SFMC
STATE FIRE MANAGEMENT COUNCIL

BUSHFIRE IN TASMANIA
A new approach to reducing our Statewide relative risk.
July 2014

Tasmania
Explore the possibilities

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Cover Photo. Burning vegetation at Taranna, 2013. Taken by Matt Drysdale, provided by the Tasmania Fire Service.

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EXECUTIVE SUMMARY

Bushfire has been a constant and natural phenomenon in Australia for many thousands of years. South-eastern Australia, including Tasmania, is particularly prone to fire and is regarded as one of the most bushfire-affected regions in the world. Although fire forms an important part of the environment and remains essential for biodiversity and renewal; its effects can be catastrophic if uncontrolled. Tasmania has experienced periodic bushfire events that have caused devastating loss to life and property. While the protection of life and property remains the underpinning principle applied by agencies to combat bushfire risk, the importance of strategic fuel management regardless of land tenure has been highlighted by recent bushfire events in south-eastern Australia.

The State Fire Management Council (SFMC), as defined under Section 14 of the *Fire Service Act 1979,* is an independently chaired body which provides advice to the Minister of Police and Emergency Management about the prevention and mitigation of bushfires. In the aftermath of the 2009 Black Saturday fires in Victoria, and in response to the recommendations of the Victorian Bushfires Royal Commission Report (VBRC), the SFMC was tasked to provide advice regarding the extent and effectiveness of fuel reduction burning programs across Tasmania.

Approximately 42% of the State has vegetation that is suitable for treatment through fuel reduction burning programs. Over the past five years records for public lands show burning is undertaken at an average of 16,500 hectares per annum. Noting that additional burns may occur on private lands where records are not as well maintained, it does not necessarily follow that communities are safer due to the current burning regime. In this vein, areas of the landscape that are strategically selected for burning, based on a Statewide appreciation of bushfire risk will be more effective than broad-area burning in remote locations in creating safer communities.

To demonstrate this, SFMC conducted a strategic risk assessment where bushfire risk was assessed across the landscape, regardless of land tenure. Bushfire risk assessment models were used to describe current bushfire risk in Tasmania and to test different fuel reduction burning strategies to determine how they could reduce such risk.

PHOENIX RapidFire fire behaviour modelling indicated the potential for a high incidence of intense fires in several locations throughout the state. Under current fuel conditions, areas south of Launceston and Deloraine, between Sorell and Little Swanport, the Huon Valley, The Channel and parts of the Southwest were particularly at risk. The modelling demonstrated that there are many areas where fuel reduction burning has the potential to reduce bushfire impacts to communities. Noting that the majority of modelled bushfire impacts occurred in the Southern, Hobart and Tamar Fire Management Areas, the challenge is clearly to prioritise areas for treatment.

Moreover, impact modelling demonstrated that fuel reduction would not reduce potential bushfire impacts in some Human Settlement Areas. This confirms that fuel reduction burning will not entirely eliminate risk, but it is an effective bushfire mitigation option in many circumstances. It must therefore be seen as one of several mitigation options, including fire prevention, mechanical fuel removal, building design, fire trail and fire break maintenance, bushfire response and community engagement in promoting safety options.

Fifteen fuel reduction burning scenarios were tested for benefits in reducing impacts to Human Settlement Areas. This included how fire intensity and fire size were reduced to more manageable levels. The scenarios were based on fuel reduction burning in fire-tolerant vegetation referred to as 'treatable vegetation'; and tested the concept of: (a) burning on public land only, and (b) burning on all tenures. The use of Fire Management Zones was tested to manage fuels intensively within 6.05km of Human Settlement Areas, and one scenario also allowed fuels to accumulate with no fuel

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treatment. Area-based targets were then developed based on fuel accumulation principles, scientific literature and recommendations from bushfire inquiries.

For each scenario, hypothetical five year burning programs were developed. The Bushfire Risk Assessment Model (BRAM) was used to prioritise burns based on bushfire risk. All hypothetical burning was conducted strategically to reduce bushfire risk at the Statewide and Fire Management Area scales.

The tenure-blind fuel reduction burning scenarios that burnt the largest areas had the greatest effect on reducing bushfire impacts, fire intensity and fire size. However, when considering the relative expense of their implementation, the loss of amenity and environmental costs, the feasibility of these scenarios in addressing bushfire risk reduction are questionable.

Inversely, the scenarios that confined burning to public land were considered achievable; but had very small effects on reducing Human Settlement Area impacts and fire size. From a whole-of-state perspective, the 5% public land only scenario did reduce fire intensities significantly across the landscape.

The most feasible scenario was therefore a balanced approach. Burning at least 31,000 ha of all treatable vegetation each year, including private and public land, with selection of burns based on a Statewide bushfire risk assessment (using the BRAM Risk Score) was both financially and operationally achievable, with reductions to modelled bushfire impacts greater than the public land only scenarios.

Specifically, this scenario significantly reduced the number of modelled bushfire impacts Statewide by 30%, and up to 50% in the Southern Fire Management Area. Greatest risk reductions were achieved in the Southern, Hobart and Tamar Fire Management Areas. In order to achieve these outcomes, approximately half of the area burnt was private property.

The modelling demonstrated the overall importance of strategically targeting blocks where the highest risk reduction can be realised. In 2004 the National Inquiry into Bushfire Management proposed zoning the areas around towns into asset protection zones and strategic fuel management zones as a way of implementing prevention programs. While this is appropriate for a local plan, once considered in a whole-of-landscape it becomes clear that a more nuanced approach is required. The balanced approach previously described provides for greater reductions in relative risk whilst burning fewer hectares, but only if the blocks are strategically targeted.

Implementation of a fuel reduction program involves a structured and adaptive process. Specifically, it includes bushfire risk assessment, identification of burning priorities, field checking, plan preparation, pre-burn preparation, burning, post-burn recovery and review. Experience from interstate indicates that it takes approximately three years to build up an expanded fuel reduction burning program. However, ongoing and long-term commitment is also required to effectively reduce the long-term bushfire risk.

Currently most burning occurs on public land, for purposes other than community risk reduction, and in areas that are remote from communities. Typically the burns are less complex and less expensive when compared to burning that occurs in close proximity to communities. Therefore a strategically planned fuel reduction burning program based on community risk reduction will require resourcing over and above historical levels.

For a program of this scale a comprehensive communication strategy, issues analysis and stakeholder analysis will be required. Some of the key issues that will need to be addressed may include, but will not be limited to:

- community acceptance of an expanded planned burning program

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- explaining the limitations of different mitigation activities; some areas will always be prone to high bushfire risk even after all mitigation options have been implemented
- access to private lands to undertake risk mitigation activities
- smoke and public health impacts
- the effects of an expanded fuel reduction burning program on other burning programs that are regulated by smoke restrictions
- the visual impacts of smoke and charring in the landscape, including their effects on tourism
- balancing risk mitigation actions with environmental impacts; and
- workforce capacity to implement a program of this scale.

While some legislative tools and policies are already in place, an implementation program that builds on collaboration, cooperation, and a whole-of-community acceptance of bushfire risk will have the best outcome. Fire Management Area Committees, through fire protection plans, will provide the risk context for prioritising mitigation activities.

The methodology and approach taken in this report has identified a new approach to understanding bushfire risk in Tasmania. The results of the analysis can be used to identify the most effective areas for strategic mitigation programs, and to underpin Fire Management Area fire protection plans. Based on the analysis provided in the report the State Fire Management Council makes the following recommendations to Government for consideration:

1. A strategic fuel reduction burning program is developed that reduces bushfire risk to communities by strategically identifying high priority areas for treatment.
2. The Tasmanian Government supports a tenure-blind approach to fuel reduction.
3. Any fuel reduction strategy implemented must aim to reduce Statewide relative risk to below 80% within eight years.
4. A period of three years is allocated to build up to a fully implemented fuel reduction burning program.
5. A minimum of 31,000 ha of treatable vegetation on both public and private land is targeted each year, measured using a five year rolling average.
6. A long term commitment is made to implement a centrally coordinated fuel reduction burning program that incorporates the entire fuel reduction burning management process, including an ongoing commitment to improve strategic selection of burning priorities.

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PURPOSE AND SCOPE

To undertake a strategic bushfire risk analysis for Tasmania, where the methodology moves from a post-event analysis to a landscape risk assessment, using scenario-based modelling tools.

Through this analysis, articulate recommendations for a strategic fuel management program.

The analysis in this report takes a tenure-blind approach, and has been undertaken at a landscape level to test strategies designed primarily to reduce the risk of bushfire impacting on Human Settlement Areas.

Included in the report is:

- Analysis of particular issues associated with fuel mitigation activities.
- Bushfire risk assessment at the Statewide scale, including identification of communities considered to be at highest risk.
- Analysis of fuel reduction burning as the primary risk treatment option.

This report does not include:

- Alternative risk treatment strategies, including but not limited to fire prevention, building location, building standards, garden establishment and maintenance, mechanical fuel treatment and bushfire response measures.
- Locally specific analysis of location and maintenance of fire breaks and trails.
- A cost benefits analysis of different fuel reduction strategies.
- Recommendations for planned burning operations associated with forest practices or ecological health.
- Recommendations regarding the broader issues of bushfire preparedness and bushfire response.
- Risk assessment sub-Fire Management Area (FMA) scale, except for the identifications of communities considered to be at highest risk.

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REPORT CONTEXT

On 7 February 2009 widespread and devastating bushfires in Victoria resulted in the death of 173 people. The Victorian Government established the Victorian Bushfires Royal Commission (VBRC) to inquire into the circumstances of these deaths and to recommend any necessary improvements to fire management in Victoria (Teague, et al., 2010). 67 recommendations were made, and all but two of these recommendations were accepted by the Government. Of particular interest to this report, was Recommendation 56, that 'The State fund and commit to implementing a long-term program of prescribed burning based on an annual rolling target of 5 per cent minimum of public land' (Teague, et al., 2010). This recommendation was made on the recognition of fuel reduction as a proven method to reduce the rate of spread and intensity of fires, minimising their damage and making suppression easier for firefighters.

On 28 September 2010 the then Premier of Tasmania, David Bartlett, announced that in response to the VBRC, the Tasmanian Government fully supported 48 of the 67 recommendations, supported a further 17 in-principle and did not support two. Of the VBRC recommendations supported in principle, the Government agreed that further detailed consideration be given to the application in Tasmania of VBRC Recommendation 56.

Subsequently, the Minister for Police and Emergency Management asked the SFMC to give detailed consideration to the value in both a qualitative and quantitative sense of prescribed burning programs that were then being undertaken or proposed to be undertaken in Tasmania. Council was also asked to report on their capacity to support a program of long-term data collection to monitor and model the effects of prescribed burning programs and bushfires on biodiversity in Tasmania. A Cabinet Briefing prepared by SFMC provided advice to Cabinet in March 2011 outlining a program by which a burning target of 5% of treatable fuels on public lands could be achieved, through a considerably expanded program over 5 years, coordinated over multiple agencies. Such an expanded program also required legislative amendments to enable the restructuring of Fire Management Area Committees (FMACs). Cabinet deferred a decision on the minute. Tasmania had no Strategic Fuel Management Plan to address Recommendation 56, or other complex issues surrounding fuel management on private land tenures. Nor had there been testing of the validity of a blanket target of burning 5% of public land as a single strategy to reduce risk.

Instead, an alternative approach was followed with legislative amendments to the *Fire Service Act 1979* providing for an enhanced and expanded role for SFMC and for FMACs. In addition a Strategic Fuel Management Project was established to test fuel management targets based on a comprehensive understanding of bushfire risk for Tasmania, on all lands not just public lands, and make recommendations for a Strategic Fuel Management Program. It should also be noted that, since the VBRC, the Final Report of the Bushfires Royal Commission Implementation Monitor advocated that the Victorian Government reassess the 5% rolling target as the primary measure of risk reduction, emphasising that the primary focus of the fuel reduction burning program should be for community protection (State of Victoria, 2012).

Tasmania experienced its own devastating fires in January 2013 with significant loss of property and community impact. The then Tasmanian Government established the Tasmanian Bushfires Inquiry. The Inquiry made 103 recommendations including:

Recommendation 92: That the Government actively support the timely development and implementation of an ongoing Strategic Fuel Management Plan.

Recommendation 93: That the Strategic Fuel Management Plan includes measurable targets and they are actively monitored and reported on to the community.

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The analysis being undertaken in this report responds to these specific recommendations. In addition to fulfilling the Government commitment to the VBRC and the Tasmanian Bushfires Inquiry, this report also addresses the bushfire hazard management priorities identified in the Tasmanian State Natural Disaster Risk Assessment (2012). In particular, it looks at developing and strengthening the strategic approach to bushfire fuel reduction activities and evaluating the impact of recently implemented bushfire risk mitigation measures on the state bushfire risk assessment.

This report contains a thorough assessment of bushfire risk across Tasmania and assesses the benefits of different fuel reduction strategies using a number of different targets and approaches. Overall, it is demonstrated that the existing levels of planned burning being undertaken in Tasmania do need to be increased substantially to significantly decrease bushfire risk to Tasmanian communities. This report outlines the different approaches that could be taken, details the methodology used to undertake that assessment, and outlines some of the challenges for implementation of a much expanded program of planned burning.

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BACKGROUND

Fire is a fundamental part of the Australian environment, and has been significant in shaping the distribution of much of Australia's flora and fauna. Our nation is a fire-prone land, and along with many parts of the world, there has been an increase in the occurrence, intensity and damage caused by bushfire particularly in the last decade.

These fires have caused significant loss of life and psychological damage to communities, as well as loss of property, infrastructure and local economies. This has occurred against a background of a changing climate, an increasingly urbanised population, encroachment of infrastructure and habitation into bushland areas, and differing expectations and understanding of bushfire risk management (Bowman, 2003).

LAND TENURE

Broadly, the land tenure in Tasmania can be divided into 4 main areas: crown, reserved, forestry and private freehold. As seen in Figure 1, approximately 42% of the state is private land, 16% is Permanent Timber Production Zone Land managed by Forestry Tasmania (FT), 3% is Crown land (which has mixed management including the Department of Defence) and the remaining 39% is reserve managed by the Parks and Wildlife Service (PWS).

FIRE IN THE ENVIRONMENT

Fire is a fundamental aspect of the Australian environment, with many vegetation types requiring periodic fire to maintain ecological values. Much of the Australian vegetation is flammable and has a known ecological response, with fossil data indicating a very long history of fire on the continent pre-dating the arrival of humans (Scott *et. al.* 2014). South-eastern Australia, including Tasmania, is particularly prone to fire and is regarded as one of the most bushfire-affected regions in the world (Hennessy, et al., 2006).

Fire forms an important part of the environment and remains essential for biodiversity and renewal. When uncontrolled though, its effects can be catastrophic. Fires may occur under conditions that threaten human life and property, may be too frequent, too intense, cause temporary reductions to air quality or disruptions to the public. The Tasmanian State Natural Disaster Risk Assessment (TSNDRA) identifies both bushfire and flood as the most significant hazard risk types. Bushfire is the most costly natural disaster hazard in Tasmania's history, in both economic and human terms. It has claimed the most lives and has previously been estimated to carry an average annual cost of $11.2 million (Bureau of Transport Economics, 2001).

As outlined in the *National Bushfire Policy Statement for Forests and Rangelands (2012)* the complexities of different ecosystems, community values and land use history means that policies and procedures with regards to bushfire management need to reflect regional needs and priorities.

FIRE HISTORY IN TASMANIA

It is not the purpose of this report to provide a thorough analysis of the fire history of Tasmania. A more comprehensive analysis of Tasmania's fire history can be found in Part B of the 2013 Tasmanian Bushfires Inquiry Report, and only summary information will be presented in this section.

The last decade has seen several major bushfires in southern Australia. These include the 2003 Canberra and alpine fires in NSW, ACT and Victoria, the 2005 Wangary fire on the Eyre Peninsula in

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South Australia, the 2006/07 Great Divide fires in Victoria, the February 2009 fires in Victoria, the Perth hills fires of 2011 and 2014, and the Blue Mountains fires of October 2013.

Major fires have also occurred in Tasmania, particularly in the last decade (Figure 2). In January 2013, Tasmania experienced its worst bushfires since 1967 fires, with many thousands of hectares burned, community infrastructure lost and over 200 buildings destroyed. The Upper Derwent Valley has been particularly hard hit, with large fires in 2010, 2012 and 2013 resulting in both the loss of property, forestry values and agricultural areas. The 1967 fires though remain the most destructive in Tasmanian history, when over a five hour period 62 people died, approximately 1400 buildings were destroyed and 265 000 hectares burnt (Luke & McArthur, 1978).

Projections from climate change models suggest that in the next few decades across much of south eastern Australia there will be major increases in the level of fire threat through increases in the incidence of high fire danger conditions. Climate change projections using a downscaled model for Tasmania suggest an overall increase in bushfire risk related to an increase in the number of high fire danger days (White, et al., 2010). This potential for the next century is based on projections showing increases in hot days and warm nights; dry days and longer dry spells; more warm spells and heat waves; and more wet days, but fewer cold spells and cold waves (which could potentially contribute to increases in fuel accumulation). The number of total fire ban days occurring each summer has also started to increase, as well as increases in lightning caused ignitions.

Planned Burning

Fuel reduction burning, or planned burning, is a recognised technique for reducing the rate of spread and intensity of fires, for minimising the damage caused by bushfires, and to provide fire-fighters with safe opportunities to contain and extinguish future fires. Burning is still considered the most cost-effective tool available for managing broad areas of vegetation fuel loads in the landscape.

In Tasmania only certain types of vegetation are suitable for planned burning, for example, dry eucalypt forest, scrub, heathland and button grass. These are what can be called ‘treatable’ vegetation types. Vegetation such as rainforest, wet eucalypt forest and alpine vegetation is not suited to fuel reduction burning for both practical and environmental reasons. Agricultural lands, whilst certainly susceptible to the impact of bushfire, are also not considered “treatable” due to the land use priority for these vegetation types. This does not preclude these areas from burning, however it means this area of land is not being included in the analysis.

Figure 3 shows the arrangement of treatable, non-treatable and agricultural lands across the state, based on TASVEG 3.0 and land use mapping as described in the methodology of this report.

The treatable vegetation is spread over different tenure as follows:

- 0.97 million hectares (39%) in reserves (PWS);
- 0.39 million hectares (16%) in Permanent Timber Production Zone Land (FT);
- 0.08 million hectares (3%) on unallocated Crown lands; and
- 1.05 million hectares (42%) on privately owned and other lands.

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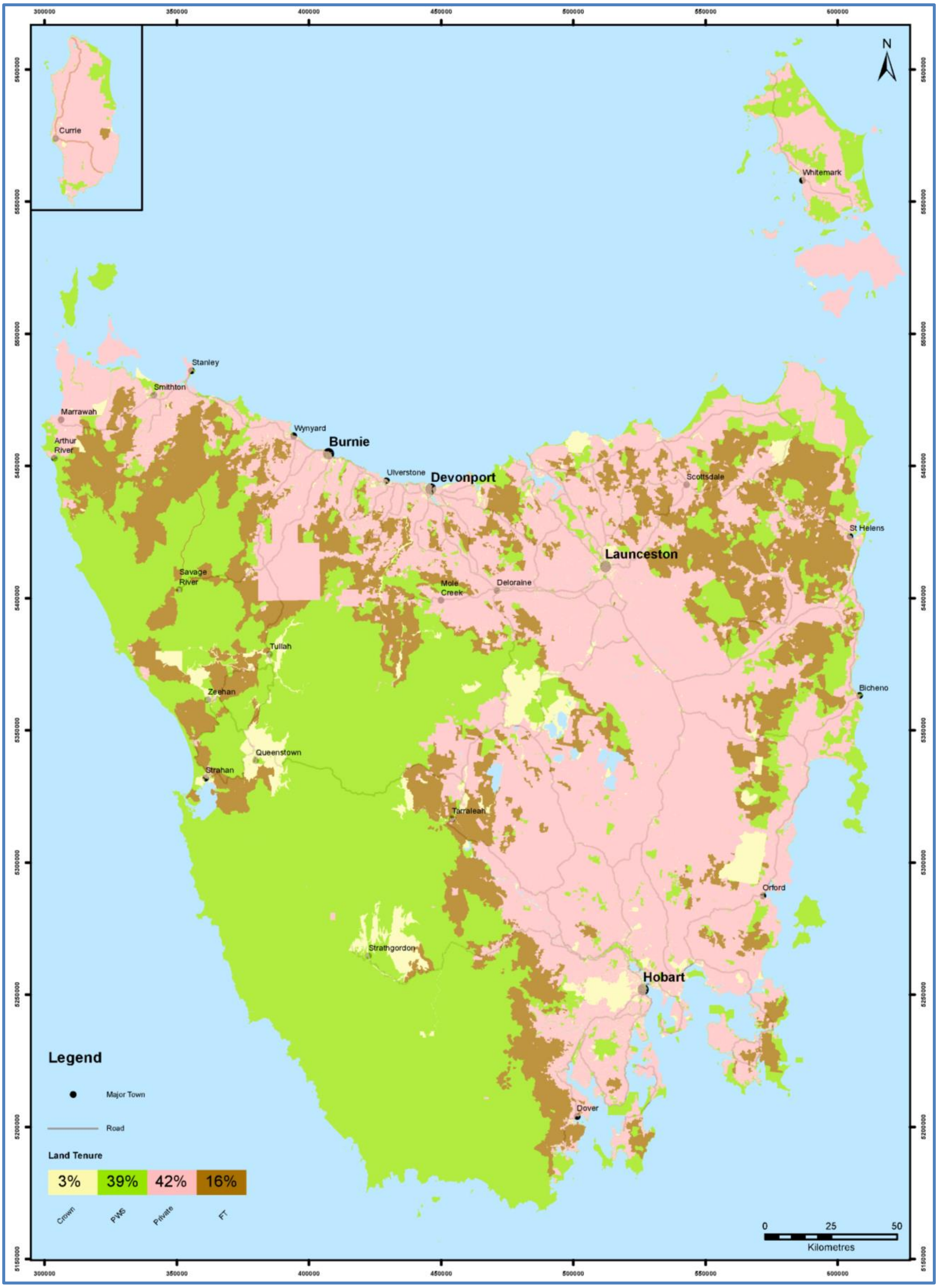

Figure 1: Broad categories of land tenure

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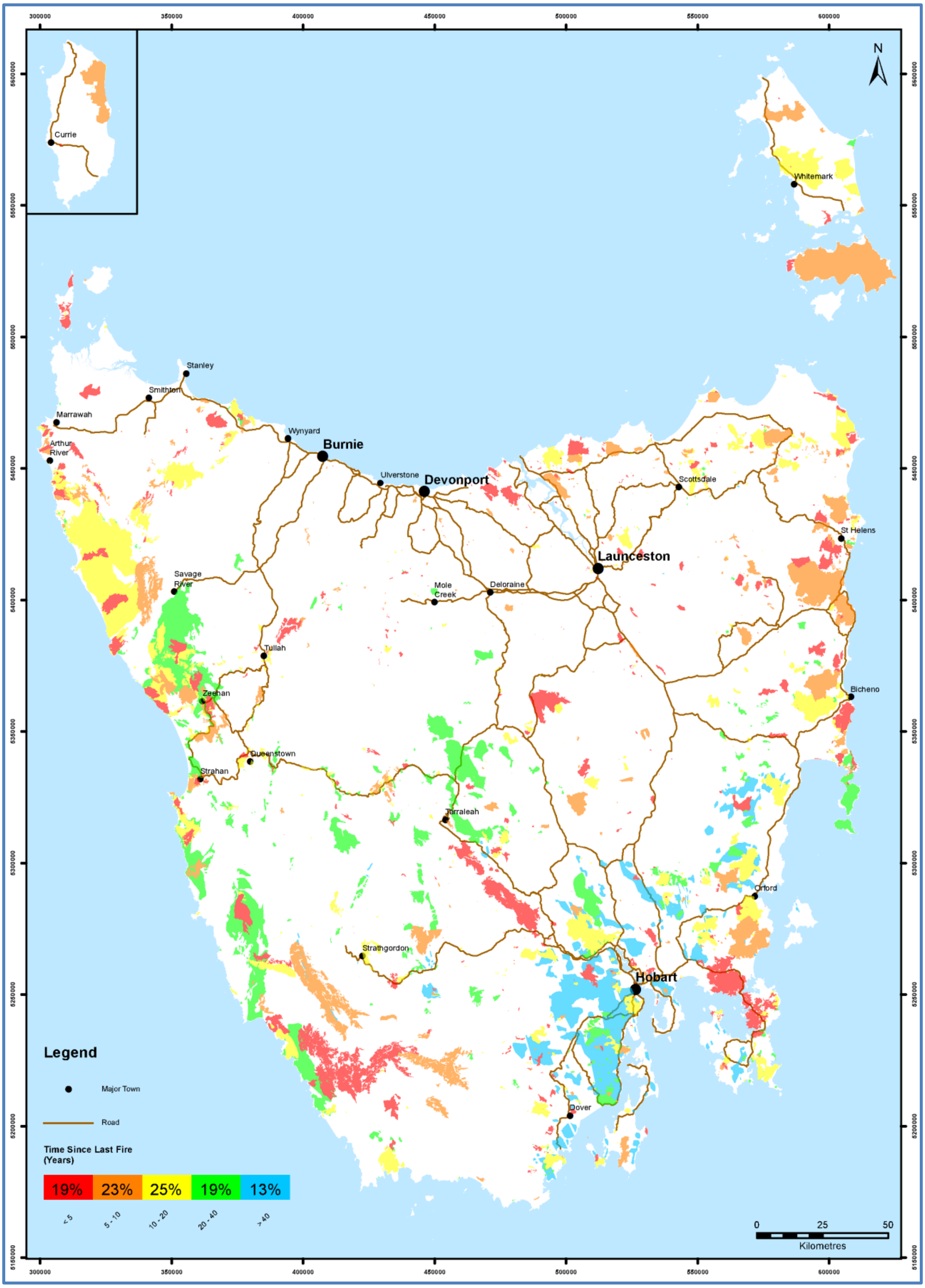

Figure 2: Time since last fire in years, up until June 2013.

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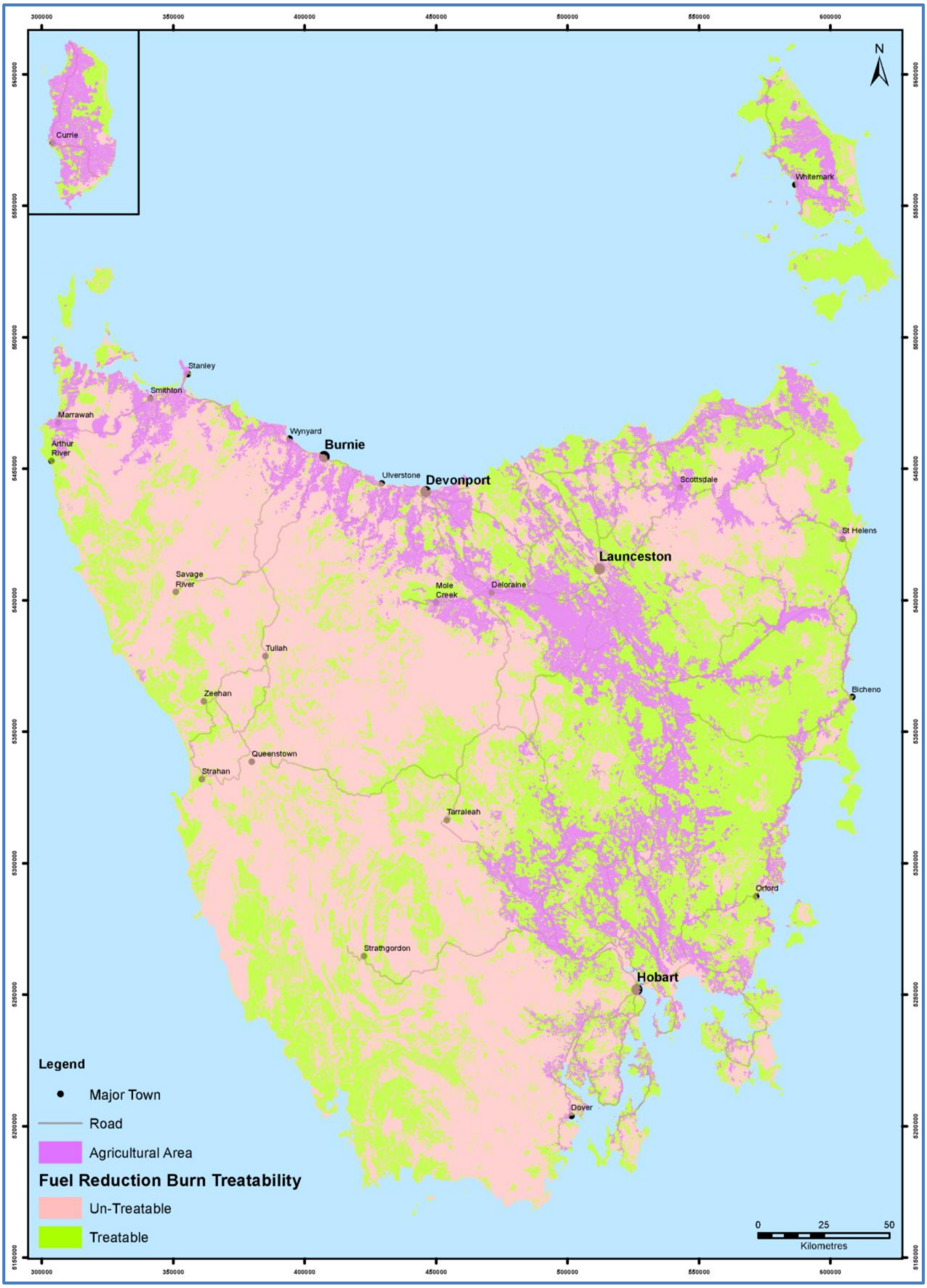

Figure 3: Treatable fuels across Tasmania

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Burning Effort Over the Past Five Seasons

The majority of planned burning is currently undertaken on public land. Both Forestry Tasmania and the Parks and Wildlife Service keep records of all the burning they undertake, and only fuel reduction burns have been included in this analysis. Burning on private land is under-reported, and where known private land burns have been included in the analysis however the records are quite incomplete. During the permit period fire size is estimated as part of the permit, however outside the permit period, fire registration is not mandated. The permit information also includes those circumstances where both Parks and Wildlife and Forestry Tasmania require permits, so using the total burn area indicated in permits doubles up some of the reporting for public land burning.

Planned burning is highly dependent on the right weather conditions and available resources to maximise opportunities when they arise. If there is a busy fire season leading into the autumn burning window, this can also diminish the amount of burning that is completed, due to crew fatigue and some still being deployed in response operations. Table 1 summarises the past five years of planned burning, as recorded in the fire history database. As can be seen in this summary, weather conditions over the 2010-2011 season were particularly favourable, and both Forestry Tasmania and the PWS achieved a significant number of burns in that year.

Table 1: Planned Burns Completed, And Total Area Expressed As A Percentage Of Treatable Fuels Over The Past Five Years.

Season	Number of burns	Number of Hectares	% of Total Treatable
2008 2009	36	8,776	0.35%
2009 2010	47	10,597	0.42%
2010 2011	70	39,429	1.58%
2011 2012	37	7,308	0.29%
2012 2013	38	16,123	0.64%
Total	**228**	**82,233**	**3.28%**
Average	**45.6**	**16,447**	**0.66%**

It is easy to measure success simply in terms of a percentage target, but this oversimplifies the issue. Targets can be achieved by burning large areas in remote locations, achieving little to protect the community. Targets need to be based on how they address risks to communities, and this issue is addressed later in this report.

In recent years more effort has been concentrated on burns where real risk reduction can be achieved, and this has been seen in fuel reduction burns undertaken around Launceston, St Helens, and Bicheno. These burns closer to communities are more resource hungry and tend to be smaller in size; however, they achieve a greater reduction in risk.

Fire Management in Tasmania

The agencies most closely involved in bushfire management in Tasmania are the Tasmania Fire Service, Forestry Tasmania and the Parks and Wildlife Service. An Inter-Agency Fire Management Protocol is signed each year that is effectively the operating agreement between the three agencies. The protocol underpins the cooperation that exists between the agencies to ensure the suppression and management of bushfire in Tasmania is safe, efficient and cost-effective. Through this arrangement there is collaboration in: training; identification of risk and mitigation; some planned burning operations; and, bushfire suppression.

In addition to the three main agencies, bushfire prevention and response activities are also undertaken by private land owners, companies (for example Norske Skog in association with their

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forest management practices), contractors, and some local governments (for example Hobart City Council). These groups are important partners in bushfire management in Tasmania, and particularly with the forest contractors, undertake the same training and use the same incident management systems for bushfire suppression.

