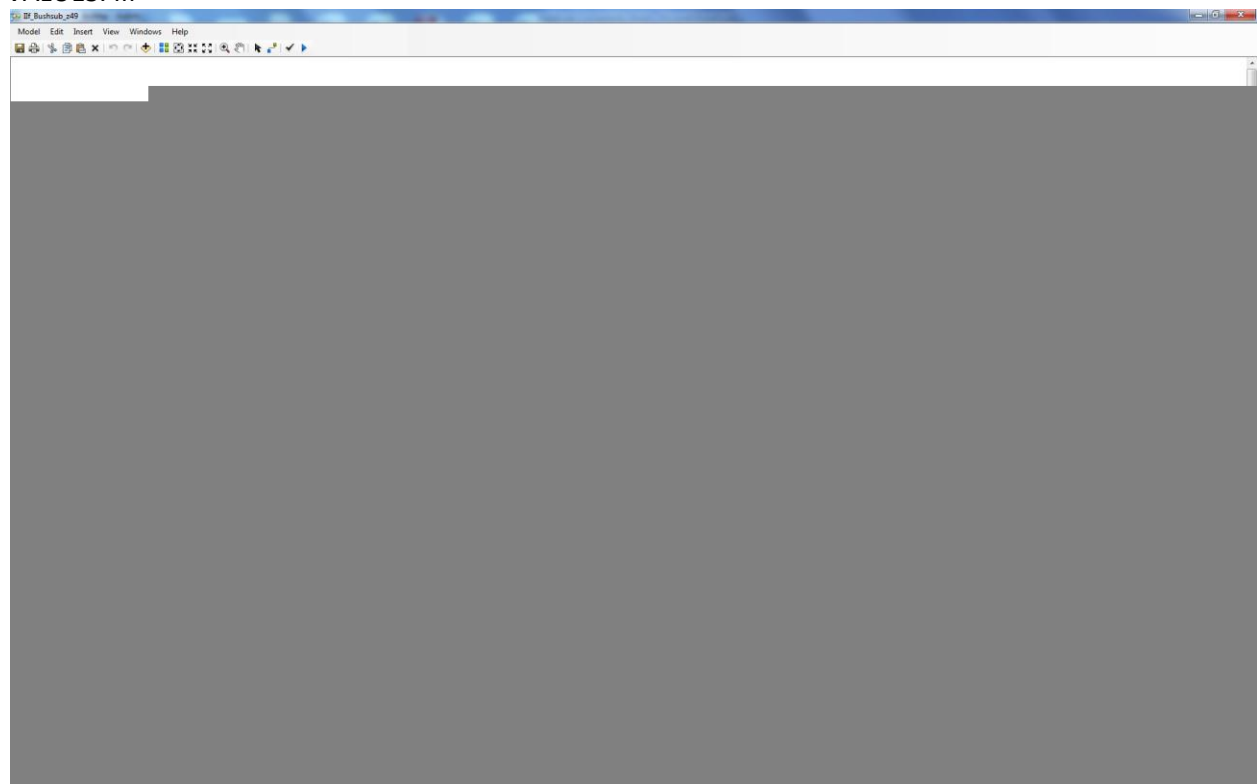




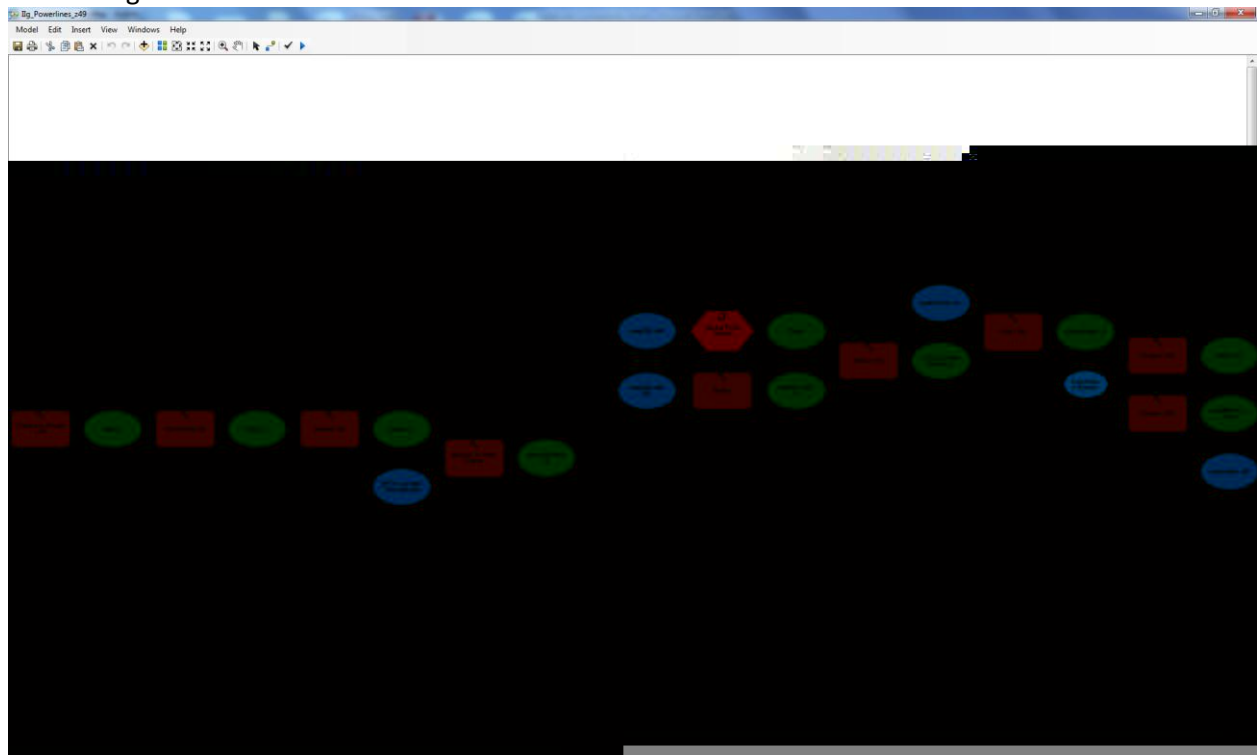
VALUES: Ile



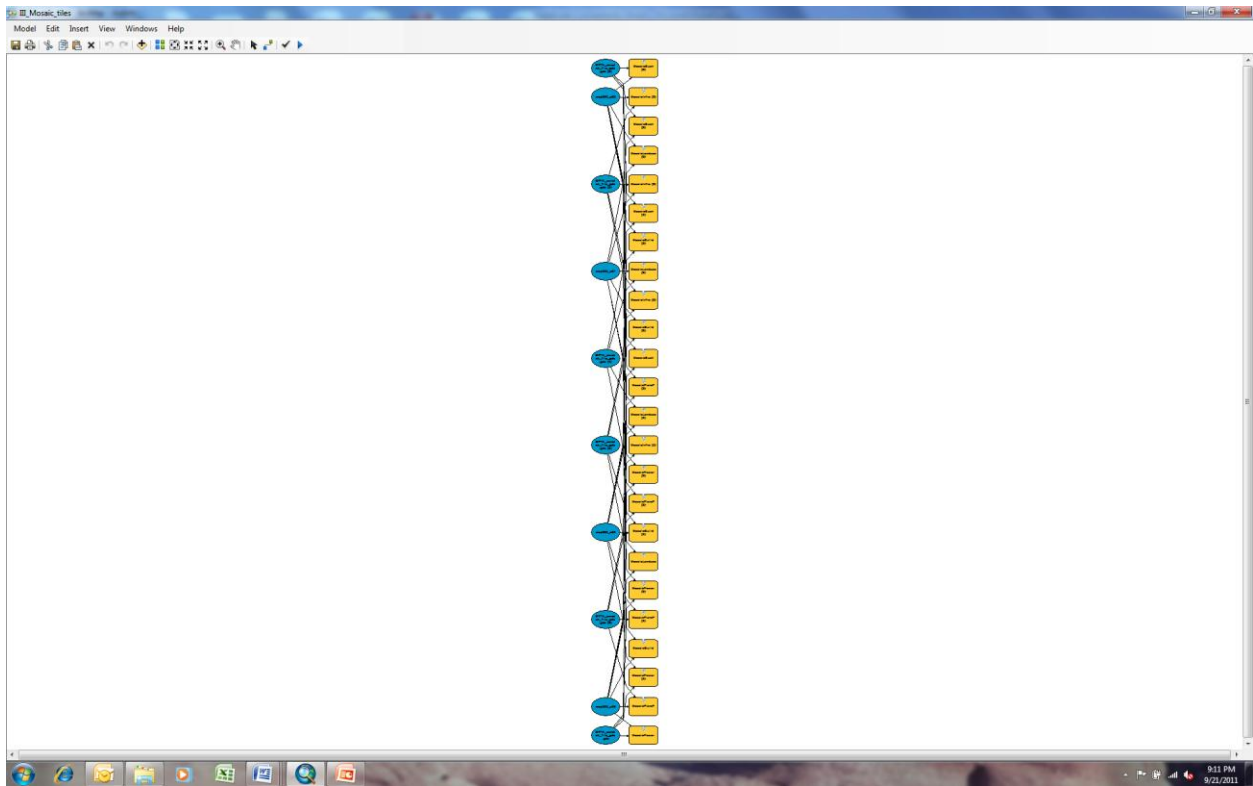
VALUES: IIf



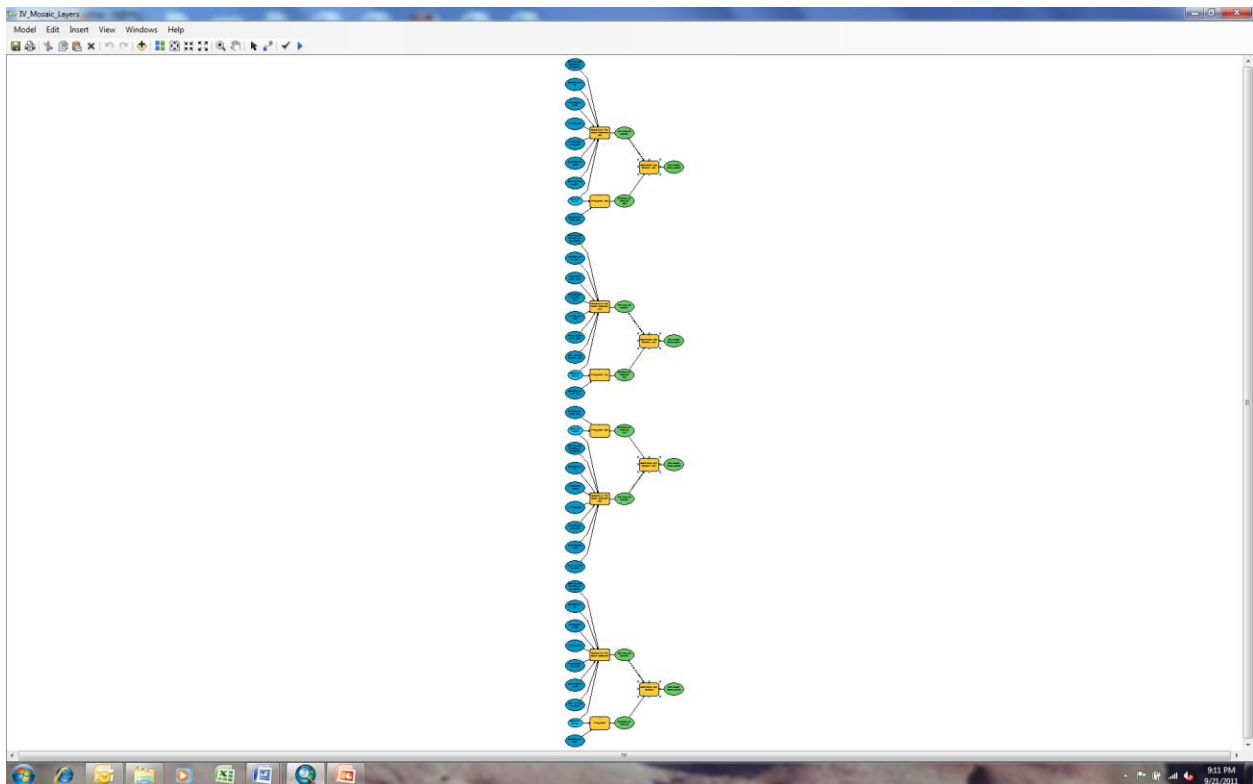
## VALUES: IIg



### VALUES: III



### VALUES: IV



## APPENDIX 3: R Script for Extracting 95<sup>th</sup> Percentile Weather Data

BEGIN SCRIPT

```
rm(list = ls()) #clear the R console of all objects
```

```
#####3
```

```
#####
```

```
#
```

```
# 3-hr data
```

```
#
```

```
# Kimberley and surrounding BOM weather zones
```

```
#####
```

```
#####333
```

```
#####
```

```
#####3
```

```
#####333
```

```
#Kimberley weather stations are (zones 1-3) + 5,6,13 for surrounding areas for interpolation:
```

```
#001006
```

```
#001007
```

```
#1013
```

```
#1018
```

```
#001019
```

```
#001020
```

```
#1025
```

```
#002012
```

```
#2014
```

```
#2032
```

```
#002056
```

```
#002064
```

```
#003003
```

```
#3004
```

```
#3030
```

```
#003032
```

```
#3040
```

```
#3051
```

```
#3057
```

```
#3059
```

```
#003080
```

```
#003093
```

```
#003096
```

```
#4019
```

```
#4028
```

```
#4032
```

```
#4035
```

```
#4043
```

```
#4083
```

```
#4090
```

```
#4095
```

```
#4100
```

#4106

#5007

#5008

#5016

#5017

#5026

#5051

#5061

#5069

#5072

#5094

#6011

#6022

#6025

#6044

#6072

#6099

#6105

#7017

#7045

#7053

#7057

#7058

#7064

#7067

#7080

#7091

#7139

#7161

#7168

#7176

#7185

#7600

#11003

#11008

#11016

#11017

#11019

#11023

#11025

#11045

#11052

#11053

#12008

#12009

#12022

#12038

#12044

#12045

#12046

#12052

#12065  
#12071  
#12090  
#12239  
#12241  
#12281  
#12300  
#12305  
#12314  
#12320

#13007  
#13011  
#13012  
#13015  
#13017  
#13030

