Big Data, Ensemble Wildfire and the Wildland Urban Interface: A Case Study on K'Gari

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Introduction

Study Objectives:

1. To determine the potential RHF exposure (and BALs) of existing settlements across K'Gari under a credible worst-case bushfire scenario and Qld Bushfire Resilient Communities Design Fires

2. To determine the potential benefit of surgical and broadscale prescribed burning across the island on settlement protection under these scenarios

3. Develop a suitable case study (non-commercial) to test new "Ember" and "Inferno" software tools developed in-house by Covey Associates

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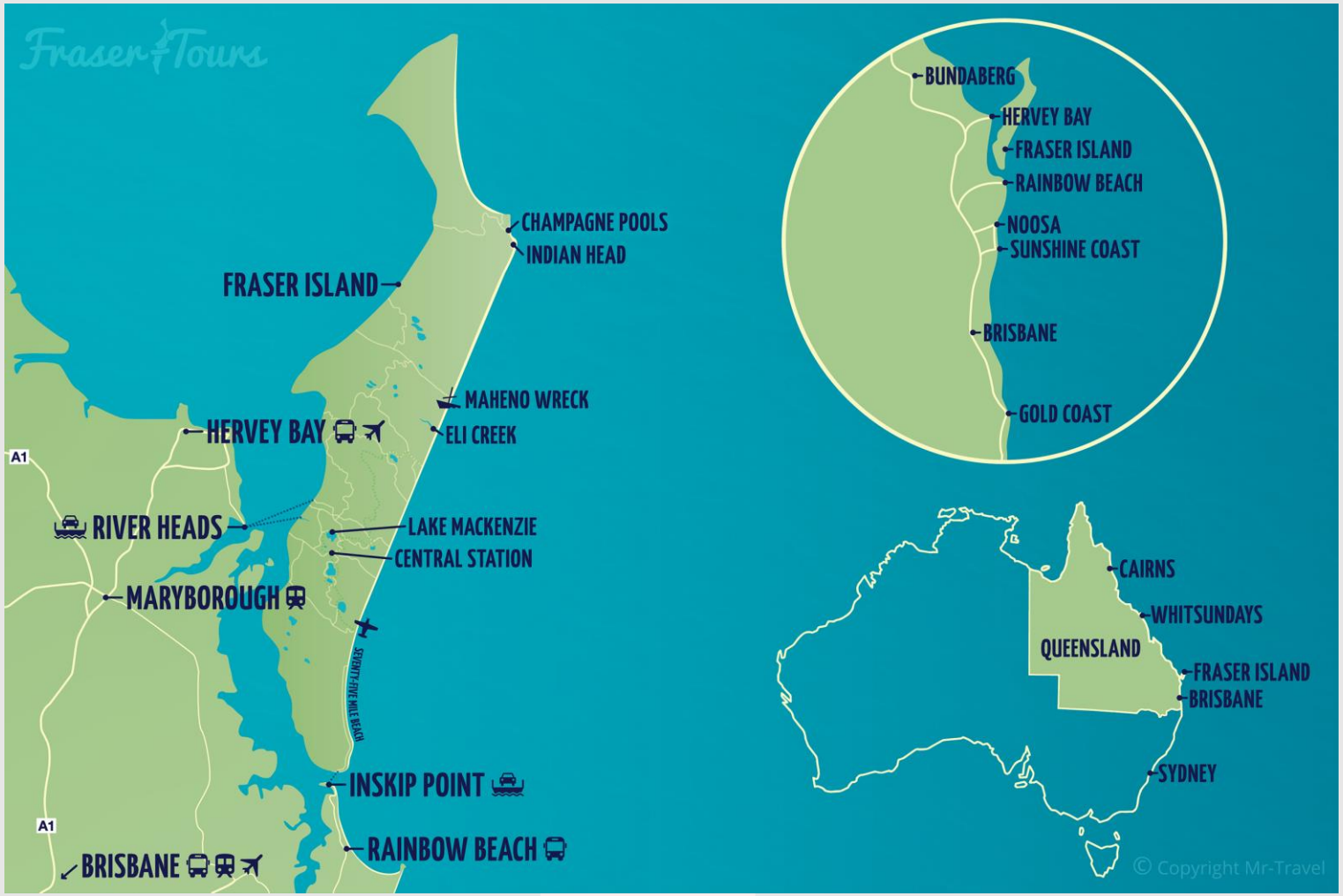
Study Area

K'Gari (Fraser Island)



Source: Fraser-tours.com

- World heritage listed island
- Approx 182 permanent residents and up to 300,000 visitors annually
- Largest sand island in the world
- Heavily impacted by bushfires in 2020 (>50% burnt)
- Diversity of vegetation types

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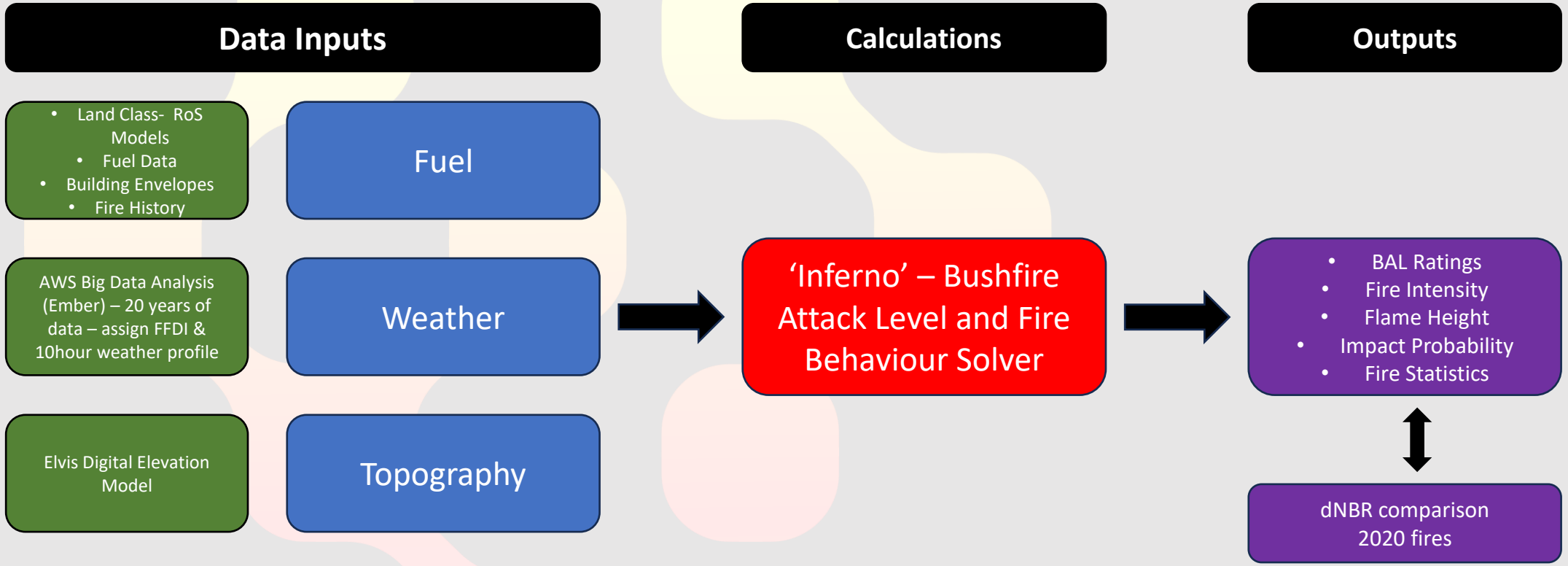
Bushfire Modelling Process



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Vegetation Types / Fuels

Vine Forests

Source: Greatasussietravel.com

Open Shrubland

Source: qld.gov.au

Moist Open Forests

Source: inaturalist.org

Broad Vegetation Groups (BVG's)

BVG Code	Description
35c	Palustrine Wetlands
28a	Complex of open shrubland to closed shrubland, grassland, low woodland and open forest on the strand and fore dune
9g	Moist to dry woodland to open forests
8b	Moist open forests to tall open forests on coastal sands
28b	Open forest to Woodland
34a	Lacustrine wetlands
3a	Evergreen to semi-deciduous, notophyll to microphyll vine forest/thicket on beach ridges and coastal dunes
29a	Open heaths and dwarf open heaths on coastal dunefields, sandplains and headlands
28e	Palustrine Wetlands on seeps and soaks
35a	Closed forests and low closed forests dominated by mangroves
35b	Bare saltpans