STATE FIRE MANAGEMENT COUNCIL

The SFMC is an independently chaired body established under Section 14 of the *Fire Service Act* 1979. Membership is prescribed in the Act as follows:

- a person nominated by the Minister of Police and Emergency Management;
- the Chief Officer of the Tasmania Fire Service;
    - a nominee of the Chief Officer;
- the Chief Executive Officer of the Forestry corporation;
    - a nominee of the chief executive officer of the Forestry corporation;
- the Director of National Parks and Wildlife;
    - a nominee of the Director of National Parks and Wildlife;
- a person nominated by the Tasmanian Farmers' and Graziers' Association;
- a person nominated by the Forest Industries Association of Tasmania; and
- a person nominated by the Local Government Association of Tasmania.

SFMC has the following functions:

- to develop a State Vegetation Fire Management Policy (see Appendix 1) to be used as the basis for all fire management planning;
- to advise and report regularly to the Minister on such matters relating to the administration of *the Fire Service Act*, as it applies to vegetation fire management, either responding to Ministerial requests or bringing matters to the Minister's attention;
- to provide advice to the State Fire Commission regarding the prevention and mitigation of vegetation fires;
- to perform such other functions relating to the prevention or mitigation of vegetation fires as the Minister may direct; and,
- to provide an annual report to the Minister and the Commission on its activities (and that of its sub-committees) for inclusion in the annual report of the Commission.

Since the inception of SFMC administrative support has been provided by the TFS. However, there has been no policy development or project management capacity within the Council, beyond what members could take on in addition to their other responsibilities. In recent years, especially since the 2009 Victorian Bushfires Royal Commission, and the 2011 Auditor General Report into Bushfire Management (Tasmanian Audit Office, 2011; Teague, et al., 2010), the expectations of SFMC went beyond what Council could deliver, and the TFS has provided the necessary funding to support the development of this strategic bushfire risk assessment. Additional funds have also been provided by a grant through the Natural Disaster Resilience Program.

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FIRE MANAGEMENT AREA COMMITTEES

In 2012 amendments were made to the *Fire Service Act* 1979 that administratively aligned the responsibility for bushfire fuel management under SFMC. FMACs that previously reported to the State Fire Commission now report to the SFMC. FMAC membership has also been changed, to reflect broader strategic goals, and the committee boundaries changed to reflect that bushfire is a landscape scale problem.

There are 10 FMAs covering the state (see Figure 4), with boundaries based on bushfire risk and topography, largely aligning to local government boundaries. The focus of the FMACs is to prepare a fire protection plan for their FMA, through the identification and prioritisation of bushfire vegetation risks, and prioritisation of strategic works to mitigate these risks. The outputs of this report provide the necessary risk assessment, and results have been prepared at both the Statewide and FMA level.

These changes have only been implemented in the last 12 months, and all committees are still in the process of preparing their first fire protection plan, with the support of SFMC. The mitigation priorities developed through these plans should form the basis of a tenure blind bushfire risk mitigation program, which can be implemented on a priority basis using the same underlying assessment of risk.

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Figure 4: Fire Management Area Boundaries

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BUSHFIRE RISK ASSESSMENT METHODOLOGY

APPROACH

Bushfire risk assessment models were used to test different fuel reduction burning strategies to determine how they would reduce bushfire risk at the Statewide scale. This approach was chosen because it provides an opportunity to compare and analyse scenarios across the entire state, and to determine cost-effective strategies. It also enables more transparent and informed discussions with stakeholders about bushfire risk, with a range of supporting maps, graphs and animations that can be produced. Similar modelling has also occurred in Victoria, South Australia and South West Tasmania.

The bushfire risk and characterisation models that were considered for this report included PHOENIX RapidFire (Phoenix), Prometheus, Pandora and Burn P3, Aurora, FireScape and the Bushfire Risk Assessment Model (BRAM). Each model had a range of strengths and limitations. Phoenix and BRAM were selected as the most appropriate models to use, with a PostgreSQL database established to handle the large quantities of spatial data generated by Phoenix. The following considerations were taken into account to select these systems:

- Their availability and cost, including support and maintenance;
- Stability of the software, and their compatibility with other existing systems;
- Data availability and preparation requirements;
- The amount of time required to prepare and run the systems and to analyse the results;
- The appropriateness of the models to Tasmanian conditions; and
- The accuracy of the models.

BRAM was used in the development of fuel reduction burning scenarios, to prioritise areas for treatment. Both Phoenix and BRAM were used to identify trends in fire behaviour under the different fuel reduction burning scenarios. Each of these models use equations to predict potential fire behaviour. The equations are based on empirical studies, where data was collected in specific vegetation types. The authors acknowledge that the models do not always accurately predict individual fire behaviour for each mapped vegetation type. However this assessment is being undertaken at a landscape scale with multiple ignitions being simultaneously analysed. Given that the primary purpose of the modelling was to compare relative differences between fuel reduction scenarios, rather than to report on absolute fire behaviour values, the models were considered to be appropriate for the purposes of the report. They were also considered the best available tool to objectively and consistently identify current bushfire risk, and potential trends in risk reduction over time, at the Statewide and FMA scale.

DEVELOPMENT OF THE FUEL REDUCTION BURNING SCENARIOS

Seven fuel reduction burning scenarios were developed to determine how different approaches to fuel reduction burning could reduce bushfire impact and fire behaviour. The objectives for developing these scenarios were that they should be based on science-based risk management principles (e.g. the Indicative National Bushfire Principles (Ellis, et al., 2004)) and should be realistic and measurable.

A 'no fuel treatment' (NFT) scenario was developed to measure how predicted fire behaviour and bushfire risk would change over time in the absence of any fuel reduction burning activities or bushfires. Each of the remaining fuel reduction burning strategies were developed to the following criteria:

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1) Base the fuel reduction burning strategies on observations and recommendations from scientific literature, bushfire inquiries and strategies used by other jurisdictions, and test them in the Tasmanian context.
2) Prioritise burning, so that high risk areas are treated first. Focus on community risk as the highest priority.
3) Confine fuel reduction burning to vegetation types that are generally known to tolerate fire, referred to as treatable fuels.

Treatable areas were defined by identifying the vegetation types, land use types and land tenures that could be treated by fuel reduction burning under each strategy. In all of the strategies, vegetation types were grouped into two categories based on whether they could generally tolerate fuel reduction burning, using Kitchener and Harris (2013) and Pyrke and Marsden-Smedley (2005) as a guide. A list of vegetation types and their treatability is provided in Appendix 2. Vegetation types categorised in TASVEG 3.0 as 'Agricultural, Urban and Exotic' were excluded as treatable areas, with the exception of areas allocated with a land use type of 'Grazing native vegetation 2.1.0' as defined in the Tasmanian Land Use Summer 2009/2010 spatial dataset (NRM North; Cradle Coast NRM; NRM South; DPIPWE;, 2009). Current fuel age and recommended fire return periods were not used to exclude recently burnt vegetation from treatable areas. It was assumed that the recently burnt areas would have a low fuel hazard, representing a low risk to communities and therefore not being selected immediately for fuel reduction burning. It is important to note that vegetation types grouped into the treatable fuel type category are considered to be tolerant to fire in a general sense. However, true tolerance to fuel reduction burning will depend on factors that have not been taken into account in this report. These include previous fire and disturbance history, tolerable fire return periods, and actual species composition including the presence of sensitive species within the vegetation communities. The authors have identified as an assumption and constraint in this report that while biodiversity should be considered as a part of a strategic fuel reduction burning program, this report has only focussed on community protection. Further work is required to understand potential biodiversity and ecological impacts.

Management Area

A landscape-scale, tenure-blind approach to bushfire risk management is promoted by the SFMC as best practice (State Fire Management Council, 2012). A group of scenarios were therefore developed that involved burning treatable fuels Statewide regardless of land tenure boundaries, which are referred to as Public and Private Land scenarios. A second, tenure-blind approach involved burning treatable fuels within fire management zones, following principles set out in (Ellis, et al., 2004) and used by the Parks and Wildlife Service for strategic fire management planning (Department of Primary Industries, Water and Environment, 2012). These scenarios were referred to as Fire Management Zone scenarios. Finally, a third group of scenarios involved burning treatable fuels on public land only, which was considered to be a realistic approach commonly used by other Australian jurisdictions to implement large-scale fuel reduction burning. The Public Land Only scenarios provided an opportunity to test how the implementation of the Victorian Bushfire Royal Commission recommendation 56 (Teague, et al., 2010) could potentially reduce bushfire impacts and fire behaviour, if implemented in the Tasmanian landscape.

Fire management zones were classified into three categories. Asset Zones were identified as Human Settlement Areas (described in Appendix 3). Asset Protection Zones were defined as the area within 1.05 km of a Human Settlement Area. Strategic Fuel Management Zones (SFMZ) occupied the space between 1.05 km and 6.05 km from a Human Settlement Area. Figure 5 shows an example of fire management zones in the Dolphin Sands area, and Figure 6 shows the treatable vegetation in the Fire Management Zones.

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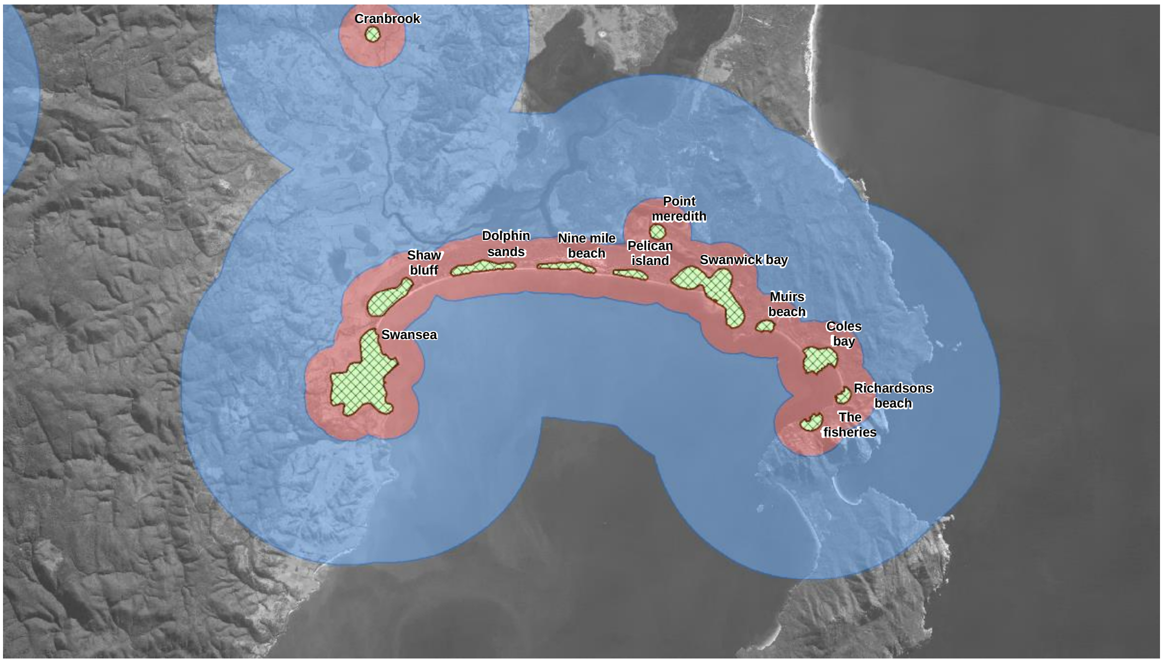

Figure 5: A greyscale orthophoto of the Dolphin Sands area in Tasmania, showing Asset Zones (Human Settlement Areas - green hatch), Asset Protection Zones (APZ - red) and Strategic Fuel Management Zones (SFMZ - blue).

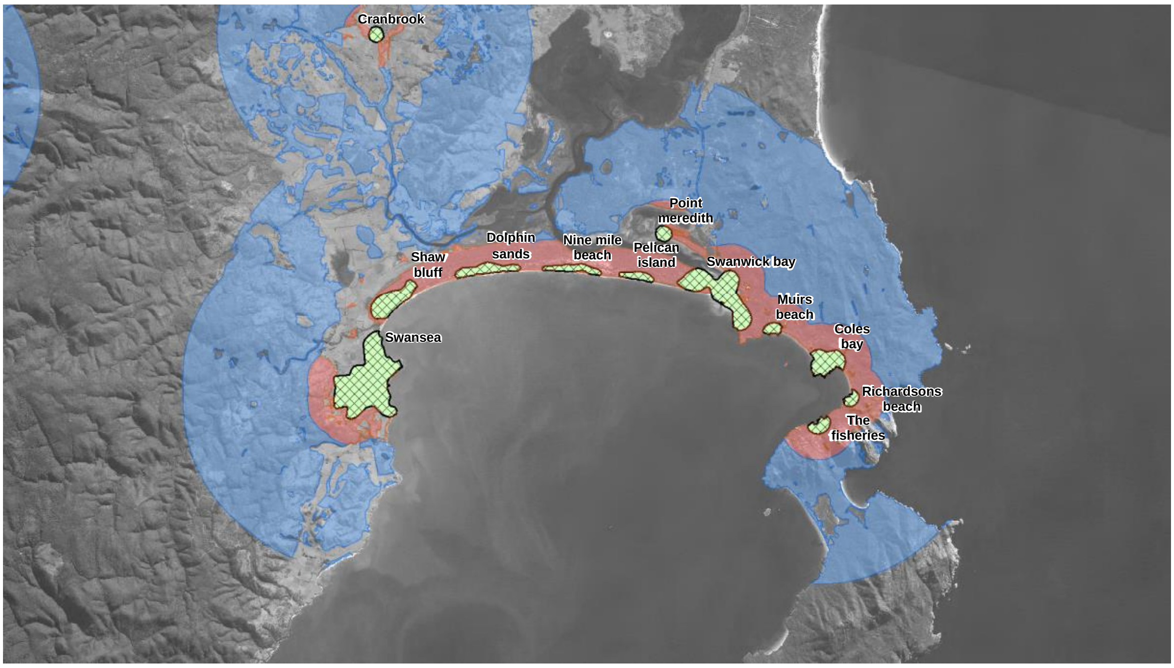

Figure 6: A greyscale orthophoto of the Dolphin Sands area in Tasmania, showing Asset Zones (Human Settlement Areas - green hatch), Asset Protection Zones (APZ - red) and Strategic Fuel Management Zones (SFMZ - blue). Untreatable vegetation types have been excluded from the Fire Management Zones.

Maps were prepared to show the total area of treatable vegetation that could potentially be burnt under each scenario (Figure 7). The total potential land area available for fuel reduction burning under these scenarios, excluding untreatable vegetation types, was approximately:

- 2.5 million hectares for the Public and Private Land scenarios
- 1.45 million hectares for the Public Land Only scenarios
- 878,150 hectares for the Fire Management Zone scenarios

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QUANTITY OF BURNING

Approximately 1% of treatable vegetation on public land is burnt every year in Tasmania, based on the last ten years of fire history records. It is unknown how much burning is undertaken annually on other tenures. Discussion with industry experts in Tasmania indicate that an increase in burning to 5% of treatable fuel would require a considerable increase in resources and effort. Based on these opinions, burning 5%, 2.5% and 1.25% of the target area per year was considered to be realistic targets for the Public Land Only and Public and Private Land scenarios. An estimate of annual burning required under each of the scenarios is shown in Table 2.

Under the Full Fire Management Zone scenario, fuel ages would be maintained at a maximum of five years old within the entire asset protection zone. At the end of the five year burning scenario, approximately 50% of the Strategic Fuel Management Zones would have a mosaic of fuel ages of five years or less. Under the Half Fire Management Zone scenario, approximately 50% of the fuels would have a fire age of five years or less within the Asset Protection Zone, and approximately 25% of the fuels in the Strategic Fuel Management Zone would have a fire age of five years or less.

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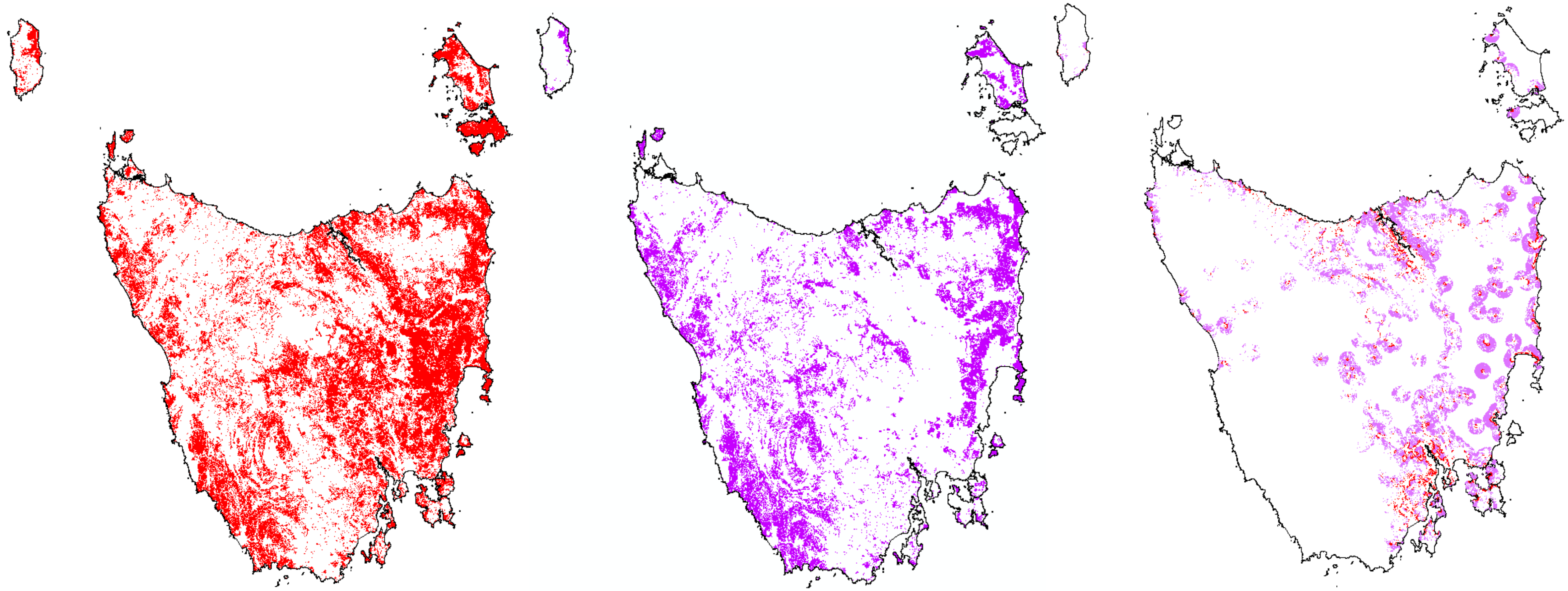

Figure 7: Total Tasmanian land area available for treatment under the Public and Private Land (red, left), Public Land Only (purple, middle) and Fire Management Zone (pink, right) scenarios.

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Table 2: Description of the fuel reduction burning strategies developed for Tasmania, for analysis in the Bushfire Risk Assessment Model and PHOENIX RapidFire.

Scenario Name	Objective	Management Area	Proximity to Communities	Proportion of area treated per annum	Minimum annual area burnt (ha)	Strategic Selection Method
No Fuel Treatment	Allow all fuels to accumulate in the absence of planned burns and bushfires.	N/A	N/A	0%	0	N/A
5% Public Land Only	Strategic fuel reduction burning that replicates VBRC recommendation 56.	Public Land Only	Unrestricted	5%	74,167	BRAM Risk
2.5% Public Land Only	Strategic fuel reduction burning, achieving half of VBRC recommendation 56.	Public Land Only	Unrestricted	2.5%	37,084	BRAM Risk
5% Public and Private Land	Strategic, tenure blind fuel reduction burning at the rate of 5% of the Tasmanian land area per annum.	All land tenures	Unrestricted	5%	123,567	BRAM Risk
2.5% Public and Private Land	Strategic, tenure blind fuel reduction burning at the rate of 2.5% of the Tasmanian land area per annum.	All land tenures	Unrestricted	2.5%	61,784	BRAM Risk
1.25% Public and Private Land	Strategic, tenure blind fuel reduction burning at the rate of 1.25% of the Tasmanian land area per annum.	All land tenures	Unrestricted	1.25%	30,892	BRAM Risk
Fire Management Zone	Maintain fuel ages of < 5 years old within 1.05 km of defined Human Settlement Areas. Maintain a mosaic of fuel ages of <10 year old fuels further out, to 6.05km from defined Human Settlement Areas.	All land tenures	Within 6.05 km of defined Human Settlement Areas.	20% in Asset Protection Zones (APZ), 10% in Strategic Fuel Management Zones (SFMZ)	24,777 (APZ) 74,934 (SFMZ) 99,711 total	BRAM Head Fire Intensity
Half Fire Management Zone	Maintain fuel ages of < 10 years old within 1.05 km of defined Human Settlement Areas. Maintain a mosaic of fuel ages of <20 year old fuels further out, to 6.05km from defined Human Settlement Areas.	All land tenures	Within 6.05 km of defined Human Settlement Areas.	10% in Asset Protection Zones (APZ), 5% in Strategic Fuel Management Zones	12,389 (APZ) 37,467 (SFMZ) 49,855 total	BRAM Head Fire Intensity

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METHODS FOR PRIORITISING FUEL REDUCTION BURNING

A five year hypothetical burning program was developed for each scenario by prioritising burns according to their bushfire risk. A polygon dataset of Analysis Blocks was created using roads, railways, major tracks, watercourses and water bodies, in an attempt to estimate potential burn blocks. Each Analysis Block contained mapped areas of treatable and untreatable vegetation types. Analysis Blocks were erased inside Human Settlement Areas, so that each Analysis Block did not contain any Human Settlement Area. Each Analysis Block recorded the following:

1. Area (ha) of treatable vegetation types
2. Area (ha) of untreatable vegetation types
3. The Analysis Block Risk Score

Analysis Blocks were allocated with an Analysis Block Risk Score. For the Public and Private Land and Public Land Only scenarios, the Analysis Block Risk Score was calculated using Equation 1. For the Fire Management Zone scenarios, the Analysis Block Risk Score was the average head fire intensity (HFI) per hectare, based on BRAM HFI. Both methods used the BRAM version released on 25 February 2014. Analysis Blocks were then sorted in descending order by Analysis Block Risk Score.

$$R_{score} = A_{Moderate}/A_{Area} + (A_{High}/A_{Area} * 5) + (A_{Extreme}/A_{Area} * 10)$$

Where:

$A_{Moderate}$ = Sum of all Moderate Scores in each BRAM output cell in Analysis Block

A_{High} = Sum of all High Scores in each BRAM output cell in Analysis Block

$A_{Extreme}$ = Sum of all Extreme Scores in each BRAM output cell in Analysis Block

A_{Area} = Total Area in hectares

Equation 1: Calculation of Analysis Block Risk Scores (R_{score} for the Public and Private Land and Public Land Only Scenarios.

Two different methods were used to select Analysis Blocks for treatment: the State Selection method and the FMA Selection method. The intent of the State Selection method was to identify bushfire risk – represented by Analysis Block Risk Score – across the entire state, then prioritise and treat the highest risk areas first. This method provides a process for addressing bushfire risk at the Statewide scale. In contrast, the intent of the FMA Selection method was to identify bushfire risk only within the FMA, and then prioritise and treat the highest risk areas. This selection method was considered to be more likely occur, because the FMACs are responsible for identifying and prioritising areas for fuel reduction burning within their FMAs.

STATE SELECTION METHOD

All Analysis Blocks were sorted in descending order by Analysis Block Risk Score. Each Analysis Block was then checked one-by-one from the top of the list. If the block contained treatable vegetation types, it would be 'burnt', i.e. the area of treatable vegetation within the block would be added to the fire history dataset with a date to represent the treatment year, starting in 2014 or 'Year 1'. If the Analysis Block did not contain treatable vegetation types, it would be skipped. The next Analysis Blocks would then be checked in order and treated or ignored until the target area shown in Table 2 was reached for the treatment year. Scoring and treatment was then repeated for each following year up to and including 2018 or 'Year 5'. If the target was over-achieved in a year because the final Analysis Block for that year was very large, the amount of burning in the following year would be reduced to compensate.

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FIRE MANAGEMENT AREA SELECTION METHOD

Within each FMA, Analysis Blocks were sorted in descending order by Analysis Block Risk Score. Each Analysis Block was then checked one-by-one from the top of the list. If the block contained treatable vegetation types, it would be 'burnt', i.e. the area of treatable vegetation within the block would be added to the fire history dataset with a date to represent the treatment year, starting in 'Year 1'. If the Analysis Block did not contain treatable vegetation types, it would be skipped. The next Analysis Blocks would then be checked in order and treated or ignored until the target area was reached for that treatment year (Table 3), where target area for treatment under the FMA Selection method was calculated based on burning the relevant proportions of treatable vegetation within each FMA. Scoring and treatment was then repeated for each following year up to and including 'Year 5'. Due to time constraints, the location of other completed or planned burns could not be incorporated into the analysis. The strategic selection of burns could be improved by incorporating more data and selecting using a number of variables, not just BRAM HFI.

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Table 3: Target Annual Treatment Area for Each Scenario Using the Fire Management Area Selection Method

Scenario Name	FMAC										
	Central North	East Coast	Flinders	Hobart	King Island	Midlands	North East	Southern	Tamar	West Coast	TOTAL
Public Land Only (5%)	3900	5927	2873	551	515	6719	11415	12066	6073	21501	71540
Public Land Only (2.5%)	1950	2964	1437	276	258	3360	5708	6033	3037	10751	35770
Public and Private Land (5%)	5788	12297	6752	1950	1492	21802	15229	14675	20467	23114	123566
Public and Private Land (2.5%)	2894	6149	3376	975	746	10901	7615	7338	10234	11557	61783
Public and Private Land (1.25%)	1447	3074	1688	488	373	5451	3807	3669	5117	5779	30892
Full Fire Management Zone (20% APZ)	1844	2688	268	3919	95	2117	2545	4552	5162	1587	24777
(10% SFMZ)	5640	10181	2440	1916	423	14661	12144	4949	17445	5135	74934
Half Fire Management Zone (10% APZ)	922	1344	134	1960	47	1059	1273	2276	2581	794	12389
(5% SFMZ)	461	672	67	980	24	529	636	1138	1290	397	6194

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Fire History and Fuel Age

A fire history dataset was compiled using fire boundaries provided by the Tasmania Fire Service, Parks and Wildlife Service and Forestry Tasmania up until the end of the 2012-2013 financial year. The dataset includes bushfires attended by all agencies, and planned burns conducted by the Parks and Wildlife Service and Forestry Tasmania. It does not include burns completed by the forest industry for silvicultural purposes, or planned burns conducted by private property owners, councils, Department of Defence or utility companies. The accuracy of the fire boundaries is extremely variable, and there are a considerable number of omissions and overestimates in terms of the actual area burnt by fire. Some fires have been recorded as far back as 1967; however fire boundary records have only consistently been recorded since around 2003.

The fire history dataset was used as an input into Phoenix and the BRAM. The models use fire history to calculate the number of years since the last fire, and they estimate fuel hazard and fuel load using fuel accumulation equations for broad vegetation types. The fuel hazard and fuel load data is then used to calculate fire behaviour characteristics.

A separate, unique fire history dataset was maintained for each scenario, which included the full fire history dataset up to 2013 as well as the treated areas up until 2018. In the results, the treatment years are differentiated from the fire history records by using the terms Year 1, 2, 3, 4 and 5 for the scenario fire history data added for 2014, 2015, 2016, 2017 and 2018 respectively. 2013 is referred to as the 'current' fuel state.

Ignitions

Phoenix is capable of simulating the spread of many individual fires across a landscape. A grid of 11,059 ignition points spaced every 2.5 km across the landscape was chosen, based on a case study comparing 1, 2.5 and 5 km grid spacing. The comparison involved running Phoenix with different grid spacing scenarios in an area between Scottsdale and Fingal that was known for its variability in fire behaviour inputs including fuel types and age, slope, as well as the presence of several communities. In the case study area, 5km spacing (equivalent to 2,765 ignition points Statewide) was found to be too coarse, leaving large areas of unburnt vegetation under current and maximum fuel load scenarios. Spacing using 1km intervals provided the most complete coverage (equivalent to 69,222 ignition points Statewide), but processing time was greatly increased and would not have been achievable within the timeframes of this report. Hence 2.5 km spacing was chosen as it provided good coverage for the objectives of the project, with achievable processing times. It was noted however that 1km spacing would be useful for finer-scale analysis, such as for bushfire mitigation planning around individual communities. A gridded ignition pattern was chosen in preference to a random distribution, or a distribution based on previously observed fire locations. This gridded pattern allowed for results over time and between different fuel treatments to be easily compared, and an even distribution of points provides the most efficient coverage of area while minimising the amount of processing required and the size of potential gaps between fires.

After the 2.5km lattice was created, all points placed in areas where they had no chance of ignition (e.g. in a lake) were moved. The process of moving the point determined using the centroid of the remaining area in the 2.5km grid cell that was suitable to place. If there was no suitable area at all in the 2.5km cell the ignition was not placed at all (i.e. in the lattice across Macquarie Harbour there was ocean that covered the entire cell hence no centroid of remaining area and no ignition point placed.

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SCENARIO WEATHER PROFILES

In Phoenix, each ignition point was allocated a scenario weather profile that was generated using observations from the nearest relevant weather station, shown in Figure 8. The objectives for creating the weather profiles were to represent a typical day of 'bad' fire weather, be realistic in terms of how often the conditions would occur in Tasmania and represent conditions under which 'impacts', for example house damage, could occur.

Tasmania was divided into 45 zones, thought to be the area represented by a local meteorological station (DPIPWE, 2014) (Figure 8). Some of the representative meteorological stations did not have long data records, so close or equivalent stations present in the SILO Patched Point Dataset (SILO-PPD) were used as alternatives.

For each station the archive of daily meteorological data, based on SILO-PPD, were retrieved for the period 1960 to 2012. Daily drought factor, based on the Keetch-Byram Drought Index (KBDI) was calculated for the station record, followed by the daily McArthur Forest Fire Danger Index (FFDI) based on 3pm conditions. The dataset for the station was limited to summer months (December to February). Days representing the 99^{th} to the 99.5^{th} percentile in FFDI values were selected. For each of these days, hourly historical meteorological conditions for the 24 hours of the day were retrieved from the Forecast.IO global archive using the provided application programming interface (API). In cases where observations were missing in this hourly data, that day was excluded from the calculations.

Hourly aggregates of each component meteorological variable were then calculated for the selected station, combining the set of selected days. The 85^{th} percentile was used for temperature, the mean value was used for drought factor and wind speed, while the 15^{th} percentile was used for humidity and the 25^{th} percentile for cloud cover. These values were selected after trial and error, and were found to produce hourly FFDI dynamics that matched closely to 'typical' conditions in which assets would be undefendable without reaching rare *Catastrophic* levels; Moderate FFDI trending towards a peak in mid-afternoon at the *Severe* category, then decline in FFDI towards evening. Hourly wind direction was decomposed into N-S and E-W vectors, averaged and converted back to an angle.

Plots were produced of the synthetic aggregate meteorological variables, as well as FFDI, in comparison to the individual daily records. The aggregated meteorological variables were written to a CSV file. One CSV file was generated per station, and these were then combined into a single CSV file for use in the simulations, with meteorological station recorded for joining with the ignition points (Figure 8). The plots, location map and aggregated meteorological variables for each weather station area are included in Appendix 4.