#KIMBERLEY  
#zone 1, n= 7  
#zone 2, n= 5  
#zone 3, n= 11

#PILBARA  
#zone 4, n= 10  
#zone 5, n= 10  
#zone 13, n= 6

#additional pilbara data (neighbors to pilbara & interior to south)  
#zone 6 n=7  
#zone 7 n=15  
#zone 11 n=10  
#zone 12 n=18

```
##KIMBERLEY
mydata_1 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_001006_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_2 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_001007_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_3 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_001013_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_4 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_001018_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_5 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_001019_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_6 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_001020_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_7 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_001025_999999996465687.txt",h
eader=TRUE,sep=",")
```

```

mydata_8 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_002012_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_9 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_002014_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_10 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_002032_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_11 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_002056_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_12 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_002064_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_13 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003003_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_14 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003004_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_15 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003030_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_16 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003032_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_17 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003040_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_18 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003051_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_19 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003057_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_20 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003059_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_21 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003080_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_22 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003093_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_23 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_003096_999999996465687.txt",h
eader=TRUE,sep=",")

```

##PILBARA & INTERIOR WA

```

mydata_1 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004019_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

mydata_2 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004028_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_3 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004032_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_4 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004035_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_5 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004043_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_6 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004083_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_7 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004090_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_8 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004095_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_9 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004100_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_10 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_004106_999999996465687.txt",h
eader=TRUE,sep=",")

mydata_11 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005007_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_12 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005008_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_13 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005016_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_14 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005017_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_15 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005026_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_16 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005051_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_17 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005061_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_18 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005069_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_19 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005072_999999996465687.txt",h
eader=TRUE,sep=",")