Highlighted BVG's are dominant across K'Gari

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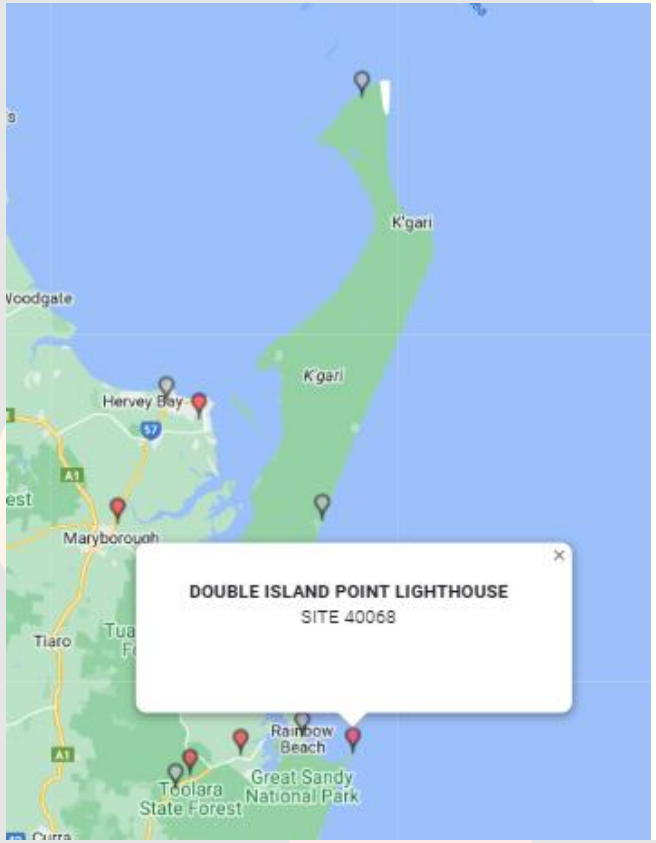
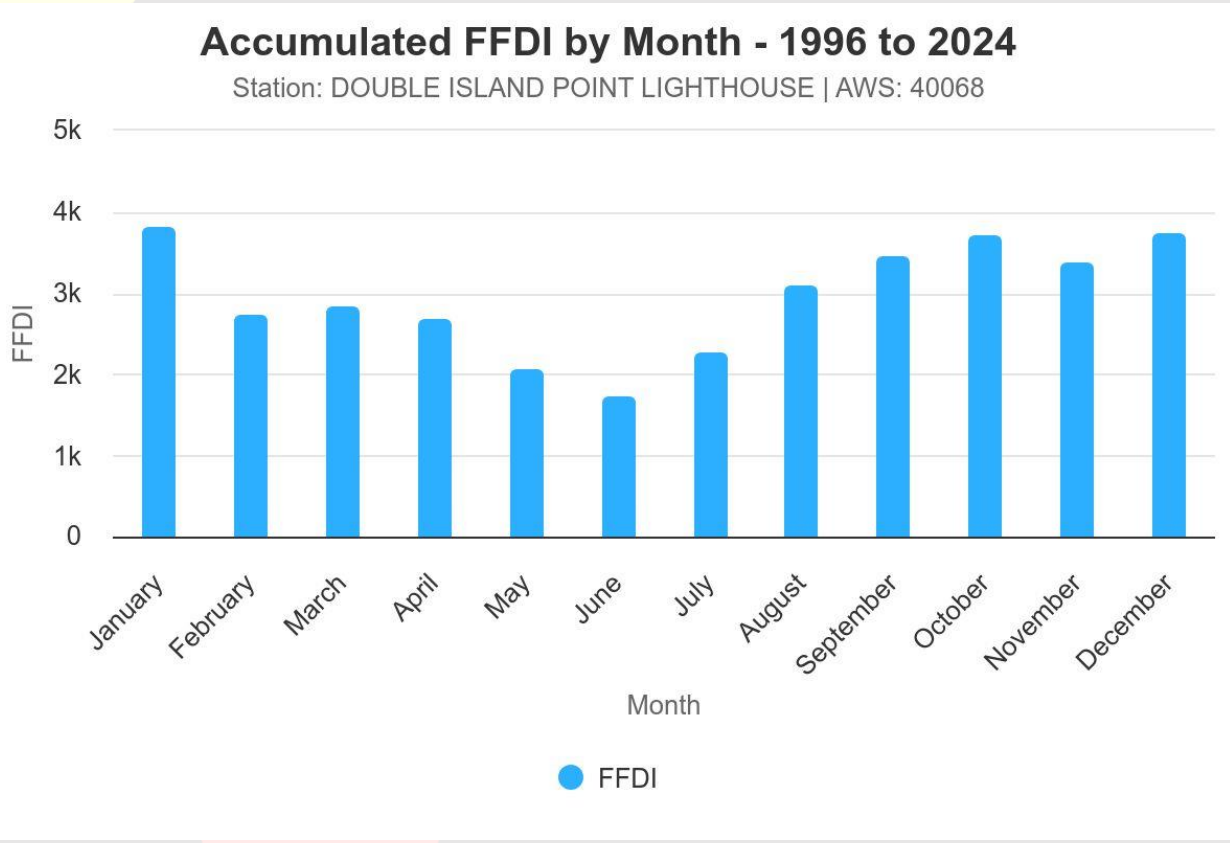
Weather Analysis





- Processed 20 years of daily weather data
- Typical Spring to Summer Bushfire Season
- Season peaks in early to mid-summer if rains do not arrive early

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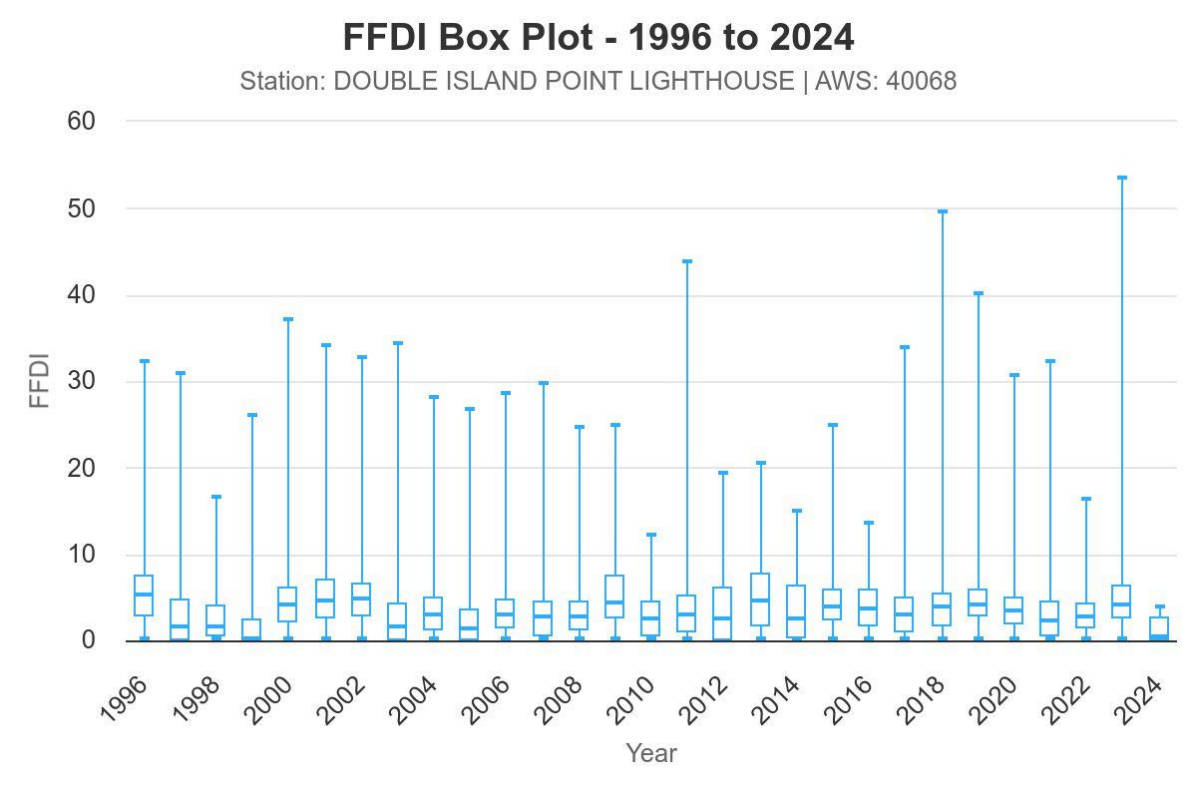
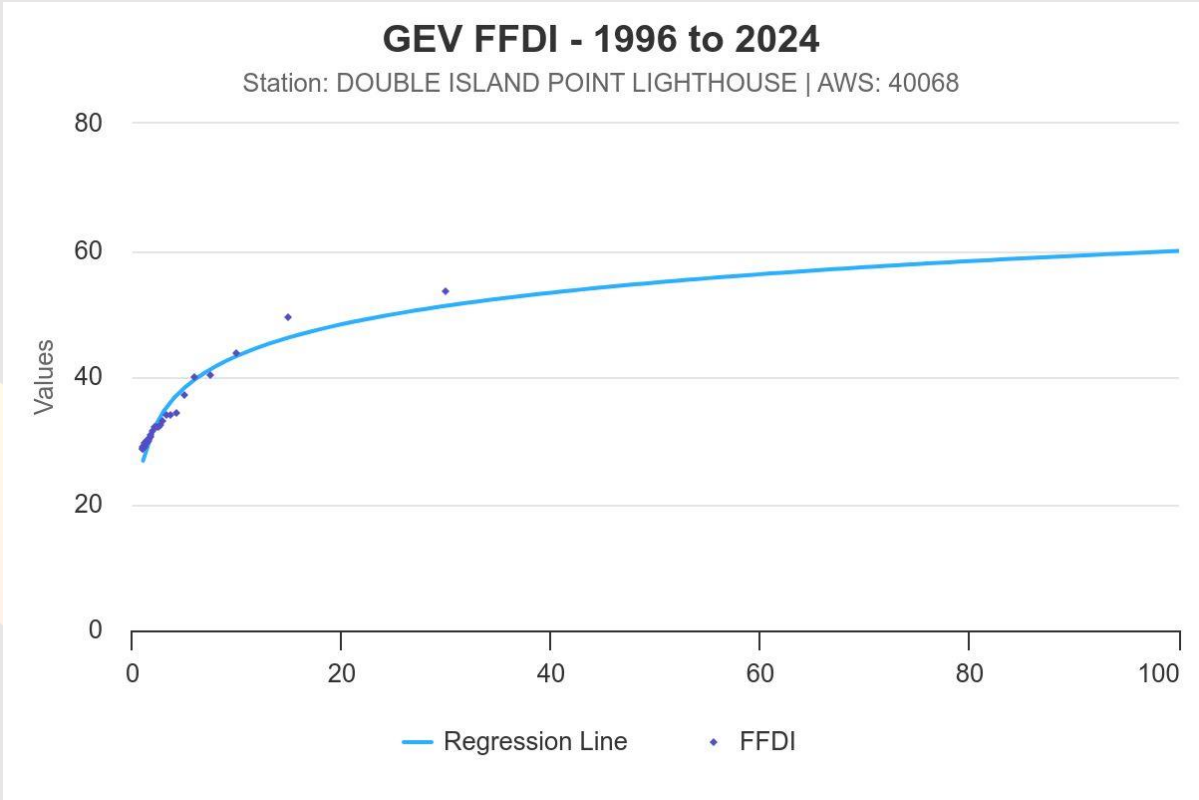
Weather Analysis





- Mean annual FFDI below 10
- Typically max FFDI each year between 20 and 40
- FFDI 50 approx. has an ARI of 1 in 25-year
- Selected a 10 hour weather profile that similar to BRC requirements for sims