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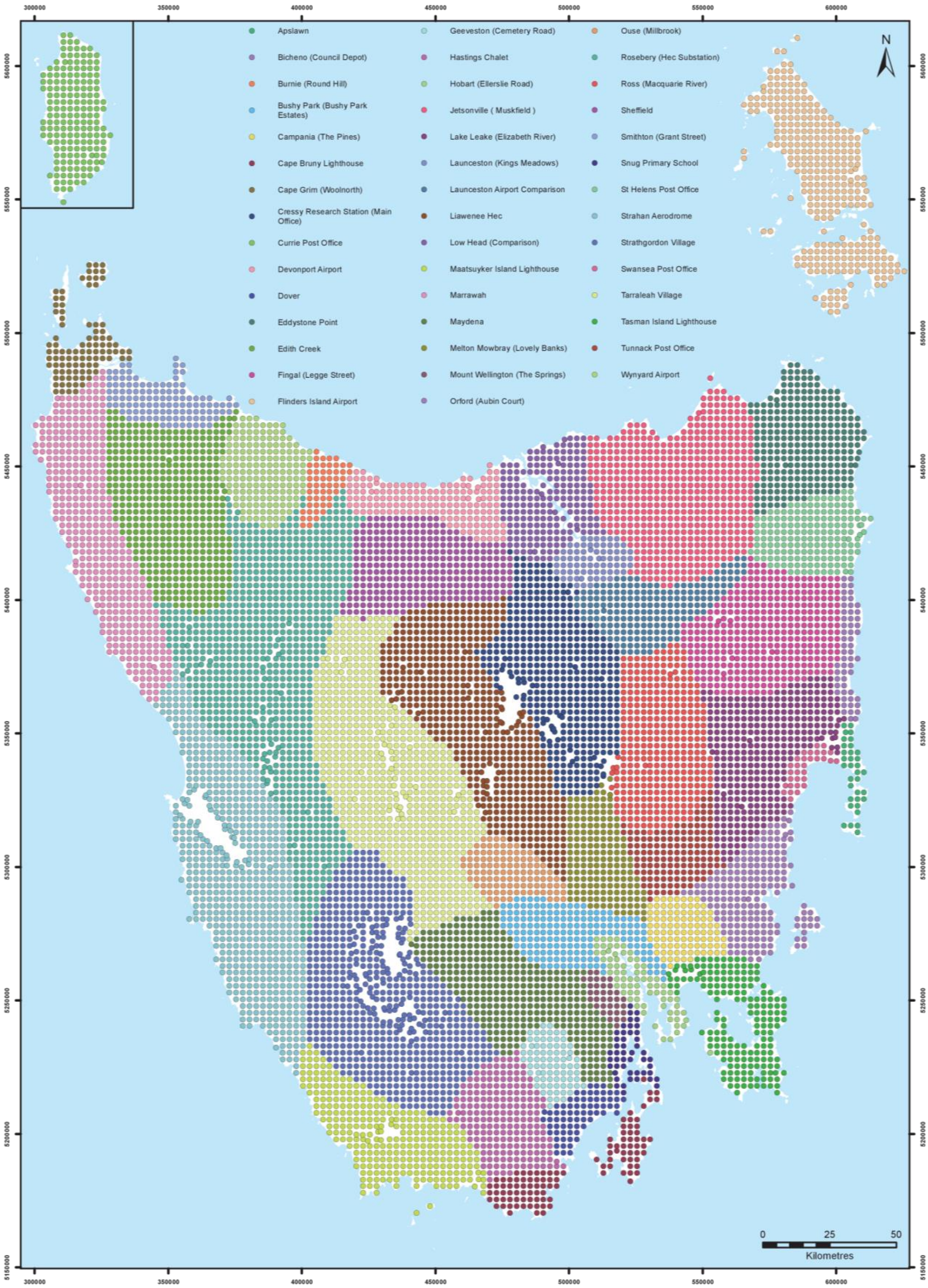

Figure 8: Ignition point and name of corresponding weather station. Weather station areas adapted from Department of Primary Industries, Parks, Water & the Environment (2014).

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PHOENIX RAPIDFIRE SIMULATIONS

Phoenix is a dynamic fire behaviour and characterisation model that responds to changes in the conditions of the fire as well as to changes in fuel, weather and topography as a fire moves across the landscape (Tolhurst, et al., 2008). Fire behaviour calculations are based on the CSIRO southern grassland fire spread model (Cheney & Sullivan, 1997; Cheney, et al., 1998) and the McArthur Mk5 forest fire behaviour model (McArthur, 1962; McArthur, 1967; McArthur, 1973; Noble, et al., 1980). Other models used within Phoenix relate to fuel accumulation rates, fuel moisture, solar radiation, linear disruption to fire behaviour, spot fire ignition, ember transport and distribution, the effects of spot fire induced indraughts at the fire front (Tolhurst, et al., 2008), wind-terrain interactions (Forthofer, 2007), asset impact (Tolhurst & Chong, 2012) and convective plume development (Chong, et al., 2012). Inputs to the model include fuel type, fire history, slope, aspect, weather, ignition point locations, time and date (Figure 10 and Figure 12). Input data grid cell sizes included 25 metres for fuel, elevation, fire history and disruption, 50 metres for road proximity and 100 metres for the wind modifiers data layer.

A 'template' Phoenix project was created that contained all ignition points and their weather profiles (Figure 10 and Figure 11). The Phoenix output grid cell size was set to 200 metres (Figure 9). Phoenix was run for each scenario and fire history/treatment year from 2003 through to 2018 (Year 5) of treatment, simulating the ignition and spread of each fire individually. The model outputs fireline intensity, flame height, flame depth, spotting density and convection. These were captured for each Phoenix output grid cell and related to each ignition point, impacted cell, Human Settlement Area, FMA, fuel reduction burning scenario and fire history/treatment year and saved in a PostgreSQL database. Figure 13 provides an example of how the outputs from the Phoenix model can be viewed for a single fire. See Appendix 6 for further information about the Phoenix system.

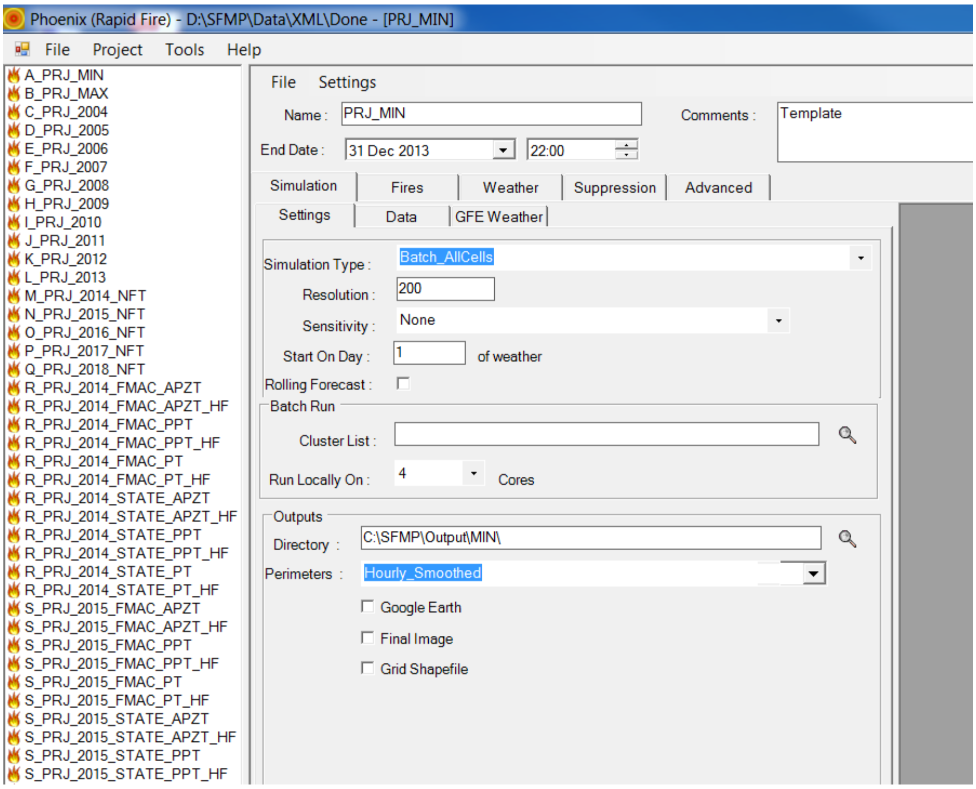

Figure 9: PHOENIX RapidFire project settings used for the Strategic Fuel Management Report.

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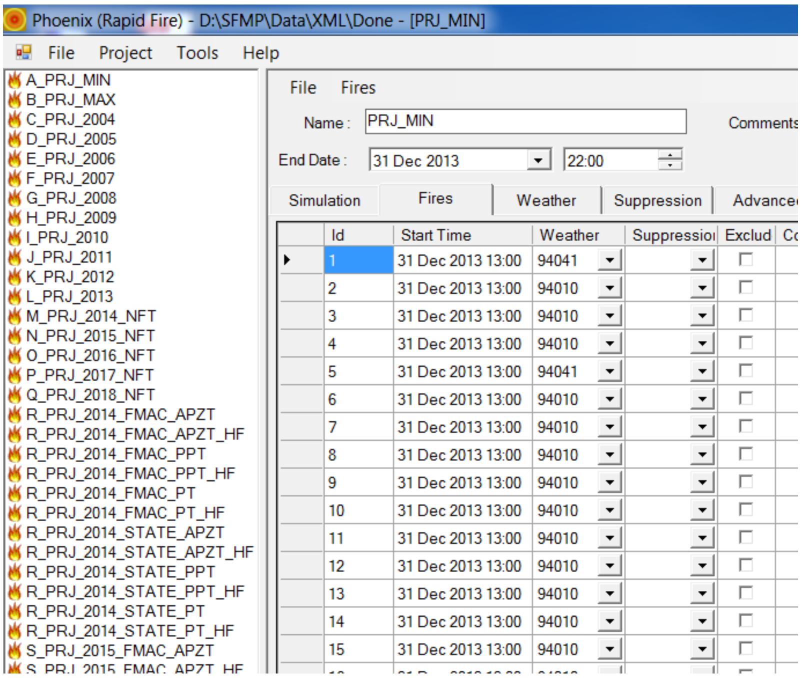

Figure 10: PHOENIX RapidFire settings for the Strategic Fuel Management Report showing a sample of ignition points, their start and end times and their weather profiles.

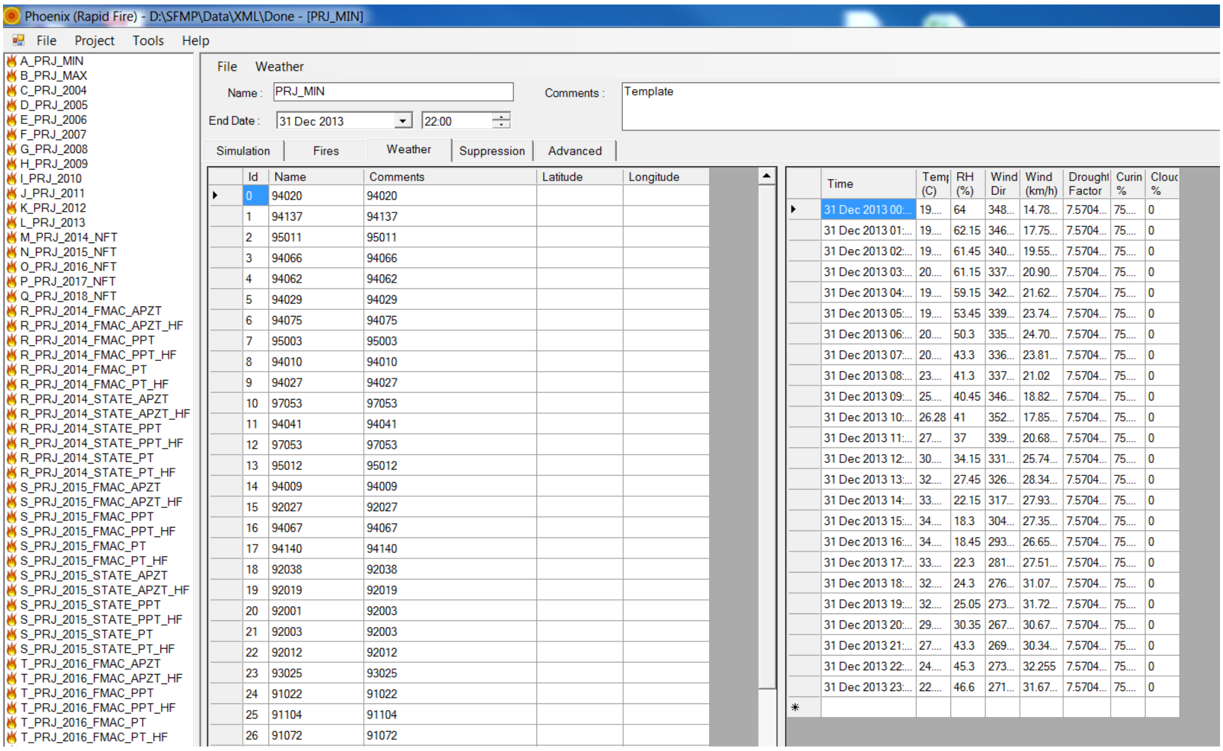

Figure 11: PHOENIX RapidFire settings for the Strategic Fuel Management Report, showing the weather profile for ignition point no. 0 based on data from the Dover weather station (no. 94020).

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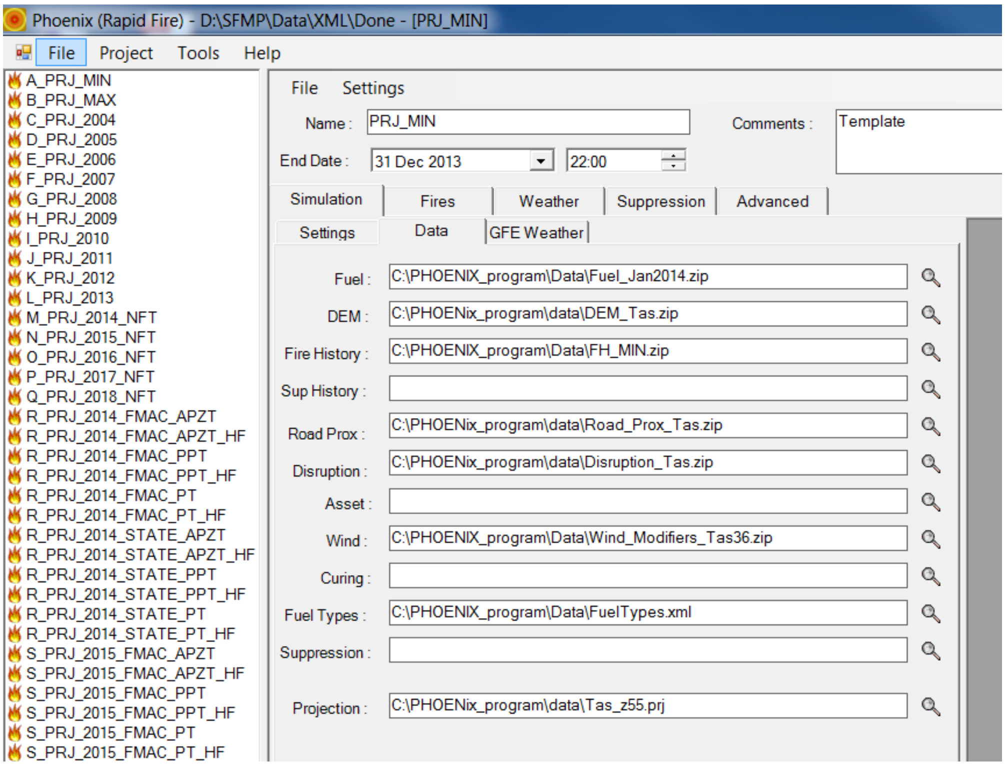

Figure 12: PHOENIX RapidFire settings for the Strategic Fuel Management Report showing the data files that were used for all simulations and the fire history file that was used specifically for the minimum treatable fuel load scenario.

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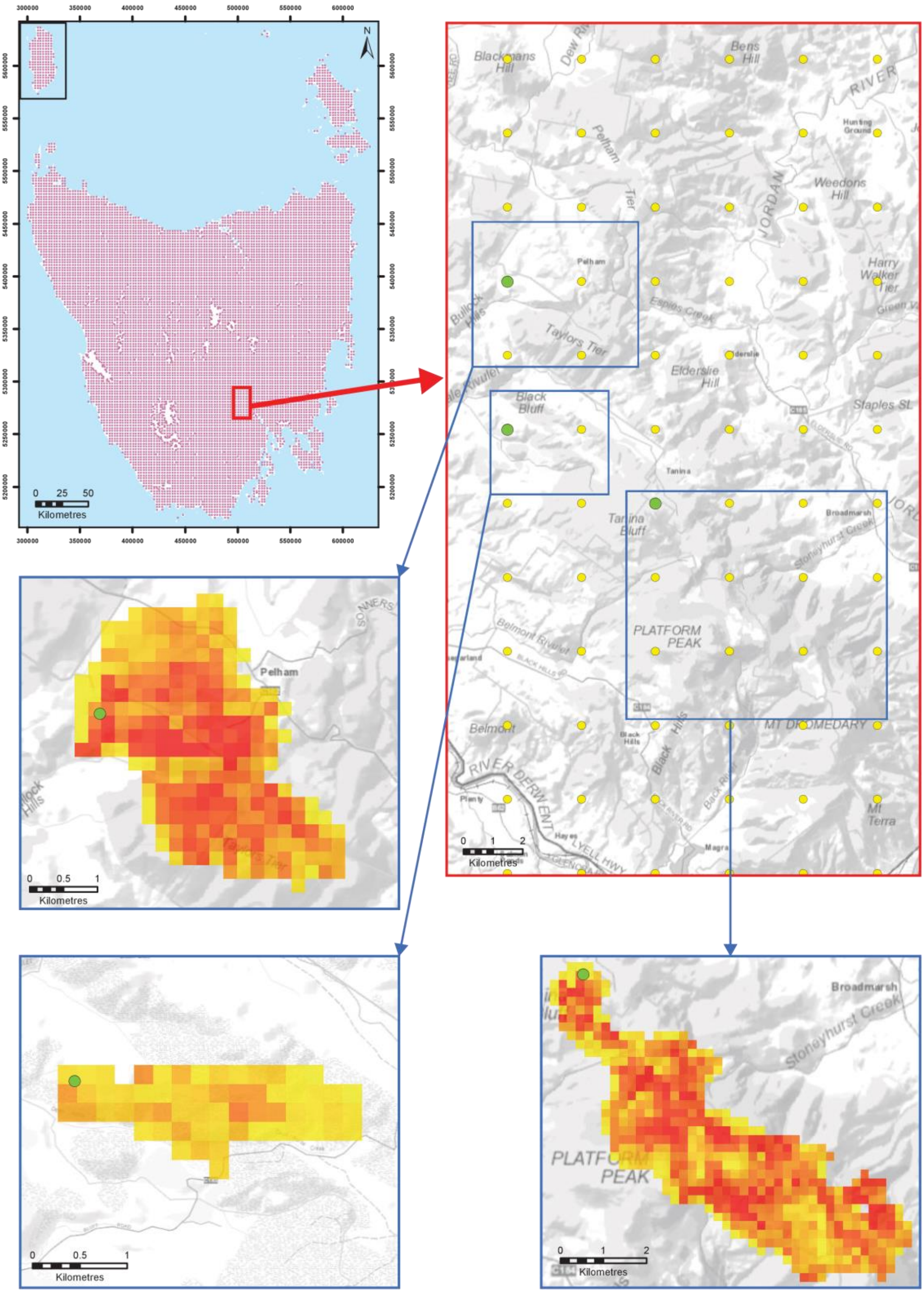

Figure 13: PHOENIX RapidFire simulations running multiple individual fires across the landscape.

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MEASURING POTENTIAL IMPACTS

Building locations, cadastre and ABS data were used to create a Human Settlement Areas (HSA) polygon dataset to define areas where people live and work, including seasonally populated and industrial areas. The accuracy and currency of the datasets on which the HSA dataset were built are questionable in some areas in Tasmania, so the HSA dataset draws from a number of datasets including building locations, cadastre and ABS data, to improve the overall quality and accuracy of the entire dataset. The HSA dataset was not designed to capture every isolated building or home, but is intended to identify higher density areas of buildings and populations, including seasonal populations like shack communities. More information about the methodology used to create the HSA dataset can be found in Appendix 3.

The Phoenix static output grid, consisting of 200m grid cells for the entire state, was overlayed with Human Settlement Areas to determine which grid cells overlapped. If a cell was intersected by the Human Settlement Areas dataset, this was recorded in the static grid as a 'Human Settlement Area' cell, shown in Figure 14. No thresholds were used to determine whether a cell was inside or out, i.e. any overlap of a grid cell with a Human Settlement Area resulted in that grid cell being marked as a Human Settlement Area.

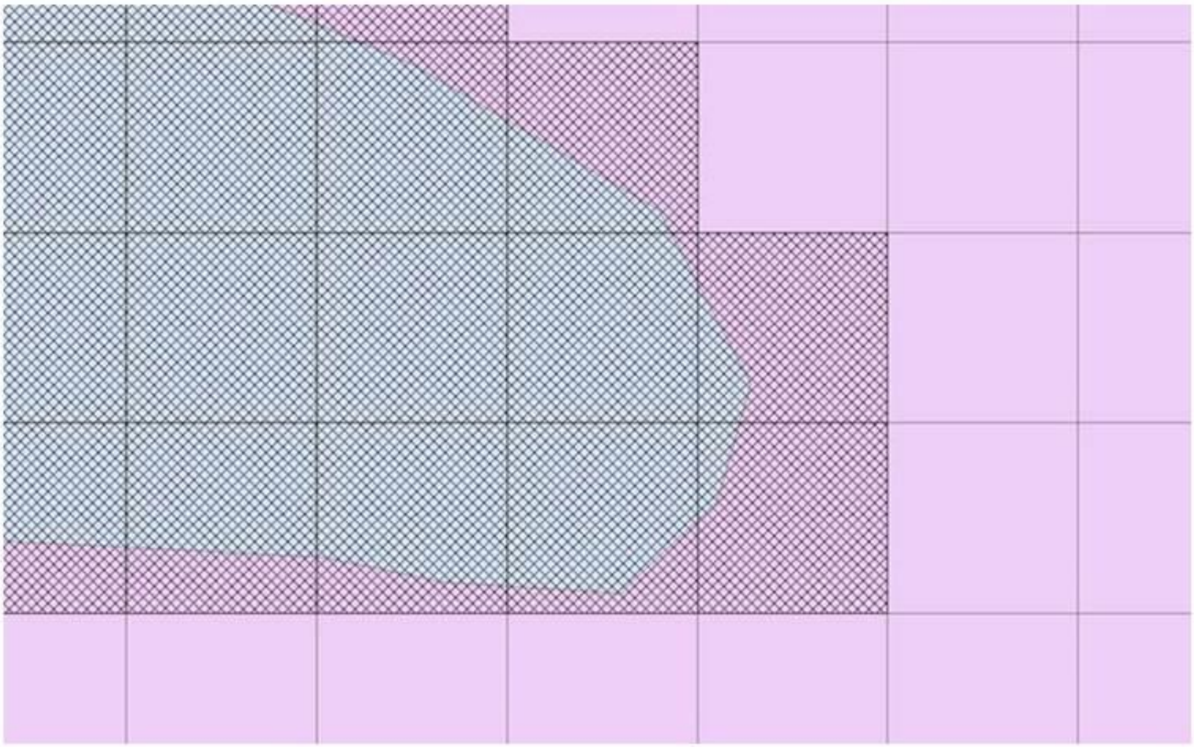

Figure 14: Phoenix static output grid (purple), overlayed with the Human Settlement Area polygon dataset (light blue). The hatched areas are the grid cells that were recorded as Human Settlement Areas in the PostgreSQL database.

An impact on a Human Settlement Area cell was measured when predicted fireline intensity exceeded 10,000kW/m and/or ember density exceeded 2.5 embers/m^2. These thresholds are the same as those used in the House-Loss-Ratio impact type in Phoenix (Tolhurst & Chong, 2012).

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STATISTICAL ANALYSIS

The significance of fuel treatment scenarios in reducing asset impact, fire intensity and fire area was determined using a generalized linear mixed model (GLMM) in the *lme4* (Bates, et al., 2013) package of the statistical language R-3.0.2 (R Core Team, 2013). This statistical methodology was chosen in order to enable some degree of replication and variation to be considered in the fire impacts. Ideally, multiple simulations would be run under varying meteorological conditions, and with stochastically varying ignition locations. However, the computation time for such an analysis was unfeasible for this study. Therefore, individual ignition points within a FMA were regarded as pseudo-replicates within a random effect model, to account for varied model intercept terms across the simulations. For each FMA, counts of number of cells meeting the intensity criteria were calculated for each ignition point, for each fuel treatment scenario in Year 5, along with the no fuel treatment (NFT) scenarios for Years 1 and 5. The cell intensity criteria for each model are as follows:

- Asset Impact - Cell intersecting asset, intensity > 10,000kW/m or ember density > 2.5m^2
- High Intensity - Intensity > 3,000kW/m
- Fire Size – Intensity > 0 kW/m

GLMM models were run with a Poisson error distribution and a log link, and modelled cell count against fuel treatment scenario as a fixed effect, and ignition point as a random effect to control for pseudoreplication.

Cell Count ~ Scenario + (1|Ignition)

95% confidence intervals were plotted for each scenario, and scenarios were regarded as having a significant effect in reducing asset impact, fire intensity or fire size when confidence intervals did not overlap those of the no fuel treatment scenarios. In addition, the three models were run using data from the whole state in addition to each separate FMA.

RELATIVE RISK PROFILES

The modelled impacts on Human Settlement Areas were measured each year from 2003 to Year 5, using the scenario fire history datasets to determine how changes in fuel loads could change potential impacts in response to a combination of bushfire and planned burning. By comparing the impact on HSAs at maximum fuel load with the impact on HSAs in the fire history and treatment scenarios, relative risk graphs were prepared to show how impacts on HSAs change over time in response to past fires and future fuel reduction scenarios. This approach is based on work pioneered by the Strategic Bushfire Risk Assessment Team, Department of Environment and Primary Industries, Victoria (Department of Environment and Primary Industries, 2013).

Relative risk was measured as the ratio of the HSA impact after a certain fuel reduction burning scenario to the impact after No Fuel Treatment, expressed as a percentage as shown in Equation 2.

$$R_{treat} = 100 \times (I_{treat} / I_{max})$$

Where:

R_{treat} is the relative risk.

I_{treat} is the count of HSA cells that exceeded the impact threshold when the bushfires were simulated under a particular fuel modification scenario.

I_{max} is the count of HSA cells that exceeded the impact threshold when the bushfires were simulated under conditions of maximum fuel load, i.e. without any level of fuel modification whatsoever.

Equation 2: Definition of relative risk.

Residual risk graphs were prepared for the entire State of Tasmania, and for each of the 10 FMAs within the State. The risk profile lines were smoothed using the Microsoft Excel 2010 smoothing function.

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SUPPRESSION

All fire spread simulations assume that there is no suppression effort in place. The Phoenix simulations therefore did not use the suppression model that is built into the software.

THE BUSHFIRE RISK ASSESSMENT MODEL (BRAM)

The BRAM was run using each scenario fire history dataset for 2013 (current), Year 1, Year 3 and Year 5. The model outputs HFI (head fire intensity), Fire Behaviour, Likelihood and BRAM Risk were stored for each scenario. Graphs (were prepared to show the area of BRAM $100m^2$ grid cells where HFI exceeded 3,000kW/m. The threshold of 3000kW/m was used to categorise fire, based on fire intensity, to indicate whether the fire was controllable or uncontrollable.

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INFLUENCE OF WEATHER ON A FUEL REDUCTION BURNING PROGRAM

PLANNED BURNING WEATHER WINDOWS

Planned burning guidelines set out by Marsden-Smedley (2009) were used to develop a simple set of weather parameters within which fuel reduction burning could potentially occur, referred to as the 'burning window'. The weather data were compared with the parameters to estimate:

1. the average number of days each year where burning could potentially occur; and
2. the average number of days each year where burning could occur, outside of the peak fire danger period.

The method used to derive the burning window is summarised in Table 4. The final set of weather parameters represent the 'best case scenario', i.e. all planned burning guidelines fall within the weather parameters that represent the burning window. The burning window does not take into account the conditions that affect smoke dispersion.

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Table 4: Weather Parameters used to define the Planned Burning Weather Window

Planned burning guidelines from (Marsden-Smedley, 2009)	Wind speed at 1.7 to 2m (km/h)	Wind speed at 10m (km/h)	Relative humidity (%)	Soil Dryness Index	Temperature (°C)	Days Since Rain (>2mm)	Fire Danger Rating
Dry eucalypt forest planned burning guidelines	-	<30	40 to 80	<126	10 to 25	-	<11 (Forest)
Heathland and dry scrub	5 to 20	-	40 to 80	-	10 to 25	-	<21 (Scrub)
Wet scrub	5 to 20	-	40 to 80	15 to 25	10 to 25	-	<21 (Scrub)
Buttongrass moorland with secure natural boundaries	<21	-	40 to 90	<10	10 to 25	2 to 10	<11 (Moorland)
Buttongrass moorland with mineral earth boundaries	<21	-	40 to 90	<20	10 to 25	4 to 10	<6 (Moorland)
Buttongrass unbounded burning*	<6	-	>60	-	<10	-	-
Native grassland**	<21	-	40 to 80	-	10 to 25	2 to 10	<6 (Grassland)
Gorse	<21	-	50 to 85	<2	10 to 25	<2	<10 (Scrub)
Best case burning windows	-	<30	40 to 90	<126	10 to 25	Rainfall to 9am < 2mm	FFDI < 11 or SFDI < 21 or MFDI < 6

* Forecast rain/dew fall to 09:00 > 0.0mm. Only weather observations will be used to determine burning windows, not forecast weather conditions.

** Curing, and therefore Grassland FDI, has not been captured in the weather observations.

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SUMMARY OF ASSUMPTIONS AND LIMITATIONS

The bushfire risk analysis is based upon modelling, and therefore has a range of assumptions that underpin the analysis. Conclusions based on this bushfire risk analysis must be referenced against the assumptions and limitations of the modelling.

This work provides the foundation for a more strategic and cost-effective approach to fire management by representing bushfire risk spatially and temporally across multiple scales from the state to regional scale, using a combination of models, data and data management systems to characterise bushfire risk. This is the first time that these models and systems have been used in such a way for Tasmania, and so will require ongoing assessment and improvement to further develop robustness and ensure that the outcomes of the risk assessment can be operationalised across all regions of Tasmania.

The BRAM was used as the basis for selecting areas for fuel reduction burning based on bushfire risk. The BRAM is a complex model built on large amounts of spatial data, of varying accuracy and currency. In some cases spatial data is missing, for example where a stakeholder does not have the capacity to provide spatial data in an appropriate format. A considerable amount of time is spent on maintaining the BRAM, but some areas (particularly on private property) do not necessary provide an accurate representation of bushfire risk.

Phoenix is a research tool developed by the University of Melbourne (Kevin Tolhurst and Derek Chong) and the Bushfire Co-operative Research Centre (Bushfire CRC). Phoenix has been used operationally by the Tasmania Fire Service, Parks and Wildlife Service and Forestry Tasmania for incident prediction and in this report for bushfire risk assessment. Phoenix is also used for incident prediction in Victoria, New South Wales and South Australia, and for bushfire risk assessment in Victoria and South Australia. Many of the models, assumptions and settings in BRAM and Phoenix are based on rigorously tested, peer reviewed scientific work. However the systems themselves have not been extensively assessed. As planning tools, they are generally acknowledged by many stakeholders as being at the cutting edge of bushfire risk assessment and critical for helping to reduce risk to life and property. Users of both systems are encouraged to understand their functions, assumptions and limitations.

Phoenix is designed for severe bushfire conditions, i.e. Forest Fire Danger Index (FFDI) > 30. The weather conditions used in this report were based on 99.0 to 99.5th percentile observations from 45 weather stations. In some areas, the maximum FFDI achieved did not exceed an FFDI of 30, and we therefore have lower confidence in the bushfire risk assessment for these areas, shown in red in Figure 15. Under conditions where a major convection column is established, such as the 2013 Forcett-Dunalley fire, Phoenix underestimates spotting and its effect on fire propagation. However such conditions are unlikely to occur under the modelled weather conditions used in this report, because FFDIs used in this report did not exceed 50.

Phoenix was used to simulate bushfires burning in a single day, one-by-one on a 2.5km systematic grid across the whole of Tasmania. A finer scale (1km) grid may be necessary for more detailed analysis of risk in some areas. Each ignition was allocated with a single weather profile representing a typical bad fire weather day in summer. The risk assessment therefore is based on a single weather event and does not reflect the whole distribution of potential weather drivers of fire behaviour, in terms of variations in meteorological components such as wind direction within the selected fire danger level, or the behaviour of fire at more extreme or catastrophic fire danger indices. A more detailed spatially explicit fire weather climatology is required for assessment of risk with a range of potential weather streams. This is being considered as part of future iterations of this report. The 45 weather profiles that were generated, using data from the nearest relevant weather stations (Figure 8), did not account for more localised variations in weather patterns, e.g. those driven by elevation or terrain as shown in Figure 16.