```



```

mydata_20 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_005094_999999996465687.txt",h
eader=TRUE,sep=",")

mydata_21 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_006011_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_22 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_006022_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_23 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_006025_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_24 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_006044_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_25 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_006072_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_26 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_006099_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_27 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_006105_999999996465687.txt",h
eader=TRUE,sep=",")

mydata_28 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007017_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_29 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007045_999999996465687.txt",h
eader=TRUE,sep=",")
#mydata_30 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007053_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_31 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007057_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_32 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007058_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_33 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007064_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_34 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007067_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_35 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007080_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_36 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007091_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_37 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007139_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

mydata_38 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007161_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_39 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007168_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_40 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007176_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_41 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007185_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_42 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_007600_999999996465687.txt",h
eader=TRUE,sep=",")

mydata_43 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011003_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_44 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011008_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_45 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011016_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_46 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011017_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_47 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011019_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_48 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011023_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_49 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011025_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_50 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011045_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_51 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011052_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_52 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_011053_999999996465687.txt",h
eader=TRUE,sep=",")

mydata_53 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012008_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_54 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012009_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_55 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012022_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

mydata_56 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012038_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_57 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012044_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_58 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012045_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_59 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012046_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_60 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012052_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_61 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012065_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_62 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012071_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_63 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012090_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_64 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012239_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_65 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012241_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_66 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012281_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_67 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012300_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_68 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012305_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_69 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012314_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_70 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_012320_999999996465687.txt",h
eader=TRUE,sep=",")

mydata_71 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_013007_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_72 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_013011_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_73 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_013012_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

mydata_74 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_013015_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_75 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_013017_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_76 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_013030_999999996465687.txt",h
eader=TRUE,sep=",")

## SOUTHWEST
#01 Aug 2011
#bring in the southwest data to get 95%ile weather data
#zone 8 n=14
mydata_1 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008025_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_2 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008028_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_3 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008039_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_4 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008050_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_5 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008051_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_6 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008088_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_7 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008095_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_8 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008137_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_9 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008138_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_10 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008225_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_11 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008251_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_12 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008290_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_13 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008296_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_14 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_008297_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

#zone 9 n=57
mydata_15 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009021_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_16 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009037_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_17 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009053_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_18 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009064_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_19 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009106_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_20 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009111_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_21 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009114_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_22 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009131_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_23 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009151_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_24 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009172_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_25 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009178_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_26 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009192_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_27 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009193_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_28 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009194_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_29 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009204_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_30 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009215_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_31 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009225_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_32 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009240_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

mydata_33 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009256_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_34 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009500_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_35 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009504_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_36 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009510_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_37 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009515_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_38 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009518_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_39 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009519_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_40 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009534_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_41 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009538_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_42 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009542_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_43 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009569_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_44 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009573_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_45 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009574_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_46 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009581_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_47 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009592_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_48 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009603_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_49 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009617_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_50 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009628_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

mydata_51 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009631_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_52 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009642_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_53 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009741_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_54 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009746_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_55 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009754_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_56 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009789_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_57 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009812_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_58 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009842_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_59 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009843_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_60 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009868_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_61 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009871_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_62 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009875_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_63 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009877_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_64 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009937_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_65 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009961_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_66 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009964_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_67 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009965_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_68 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009968_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

mydata_69 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009977_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_70 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009994_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_71 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_009998_999999996465687.txt",h
eader=TRUE,sep=",")

#zone 10 n=30
mydata_72 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010007_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_73 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010035_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_74 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010058_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_75 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010073_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_76 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010092_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_77 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010093_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_78 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010111_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_79 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010140_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_80 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010286_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_81 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010311_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_82 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010515_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_83 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010524_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_84 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010536_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_85 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010568_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_86 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010579_999999996465687.txt",h
eader=TRUE,sep=",")