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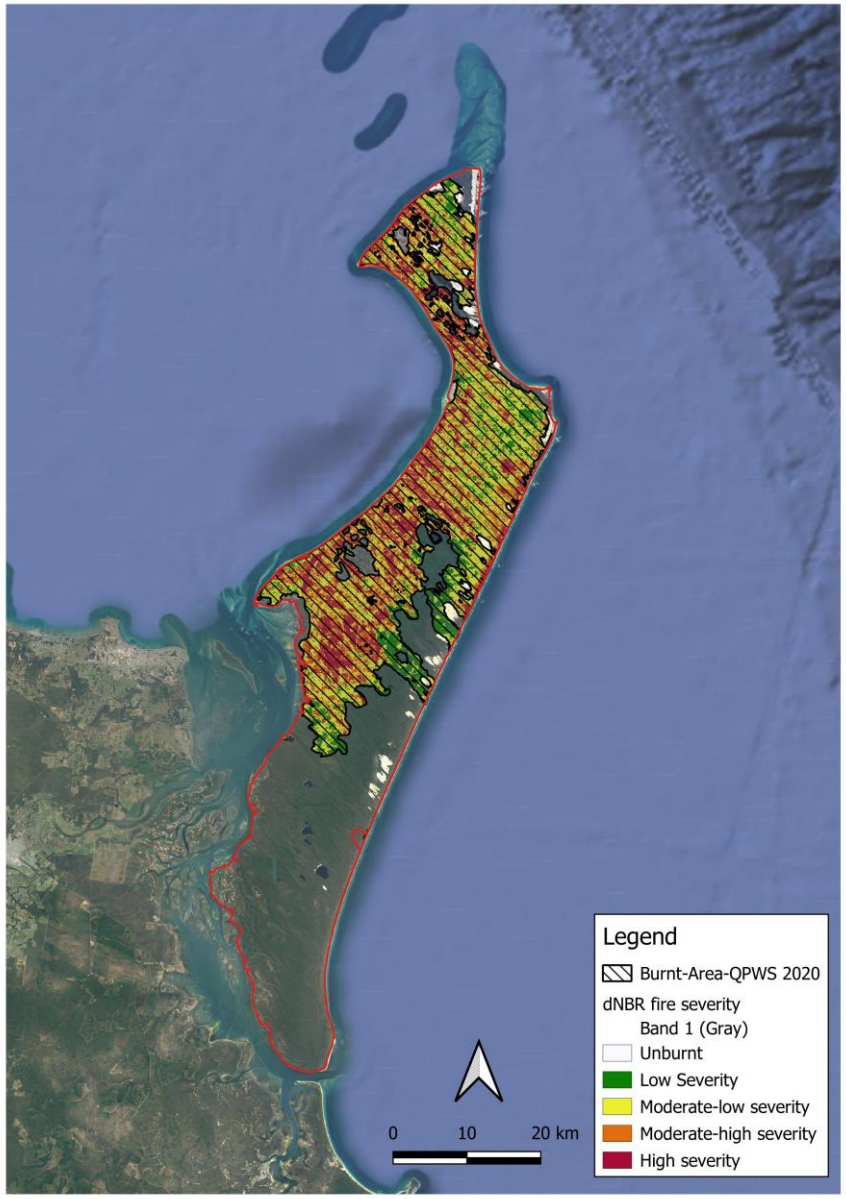
2020 Bushfire Extent - dNBR



- Started 14 Oct 2020 (illegally lit fire)
- Fire declared out on 16 Dec 2020
- Sentinel Satellite Imagery (bands 8 & 12 used) to complete dNBR – fire severity analysis
- Impacted areas of cultural and environmental significance
- Local townships were threatened
- Significant impact on the local economy, tourism and businesses

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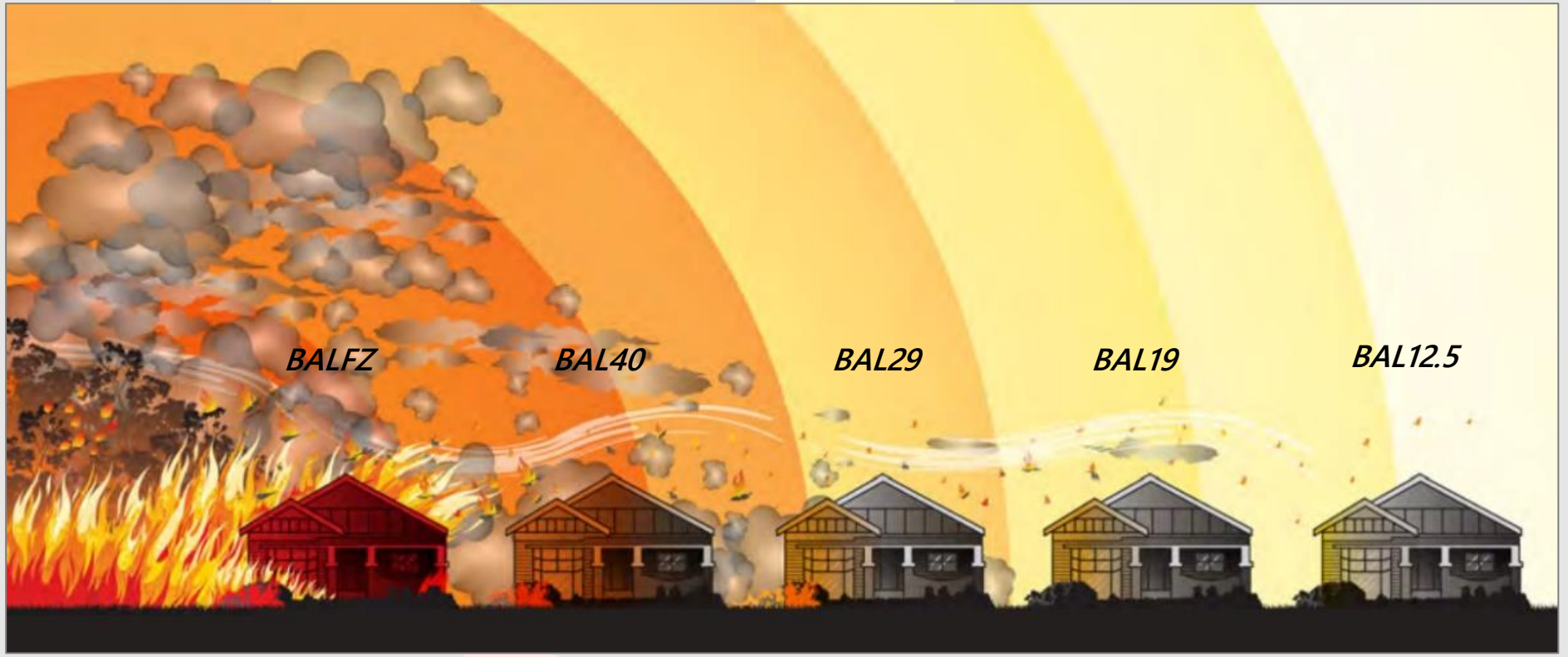
Bushfire Attack Level (BAL) Ratings Overview

Used in AS3959: *Construction of Buildings in Bushfire Prone Areas* and most land use planning regulation



- BAL determined using 1d look-up table (method 1)

or

- Using 1d model inputs (method 2)

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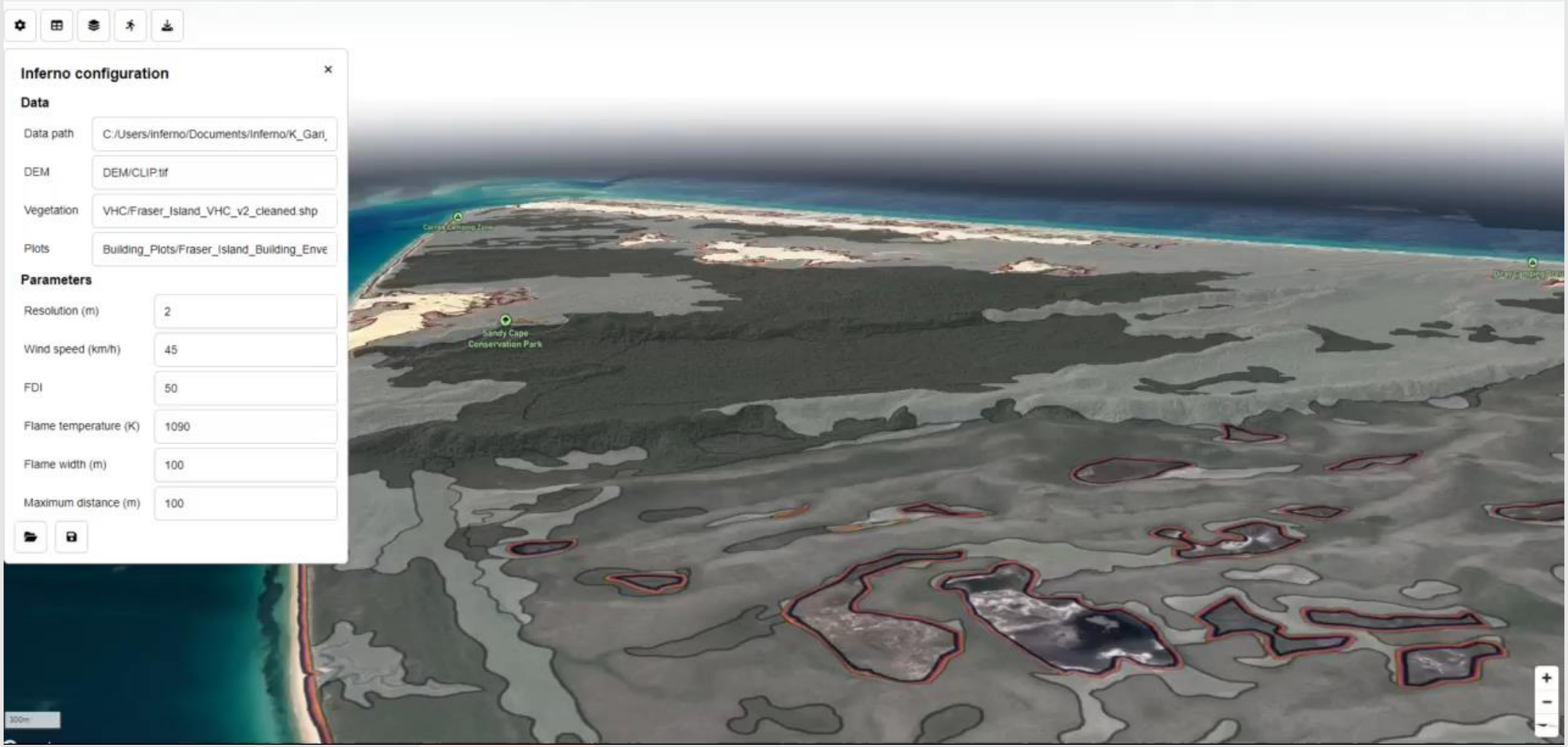
2d Static – ‘Inferno BAL’ user interface