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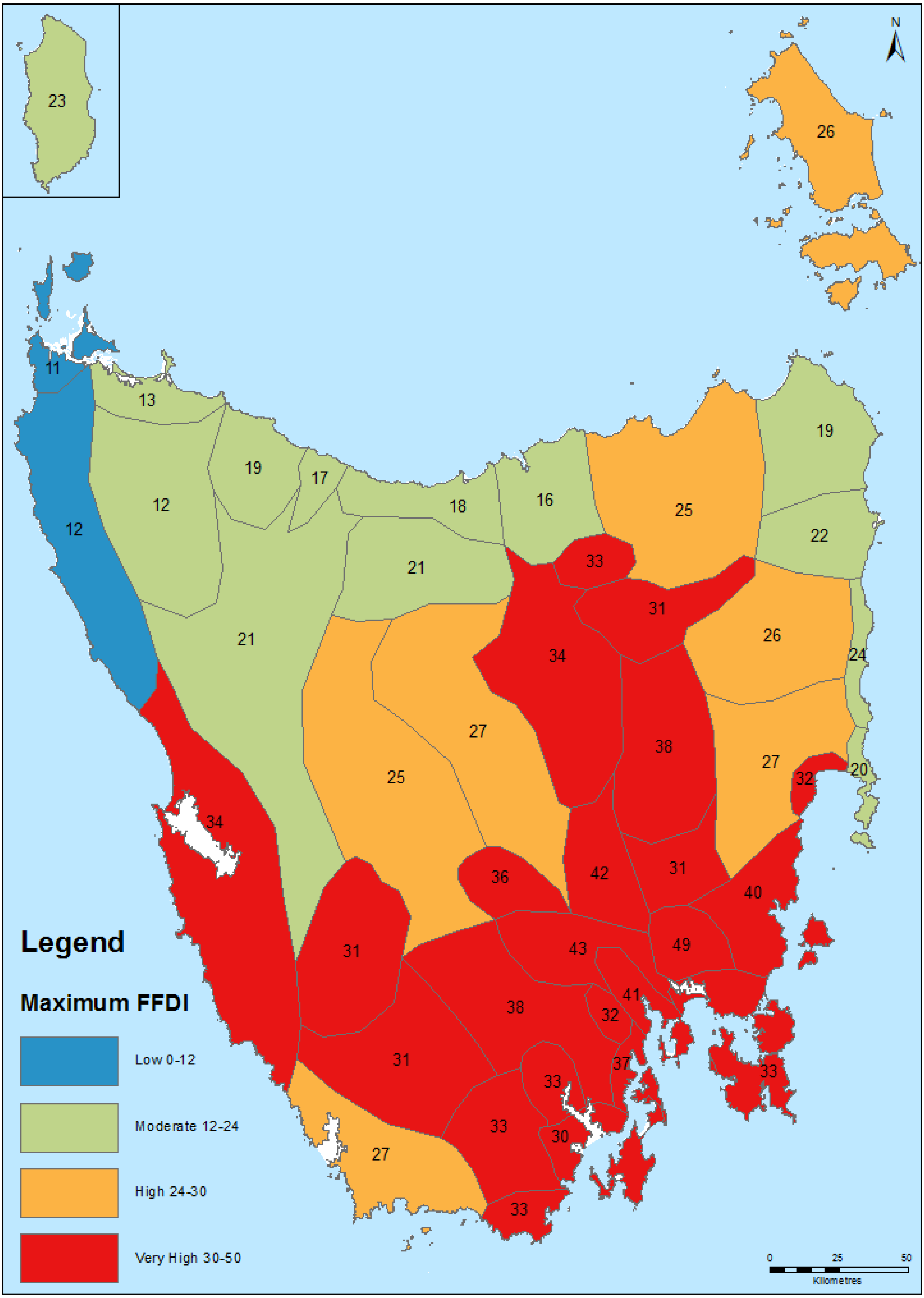

Figure 15: Maximum FFDI in each weather station area based on the 99.0 to 99.5 percentile 10-hour weather profile constructed for the PHOENIX RapidFire modelling.

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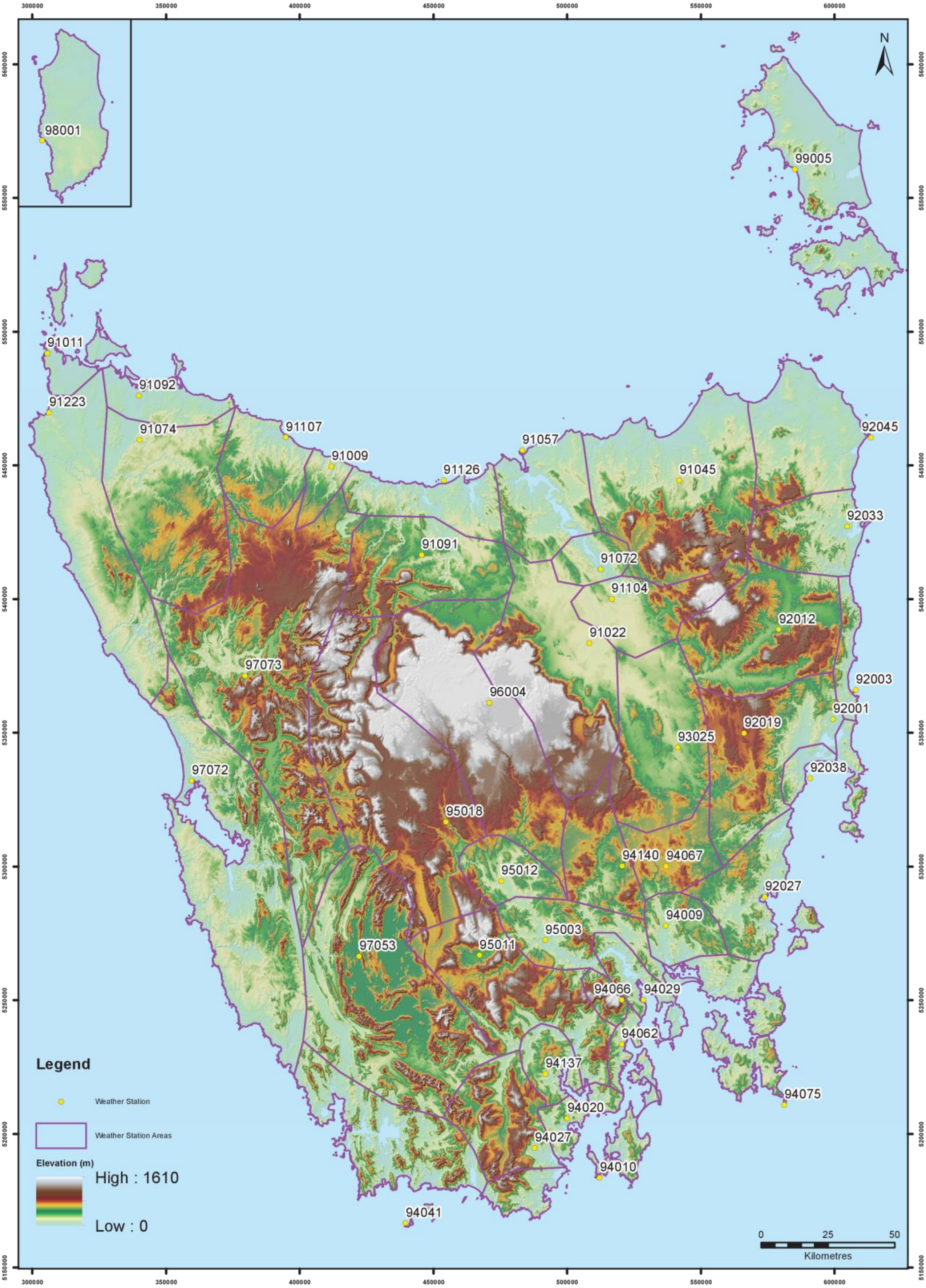

Figure 16. Elevation map, showing weather station locations.

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A Human Settlement Area (HSA) dataset was created for this report to identify the areas in Tasmania where people live and work. The accuracy and currency of the datasets on which the HSA dataset were built are questionable in some areas, which is why the HSA dataset draws from a number of datasets to improve the chances of identifying HSAs in the absence of good data. The HSA dataset was not designed to capture every isolated building or home, but it is intended to identify higher density areas of buildings and populations, including seasonal populations like shack communities. A review of the HSA dataset may result some name changes to existing polygons, and in some changes to better define how smaller and more dispersed communities are included in HSAs.

The priority of this report was to model the risk of bushfires impacting on communities. The property impact metrics used in Phoenix are currently threshold-based and have significant limitations. A shift to a continuous probability of house loss function, incorporating convection, is being investigated by the Phoenix developers as a preferred method for estimating property loss.

Expert opinion has been used to describe treatability of vegetation types, based on work done by Pyrke and Marsden-Smedley (2005). Vegetation types in TASVEG 3.0 (Kitchener & Harris, 2013) were broadly categorised as vegetation that was either treatable or untreatable in relation to fuel reduction burning, based on the typical species composition within each vegetation type and their known sensitivity to fire.

Spatial records of fire history have been used to represent the historical fire disturbance in the landscape. These data have many errors, overestimates and omissions. Future work aims to improve the fire history dataset including burning on council land, privately owned land, burning for silviculture and other burning that is currently not captured. BRAM and Phoenix use different models to calculate fuel quantity and accumulation rates after fire.

Fuel accumulation equations are based on empirical data collected in the field. Fuel accumulation rates and subsequent fire intensity calculations are based on data collected from a range of sites that were burnt under different conditions, from prescribed low intensity fire through to high intensity bushfires. Therefore the fuel accumulation curves are assumed to represent the average fuel accumulation rate, allowing for a variety of fire intensities.

Data used to estimate burning costs provided by FT and HCC show a large variability in the cost of burning. More information could be provided from other agencies such as PWS, councils and other practitioners, and would provide a better data set on which to estimate the potential cost of burning.

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RESULTS AND DISCUSSION

CURRENT BUSHFIRE RISK

Figure 17 shows the location of modelled high intensity fires of >3,000kW/m, with shading indicating the number of times that those areas were impacted by high intensity fires under the modelled current fuel conditions. These maps provide an indication of the likelihood of high intensity fire in response to terrain, current fuel type and load, and 99th percentile summertime weather conditions modelled in Phoenix. Figure 17 shows a potentially high incidence of high intensity fire south of Hobart in the Huon Valley extending through to the Channel, large areas from Sorell north east to Little Swanport, large tracts of areas modelled primarily as grassland south of Launceston, forest south of Fingal Valley, parts of the Derwent Valley and tracts of buttongrass in the Southwest.

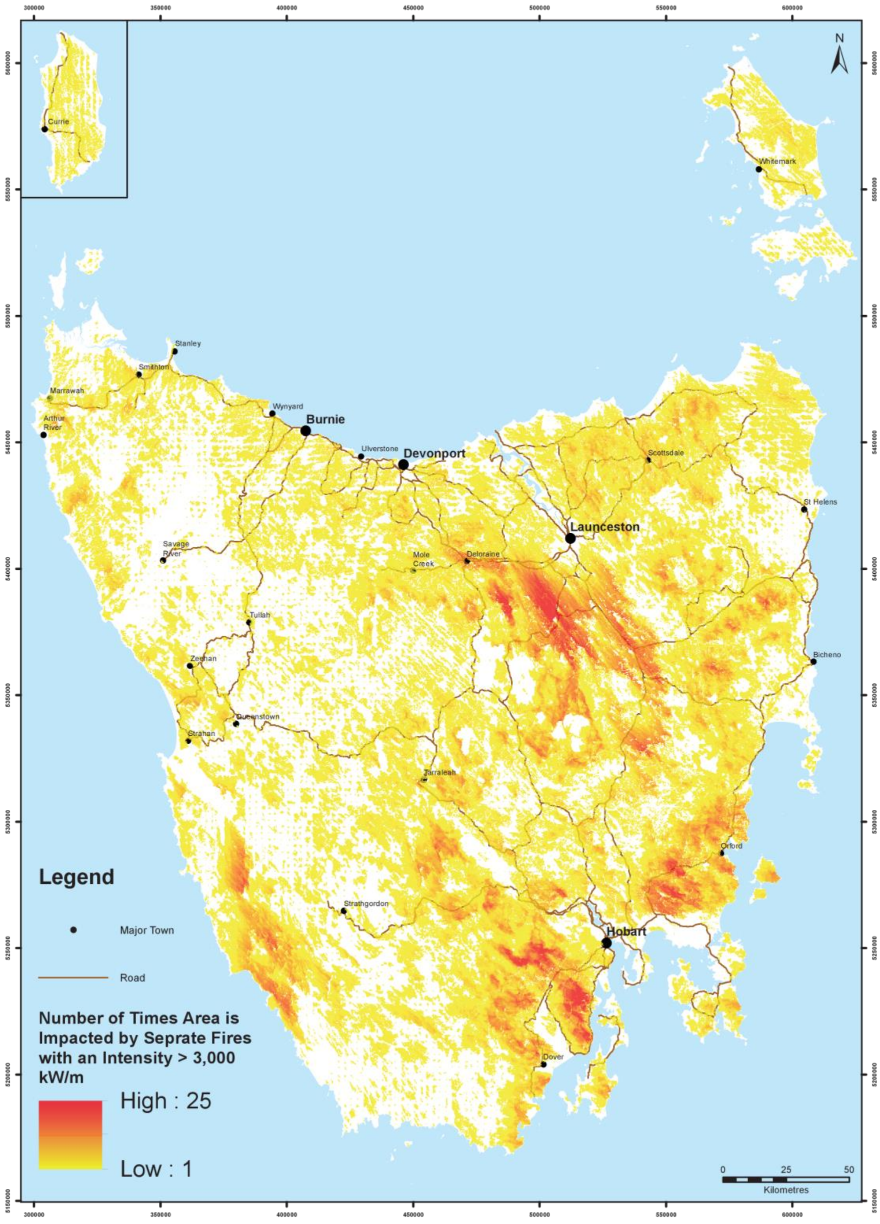

Figure 17: Location of high intensity fire impacts over 3,000kW/m under current fuel conditions, modelled in Phoenix.

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Modelled Impacts on Human Settlement Areas Under Current, Maximum and Minimum Treatable Fuel Loads

Information provided by vegetation mapping, fire mapping and fuel re-accumulation rates were used in Phoenix to model the potential for bushfires to impact on Human Settlement Areas. Predicted fire intensity and ember density was used to estimate the potential for house loss within Human Settlement Areas. Predicted impacts under current fuel load conditions were also compared to the maximum potential number of bushfire impacts that could occur if the fuel loads were allowed to accumulate to their maximum potential, i.e. if there had been no fuel reduction burning or bushfires to reduce the fuel loads to their current state. Impacts were then measured under conditions where the fuel age in all treatable vegetation was set to zero, allowing us to map the areas in the state where fuel reduction burning could potentially reduce bushfire impacts on Human Settlement Areas.

Areas shown in orange in Figure 19 indicate the additional extent of Human Settlement Area that could be impacted if fuels were at their maximum potential load according to the fuel accumulation equations used in the models. Some of these locations provide good examples of where fires in the past have reduced the bushfire risk to communities, e.g. along the northern suburban fringe of Hobart's Eastern Shore (Figure 18). The additional area representing impacts under maximum fuel loads is relatively small when compared to impacted cells under current fuel load conditions, indicating that in many areas fuel loads are likely to have accumulated to their maximum potential.

Figure 18: A bushfire burning north of Hobart's Eastern Shore Suburbs, 12 October 2006. Photographer: Ian Stewart.

In Figure 19, areas shown in red are the extent of Human Settlement Areas that were impacted by the modelled bushfires when the fuel age in all treatable vegetation was set to zero. Clusters of these areas occurred south of Hobart, south of Launceston and Deloraine, along the North West Coast, south of Scottsdale and around Sorell. By measuring impacts under minimum treatable fuel loads, we can identify Human Settlement Areas that are vulnerable to bushfire impacts, where nearby vegetation cannot be treated with fuel reduction burning. For these areas, other bushfire mitigation options like fire prevention, building design, garden maintenance, mechanical fuel removal, access, fire trail and fire break maintenance, bushfire detection and reporting, bushfire response plans, and effective communication including community education become even more important, as well as strategic fuel reduction in areas that may carry fire into the untreatable vegetation.

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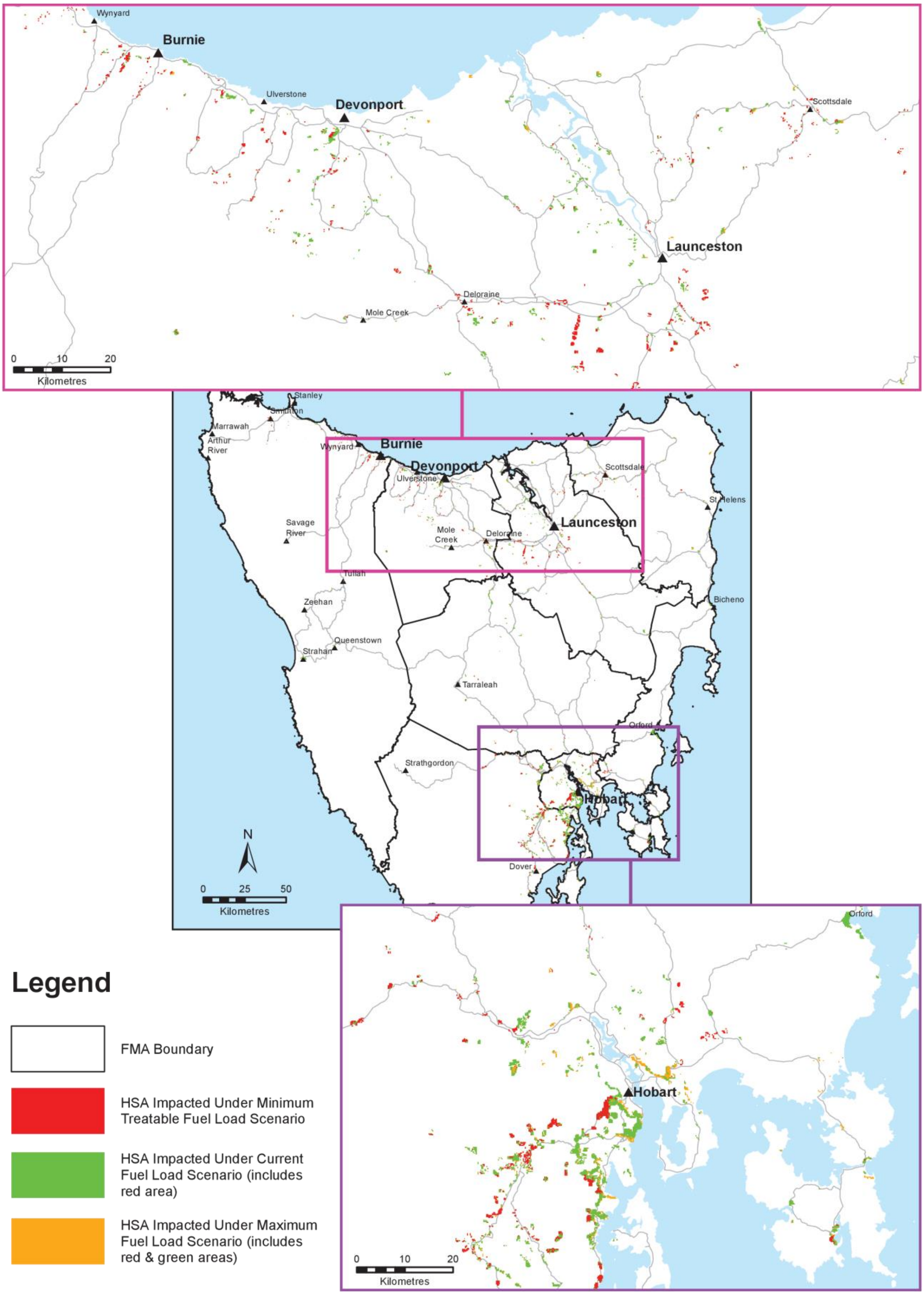

Figure 19: Modelled Human Settlement Area impacts under current, maximum and minimum treatable fuel loads.

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The following pie chart (Figure 20) shows the number of impacts that were measured in each of the FMAs, comparing the impacts under current fuel conditions to impacts that were measured under minimum treatable fuel conditions. The chart indicates that the majority of impacts in each FMA could potentially be managed with fuel reduction burning. However capacity to conduct fuel reduction is limited, so the challenge is to understand where to prioritise fuel reduction given the constraints to burning, for example budget, time and resources, and the need to manage for multiple objectives including biodiversity and environmental health, amenity and air quality.

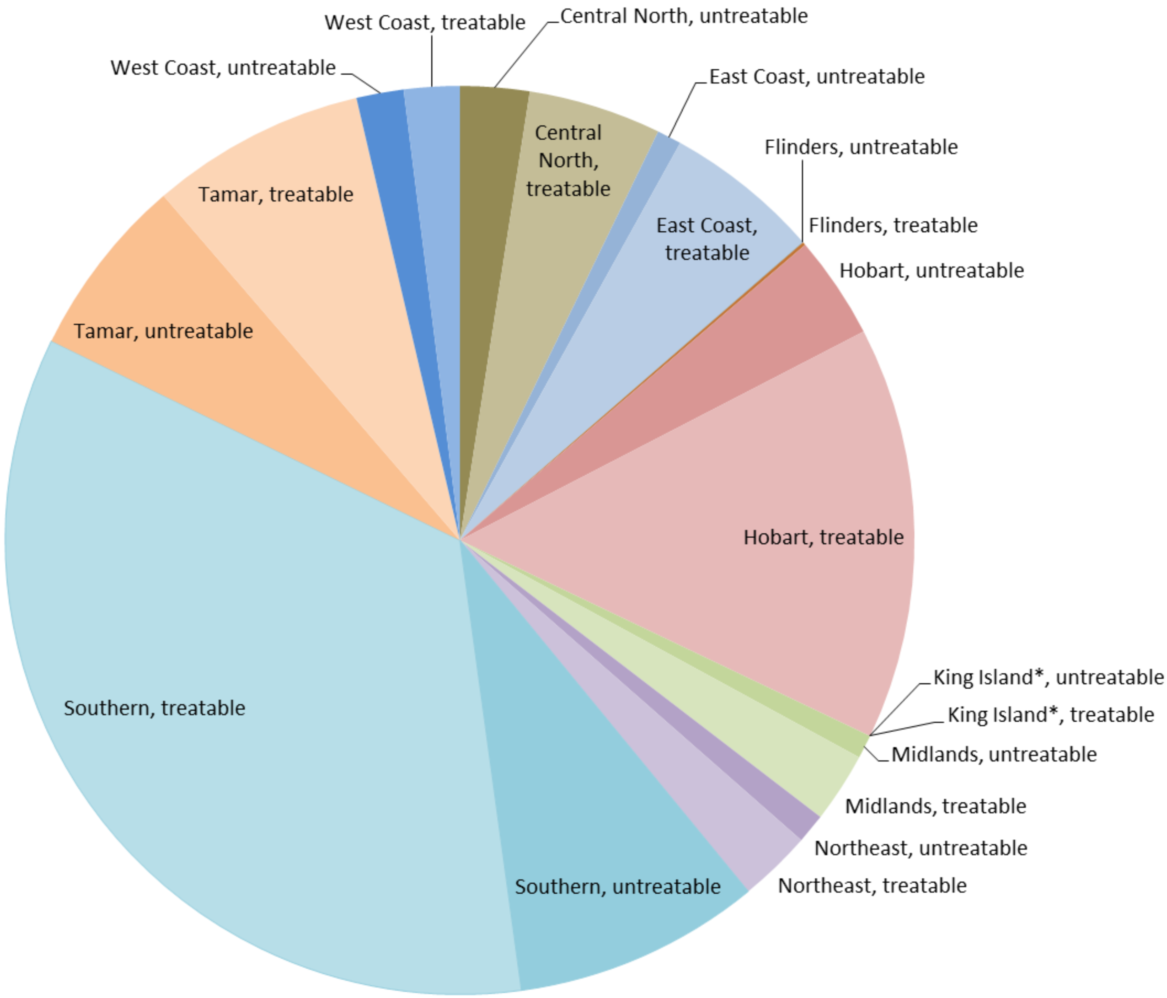

Figure 20: Total number of modelled Human Settlement Area impacts in each Fire Management Area, categorised as treatable and untreatable with fuel reduction burning. *No Human Settlement Area impacts were measured on King Island.

PREDICTED IGNITION POINT IMPACTS UNDER CURRENT FUEL CONDITIONS

Maps were prepared to show the ignition points that led to impacts on Human Settlement Areas. Often the ignition occurred a considerable distance away from the locations where the impacts were measured. These maps provide useful information to determine where fuel reduction can be strategically located to treat bushfire risk at potential ignition sources. Fires that start in areas of reduced fuel are more likely to self-extinguish or take longer to build in size and fire intensity, largely because the vegetation structure is less continuous, slowing the fire's progression.

Figure 21 shows the ignition points that led to measured impacts on Human Settlement Areas, with shading to indicate how many hectares of Human Settlement Area were impacted by each ignition point. Ignition points that led to the greatest impacts were located around Hobart, the Huon Valley and Orford.

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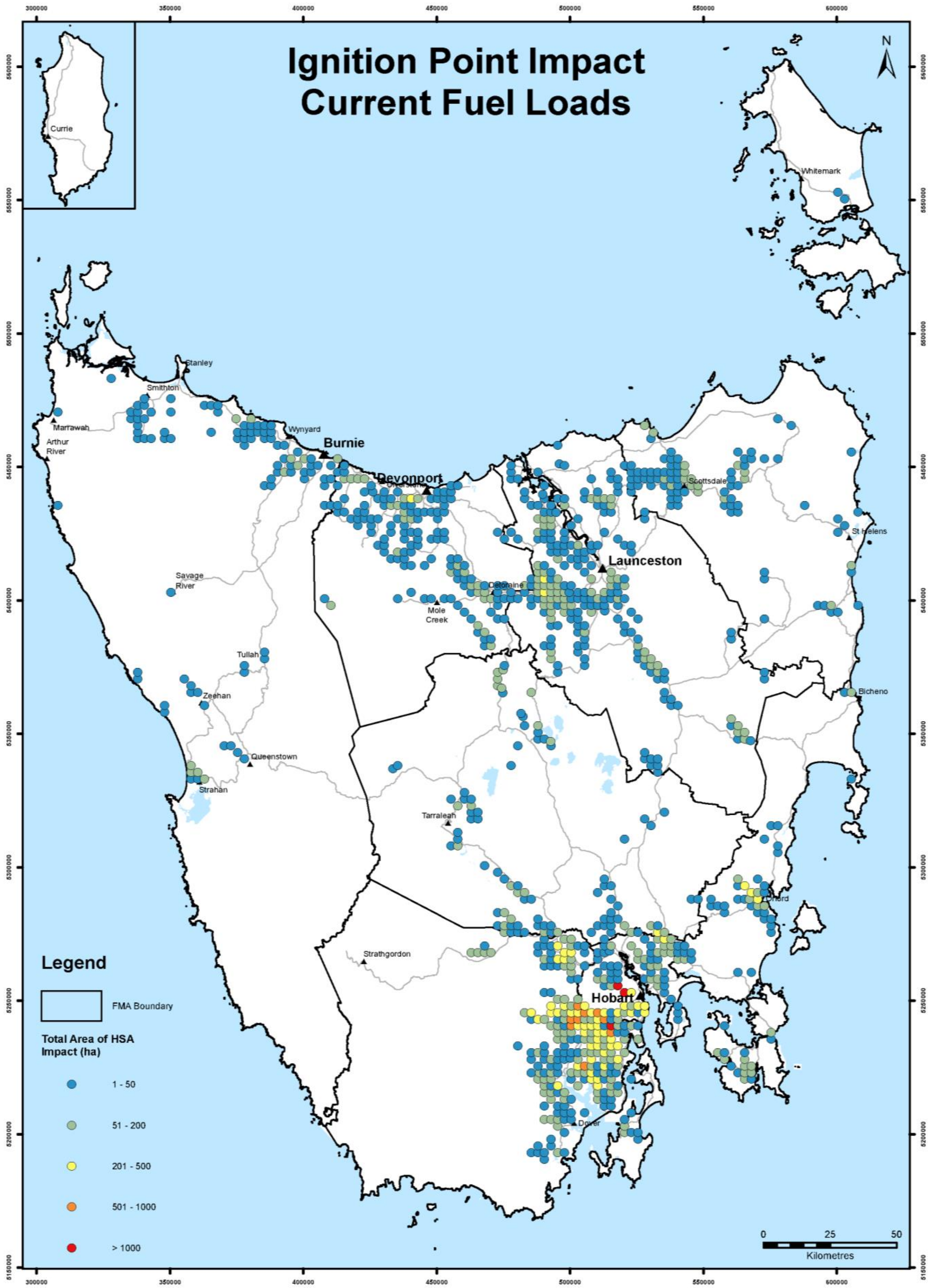

Figure 21: Ignition points that led to impacts on Human Settlement Areas under current fuel conditions.

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FUEL REDUCTION BURNING SCENARIOS

As mentioned earlier in this chapter, the majority of potential bushfire impacts could be managed using fuel reduction burning as a mitigation technique. However the challenge is to prioritise treatment so that fuel reduction burning can be carried out within existing constraints. The scenarios that were developed for this report attempt to take into account some of the quantifiable constraints to burning including the treatability of different vegetation types, the locations where burning may potentially occur based on land tenure and proximity to communities, and the amount of burning that could occur each year.

The scenarios consider the protection of communities as the highest priority. Human Settlement Areas, i.e. places where people live and work, were identified to represent the location of communities in the context of the report. The scenarios have not been developed to protect other values, for example natural values, agricultural crops and forestry assets. However, the BRAM has been used to prioritise burning, which does take these values into account.

TREATABLE VEGETATION

The West Coast, Midlands and Tamar, followed by Southern, Northeast and East Coast FMAs have the greatest area available for fuel reduction burning (Figure 22). These figures reflect the relatively large sizes of some of the FMAs, particularly the West Coast.

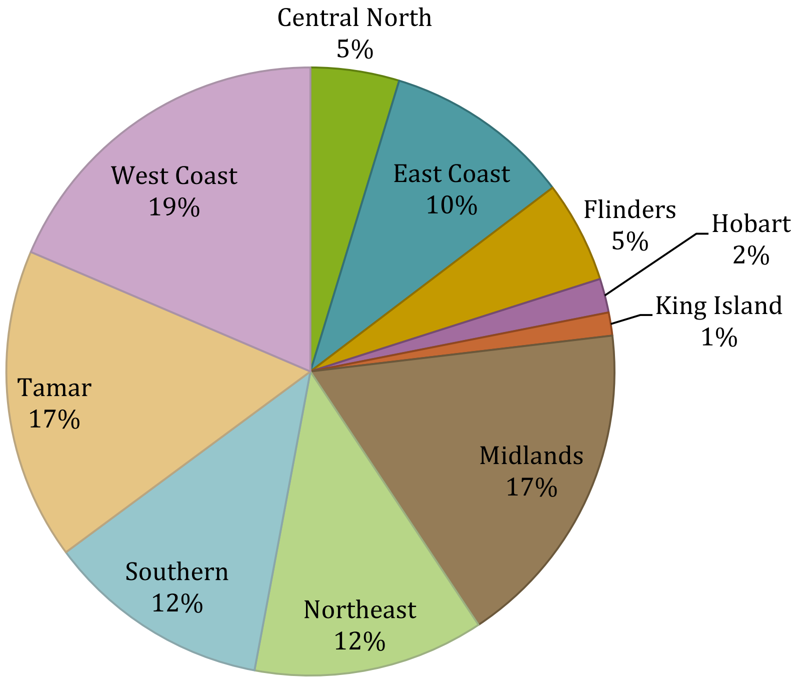

Figure 22: Distribution of treatable vegetation across the state, as a proportion of the total Tasmanian land area.

Figure 23 shows that the Flinders and East Coast FMAs have the highest proportion of treatable vegetation, with about two thirds of their area being treatable. Tamar, Northeast, Midlands and Hobart have treatable fuels in just under half of their management area, and Southern, King Island, West Coast and Central North have proportionally the least area available for treatment, around a quarter. Both Figure 22 and Figure 23 suggest that FMAs with large areas to manage, large areas of treatable fuels and more Human Settlement Areas are more likely to have larger fuel reduction burning programs as part of their Fire Protection Plans, for example Northeast, Midlands, Tamar, West Coast and East Coast.