```



```

mydata_87 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010582_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_88 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010583_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_89 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010592_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_90 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010612_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_91 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010614_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_92 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010622_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_93 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010626_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_94 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010633_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_95 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010647_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_96 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010692_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_97 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010897_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_98 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010905_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_99 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010911_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_100 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010916_999999996465687.txt",h
eader=TRUE,sep=",")
mydata_101 <-
read.table("C:\\BOM_data\\HC06D_3hourly_WA\\HC06D_Data_010917_999999996465687.txt",h
eader=TRUE,sep=",")

```

```

str(mydata_1)
library(lattice)
bwplot(Precipitation.in.mm ~ Month|Year,data=mydata_1)

```

```
#####
#####3
# CALCULATE 95th percentile
# temperature, RH, wind

numStations <- 23 #Kimberley (BOM zones 1-3)
numStations <- 76 #Pilbara & Interior (BOM zones 4-7, 11-13)
numStations <- 101 #Southwest (BOM zones 8-10)

weatherOut <- matrix(0,numStations,4)
weatherOut <- data.frame(weatherOut)
colnames(weatherOut) <- c("temp","RH","wind","numYrs")
weatherOut
#mydata_1[1:10,1:4]
#mydata_30 <- mydata_29
for (k in 1:numStations)
{
  fred <- get(paste("mydata", k , sep = "_"))
  #bob <- subset(fred,fred$Month>6) #KIMBERLEY, remove this line of code to use all 12
months of data
  bob <- subset(fred,fred$Month!=5 & fred$Month!=6 & fred$Month!=7 & fred$Month!=8 &
fred$Month!=9 & fred$Month!=10) #SOUTHWEST
  #bob <- fred #PILBARA, just pass the objects to one another
  temp95 <- quantile(bob[,10],probs=0.95,na.rm=TRUE,type=7)
  weatherOut[k,1] <- temp95 # units = degrees C
  RH95 <- quantile(bob[,16],probs=0.05,na.rm=TRUE,type=7)
  weatherOut[k,2] <- RH95 # units = %
  wind95 <- quantile(bob[,18],probs=0.95,na.rm=TRUE,type=7)
  weatherOut[k,3] <- wind95 # units = km h-1
  weatherOut[k,4] <- max(bob$Year)-min(bob$Year)
}

weatherOut
#write.table(weatherOut,file="F:\\FESA\\BFTA_WAtender\\DataProducts\\Weather95PercentCalc
s3hr.csv",col.names=TRUE, row.names=FALSE,sep=",")
write.table(weatherOut,file="F:\\FESA\\BFTA_WAtender\\DataProducts\\Weather95PercentCalcs
3hrKimberley.csv",col.names=TRUE, row.names=FALSE,sep=",")
write.table(weatherOut,file="F:\\FESA\\BFTA_WAtender\\DataProducts\\Weather95PercentCalcs
3hrPilbara.csv",col.names=TRUE, row.names=FALSE,sep=",")
write.table(weatherOut,file="F:\\FESA\\BFTA_WAtender\\DataProducts\\Weather95PercentCalcs
3hrSouthwest.csv",col.names=TRUE, row.names=FALSE,sep=",")

#read in data if needed
# using a compiled data file of 95% obs for all the weather stations
#weatherOut <-
read.csv("F:\\FESA\\BFTA_WAtender\\DataProducts\\Weather95PercentCalcs.csv",header=TRU
E, sep=";",)
weatherOut <-
read.csv("F:\\FESA\\BFTA_WAtender\\DataProducts\\Weather95PercentCalcsCompiled.csv",hea
der=TRUE, sep=";",)
str(weatherOut)
```

```

numStations <- 200
RoScalc <- matrix(0,numStations,12)
RoScalc <- data.frame(RoScalc)
colnames(RoScalc) <-
c("NA_OG","NA_W","NA_OF","HG_Wind2m","LowSpread","McAFDI","NoSpread","Rmh","Rsh","
Re","Rcu","Rn")
RoScalc

### Equations from Sullivan 2010 Adv Agronomy
#These cover NA_OG, NA_OF, NA_W --open grasslands, open forests, woodlands of Northern
Australia
for (i in 1:numStations)
{
Cure <- 100 #assume grass is 100% cured
phiC <- 1.12/(1 + 59.2*exp(-0.124*(Cure-50))) #eqn 1, curing coefficient
#phiC
Mf <- 9.58 - 0.205*weatherOut[i,1] + 0.138*weatherOut[i,2] #fuel moisture units = %
#Mf

# if Mf is <12% then
phiM <- exp(-0.108*Mf) #eqn 3, moisture coefficient
#phiM

#RATE OF SPREAD
RoS <- phiM*phiC*(1.4 + 0.838*(weatherOut[i,3] - 5)^0.844) #units = km h-1
RoScalc[i,1] <- RoS*1000 # north australian grassland to get m hr-1
RoScalc[i,2] <- RoS*0.5*1000 #northern woodlands m hr-1
RoScalc[i,3] <- RoS*0.3*1000 #northern open forests m hr-1
RoS_Re <- phiM*phiC*(0.55 + 0.357*(weatherOut[i,3] - 5)^0.844) #units = km h-1, eaten out
pasture
RoS_Rcu <- phiM*phiC*(1.1 + 0.715*(weatherOut[i,3] - 5)^0.844) #units = km h-1, mowed/cut
pasture
RoScalc[i,10] <- RoS_Re*1000 # eaten out pasture: Re to get m hr-1
RoScalc[i,11] <- RoS_Rcu*1000 # grazed/cut pasture: Rcu to get m hr-1

#Next we move to the Mueller report and original publications to get equations

#Rmh RoS mallee heath
#IMPORTANT: per 24 June meeting with FESA, we will drop this equation and apply Rsh to all
vegetation of this cover type
#Mld <- 0.113*weatherOut[i,2] - 0.218*weatherOut[i,1] + 12.5 # % moisture content of deep litter
for 0600-1200 or within 2 days of >=12.5mm rain
Mld <- 0.132*weatherOut[i,2] - 0.168*weatherOut[i,1] + 6.8
U2m <- (weatherOut[i,3]*0.71)/3.6 #correction factor to go from 10m to 2m wind speed and
change from kph to m sec-1
Rmh <- 0.292*U2m^1.05*exp(-0.11*Mld) #rate of spread in mallee heath in m sec-1
Rmh_kph <- Rmh*3.6*1000 #go to m hour-1 from m sec-1

#Rsh rate of spread in shrublands
#Rsh = a(U2^b)*H^c
H <- 1.8 #veg ht in meters Mueller used 1.0 m but in northern australia seems like we should add
a little
U2m <- weatherOut[i,3]*0.71 #standard correction to go from U10 (wind at 10m) to U2 (wind at
2m height)