- Calculated using model inputs (method 2) in a 2d field

2d Static – Orchid Beach RHF Curves

- RHF curves per method 2 of AS3959 determined
- Inferno allows adjustment of Flame Temperature, flame width, FFDI, wind speed and resolution
- Fuels may be developed/modified in a GIS and loaded into Inferno (fuel extents and values)

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2d Static – Orchid Beach RHF Curves

- Individual building envelopes may be queried in the program
- All results can be exported to a GIS for further analysis
- RHF for every point in the landscape is calculated

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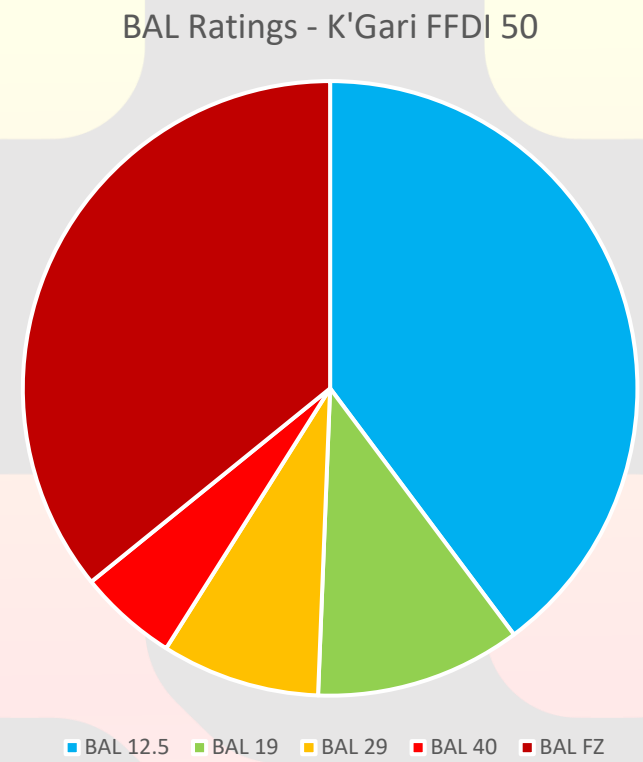
2d Static RHF Model Results (per AS3959 Method 2 & BRC) – no simulated hazard reduction burning



BAL Rating	n	%
BAL 12.5	191	39.8
BAL 19	52	10.8
BAL 29	40	8.3
BAL 40	25	5.2
BAL FZ	172	35.8

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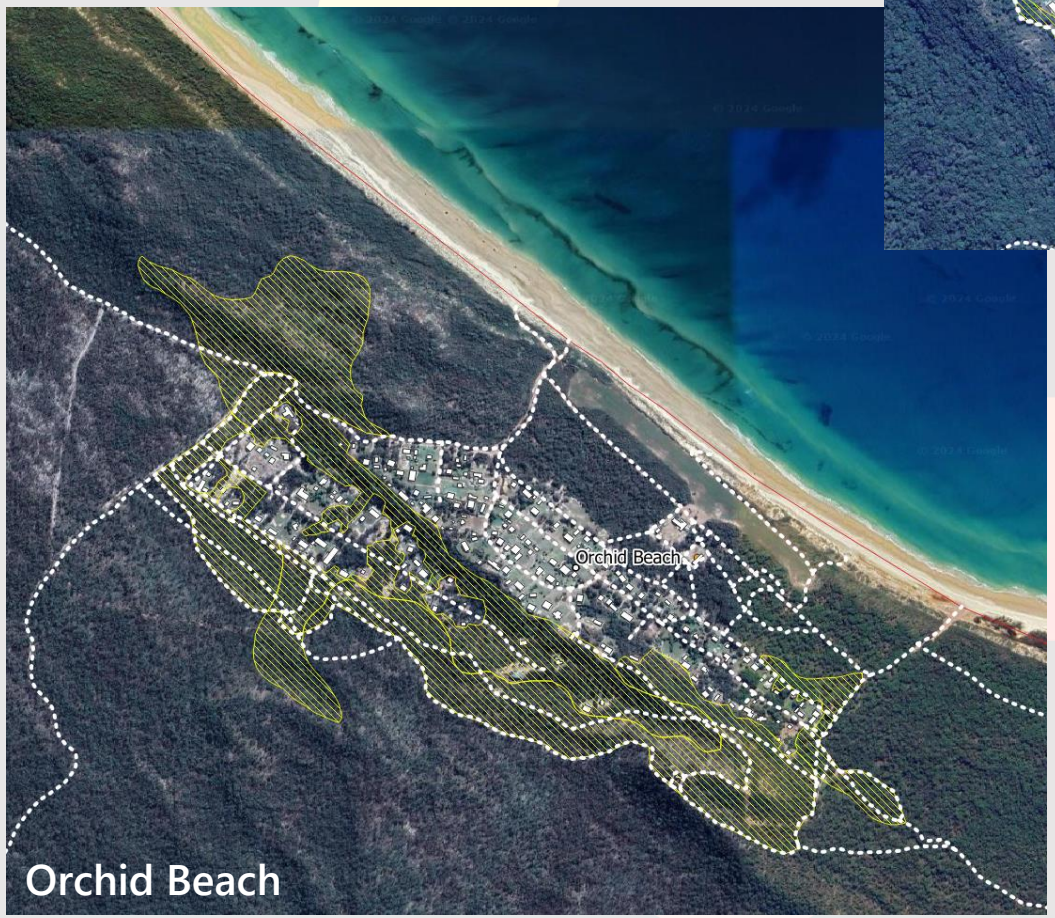
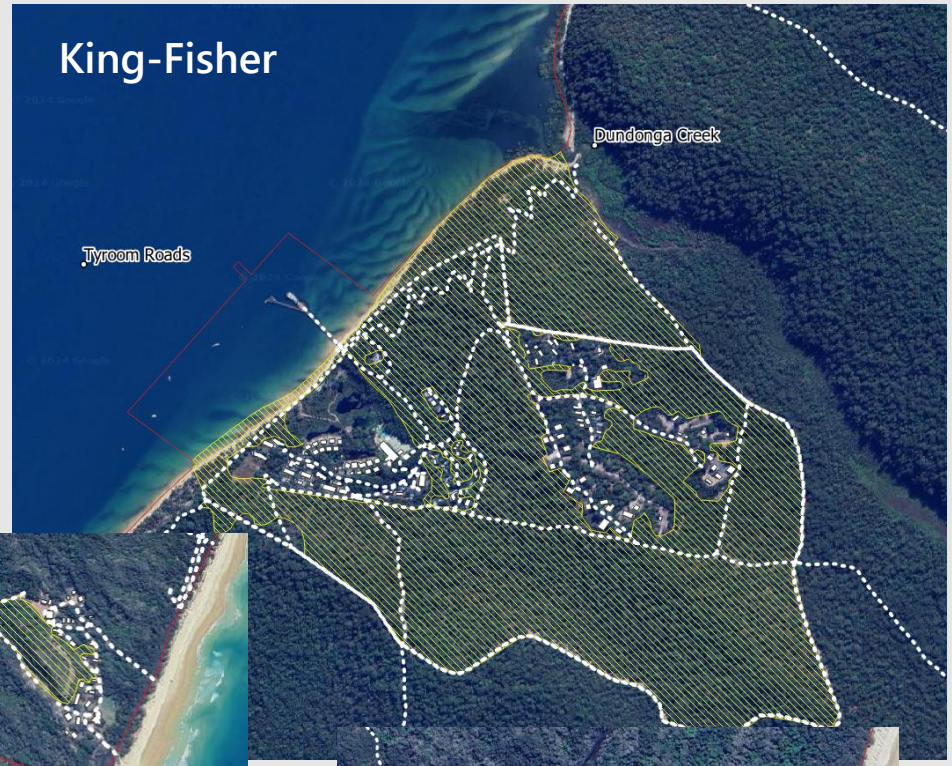
Surgical Prescribed Burning

(256ha of burning-approx. 0.16%)
Total area K'Gari 166,000ha





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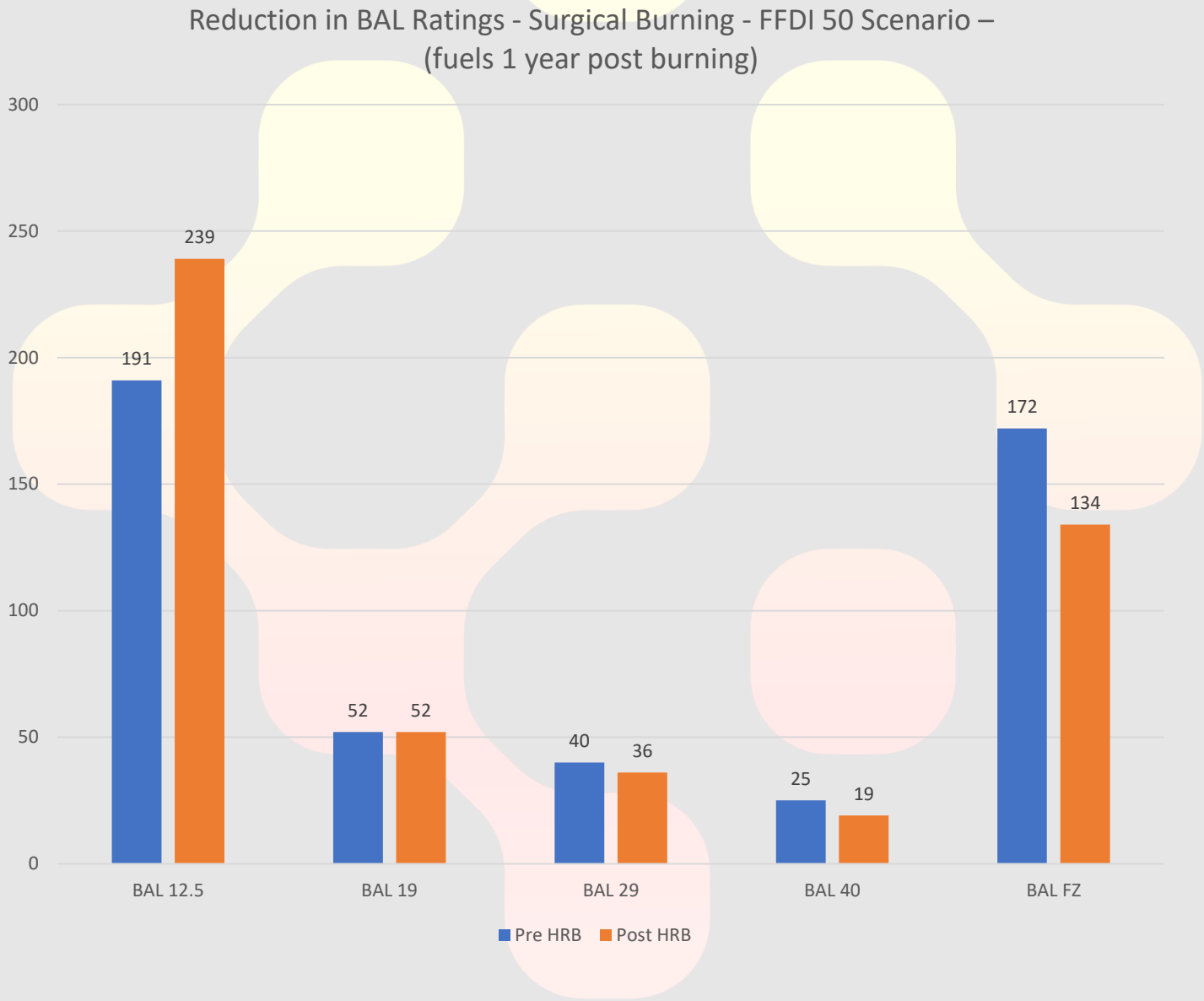
2d RHF Model Results (AS3959 Method 2) FFDI 50 per BRC