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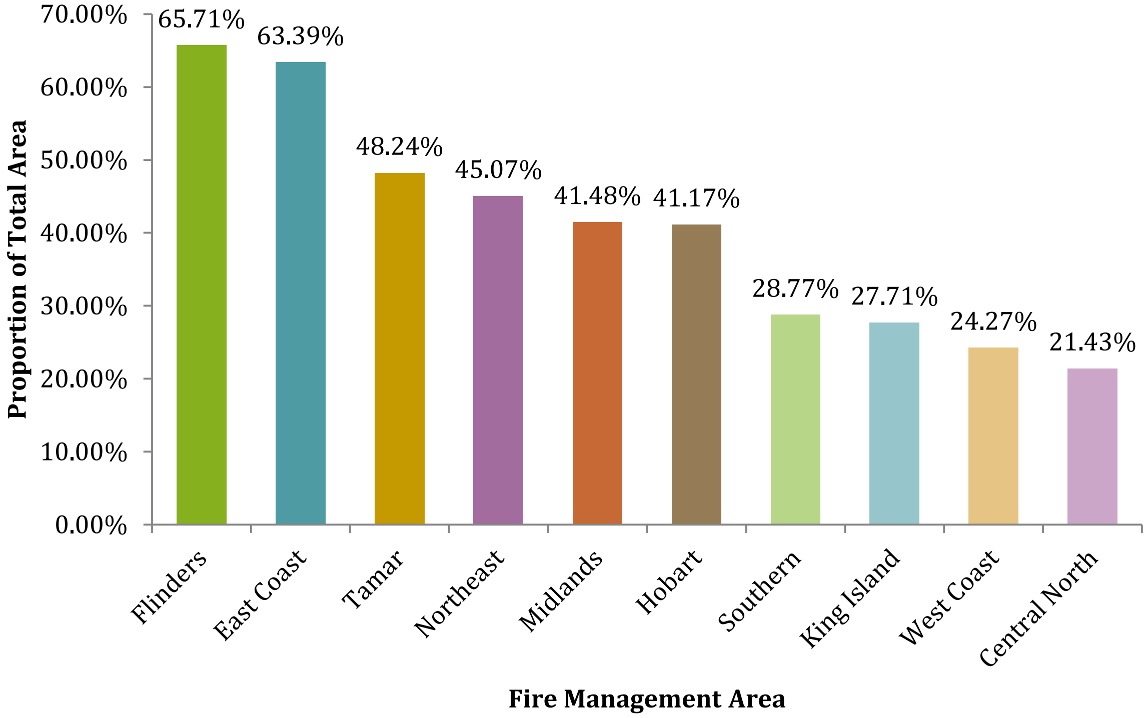

Figure 23: Treatable vegetation as a proportion of the total land area of each Fire Management Area.

Public Land Only Scenarios

The Public Land Only Scenarios compared burning 5% and 2.5% of treatable fuels only on public land. Burn area selection was based on Statewide bushfire risk, with selected burn areas chosen using State Selection or FMA Selection methods. Maps for each of the five year burning scenarios can be found in Appendix 5.

Approximately 58% of the state is public land, most lying in the western half of the State where large areas of vegetation are untreatable in terms of fuel reduction burning. The Public Land Only treatments therefore treated less area annually compared to the tenure-blind (Public and Private Land Only) scenarios. Much of the private land is concentrated around major population centres, so the Public Land Only scenarios tended to burn areas that were further away from communities compared to the Public and Private Land and Fire Management Zone scenarios. The 5% and 2.5% Public Land Only scenarios involved burning a minimum of 74,000 and 37,000 hectares of treatable vegetation on public land, respectively.

There were considerable differences in strategic burn selection when comparing the state and FMA Selection methods. The State Selection method, which prioritised burning based on Statewide risk, resulted in more burning occurring in the north-east and east coast. In comparison the FMA Selection method resulted in more burning in the far southwest of the state. The State Selection method resulted in more immediate treatment of areas around greater Hobart, the Channel, the Huon Valley and the Central Highlands. The FMA Selection method resulted in more immediate treatment of bushfire risk in the northwest and northeast of the state, compared to the State Selection method.

Figure 24shows the land managers responsible for burning under the four Public Land Only Scenarios. Brown shows areas where burning is managed by Forestry Tasmania, and the green and yellow are managed by the Parks and Wildlife Service. There were considerable differences in terms of the proportion of responsibility for burning, with the Parks and Wildlife responsible for half to three quarters of the treatment area over the five years, largely driven by the selection of extremely large Analysis Blocks in the Western and Southern FMAs.

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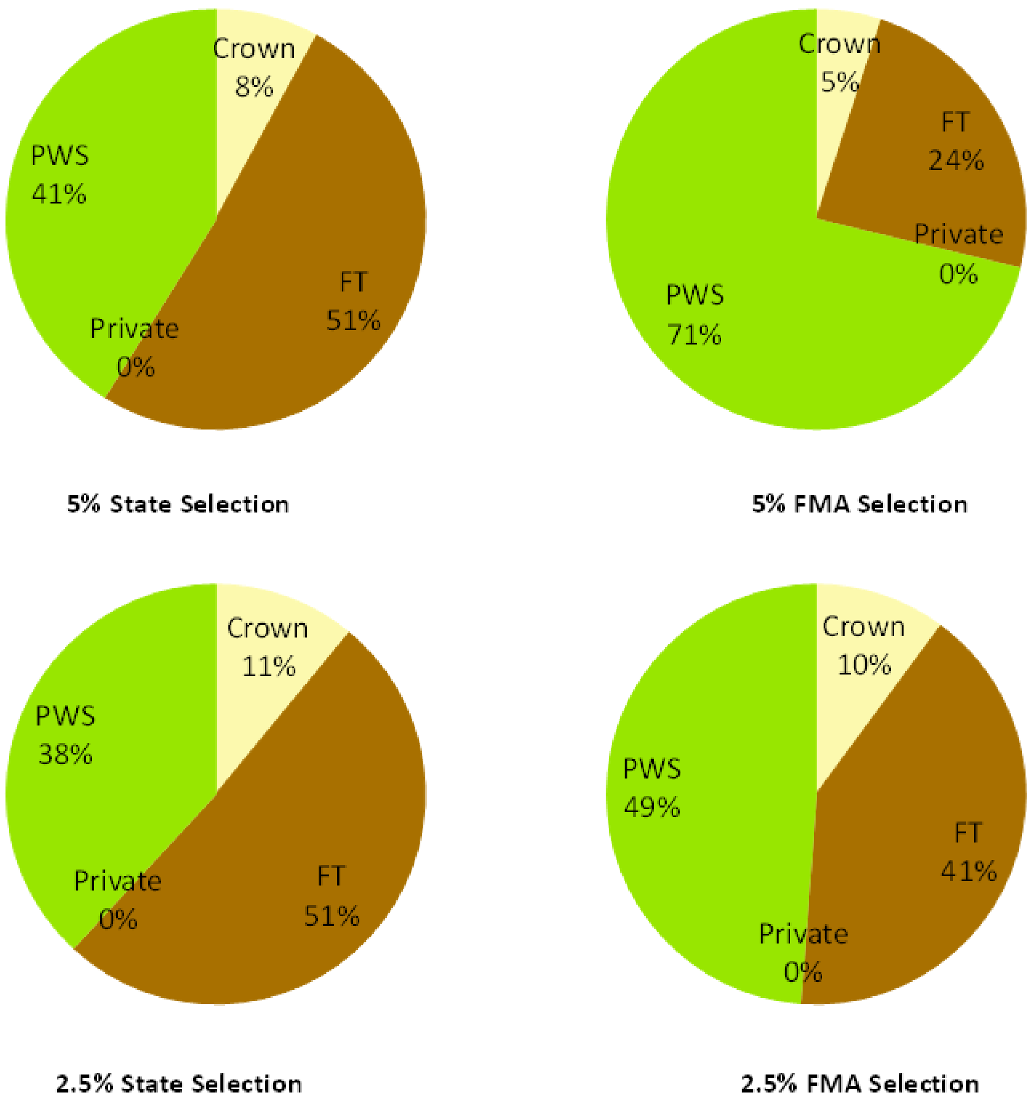

Figure 24: Distribution of treatment area by land tenure under the Public Land Only scenarios. Clockwise from top left, burning 5% of treatable vegetation per year using the State Selection method, 5% using FMA selection, 2.5% using FMA selection , 2.5% using state selection.

PUBLIC AND PRIVATE LAND SCENARIOS

The Public and Private Land scenarios in comparison were the least restricted in terms of the area that could be treated with fuel reduction burning. For these scenarios, the amount of burning was based on 5%, 2.5% and 1.25% of treatable vegetation, resulting in the treatment of at least 124,000 hectares, 62,000 and 31,000 hectares per year, respectively.

More burning occurred in the northeast, Central Highlands, central north and Midlands using the State Selection method to prioritise burns. In comparison the FMA selection resulted in more burning occurring in the southwest and northwest. More immediate priority was given to burning in the southeast, Central Highlands, northeast and East Coast under the State Selection method, whereas the FMA Selection method resulted in more immediate priority being given to areas in the northwest, and the Tamar valley.

Figure 25 shows that private land owners would be responsible for nearly half of the area treated under the Private and Public Land scenarios. PWS and FT would be responsible for around one quarter each.

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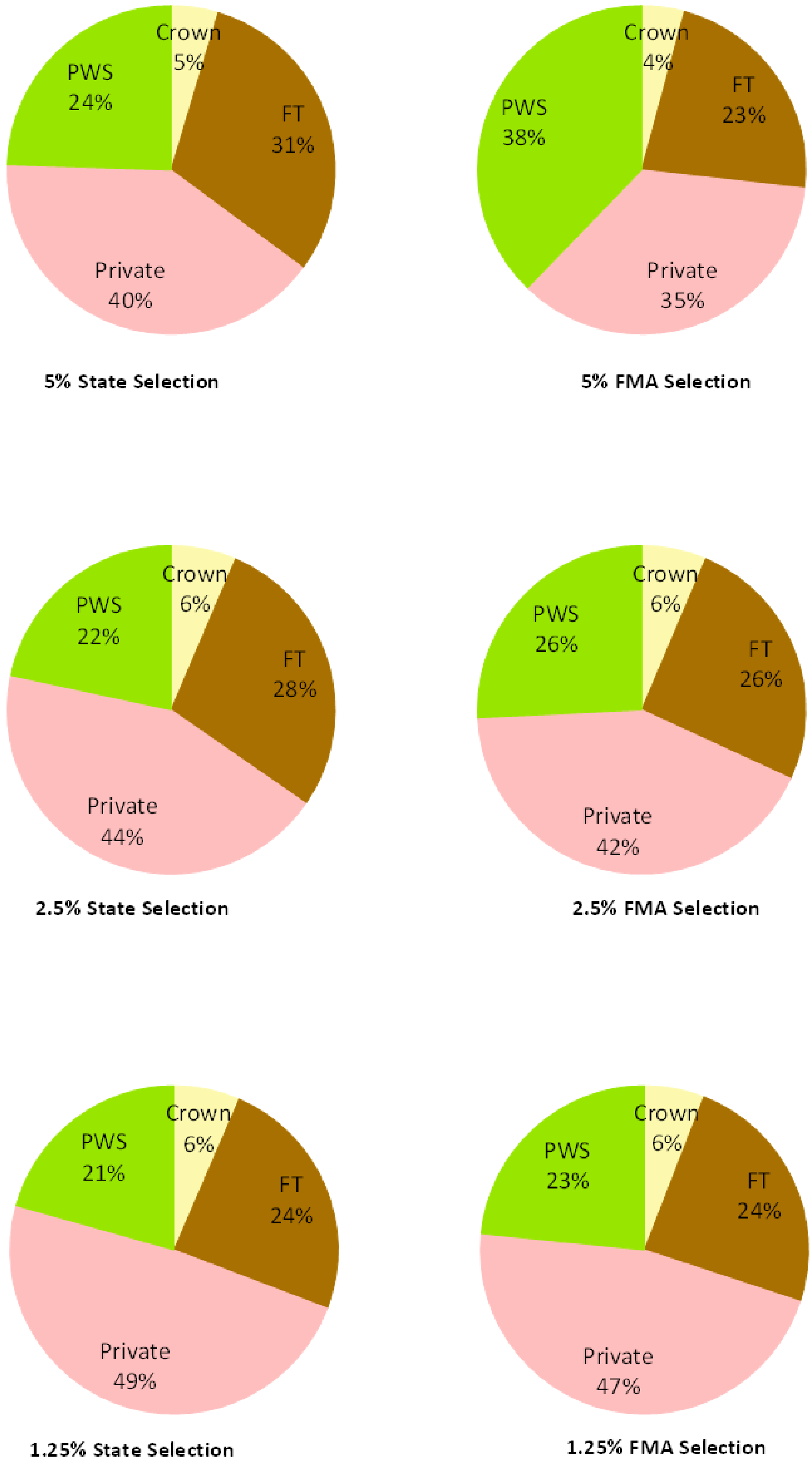

Figure 25: Distribution of treatment area by land tenure under the Public and Private Land scenarios.

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FIRE MANAGEMENT ZONE SCENARIOS

The fire management zone scenarios confined fuel reduction burning to within 6.05km of each Human Settlement Area. The development of these scenarios were based on recommendations from the National Inquiry into Bushfire Management (Ellis, et al., 2004) and research into the effects of fuel on fire severity (Bradstock, et al., 2010). Two levels of treatment were compared, referred to as the Full and Half treatments.

In the Full Fire Management Zone scenario, 20% of the treatable vegetation in Asset Protection Zones (within 1.05km of settlements) were burnt each year. 10% of the Strategic Fuel Management Zone (between 1.05 and 6.05km from the settlements) were burnt each year. This means that if the scenario was fully implemented, then all treatable vegetation inside Asset Protection Zones would have fuel ages of no more than five years, by the fifth year of treatment. Further out, half of the treatable vegetation would have a fuel age of less than five years inside the Strategic Fuel Management Zones. The Full Fire Management Zone scenario would require the treatment of approximately 100,000 hectares of treatable vegetation each year.

The Half Fire Management Zone scenario involved burning 10% of the treatable vegetation in Asset Protection Zones each year, resulting in treatment of half of the Asset Protection Zone within five years of a fully implemented program. Further out, 5% of the treatable vegetation in the Strategic Fuel Management Zone would be burn each year, so that 25% of the treatable vegetation would be burnt by Year 5. Therefore the Half Fire Management Zone scenario resulted in a much patchier treatment of fuels within 6.05 km of Human Settlement Areas.

The BRAM's Head Fire Intensity (HFI) score was used to prioritise areas for treatment. Statewide, BRAM HFI values close to communities were highest in coastal, scrub and buttongrass areas in the state's west and north-west, King Island and Flinders Island, along most of the north coast with much smaller areas along the east coast and south of Dover. This resulted in more burning, and more immediate treatment, around communities in the state's west and northwest. In fact the high HFI values in areas of the West Coast FMA resulted in most of the burning occurring in that area in Year 1. In comparison there was less burning and much later treatment in the State's southeast, particularly in the Half Fire Management Zone scenario.

The FMA Selection method in comparison distributed risk treatment more evenly around the state. Because burning was confined to areas close to communities, the FMA Selection method didn't lead to the treatment of large areas of public land in the southwest by Year 5, compared to other scenarios that used the FMA Selection method.

Given the proximity to Human Settlement Areas, over half of the burning occurred in areas managed as private property (Figure 26). Around one third of the area fell on land managed by PWS (who also manage fires on Crown), and the smallest proportion of area, shown in brown, was managed by FT.

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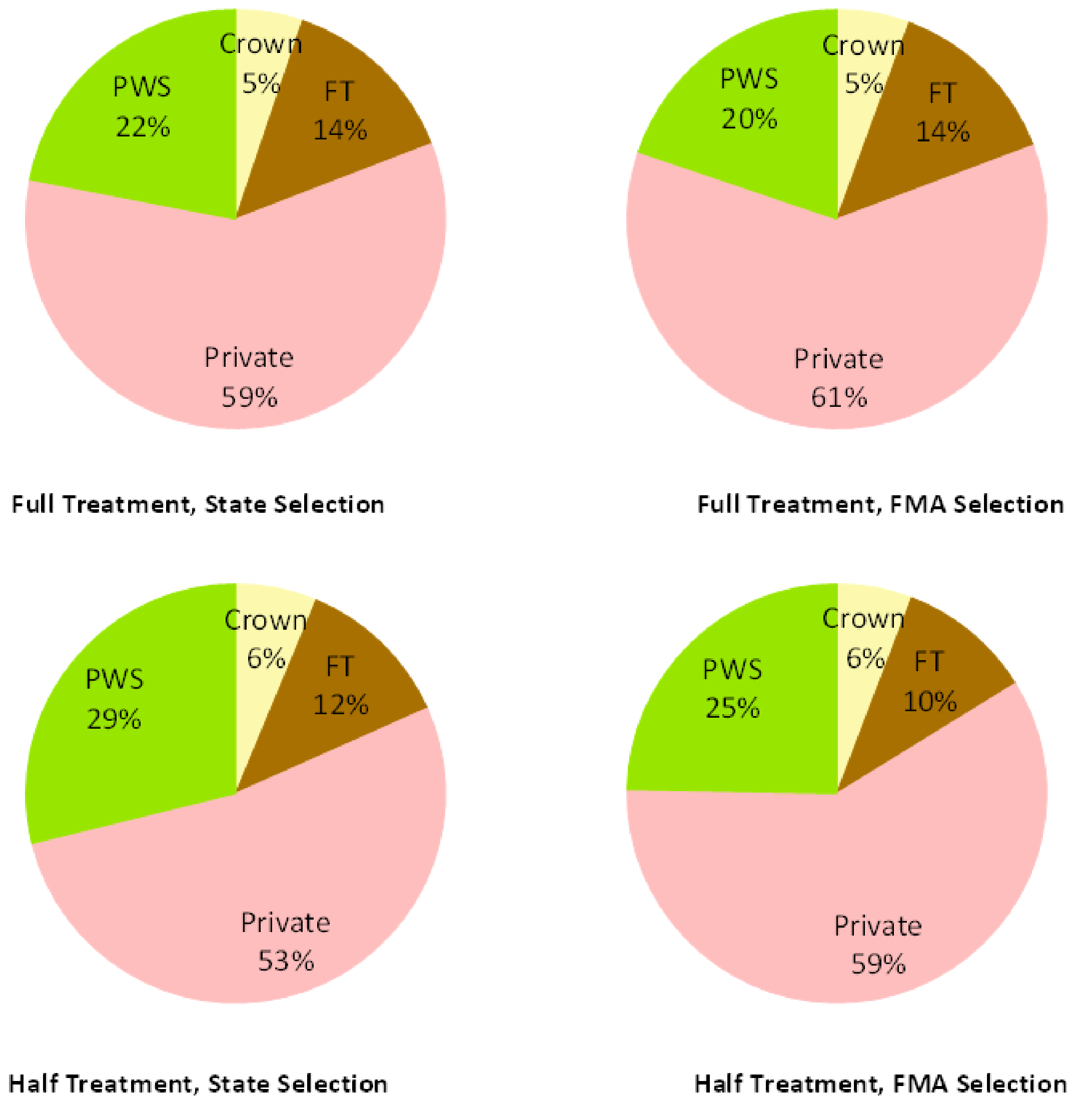

Figure 26: Distribution of treatment area by land tenure under the Fire Management Zone scenarios.

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STATEWIDE EFFECTS OF FUEL REDUCTION BURNING

HUMAN SETTLEMENT AREA IMPACTS

The risk profile for Tasmania is shown in Figure 27. The black line shows how the modelled impacts on Human Settlement Areas changed from year to year up until 2013. As described in the methodology, it is expressed as a proportion of the number of modelled impacts over the number of maximum potential impacts if all fuels had accumulated to their maximum potential.

The graph also shows the area burnt each year according to bushfire and fuel reduction burning histories. The chart shows projected relative risk over the next five years based on No Fuel Treatment, and planned burning associated with the fuel reduction scenarios that were developed using Statewide bushfire risk to prioritise burning.

Figure 27 shows that relative risk increased slowly to its highest level in 2013, where it currently lies at over 90% of maximum potential human settlement impacts.

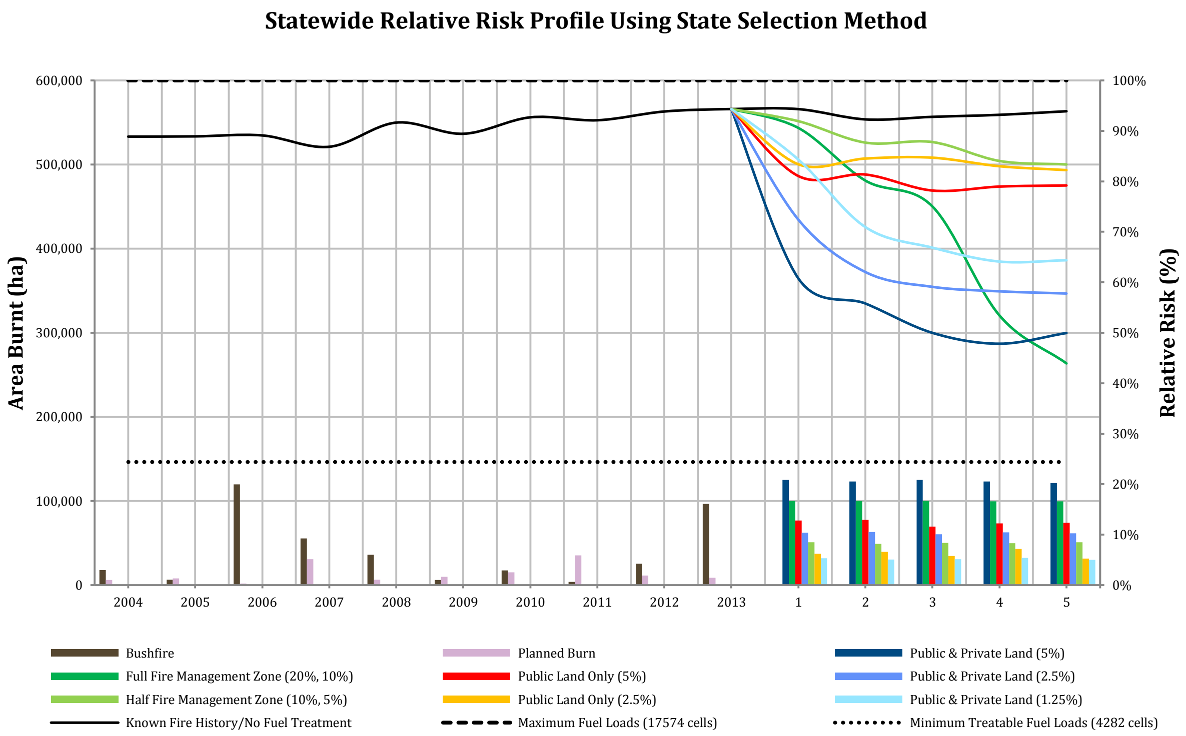

Figure 27: Relative risk profile for Tasmania based on weather scenarios representing 99.0 to 99.5 percentile summertime weather conditions. Fire history (bushfires and planned burning) is included for 2003-2013, along with the five year burning scenarios that were based on treating highest bushfire risk at the Statewide level.

The dotted line shows the number of Human Settlement Area impacts measured under conditions where all treatable vegetation types were given a fuel age of zero. This provides an indication of the level of fuel reduction burning that would be required to reduce impacts to their minimum. The number of impacts measured under minimum fuel loads shows that fuel reduction burning will never totally remove bushfire risk and potential house loss in all areas. In reality, a fuel reduction burning program could never reduce fuels to a point where all treatable vegetation was burnt in the same year. A relative risk profile would only drop below the minimum relative risk if bushfires burnt large areas of treatable and untreatable vegetation, under weather conditions that were similar to the modelled weather conditions.

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The coloured lines represent projected relative risk using the State Selection method, assuming that the scenarios were fully implemented in the five years following 2013. There was no attempt to estimate area burnt by bushfires in the five year forward projection. The state relative risk profile closely resembled the risk profiles for Southern and Hobart, because most of the impacts occurred in those FMAs. Relative risk charts were therefore prepared for each of the FMAs as well as the state, to get a better understanding of how the fuel reduction burning scenarios affected relative risk in areas other than the Southern and Hobart FMAs.

All treatments significantly reduced Human Settlement Area impacts except for the 2.5% Public Land Only scenarios, and the Half Fire Management Zone scenario using the State Selection method. The state relative risk profile dropped at the fastest rate, to just over 50% if 5% of treatable fuels were burnt each year on public and private land, using both the state selection and FMA Selection methods. Burning 2.5% and 1.25% of treatable vegetation on public and private land each year also reduced relative risk significantly, to about 60% in year 5 using the State Selection method.

The Full Fire Management Zone scenarios reduced relative risk to the lowest level by year 5 to just over 40% under both state and FMA Selection methods. The FMA Selection method (Figure 28) resulted in a faster decline in relative risk because more treatment occurred in the Southern and Hobart FMAs in the first few years. Under the State Selection method, treatment of high risk areas in the Southern and Hobart FMAs did not occur until years 4 and 5 of full treatment. Halving the program resulted in high risk areas not being treated within the five year period, i.e. they would probably have been treated around Years 8 to 10 of a longer-term program. Furthermore, the FMA Selection methods show large areas of remote public land in the southwest being treated by Years 4 and 5, with no apparent change in relative risk. Figure 27 and Figure 28 demonstrate how a strategic burning program can reduce potential bushfire impacts. The angle of the curves in Figure 28 indicate that long-term fuel reduction burning programs, in the order of decades, may be required under the more conservative burning programs (i.e. the Half Fire Management Zone and the 1.25% Public and Private Land scenarios) to reduce bushfire risk over time.

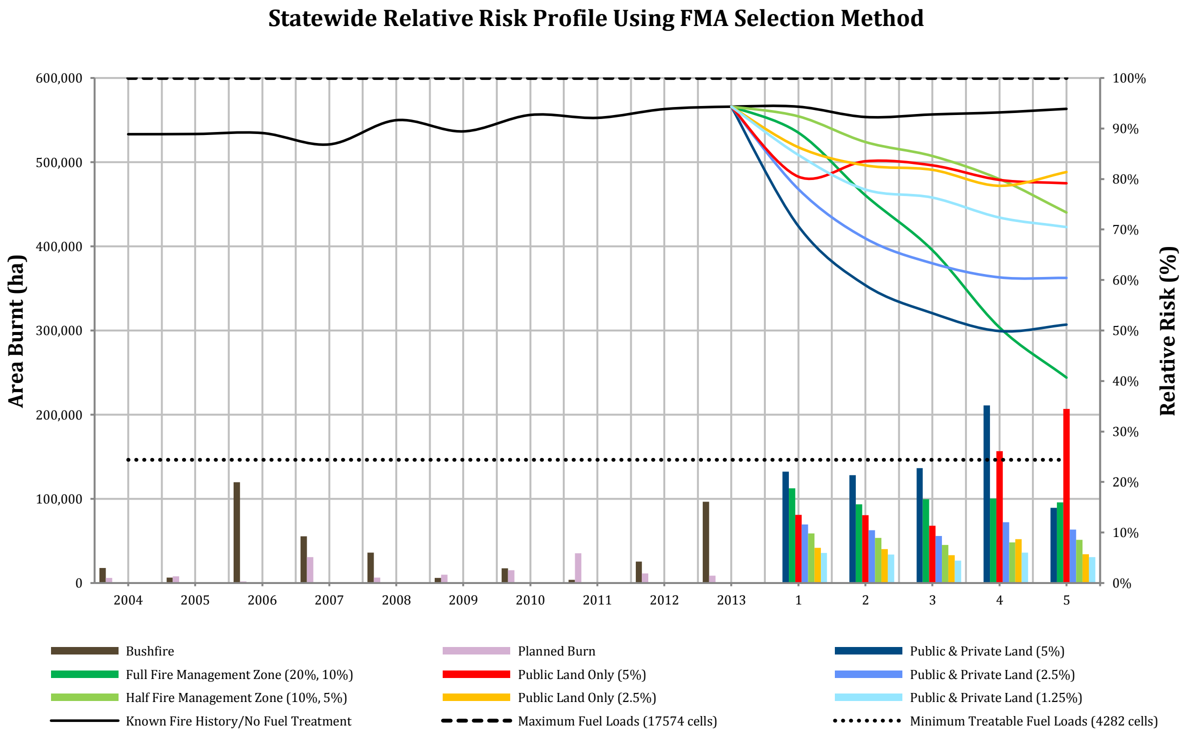

Figure 28: Relative risk profile for Tasmania based on weather scenarios representing 99.0 to 99.5 percentile summertime weather conditions. Fire history (bushfires and planned burning) is included for 2003-2013, along with the five year burning scenarios that were based on treating highest bushfire risk within each Fire Management Area.

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IMPACTING IGNITION POINTS

Figure 29 shows how fuel reduction at ignition points reduced Human Settlement Area impacts after Year 5 of treatment. The results from each scenario were quite similar, showing that the greatest reductions occurred in the Southern FMA. These maps provide an indication of where strategic fuel reduction burning could be located to reduce the potential for potentially high impact bushfires, if a fire were to start in that area.

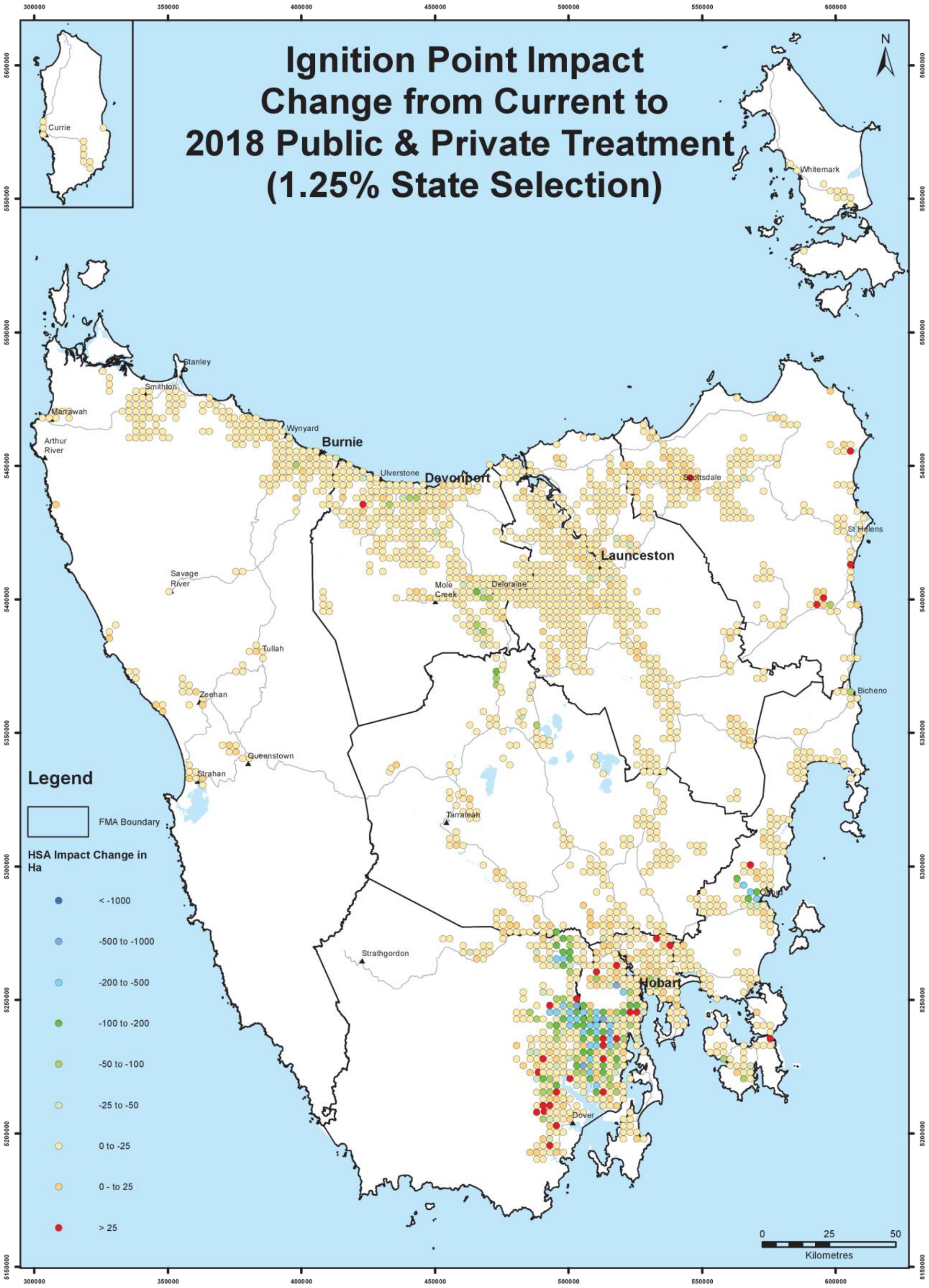

Figure 29: Location of ignition points that impacted on Human Settlement Areas, showing the difference in impact count between 2013 and Year 5 of the 2.5% Public and Private Land scenario using the State Selection method.