```

```

Rsh <- (0.801*U2m^1.10)*H^0.49 #m min-1
Rsh_kph <- Rsh*0.06 #to go to km hour-1

#Hummock Grasslands (spinifex)
#assume 10 tonnes ha-1 (based on Flammable Australia)

FQ <- 10 # 10 tonnes ha-1
PMC <- 12 #12 percent from Mueller pg 52
U2m <- (0.8329 + 0.57055*weatherOut[i,3])/3.6 #correction factor from Mueller pg 52, kph, note
bad math he used in his unit conversions
HG_RoS <- 154.9*U2m + 140.6*FQ - 228*PMC + 1581

#Low spread
RoSLow <- 0.10*Rsh_kph #assumed to be 10% of Rsh, Mueller pg 52

#colnames(RoScalc) <-
c("NA_OG","NA_W","NA_OF","HG_Wind2m","LowSpread","McAFDI","NoSpread","Rmh","Rsh")

RoScalc[i,8] <- Rmh_kph*1000 #mallee-heath
RoScalc[i,9] <- Rsh_kph*1000 #shrubland
RoScalc[i,5] <- RoSLow*1000 #low spread
RoScalc[i,4] <- HG_RoS #hummock grassland (spinifex)
}

RoScalc
write.table(RoScalc,file="F:\\FESA\\BFTA_WAtender\\DataProducts\\RoScalcsALLstations18Oct2
011.csv",col.names=TRUE, row.names=FALSE,sep=",")

```