- Results similar to pre-hazard reduction burning due to rapid reaccumulating of fuels
- There remains a clear reduction in higher BAL Rating's and an increase in lower BAL Rating's, at 1-year post-burning
- Results would differ immediately and 2, 3, 4, 5 years etc, after burning

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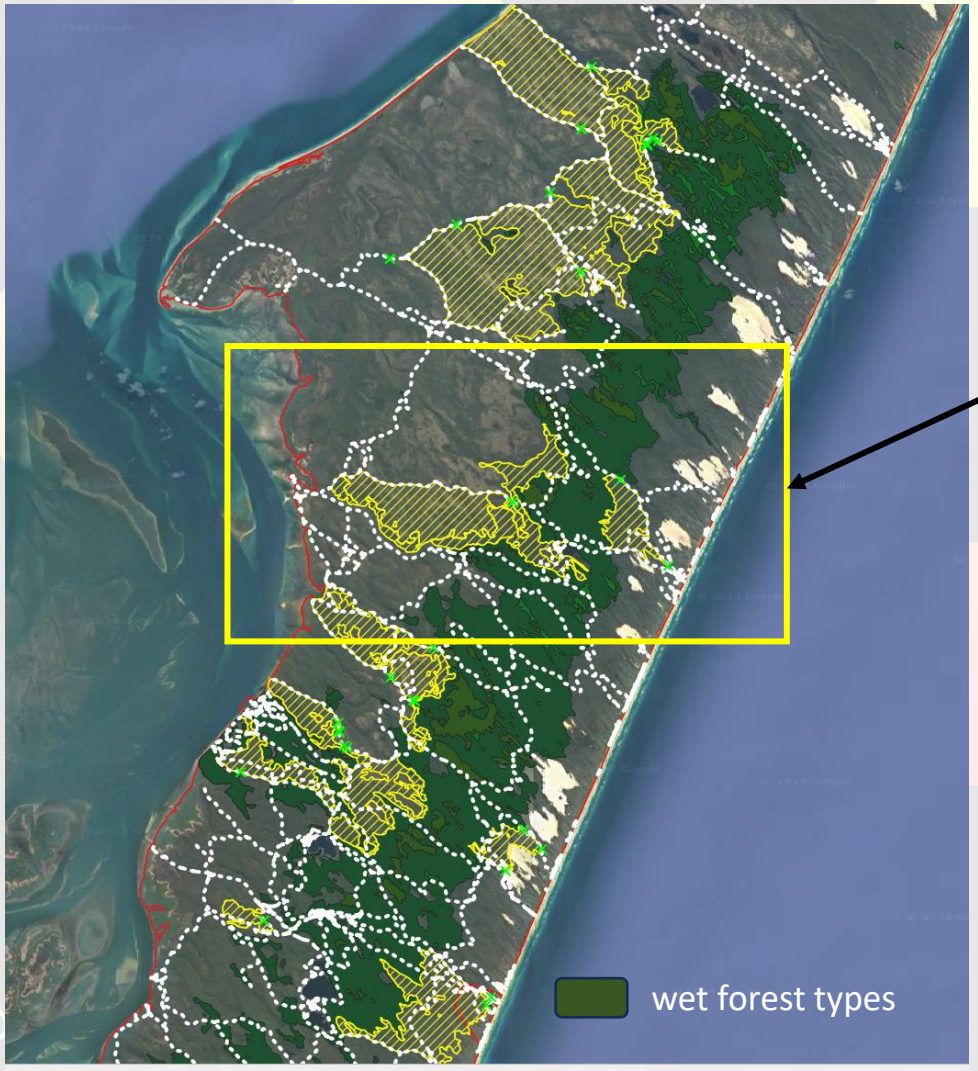
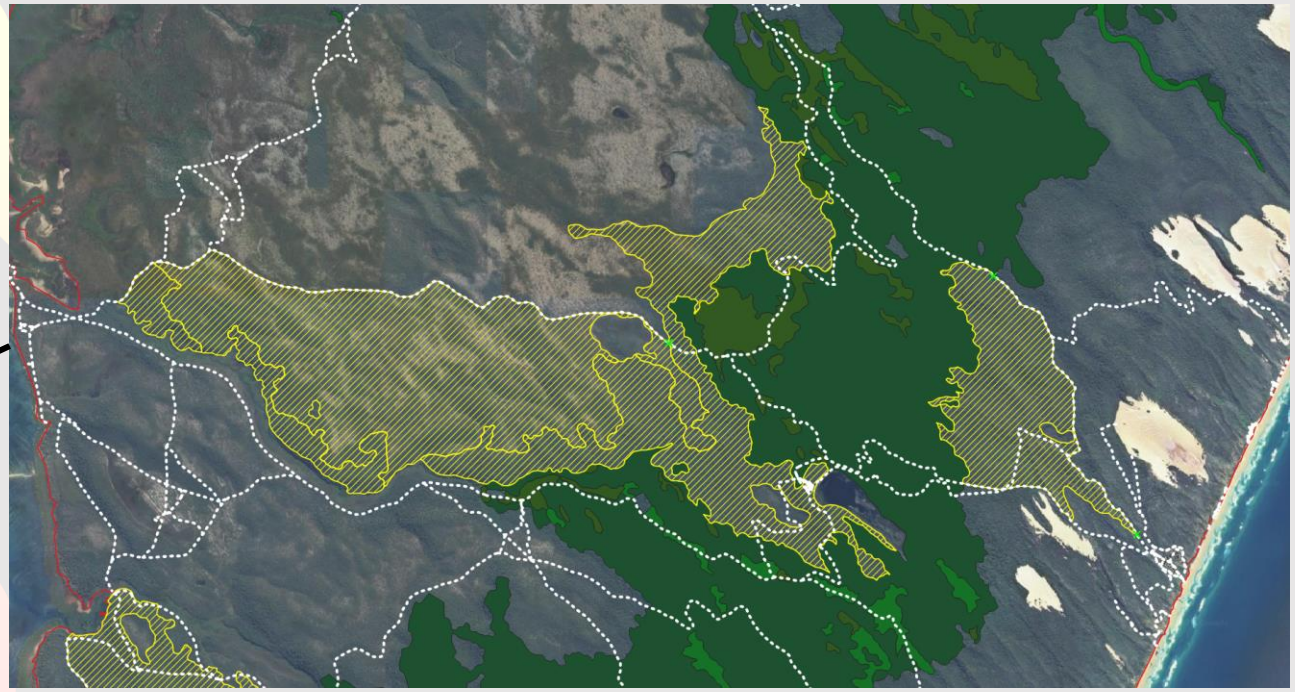
Broadscale + Surgical Prescribed Burning

(20,230ha burning – approx. 12%)
Total area K'Gari 166,000ha





Burning using existing track/control lines and wet forests for unbounded burning (chosen as a plausible strategy)