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Ease of Suppression

Two measures were used to quantify ease of suppression: fire intensity and fire size. Fire intensity was categorised into low and high intensity fire using a threshold of 3000kW/m, representing the upper limit for effective firefighting. Over 3000kW/m, firefighting was considered to be less effective and unsafe. In reality it is difficult to quantify the point at which fire suppression is considered to be unsafe, because there are many elements of fire behaviour that influence ease of suppression, e.g. terrain, rock, forest cover, resource type and skill level (McCarthy, et al., 2003).

These results should be treated with some care. Fuel accumulation equations are based on empirical data collected in the field. Therefore fuel accumulation rates and subsequent fire intensity calculations are generally based on data collected from a mixture of areas burnt at a range of intensities, from prescribe low intensity fire through to high intensity bushfires. The fuel accumulation rates and subsequent fire behaviour calculations are based on an average of fire conditions.

Figure 30 provides a comparison of high intensity fire effects per ignition after Year 5 for each fuel reduction burning scenario. Scenarios with error bars that do not overlap with the NFT_1, i.e. entirely below the line, indicate statistically significant reductions in fire intensity after five years of treatment compared to impacts modelled under current fuel loads. Scenarios with error bars that do not overlap with the NFT_5 indicate statistically significant differences compared to impacts if fuels were allowed to accumulate with no treatment over five years. These results show that, at the Statewide scale, fire intensity was significantly lower than the no fuel treatment scenario in virtually all scenarios. When compared to current fuels, the scenarios that burnt the largest areas, i.e. the Full Fire Management Zone (FMAC_APZT, STATE_APZT), Public and Private Land burning5% and 2.5% of treatable fuel (FMAC_PPT, FMAC_PPT_HF, STATE_PPT, STATE_PPT_HF), and Public Land Only scenarios burning 5% of treatable fuels (FMAC_PT, STATE_PT), significantly reduced the amount of high intensity fire in the landscape to below 3000kW/m.

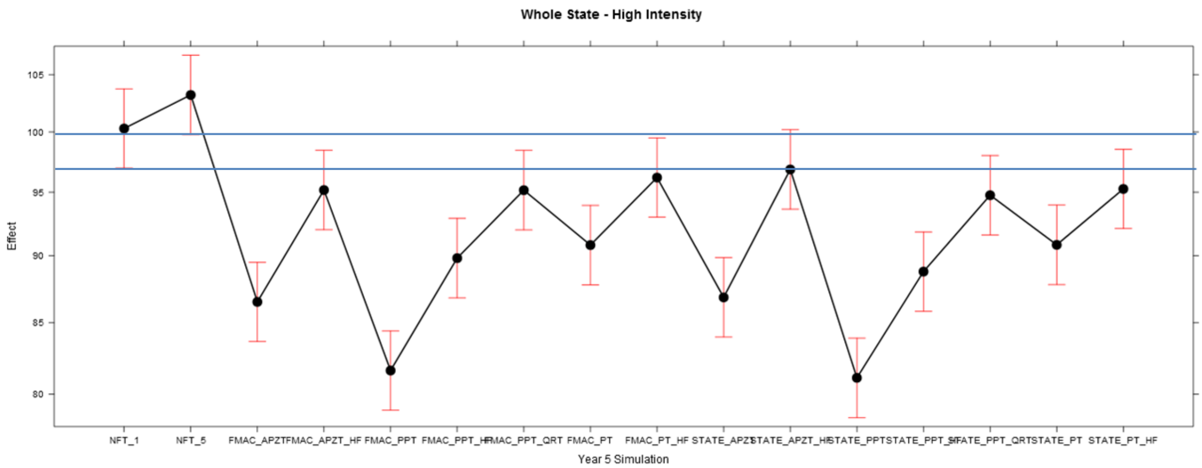

Figure 30: A Statewide comparison of high intensity fire effects per ignition after Year 5 for each fuel reduction burning scenario, modelled in PHOENIX RapidFire.

The fuel reduction scenarios were also compared against current and no fuel treatment using the Head Fire Intensity (HFI) component of BRAM, which uses different fuel accumulation and fire behaviour equations to calculate fire intensity for every 100m^2 grid cell in Tasmania based on fuel types, fuel age, fuel loads and a standard 90th percentile weather profile based on weather observations from the nearest relevant weather station (InsightGIS, 2013). The BRAM results confirmed a reduction in the occurrence of high intensity fire >3,000kW/m, reducing up to 100,000 ha of area down into the low intensity category within 10km of Human Settlement Areas (Figure 31).

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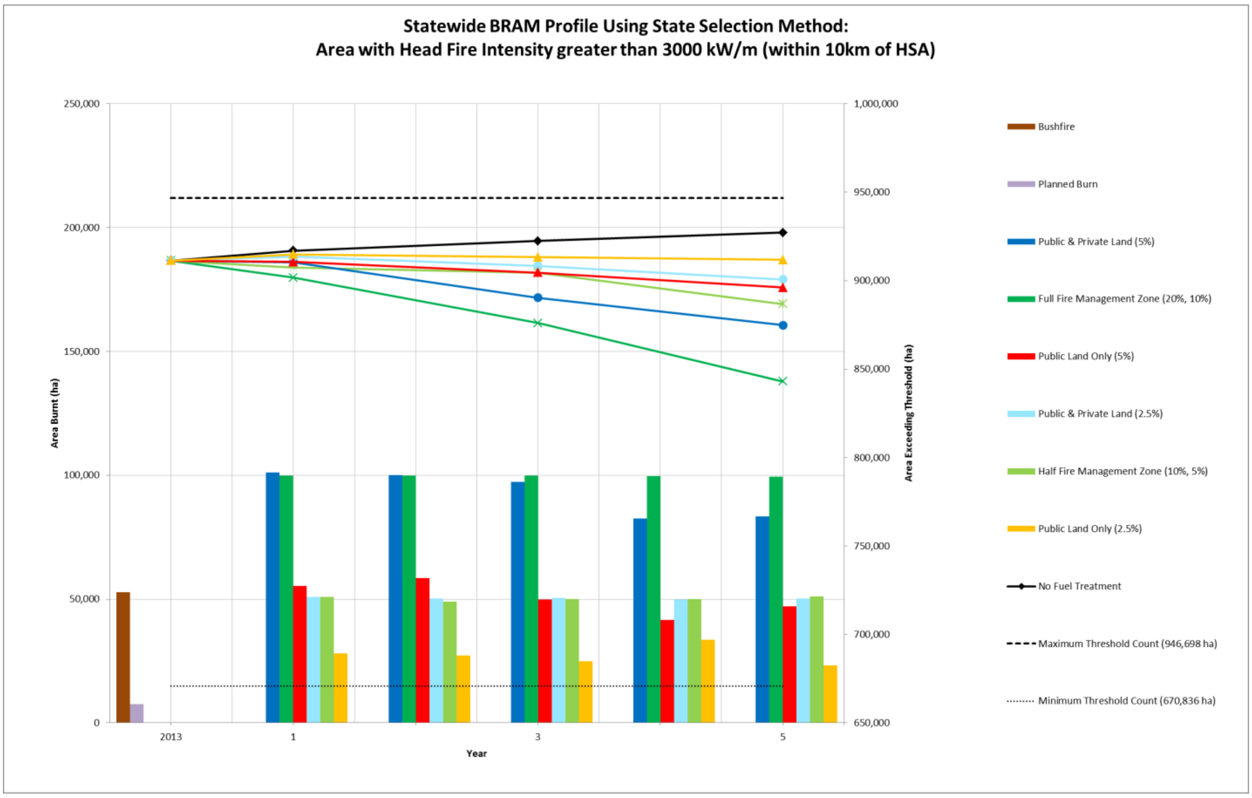

Figure 31: Area (ha) within 10km of Human Settlement Areas that exceeded 3,000kW/m of maximum BRAM head fire intensity in Years 1, 3 and 5 of fuel treatment.

The scenarios had less significant effects on reducing fire size, with significant reductions under the Public and Private Land scenarios burning 5% & 2.5% of treatable fuels (FMAC_PPT, FMAC_PPT_HF, STATE_PPT, STATE_PPT_HF in figure 32), and the Public Land Only scenario burning 5% of treatable fuel, using the FMA Selection method (FMAC_PT). These results suggest that all of the fuel reduction burning scenarios except for the 2.5% Public Land Only scenario significantly reduced fire behaviour to more manageable levels when compared to no fuel treatment. While fire size did not change as significantly, the greatest effect was a reduction in fire intensity.

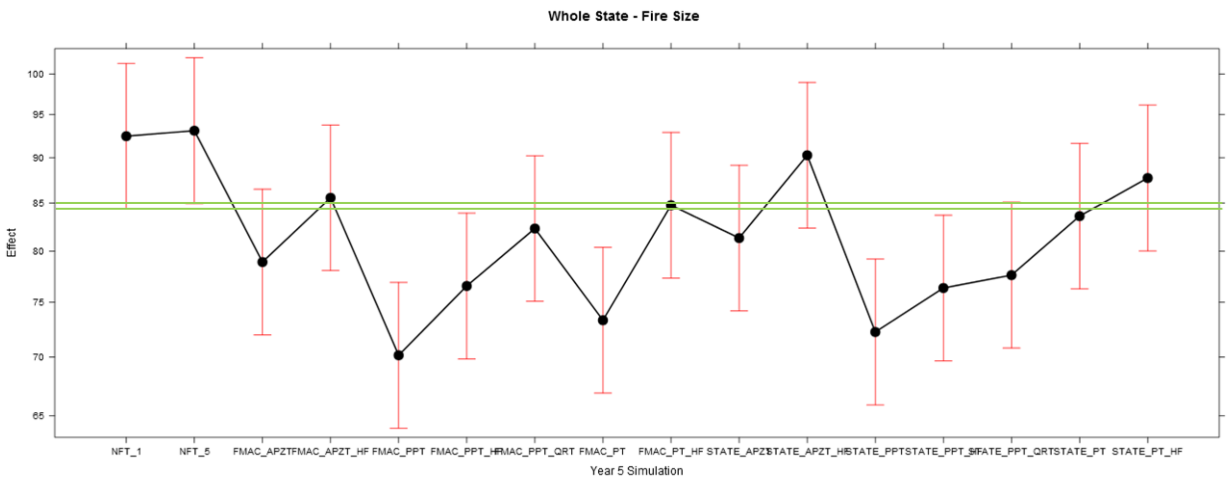

Figure 32: Comparison of area burnt per ignition after Year 5 for each fuel reduction burning scenario, modelled in PHOENIX RapidFire.

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SOUTHERN FIRE MANAGEMENT AREA

In the Southern FMA, relative risk remained near the maximum level (100%) for the entire period between 2003 and 2013. The Southern FMA had the greatest potential for Human Settlement Area impacts of all the FMAs, as well as the greatest potential to reduce Human Settlement Area impacts through fuel reduction. In comparison to other FMAs, Southern FMA still had considerable Human Settlement Area where fuel reduction would be unlikely to reduce potential impacts. The dotted line in Figure 33 shows the theoretical minimum relative risk for the hypothetical scenario of burning all treatable vegetation in the Southern FMA, which is 20% of the total number of potential impacts under maximum fuel conditions. However 20% still represents a large amount of Human Settlement Area (1454 200m^2 grid cells) when compared to most other FMAs, which have much lower densities of Human Settlement Area. It should be noted the HSA impacted area might be counted cumulatively if multiple fires impact on the same Human Settlement Area.

There was a considerable difference in the rates of reduction in Human Settlement Area impact between the State Selection method (Figure 33) and the Fire Management Area selection method (Figure 34). The increased reduction rates in the Southern FMA confirm that the State Selection method using the BRAM Risk Score was effectively identifying high risk areas for treatment.

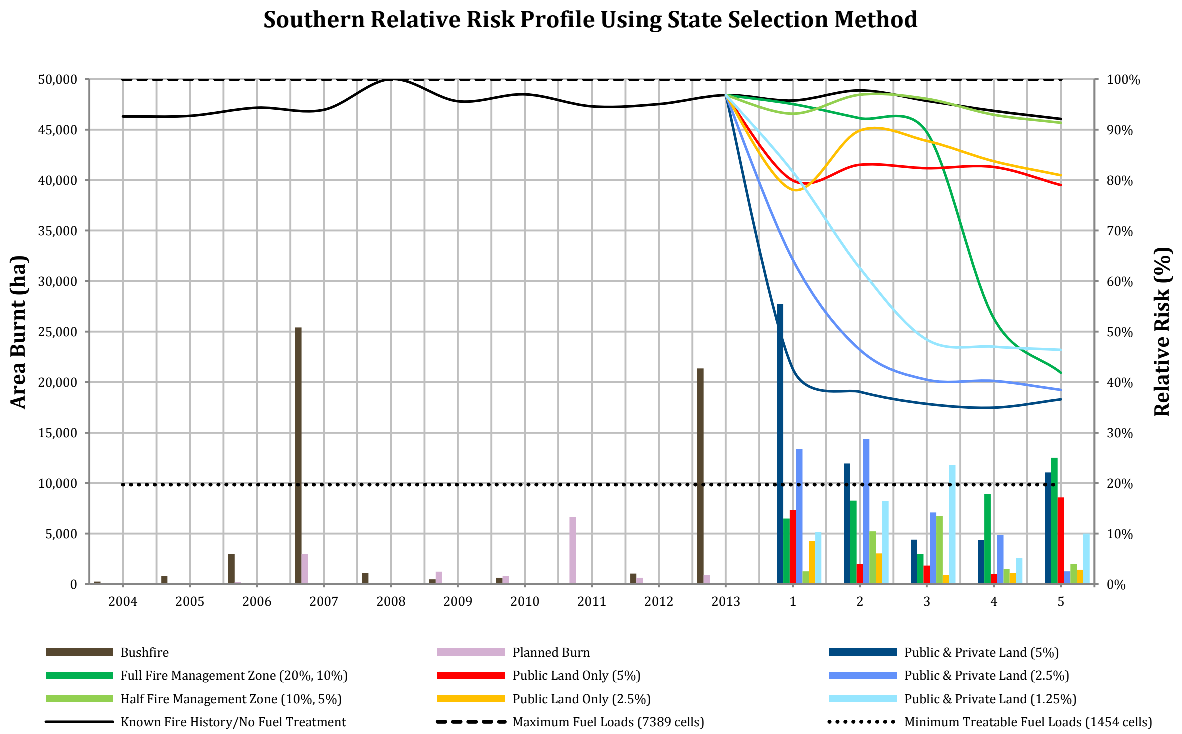

Figure 33: Relative risk profile for Southern Fire Management Area using the State Selection method to reduce bushfire risk.

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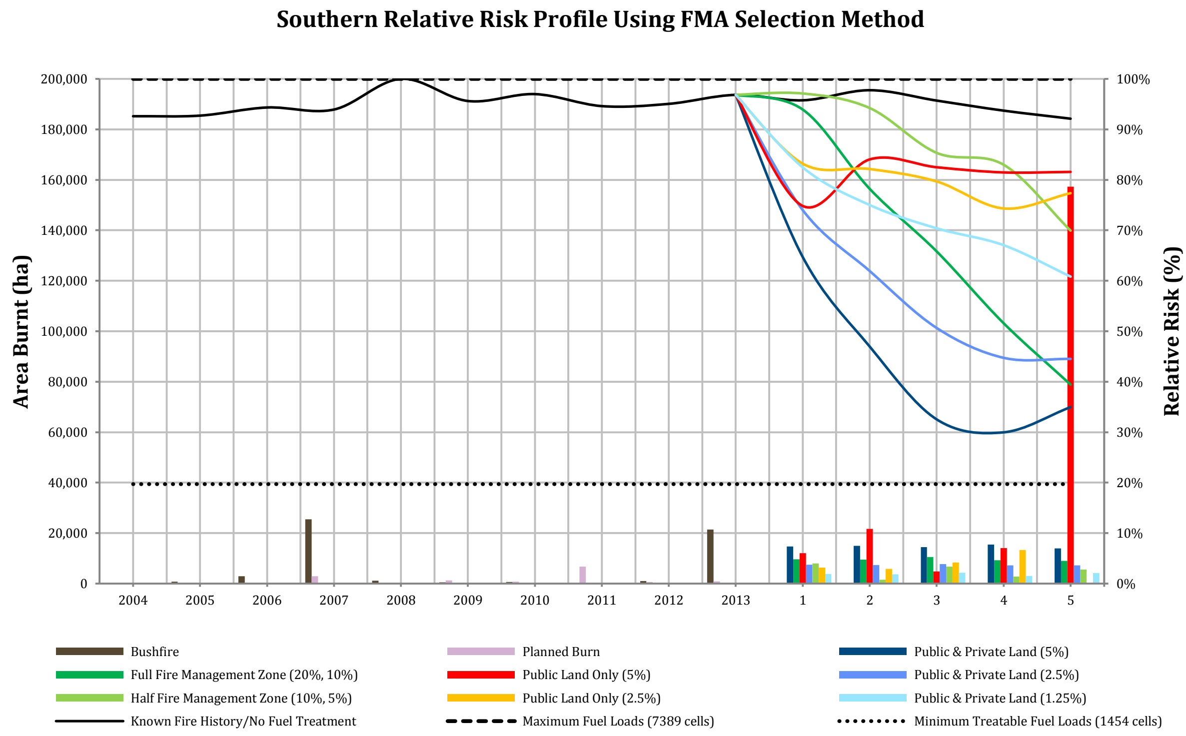

Figure 34: Relative risk profile for Southern Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

Table 5 provides a summary of the fuel reduction burning scenarios that resulted in statistically significant reductions in HSA impacts, fire intensity and fire size. All of the Public and Private Land scenarios reduced HSA impacts. Fire intensity and size were significantly reduced in all of the 5% and 2.5% scenarios on Public and Private Land. The 1.25% scenario using the state selection significantly reduced fire intensity but not fire size. The Full Fire Management Zone scenarios significantly reduced impacts, but with no significant reductions in fire intensity and fire size.

Table 5. Statistically Significant Reductions in Human Settlement Impacts, Fire Intensity and Fire Size after Year 5 of Treatment in the Southern Fire Management Area.

Treatment Scenarios	Human Settlement Area Impacts	Fire Intensity	Fire Size
FMA Full Fire Management Zone (20%, 10%)	X		
FMA Half Fire Management Zone (10%, 5%)			
FMA Public and Private Land (5%)	X	X	X
FMA Public and Private Land (2.5%)	X	X	X
FMA Public and Private Land (1.25%)	X		
FMA Public Land only (5%)		X	X
FMA Public Land Only (2.5%)			
State Full Fire Management Zone (20%, 10%)	X		
State Half Fire Management Zone (10%, 5%)			
State Public and Private Land (5%)	X	X	X
State Public and Private Land (2.5%)	X	X	X
State Public and Private Land (1.25%)	X	X	
State Public Land only (5%)			
State Public Land Only (2.5%)			

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HOBART FIRE MANAGEMENT AREA

In the Hobart FMA, fires in the decade leading up to 2003 resulted in the relative risk profile moving from around 70 to 90% (Figure 35). The sudden drop in relative risk in Year 2 of No Fuel Treatment and the Fire Management Zone scenarios appears to be coincidental. Complex relationships between different vegetation types, slope, major roads, and wind changes affected the timing of peaks in fire intensity, rate of spread and spotting, resulting in fewer impacts in Year 2 for a single fire modelled between Hobart and Kingston, even though no burning occurred in that area.

The Hobart FMA had a very high potential for Human Settlement Area impacts under current fuel conditions, as well as a high potential to reduce Human Settlement Area impacts through fuel reduction (Figure 35 and Figure 36). In comparison to other FMAs, Hobart FMA had considerable Human Settlement Area impacts where fuel reduction would probably not reduce potential bushfire impacts, although not as many as in the Southern or Tamar FMAs.

Hobart Relative Risk Profile Using State Selection Method

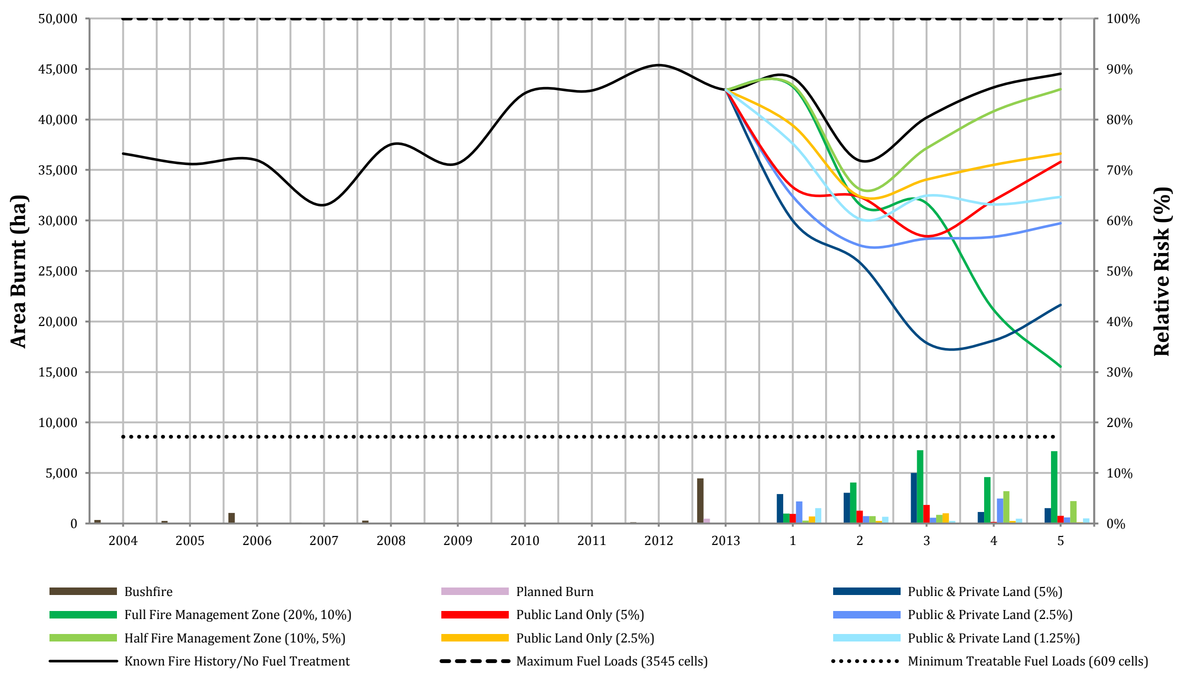

Figure 35: Relative risk profile for Hobart Fire Management Area using the State Selection method to reduce bushfire risk.

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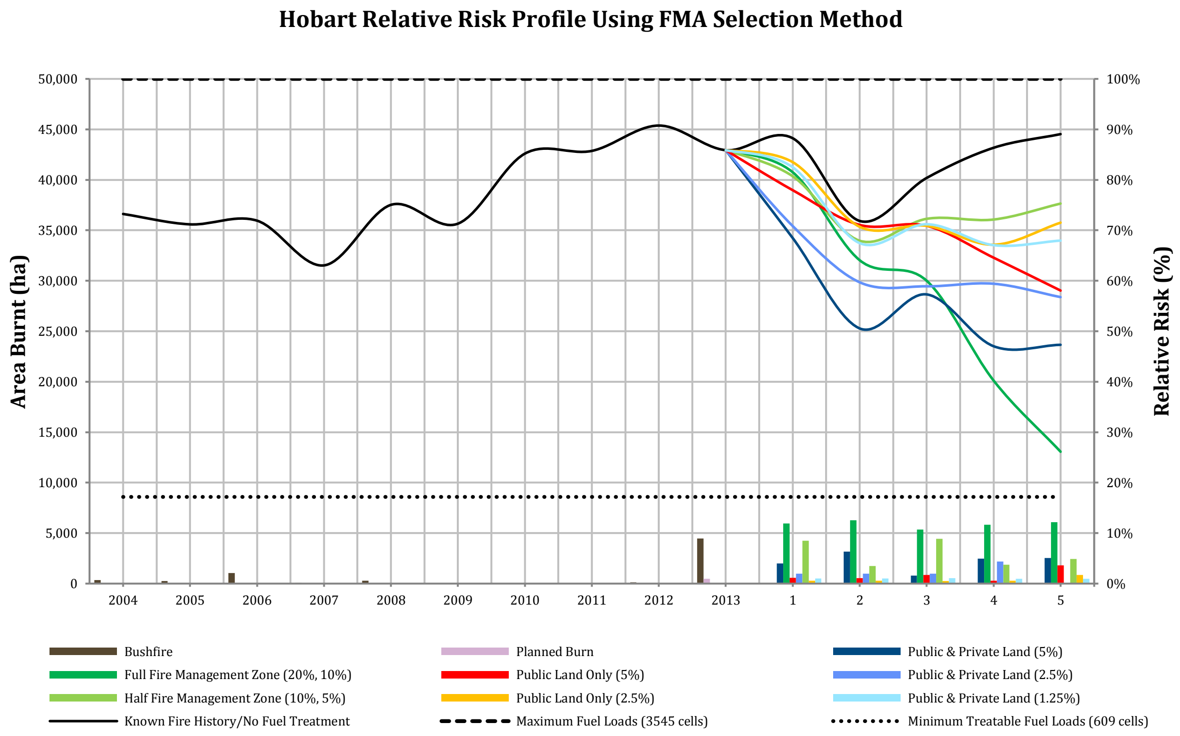

Figure 36: Relative risk profile for Hobart Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

Impacts were reduced significantly under the Full Fire Management Zone and the 5% Public and Private Land scenarios. The 1.25% Public and Private Land and 5% Public Land Only scenarios also appear to have considerably reduced bushfire impacts to below 70%. In the Half Fire Management Zone scenario, the FMA Selection method resulted in more reductions to Human Settlement Area impacts compared to the State Selection method because considerably more burning occurred within the FMA in Years 1 and 2. High intensity fire behaviour was only reduced significantly by the Full Fire Management Zone scenario. Fire size was only significantly reduced under the Full Fire Management Zone scenario using the FMA Selection method.

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TAMAR FIRE MANAGEMENT AREA

When compared to other FMAs, Tamar had a very high number of potential Human Settlement Area impacts under minimum treatable fuel load conditions (Figure 37), second to the Southern FMA. Tamar also had the lowest potential to reduce bushfire impacts with fuel reduction when compared to other FMAs like North East, Midlands and Hobart, considering that 48% (68,600 ha) of the vegetation mapped in the area is considered to be treatable (Figure 22 and Figure 23). This result indicates that a relatively high proportion of Human Settlement Areas are located within the vicinity of either untreatable vegetation or agricultural land with the potential to carry high intensity fire, compared to other FMAs.

The Full Fire Management Zone scenario significantly reduced asset impact, fire intensity and fire size. The Half Fire Management Zone using the State Selection method and the 5%, 2.5% and 1.25% Public and Private Land scenarios using the FMA Selection method reduced relative risk, but not so far as to be statistically significant.

Tamar Relative Risk Profile Using State Selection Method

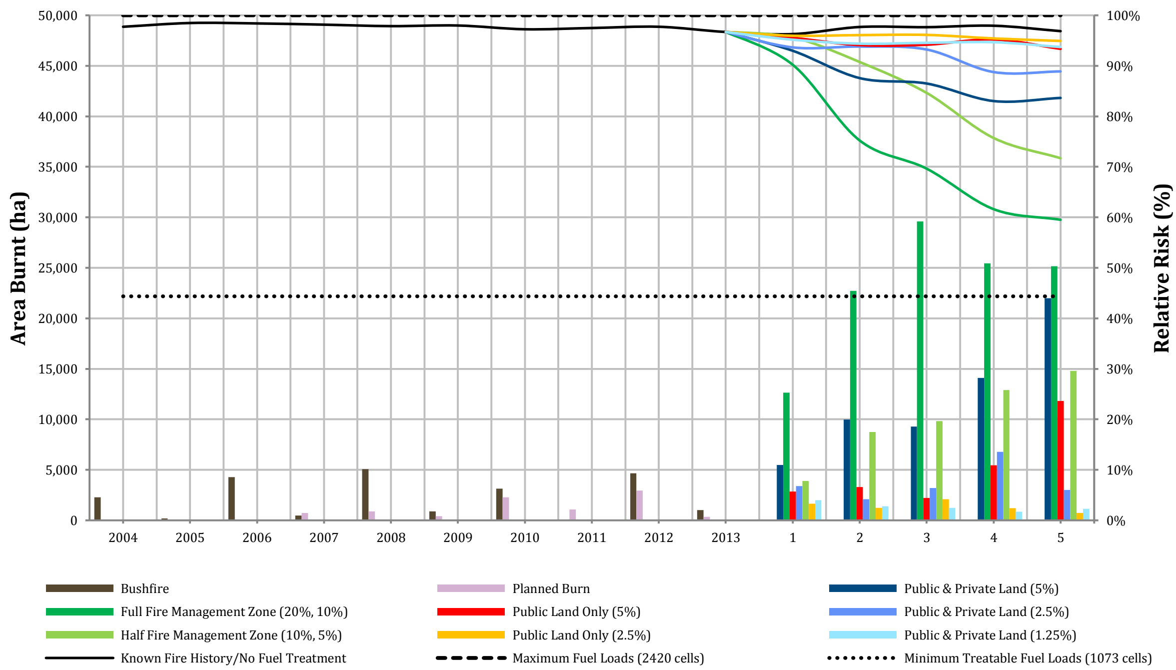

Figure 37: Relative risk profile for Tamar Fire Management Area using the State Selection method to reduce bushfire risk.

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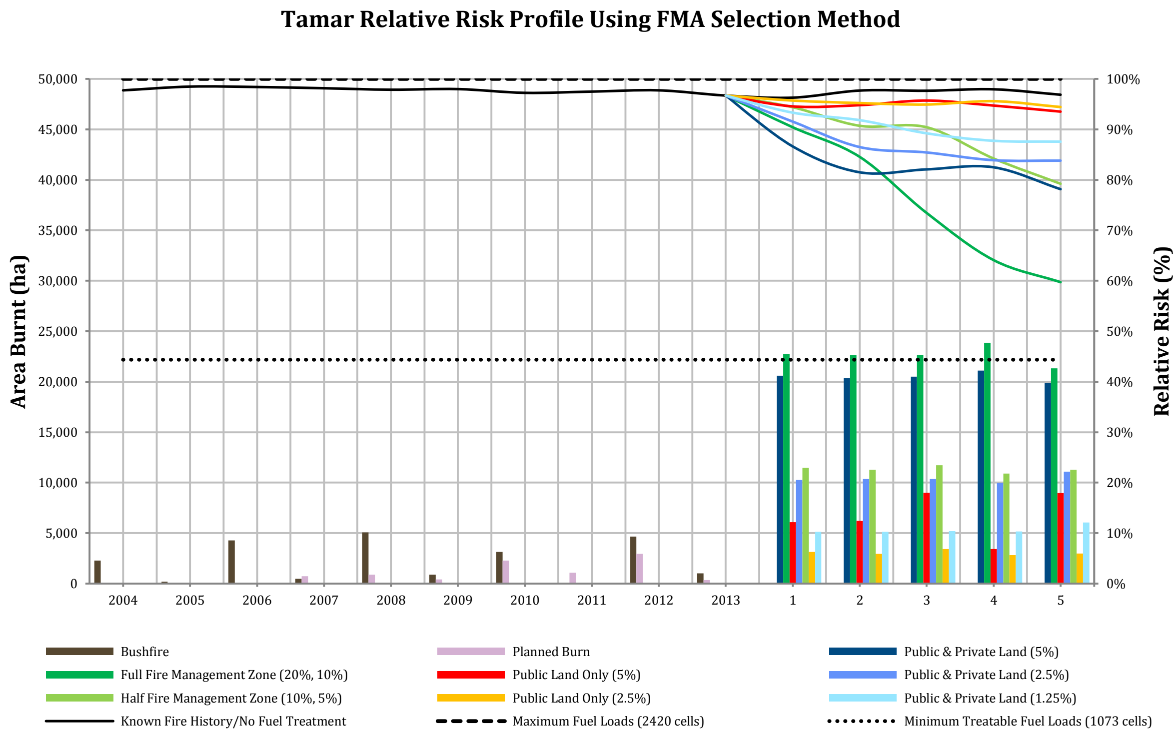

Figure 38: Relative risk profile for Tamar Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

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CENTRAL NORTH FIRE MANAGEMENT AREA

In the Central North FMA, the relative risk has reached its maximum potential. Central North only has around 5,500 ha (21%) of treatable vegetation within the entire FMA (Figure 23), much lower than most other FMAs. Despite this, there appears to be reasonable potential to reduce Human Settlement Area impacts with fuel reduction. The Full Fire Management Zone scenarios and the 5% Public and Private Land scenario using the State Selection method resulted in significant reductions in Human Settlement Area impacts. Furthermore, the remaining Public and Private Land scenarios, the Half Fire Management Zone scenarios and the 5% Public Land Only scenario using the State Selection method reduced impacts, but to a lesser extent (Figure 39 and Figure 40).

Fire intensity and fire size were significantly reduced in the 5% Public and Private Land scenario using the State Selection method. Using the same selection method, the 2.5% Public and Private Land scenario and the 5% Public Land Only scenario significantly reduced fire intensity, but not fire size.

Central North Relative Risk Profile Using State Selection Method

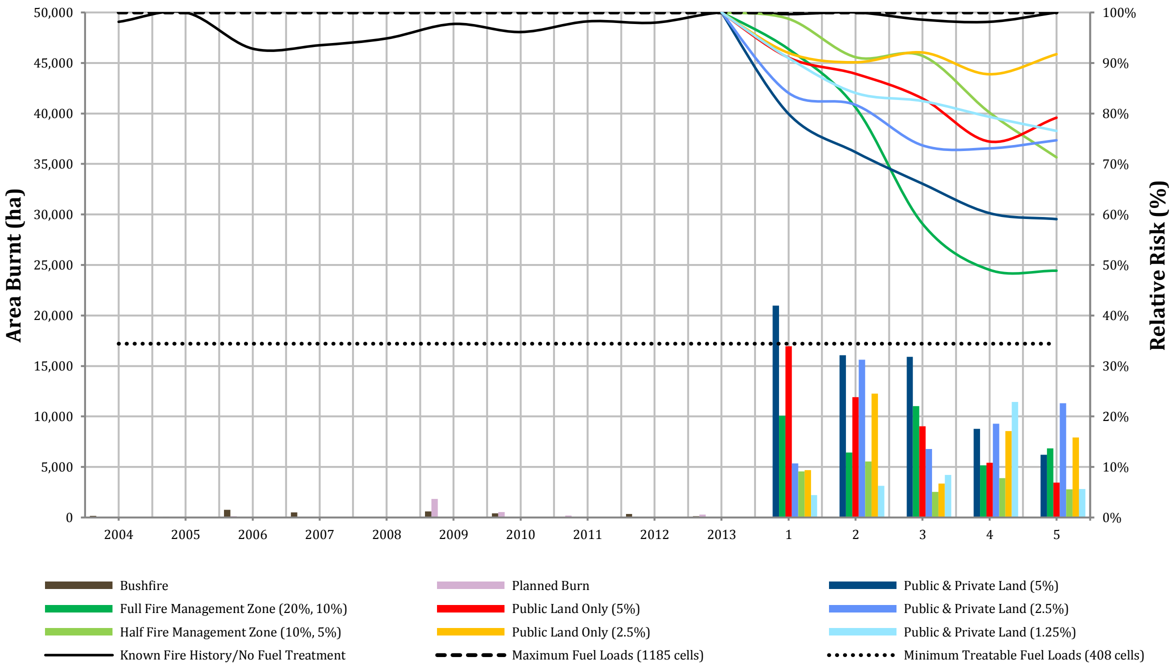

Figure 39: Relative risk profile for Central North Fire Management Area using the state management area selection method to reduce bushfire risk.

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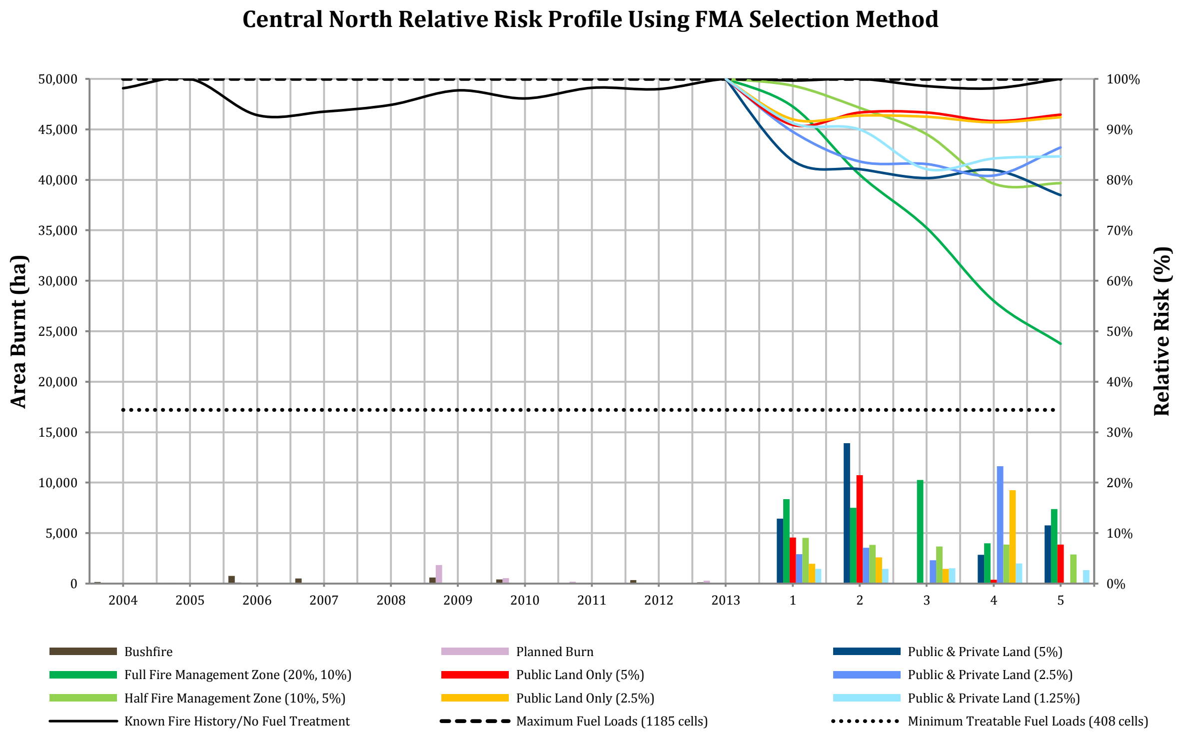

Figure 40: Relative risk profile for Central North Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

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East Coast Fire Management Area

Relative risk is currently at maximum levels in the East Coast FMA, largely because of the potential for fires to impact on Orford. This FMA has high potential to reduce impacts with fuel reduction, with a high proportion of area available for burning (63% or 23,000 ha) and the theoretical potential to reduce impacts to very low levels of around 14% (Figure 41). The Forcett-Dunalley fire in 2013 had very little impact on the relative risk profile for the area, because the modelled 99th percentile weather profile used in the modelling was far less severe resulting in a small number of modelled impacts, and only on the fringes of Human Settlement Areas. In comparison, the conditions experienced on the 4th of January 2013, were unusually severe and the worst ever recorded for the area. The analysis would have had to use weather profiles representing the worst-case scenario, rather than the 99th percentile, to replicate the impacts that occurred in the area.

By Year 5, relative risk reductions were quite similar, although there was a more pronounced reduction caused by the Full Fire Management Zone scenario using the FMA Selection method to reduce bushfire risk (Figure 42). The Full Fire Management Zone scenario produced significant reductions in Human Settlement Area impacts, with the 5%, 2.5% and 1.25% Public and Private Land scenarios reduce impacts considerably. Fire intensities and fire size were significantly reduced per ignition point by the 5% Public and Private Land scenarios, and the 2.5% Public and Private Land scenario using the State Selection method.

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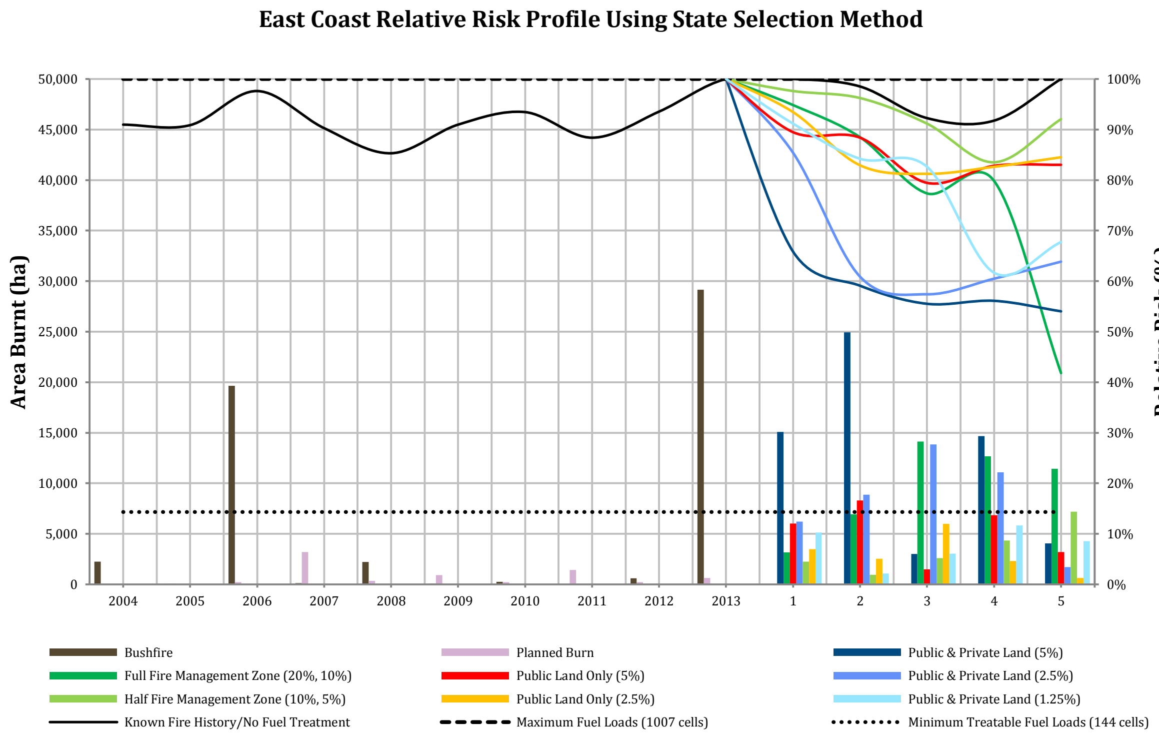

Figure 41: Relative risk profile for East Coast Fire Management Area using the State Selection method to reduce bushfire risk.

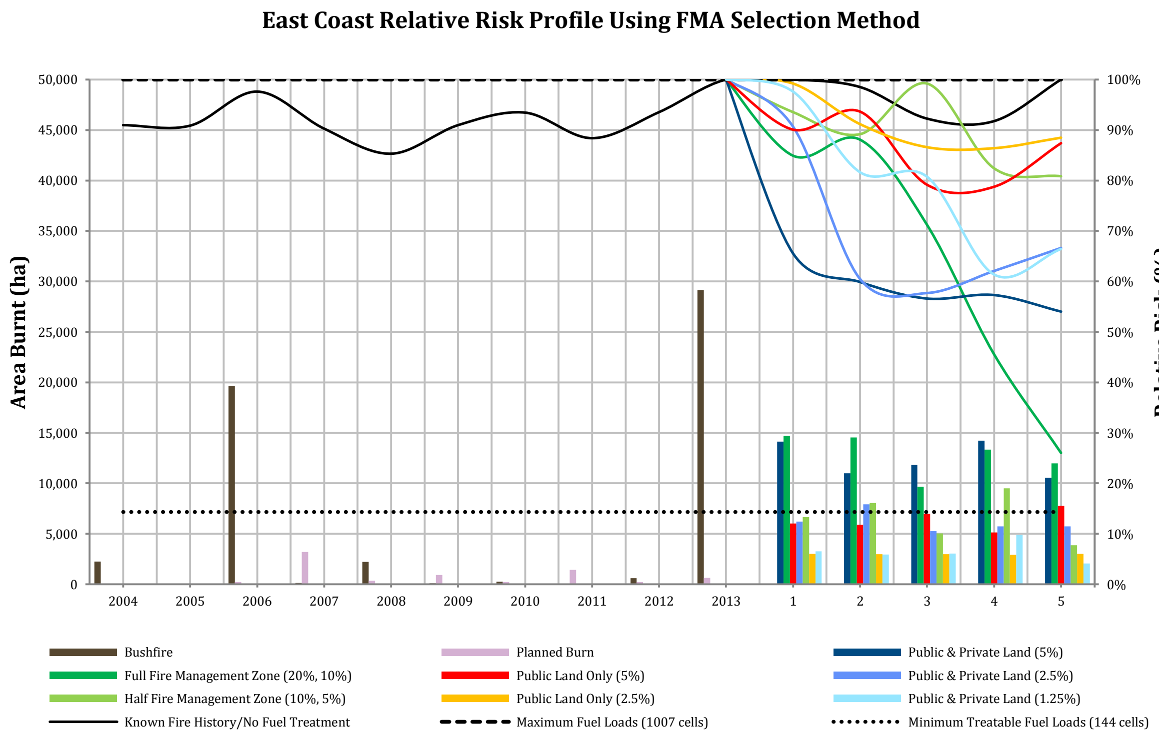

Figure 42: Relative risk profile for East Coast Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

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NORTH EAST FIRE MANAGEMENT AREA

Large areas of the North East FMA were burnt over the last 20 years, resulting in a relative risk that dropped to its lowest levels after the St Marys fire in 2006 (Figure 43). The relative risk profile has gradually increased since then, to the same level as before the St Marys fire at around 75%. If no further bushfires or fuel reduction occurred, predicted impacts to Human Settlement Areas are predicted to be near their maximum level in 2018. Northeast still has good potential to reduce Human Settlement Area impacts with fuel reduction. 45% or 38,000 ha of the vegetation is mapped as potentially treatable.

North East Relative Risk Profile Using State Selection Method

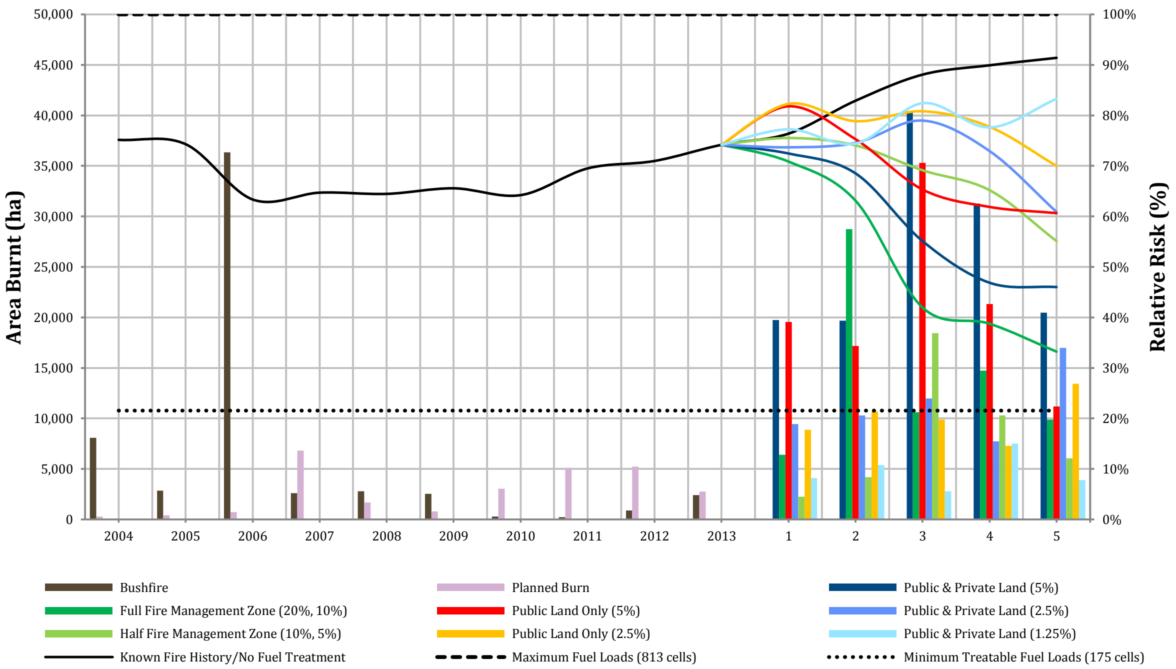

Figure 43: Relative risk profile for North East Fire Management Area using the State Selection method to reduce bushfire risk.

Over the five years of treatment, all scenarios either reduced impacts to lower than predicted under current fuel conditions or (as for the 2.5% Public Land Only and 1.25% Public and Private Land scenarios) resulted in bushfire impacts maintaining or increasing at slower rates than under the No Fuel Treatment scenario (Figure 43, Figure 44). The 5% Public and Private Land scenario using the State Selection method significantly reduced Human Settlement Area impacts, fire intensity and fire size. In contrast, the 5% Public Land Only scenario significantly reduced fire intensity and fire size, but without a significant reduction in Human Settlement Area impacts. Further reductions are summarised in Table 6.

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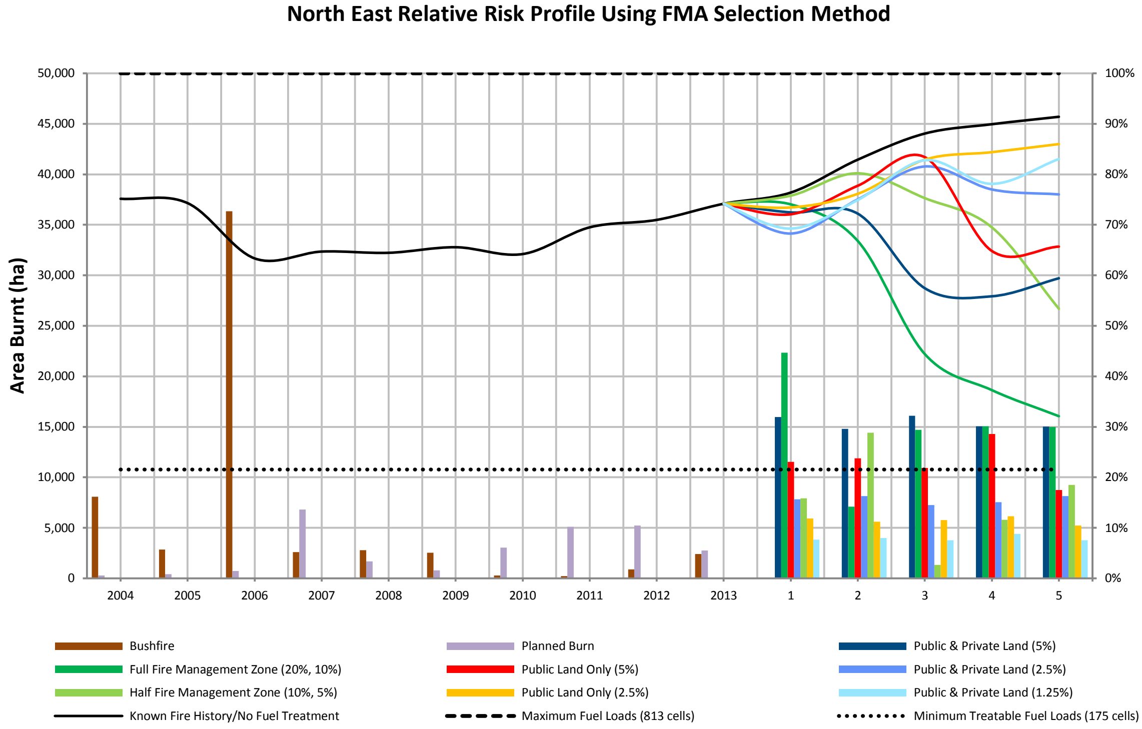

Figure 44: Relative risk profile for North East Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

Table 6: Statistically Significant Reductions in Human Settlement Impacts, Fire Intensity and Fire Size after Year 5 of Treatment in the North East Fire Management Area.

Treatment Scenarios	HSA Impacts	Fire Intensity	Fire Size
FMA Full Fire Management Zone (20%, 10%)	X	X	
FMA Half Fire Management Zone (10%, 5%)	X		
FMA Public and Private Land (5%)			
FMA Public and Private Land (2.5%)			
FMA Public and Private Land (1.25%)			
FMA Public Land only (5%)			
FMA Public Land Only (2.5%)			
State Full Fire Management Zone (20%, 10%)	X	X	
State Half Fire Management Zone (10%, 5%)	X		
State Public and Private Land (5%)	X	X	X
State Public and Private Land (2.5%)			
State Public and Private Land (1.25%)			
State Public Land only (5%)		X	X
State Public Land Only (2.5%)			

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MIDLANDS FIRE MANAGEMENT AREA

The relative risk for the Midlands FMA is currently close to its maximum potential. However there is good potential to reduce risk using fuel reduction. All fuel reduction scenarios measured considerable reductions in Human Settlement Area impacts, with the greatest reductions resulting from all of the Fire Management Zone and the 5% Public and Private Land scenarios (Figure 45, Figure 46). Midlands is characterised by considerably smaller and more fragmented Human Settlement Areas than the FMAs mentioned previously in this section.

The most effective fuel reduction scenario was the 5% Public and Private Land scenario using the State Selection method, significantly reducing Human Settlement Area impacts, fire intensity and fire size (Table 7).

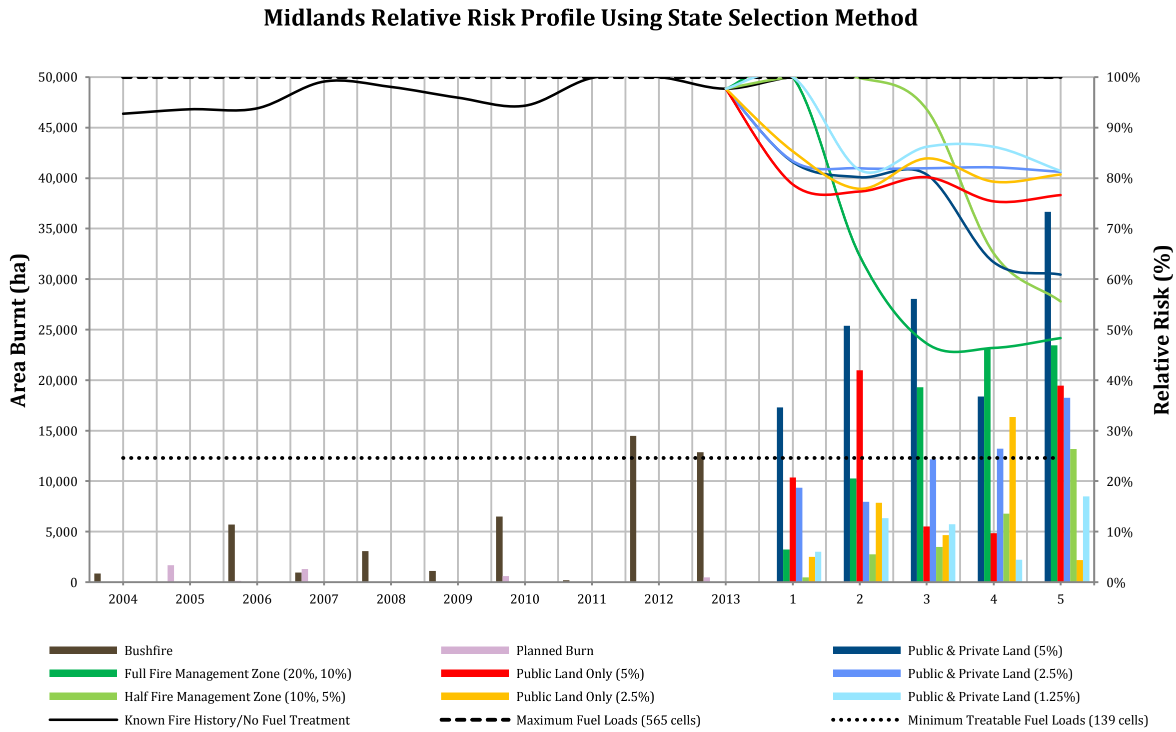

Figure 45: Relative risk profile for Midlands Fire Management Area using the State Selection method to reduce bushfire risk.

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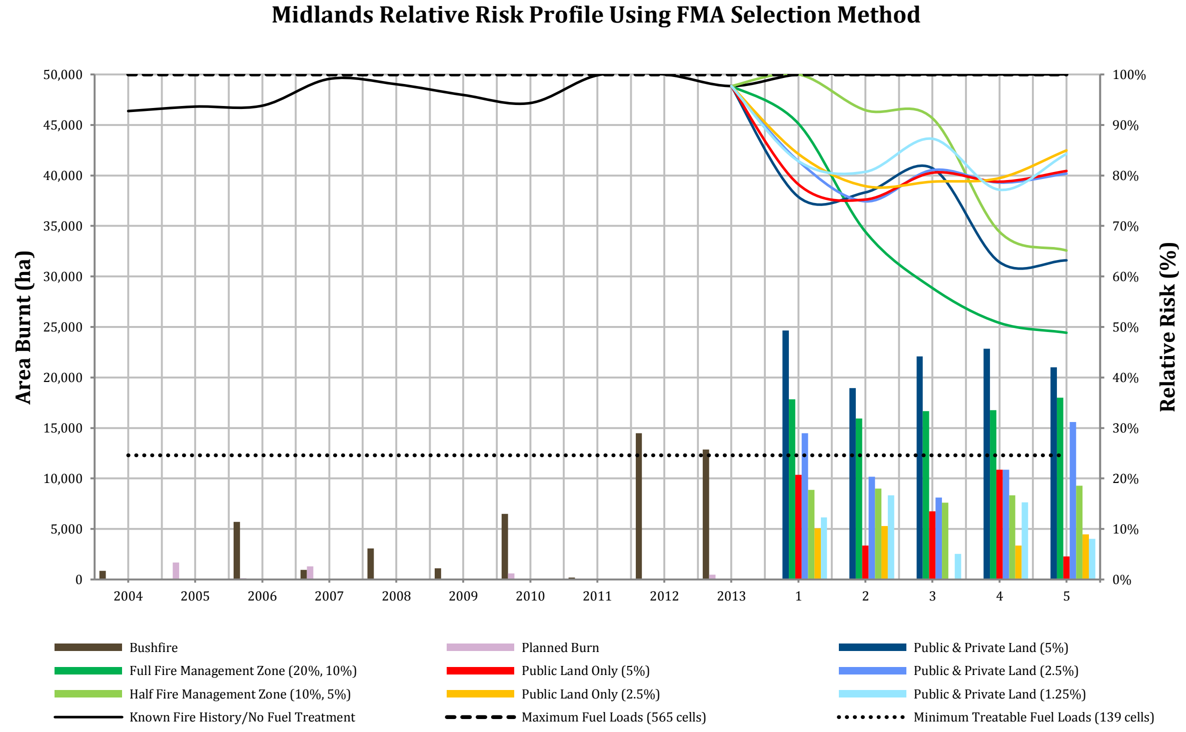

Figure 46: Relative risk profile for Midlands Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

Table 7: Statistically Significant Reductions in Human Settlement Impacts, Fire Intensity and Fire Size after Year 5 of Treatment in the Midlands Fire Management Area.

Treatment Scenarios	HSA Impacts	Fire Intensity	Fire Size
FMA Full Fire Management Zone (20%, 10%)	X		
FMA Half Fire Management Zone (10%, 5%)			
FMA Public and Private Land (5%)		X	X
FMA Public and Private Land (2.5%)			
FMA Public and Private Land (1.25%)			
FMA Public Land only (5%)			
FMA Public Land Only (2.5%)			
State Full Fire Management Zone (20%, 10%)	X		
State Half Fire Management Zone (10%, 5%)			
State Public and Private Land (5%)	X	X	X
State Public and Private Land (2.5%)			
State Public and Private Land (1.25%)			
State Public Land only (5%)			
State Public Land Only (2.5%)			

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West Coast Fire Management Area

The relative risk graphs and statistical results are summarised here for the West Coast FMA. However given the nature of the vegetation types and weather profiles for the area, there is relatively low confidence in these results and a different approach to assessing relative risk in the West Coast FMA should be considered.

According to the residual risk profile, relative risk is currently close to its maximum potential. Large areas have been burnt over the last 40 years, although most of the burning has not been close to Human Settlement Areas. The scenarios indicate relatively small reductions in relative risk after five years of treatment overall, however the reductions appear to be about a quarter to a third of the maximum potential reduction to relative risk indicated by the dotted line (Figure 47, Figure 48). None of the fuel reduction burning scenarios produced statistically significant reductions in Human Settlement Area impacts, fire intensity or fire size.

West Coast Relative Risk Profile Using State Selection Method

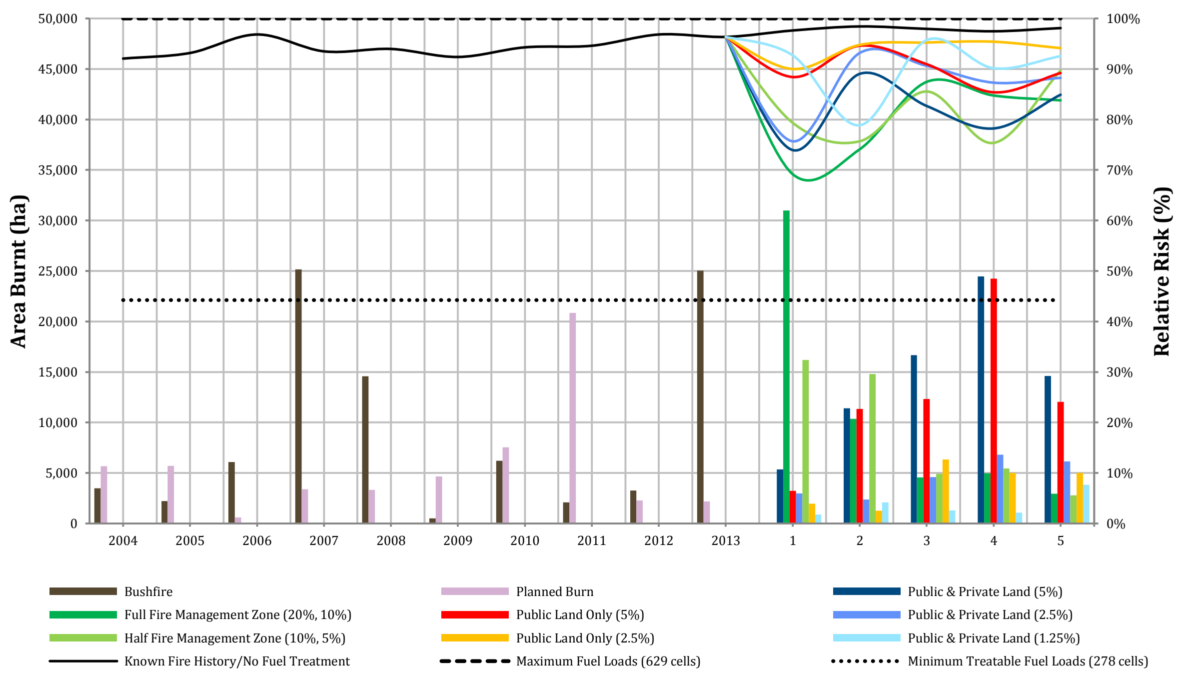

Figure 47: Relative risk profile for West Coast Fire Management Area using the State Selection method to reduce bushfire risk.

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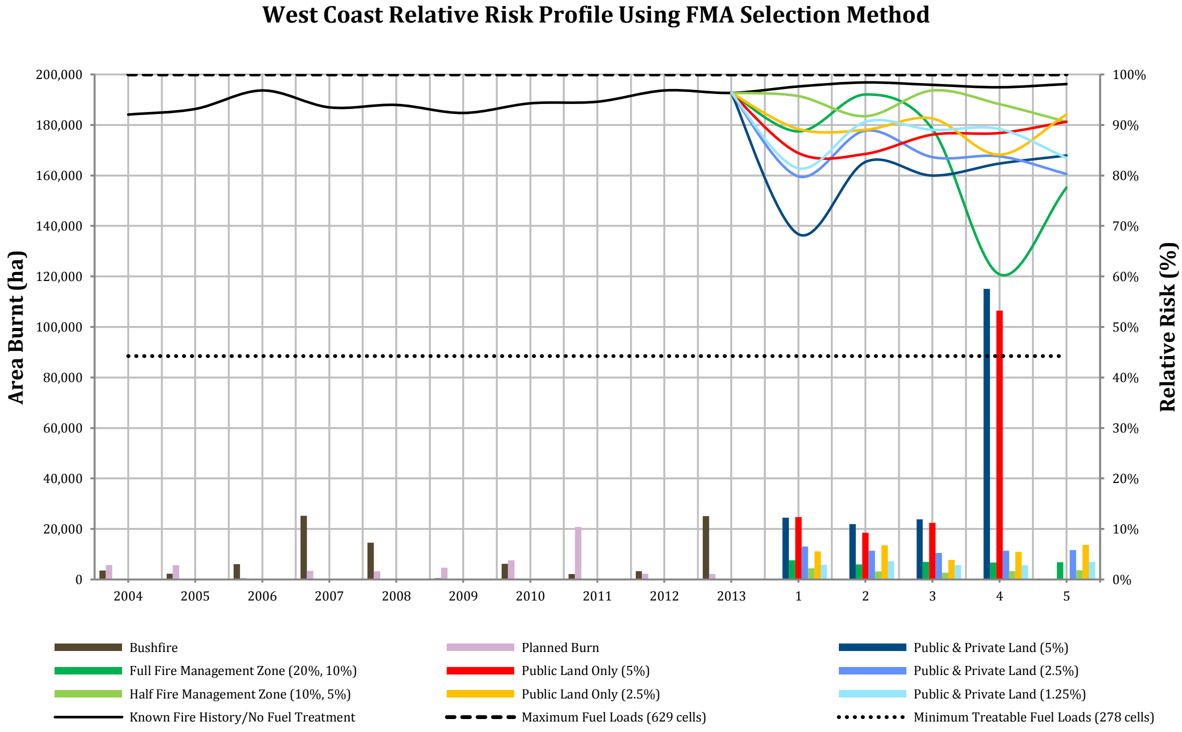

Figure 48: Relative risk profile for West Coast Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

An analysis of the BRAM HFI in the West Coast FMA (showed a steady potential increase in fire intensity over time, indicating that currently a considerable area of fuels in the West Coast FMA have not currently reached their maximum potential accumulation, due to the role that fire has played in the FMA up until now. These results that the 5% Public Land Only scenario had the greatest effect on reducing the rates of fuel accumulation, and therefore increases in fire intensity.