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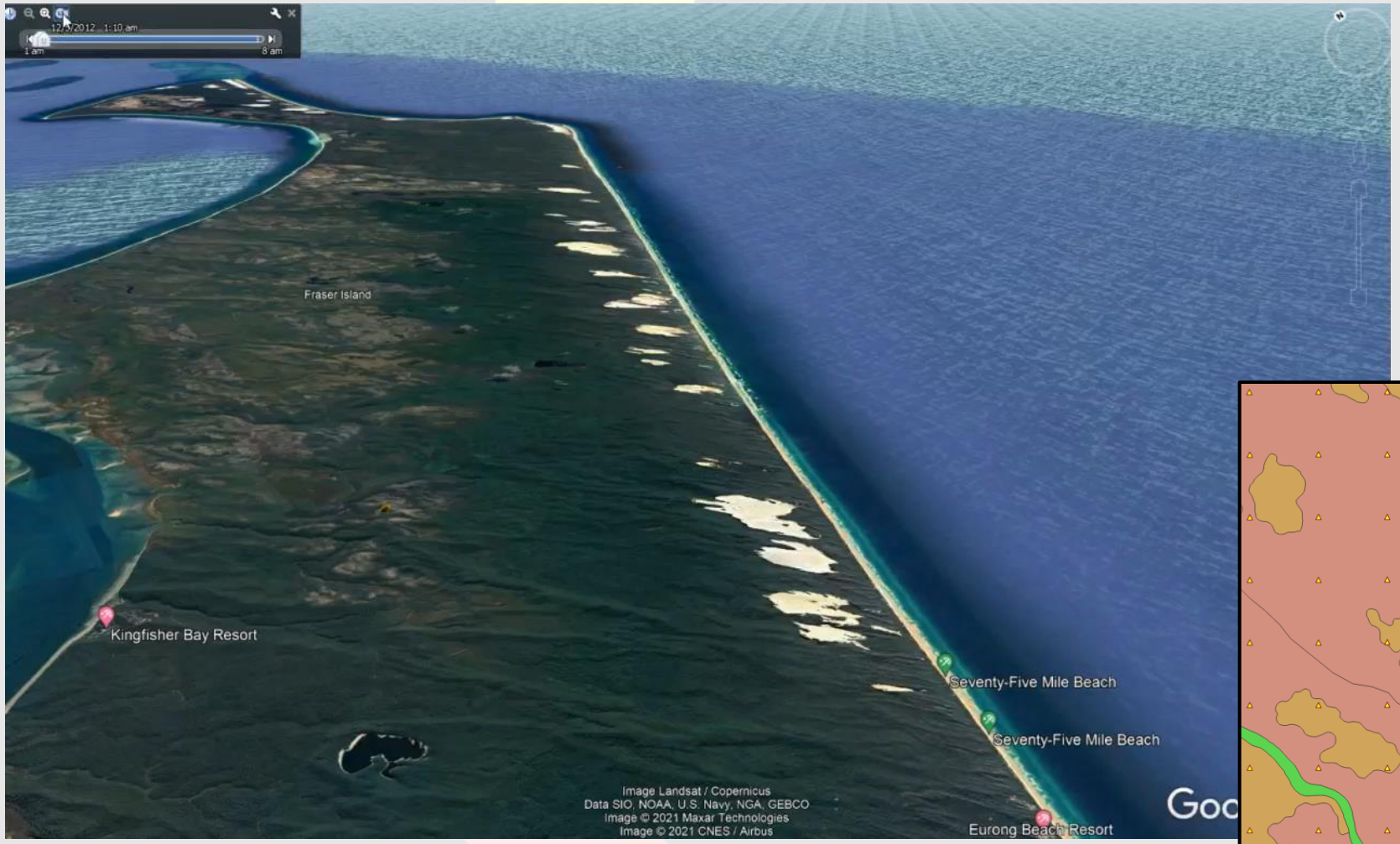
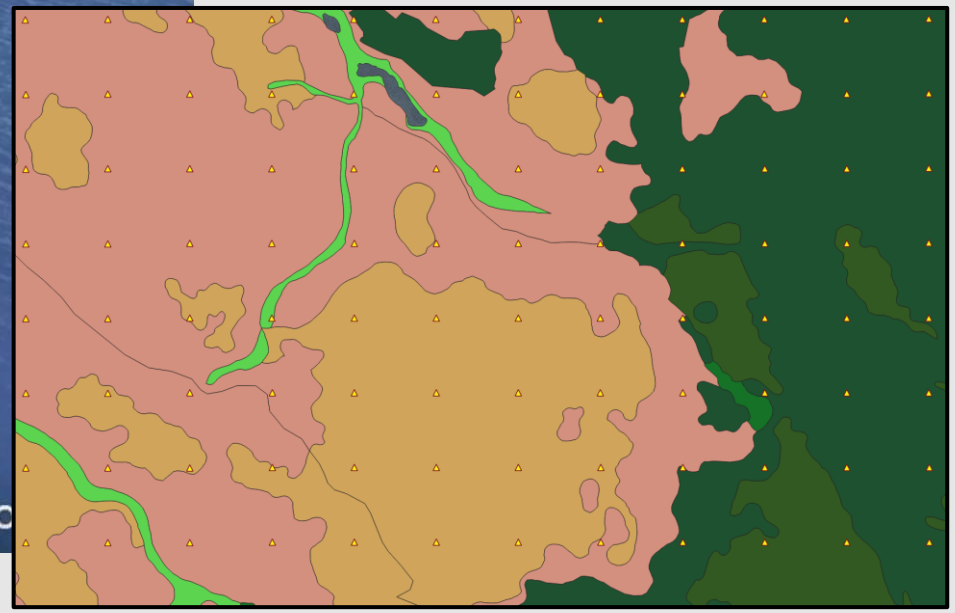
Dynamic Fire Simulations



- Using locally meaningful worst-case weather (peak at FFDI 58)
- Dominant SW wind with late afternoon wind change from the N
- 11.00 am ignition time



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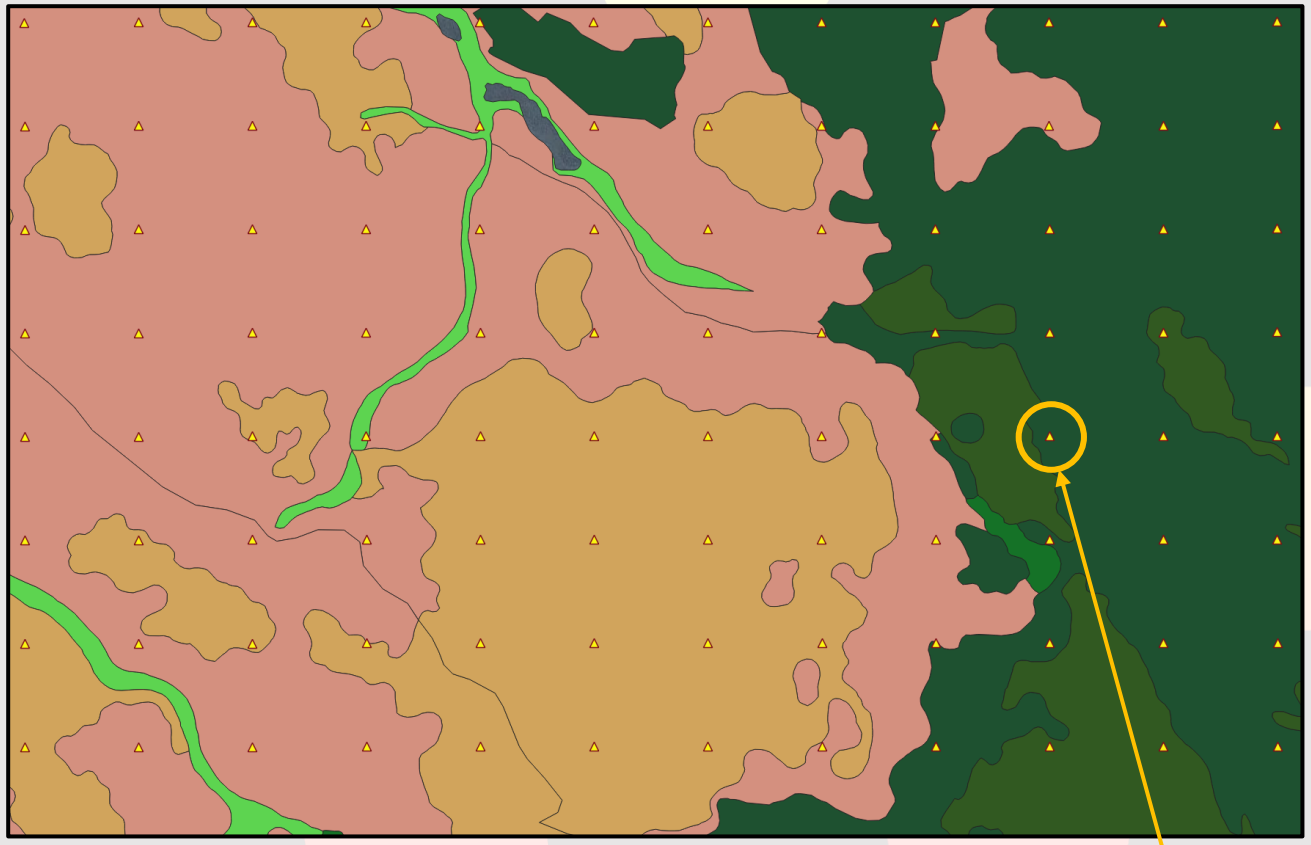
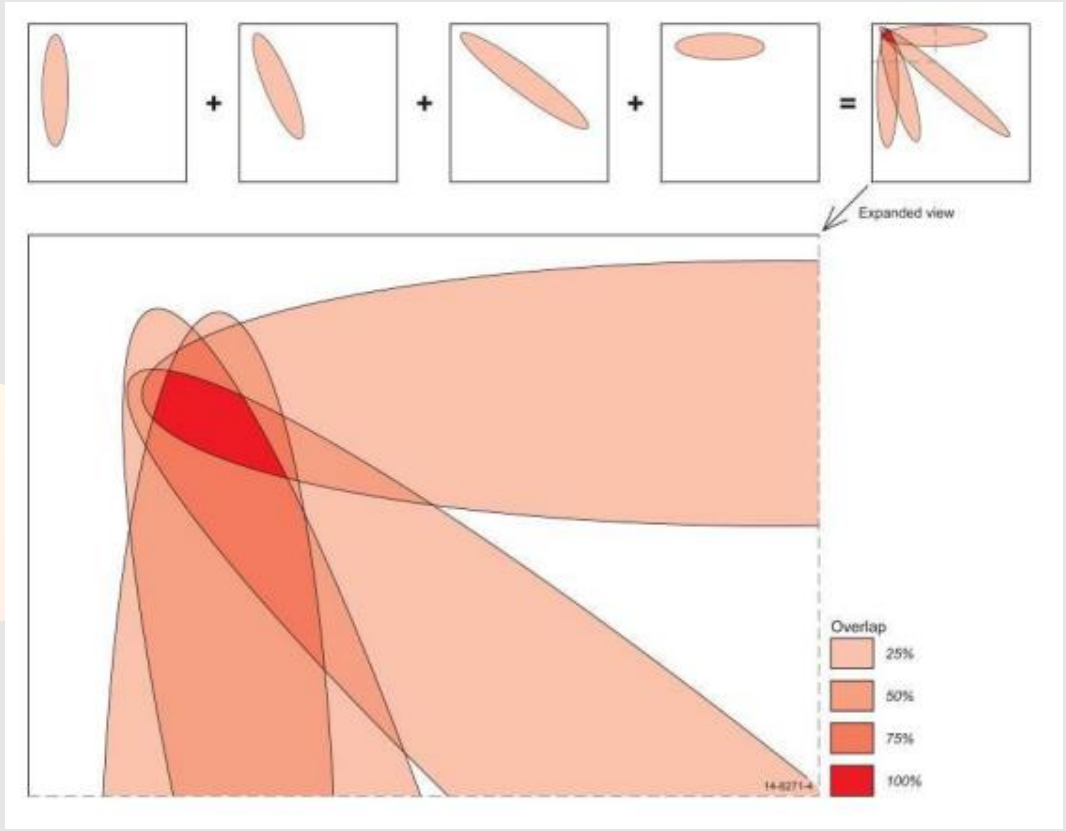
Ensemble Fire Simulation Concept





- Ability to simulate thousands of fires starting at each part of the landscape
- Fires are overlapped and derived value (e.g. max) extracted at each point

1 ignition point

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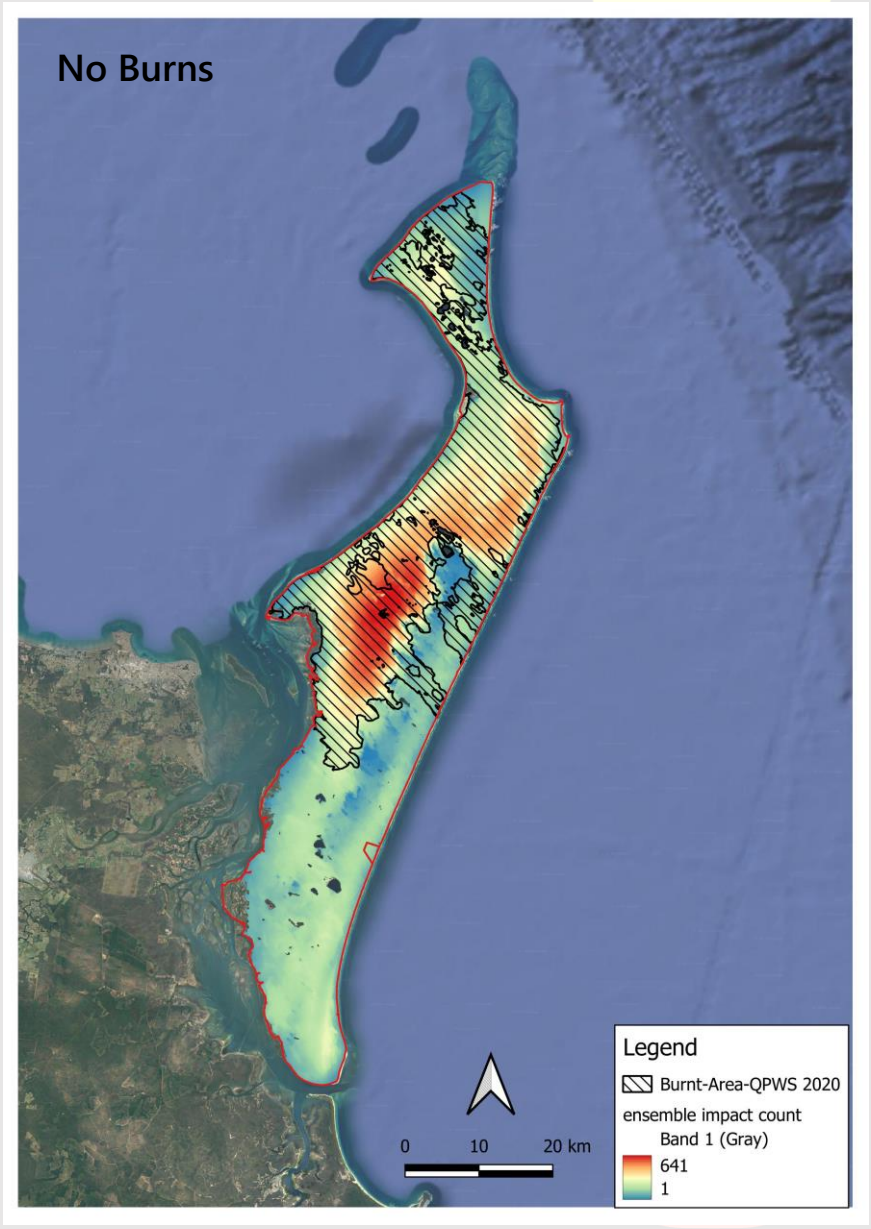
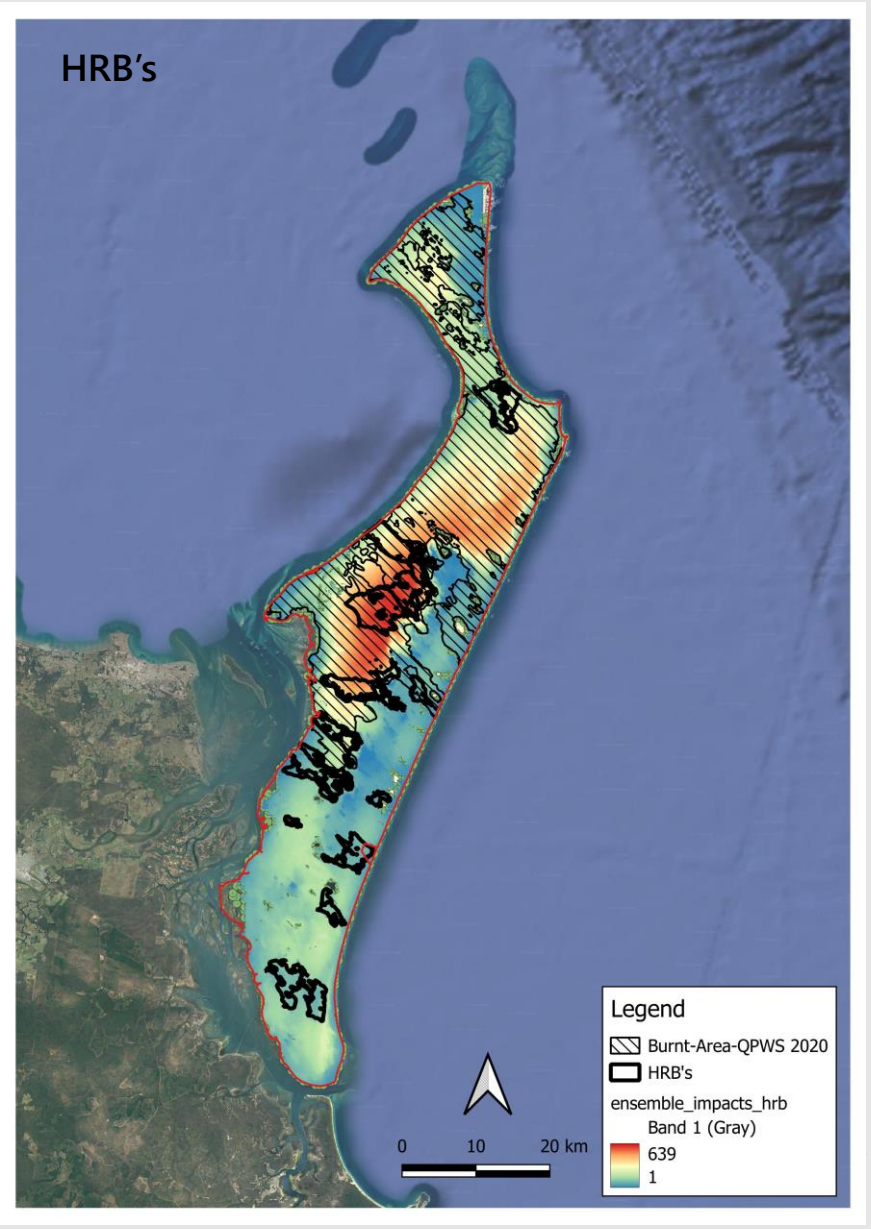
Ensemble Analysis Results – impact count





- 6,776 ignitions in ensemble within flammable land classes
- 500m ignition spacing
- 10-hour simulation run time
- Areas most likely to burn are near the centre of the island and to the west of the wet forests
- The overall flammability potential of K'Gari over 6,776 ignitions does not change significantly with this weather scenario
- Cell impact count correlates well to the 2020 burn scar that impacted over 50% of the island

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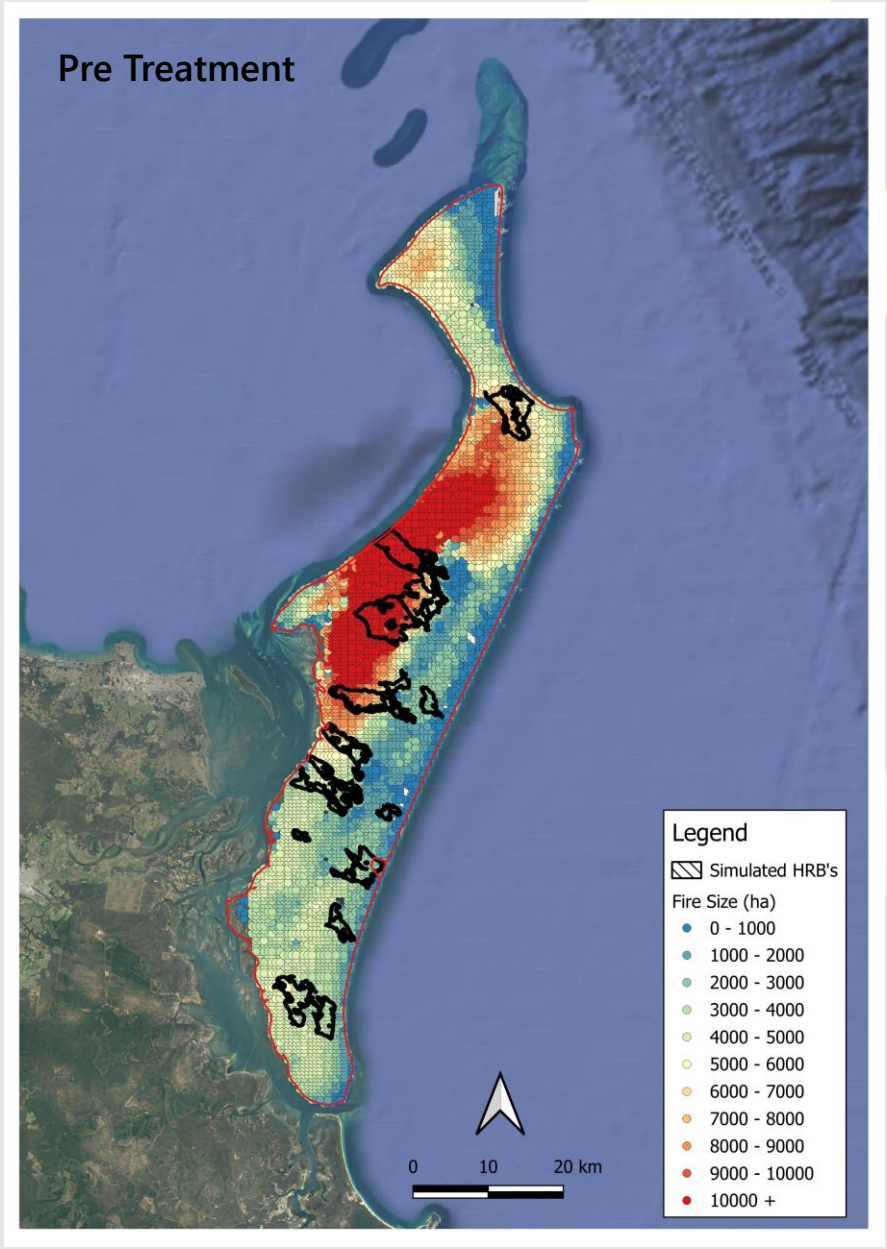
Ensemble Analysis – fire area based on ignition location



- The size and perimeter of each fire from all ignition points can be measured in the simulations and ranked and mapped
- This affords decision-makers the ability to determine the parts of the landscape with the potential to generate the largest fires
- The largest potential fires coincide with ignition locations, with the longest ‘fire runs’ through flammable fuels and dominant wind directions

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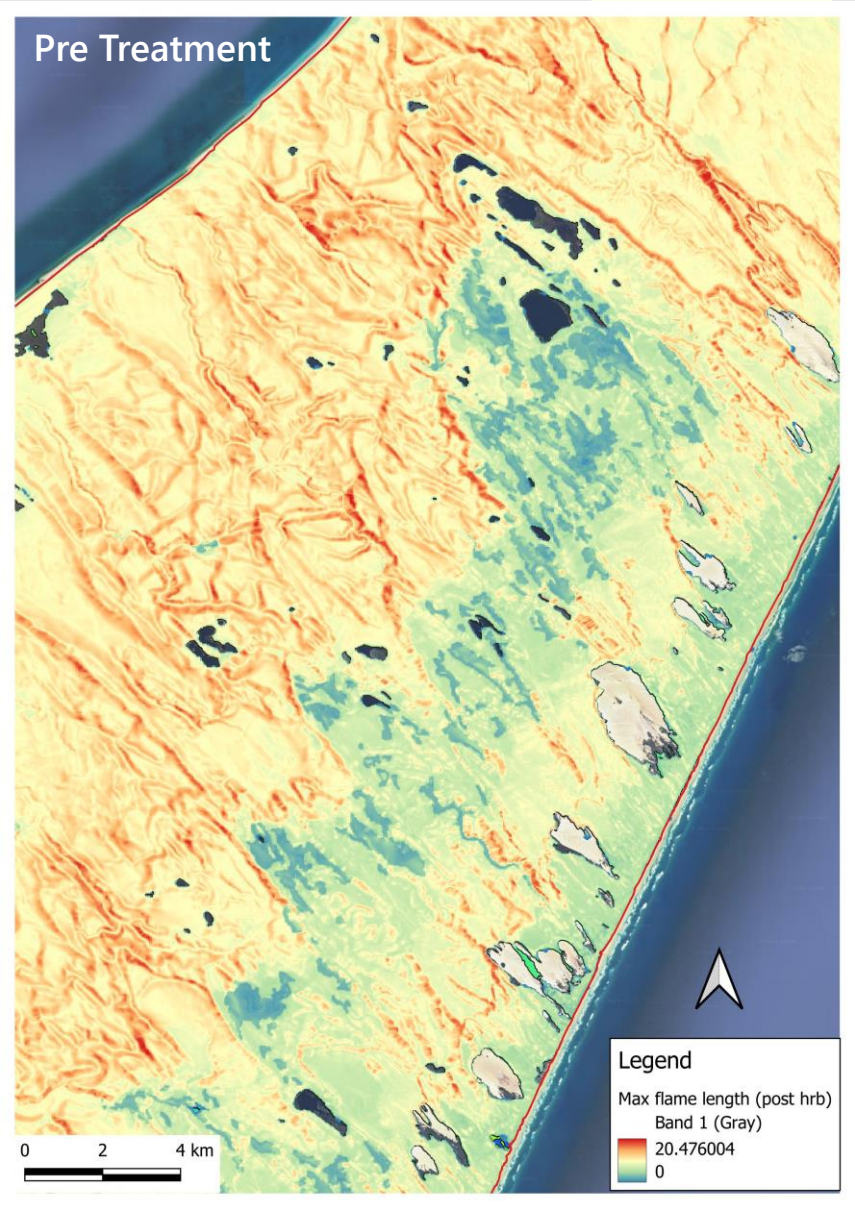
Ensemble Analysis – flame length



- Flame lengths longest in areas of higher fuels, peak weather and steeper topography and at the head of the fire
- Flame lengths can be queried at 30m resolution (min/avg/max)
- Potential to be translated into RHF Method 2 (using view factor) or (ray casting) methods

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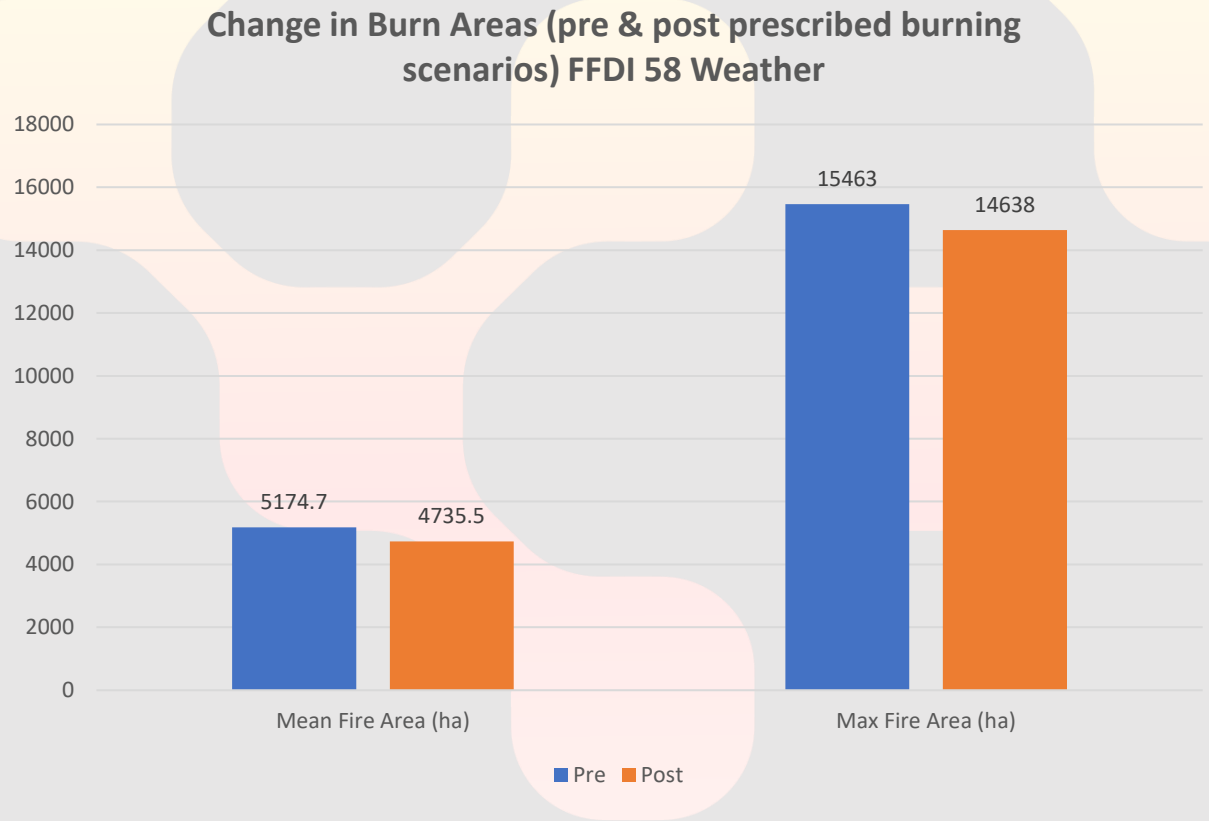
Ensemble Analysis – burning vs no burning comparison

(under credible worst-case scenario and 12% area treatment)

Ensemble Output	Pre	Post	% Change	Change Dir
Mean Fire Area (ha)	5174.7	4735.5	-8%	Lower
Max Fire Area (ha)	15463	14638	-5%	Lower
Mean (Max Flame Lengths) metres	16.79	15.77	-6%	Lower



Preliminary Insights

- Surgical HRB's may need to be developed alongside other mitigation measures to be effective during the peak of worst-case fire weather to reduce RHF at building envelopes
- However, Surgical HRB's could be temporally effective under more 'typical' and benign fire weather
- Broadscale burning may reduce overall landscape risk and is likely to be effective in helping to contain individual fires (if they interact), however, it's difficult to mitigate every possible worst-case scenario
- The area of the island most likely to carry fire is to the centre and west of the island. These are also the areas where the largest fires are most likely to develop from
- The wet forest types running north to south inhibit fire movement from west to east and vice versa
- However, risk shifts/moves around depending on fire scenarios (changes in fuel and weather – spatially and temporally)

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Advantages of approach

- Modelling tools are extremely useful for gaining insights into potential fire behaviour and risk, as well as risk change over time or through intervention
- Models are very flexible, with a wide choice of fire behaviour model algorithms, inputs and outputs
- Models can be set up to answer a wide variety of risk analysis questions and tasks
- Key requirements are to obtain quality data inputs
- Can model very large areas quickly (ens. sims approx. 1 hour and 2d BAL model approx. 10s)

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Future Work

- Modelling using different fire weather (ensembles of the weather)
- Generate RHF profiles from dynamic simulations (currently under development) and compare them to static 2d (AS3959 Method 2 Approach)
- Test different fuel reduction burning strategies, including the addition of firebreak widening around the settlements for RHF modelling

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Thank you!

Questions?

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