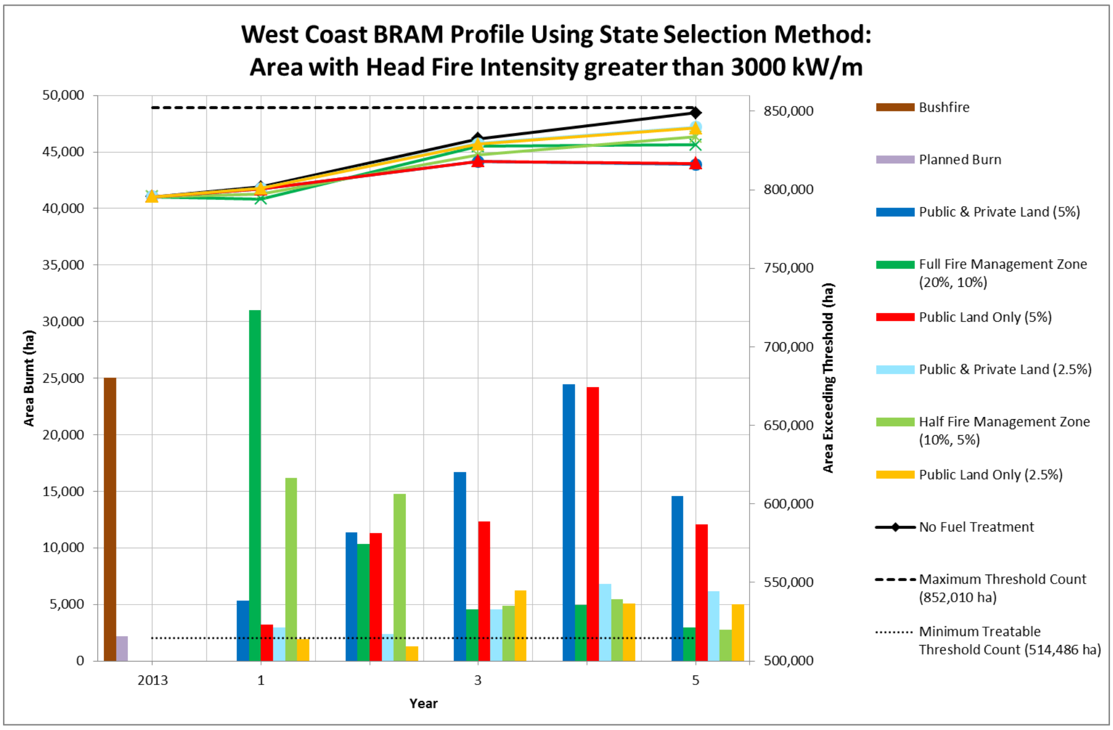

Figure 49. Area (ha) that exceeded 3,000kW/m of maximum Bushfire Risk Assessment Model head fire intensity in Years 1, 3 and 5 of fuel treatment in the King Island Fire Management Area.

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FLINDERS FIRE MANAGEMENT AREA

Six Human Settlement Areas were identified on Flinders Island. At Lady Barron, 21 Human Settlement Area grid cells were impacted under current and maximum fuel load conditions, with only 2 impacted under minimum fuel load conditions (Figure 50, Figure 51). These results indicate that there is potential to use fuel reduction to treat potential bushfire risk in the area directly north of Lady Barron. Reductions in 2011 and Year 2 of No Fuel Treatment appear to be coincidental, affecting only one grid cell. Each of the tenure-blind scenarios reduced impacts by at least 20% by Year 5 of treatment. By Year 5 the Public Land Only scenarios had very little effect, only reducing impact to one grid cell.

Flinders Relative Risk Profile Using State Selection Method

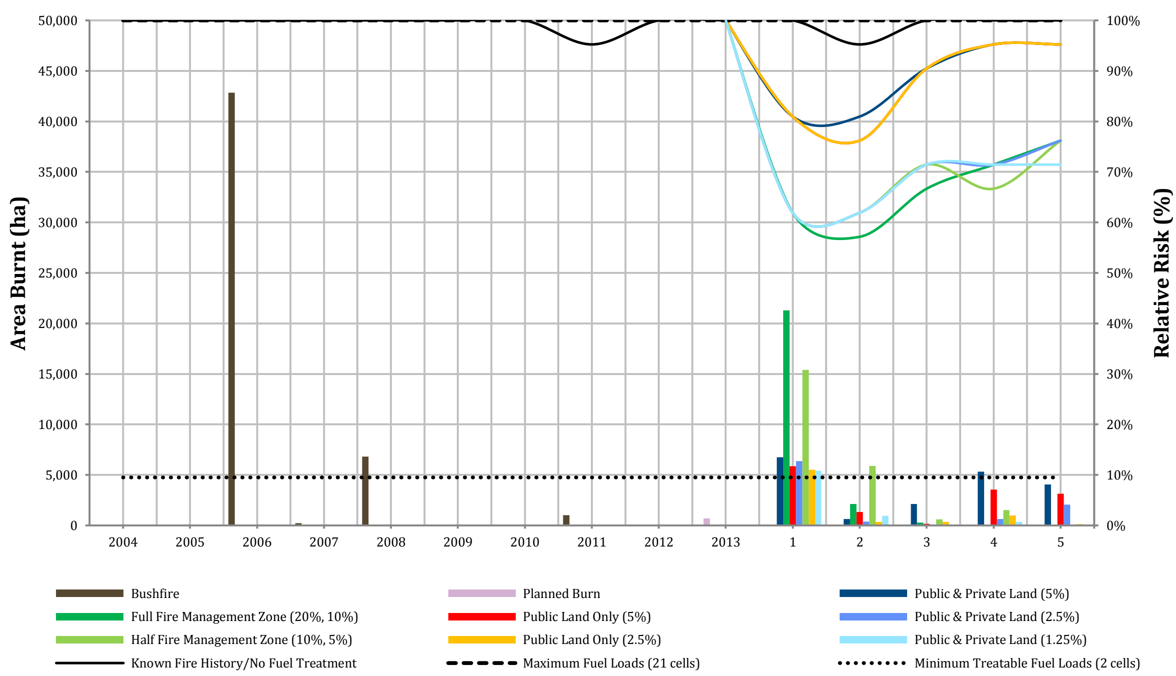

Figure 50: Relative risk profile for Flinders Fire Management Area using the State Selection method to reduce bushfire risk.

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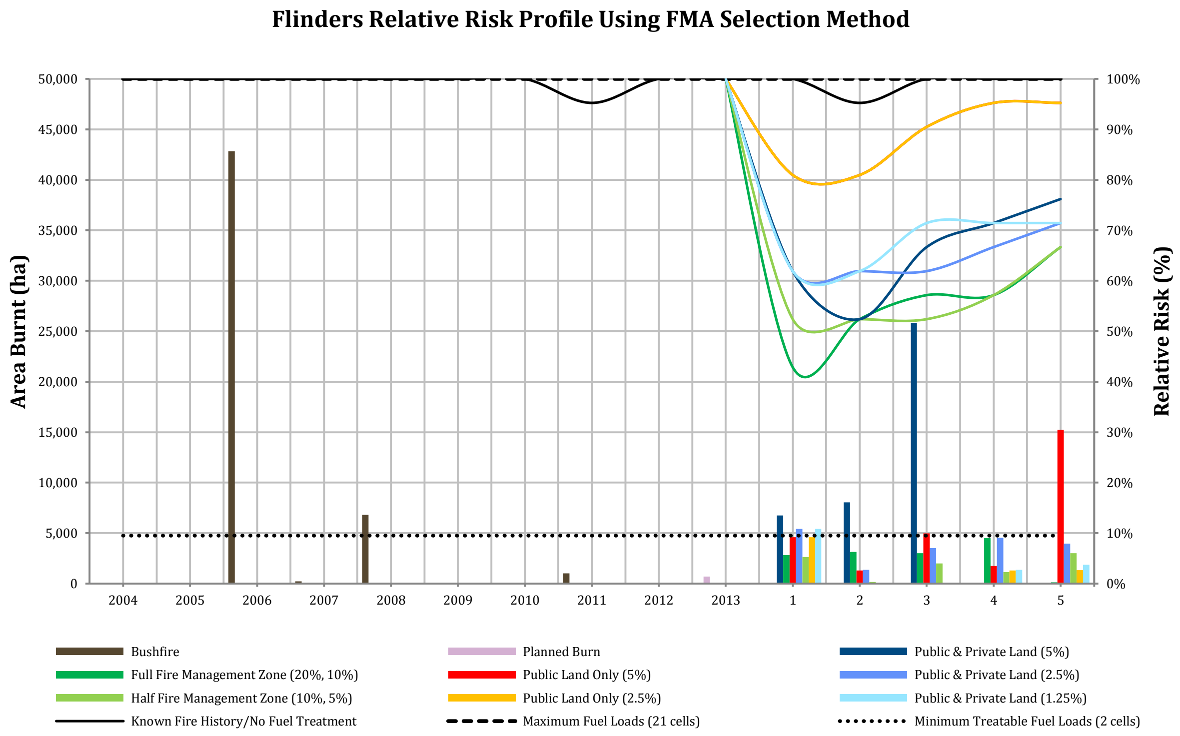

Figure 51: Relative risk profile for Flinders Fire Management Area using the Fire Management Area selection method to reduce bushfire risk.

The sample size was too small to perform a statistical analysis. The Public Land Only scenarios appear to have some small reduction in fire intensity into the more manageable category (i.e. below 3000kW/m), approximately 25 hectares of the modelled fires by Year 5. The No Fuel Treatment scenario saw a small increase in high intensity fire by Year 1 (Figure 52).

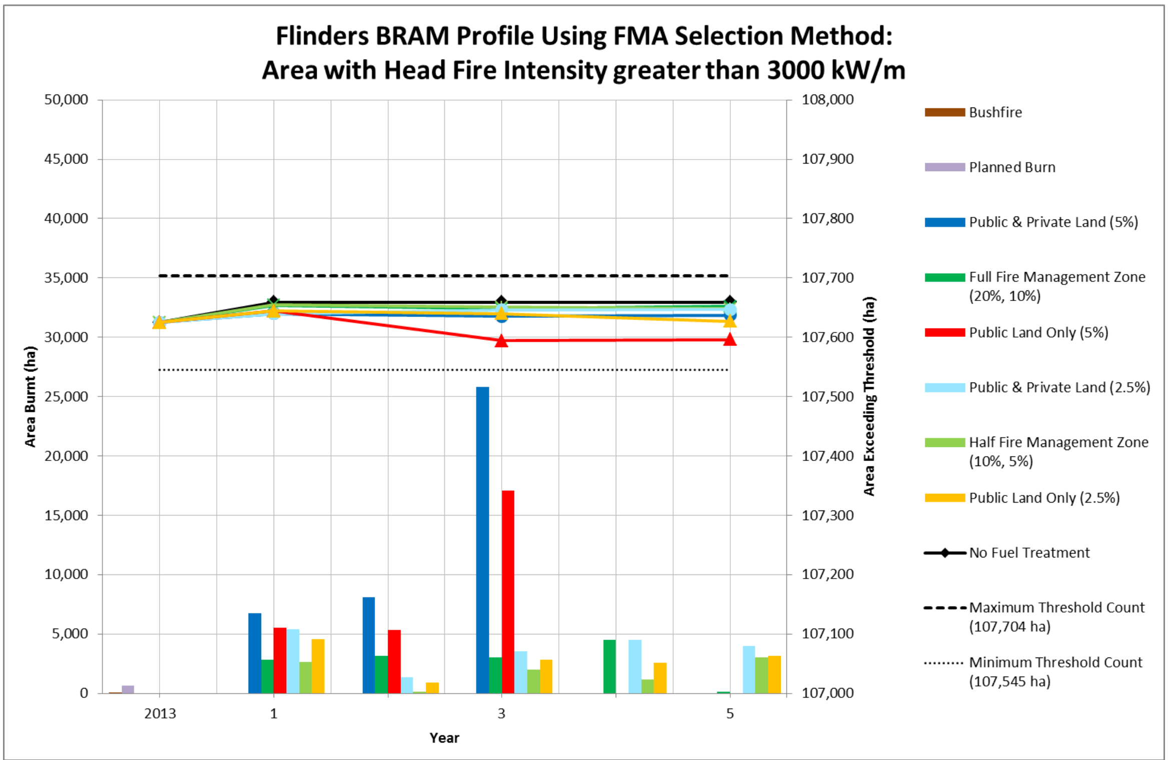

Figure 52: Area (ha) that exceeded 3,000kW/m of maximum Bushfire Risk Assessment Model head fire intensity in Years 1, 3 and 5 of fuel treatment in the Flinders Fire Management Area.

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KING ISLAND FIRE MANAGEMENT AREA

Fuel reduction burning scenarios were developed for King Island; however the fire modelling in Phoenix did not result in any impacts to the Human Settlement Areas identified on the island. Relative risk profiles could not be generated to measure how impacts change over time.

The reductions in fire intensity were plotted in Figure 53 and Figure 54 to see how the burning scenarios reduced fire intensities to more manageable levels. Considerable reductions in fire intensity were predicting using BRAM HFI, where several thousand hectares of area was reduced into the more manageable potential fire intensity category in Years 1 and 5 when the fuel reduction burning used the FMA Selection method.

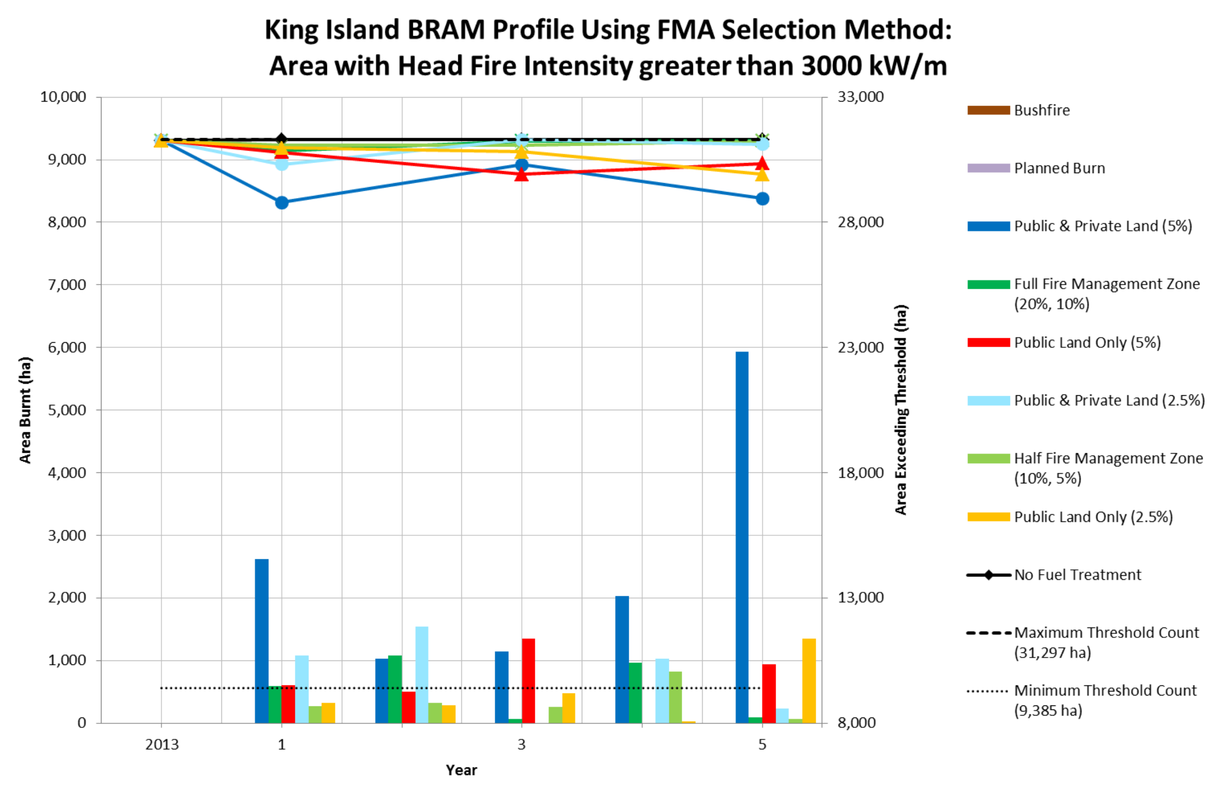

Figure 53: Area (ha) within 10km of Human Settlement Areas that exceeded 3,000kW/m of maximum Bushfire Risk Assessment Model head fire intensity in Years 1, 3 and 5 of fuel treatment in the King Island Fire Management Area.

ISBN: 978-0-9925970-0-9

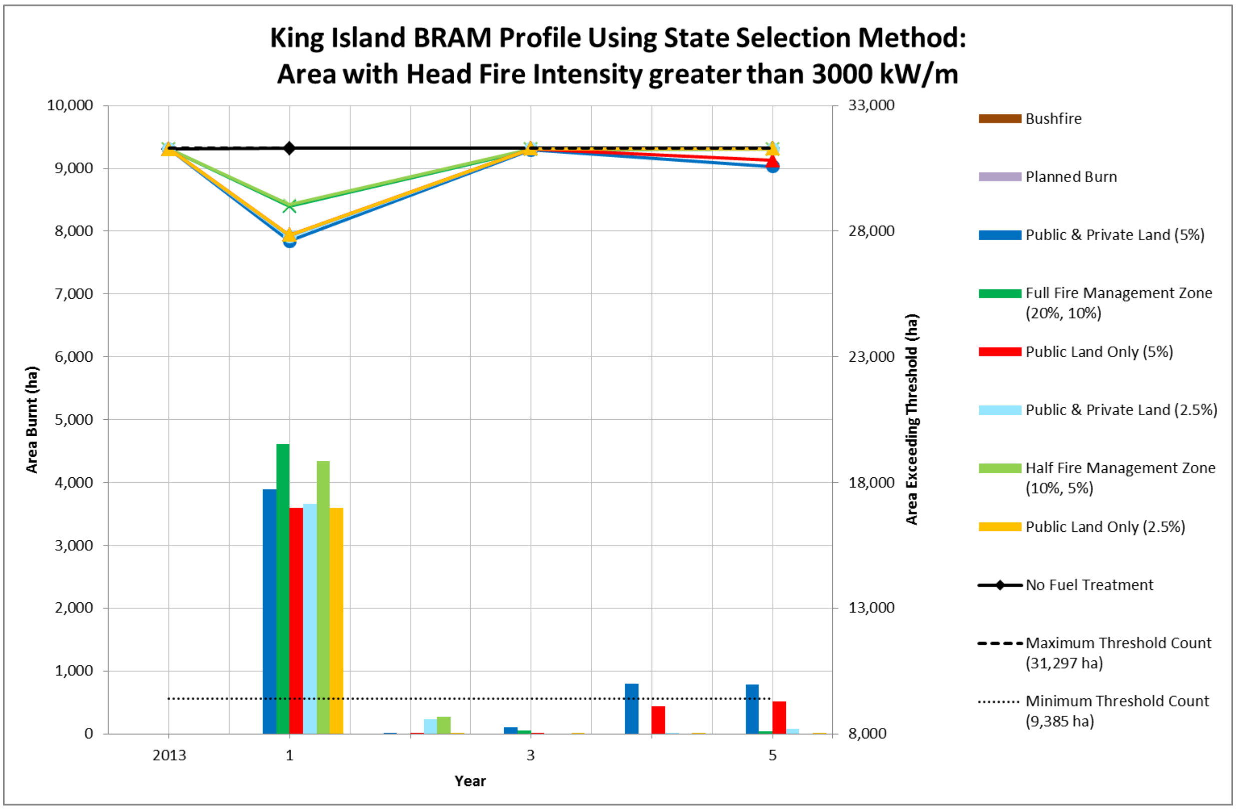

Figure 54: Area (ha) that exceeded 3,000kW/m of maximum Bushfire Risk Assessment Model head fire intensity in Years 1, 3 and 5 of fuel treatment in the King Island Fire Management Area.

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IMPLEMENTATION OF A STRATEGIC BURNING PROGRAM

THE PROCESS

The implementation of a strategic burning program is not a single step process. Rather it is based on risk assessment and planning principles similar to those outlined in the National Emergency Risk Assessment Guidelines (National Emergency Management Committee, 2010). As discussed previously in this report, burning priorities are identified through a bushfire risk assessment that considers a range of bushfire mitigation options. This report has demonstrated how strategic fuel reduction burning can significantly reduce impacts to communities, but doesn't entirely eliminate risk. Therefore burning will be one of a combination of mitigation options that are considered to strategically reduce bushfire risk.

Figure 55 illustrates where burning occurs in the risk assessment and mitigation process; thereby highlighting that burning cannot occur without the appropriate planning, preparation and resources. It is important to note that a considerable amount of this work can be completed outside of the burning season; which maximises the use of suitable conditions.

THE EFFECTS OF SEASON AND WEATHER ON BURNING OPPORTUNITIES

Daily and seasonal weather patterns have a very strong influence on the success of a fuel reduction burning program. The annual planned burning programs in Tasmania show considerable variability in the area burnt each year, largely due to the effects of weather (Table 1). Planned burning is conducted within a set of weather parameters to manage the burn within the appropriate boundaries and with the resources that are available. The aim is to achieve a set of objectives inclusive of crew and public safety, fire size and intensity (Marsden-Smedley, 2009).

With training and experience, practitioners develop an understanding of seasonal weather patterns that affect fuel moisture. The potential success or failure of a burn is monitored by checking the state of the fuels on site, and by using a variety of weather and atmospheric observations and forecasts to determine whether the conditions will be suitable for burning.

Planned burning weather windows were mapped for Tasmania based on the nearest relevant weather station. Figure 56 provides a very general indication of the average number of days each year where weather conditions may fall within the guidelines for prescribed burning, not taking into account the effects of weather on smoke dispersion and excluding days during the peak of summer. This map provides a very general guide and doesn't take into account differences in elevation and aspect that can result in considerable differences in on-site weather conditions when compared to the conditions measured at a weather station.

This map was presented to a workshop in May 2014, where experienced fire practitioners from SFMC, Parks and Wildlife Service, Tasmania Fire Service and Forestry Tasmania agreed that this map provided a good indication of how the availability of burning windows can vary considerably across the state. There are no hard boundaries (as are drawn on this map) between regions. However, there was a general consensus that there are considerably fewer days available for burning each year in western, central and highland areas of Tasmania compared to the coastal areas in the southeast, east, northeast and central north.

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Figure 55: Steps for implementation of a strategic burning program.

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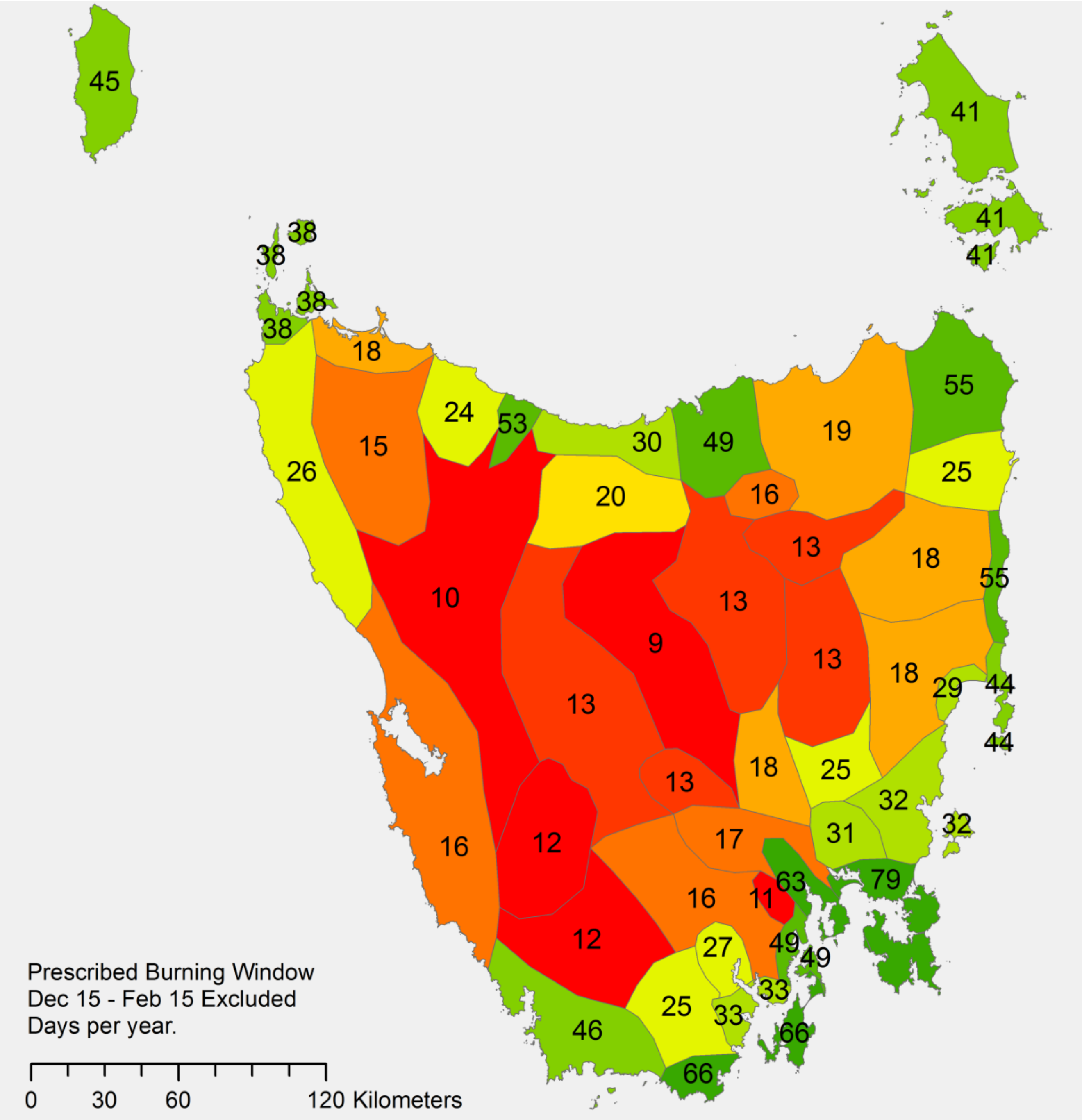

Figure 56: Average number of days per year when weather observations fell within the full range of prescribed burning weather guidelines described in (Marsden-Smedley, 2009). Days during peak fire danger, between December 15 and February 15, have been excluded.

There are periods in the burning season where weather conditions can be favourable across a large area, but resources are not available to conduct all of the burns on a single day. In these situations, burning is prioritised to those areas with narrower burning windows so burns are completed before opportunities are lost as seasonal weather conditions change. Figure 56 can also provide some context to understand the amount of effort required during the burning season to complete a burning program before the opportunities for burning are lost. Employees in the Tasmanian fire and land management agencies can be required to leave their normal duties, and seasonal and contract fire crews are called upon so that there are sufficient resources to complete the burning program while the conditions are suitable.

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IMPLEMENTATION ISSUES

For a program of this scale a comprehensive communication strategy, issues analysis and stakeholder analysis will be required. Some of the key issues that will need to be addressed may include, but will not be limited to:

- Community acceptance of an expanded planned burning program
- Explaining the limitations of different mitigation activities; some areas will always be prone to high bushfire risk even after all mitigation options have been implemented
- Access to private lands to undertake risk mitigation activities
- Smoke and public health impacts
- The effects of an expanded fuel reduction burning program on other burning programs that are regulated by smoke restrictions
- The visual impacts of smoke and charring in the landscape, including their effects on tourism
- Balancing risk mitigation actions with environmental impacts
- Workforce capacity to implement a program of this scale.

There is a potential that the Tasmanian public will find a high level of fuel reduction burning unacceptable. This could be for a number of different reasons, including high levels of smoke, escapes from planned burns onto non-target areas or resentment with regards to providing access to private property for burning.

On the other hand, it is evident to fire managers that following the devastating Tasmanian fires of January 2013, the public acceptance of smoke nuisance from fuel reduction burning is much higher that it was prior to these fires. This was illustrated by the Mt Direction fuel reduction burn of May 2013 which created significant smoke over Hobart's Eastern Shore suburbs for several nights; however, no complaints from the public were received by the EPA. Never-the-less, it is conceivable that with frequent burning around towns and settlements every autumn and spring this social acceptance declines over time, particularly if Tasmania experiences several quiet bushfire seasons. It will be essential that communication, public education and stakeholder engagement are planned and implemented to ensure that the Tasmanian public understand the benefits of fuel reduction burning, the limitations and the timing behind the strategies.

Through the Forest Practices Authority and the Environmental Protection Authority, a coordinated smoke management strategy is in place to manage the amount of smoke in the atmosphere. This system is currently only used by the forest industry and the PWS. While 'smoke trading' does occur (i.e. the participants work together to limit the total amount of smoke produced in an airshed each day) it is not prioritised on a burn objective basis. Regardless, it is certain that the burning required by a targeted risk reduction program will result in communities being affected at times, even when the best information is used to manage the timing of burns in relation to forecast smoke dispersion. A good notifications process will provide current information and expected developments to the community, allowing them to prepare for the event. There are also concerns regarding the impacts of smoke on some agricultural activities, particularly apiculture and viticulture. It will be essential to work closely with relevant groups as burns are implemented in areas, and to be as flexible as possible with program implementation.

Tasmania's capacity to implement an increased fuel reduction burning program is a significant issue that is not unique to Tasmania. The implementation of the Victorian, West Australian and South Australian programs has been hampered by not having sufficient resources available on the days when successful burning is achievable. Also, it has taken time to build up the appropriate skills and experience to implement the burns, particularly those that are complex. Within Tasmania, filling these positions with the right skills and experience can mean losing that expertise from the other fire management agencies, where it will still be required.

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Certainly there are opportunities to engage contractors to undertake much of the work, particularly in fire trail maintenance and preparatory works. There is also an exciting opportunity to offer training and employment programs, though much of the work is very seasonal in nature. Volunteer brigades will also certainly be part of the implementation however it is acknowledged that many also have to keep their own work and business commitments. In both South Australia and Victoria it took three years to build up their plans and workforce to get their burning programs working on an ongoing basis.

LEGISLATIVE AND POLICY CONSIDERATIONS

As demonstrated in the results, the most effective risk mitigation program is achieved when action is taken on both private and public lands. Most private landowners do not have the skills, training and equipment to undertake fuel reduction burning on their own land. Therefore this raises issues of liability and treatment of risk on private tenure for a greater community good if government is going to take a role in burning on private land.

Table 8 provides a summary of legislation that is relevant, and some of the issues that will need to be managed in the implementation of a burning program. Whilst this list looks intimidating, many of these are the issues that are already accounted for by public land managers and established procedures are in place. Most can be managed through a careful planning process undertaken by experienced practitioners.

Table 8: Relevant legislation and policies for implementation of a strategic burning program

Act	Comments and Possible Issues
Emergency Management Act 2006	The Act of precedence for all emergency risk mitigation and has power to override other legislation to enable mitigation. In effect, supports section 49 of the *Fire Service Act 1979*. The planning framework for the Fire Protection Plans sits under the Tasmanian Emergency Management Plan, authorised under this Act. The fire protection plans, developed through the FMACs, are a key document to prioritise bushfire risk treatment programs and the identification of strategic management areas.
Fire Service Act 1979	Section 49 details the treatment of fire hazards, including vegetation, on private property. There are some provisions that may need amendment to enable fuel reduction burning on private property by third parties. Section 121 details the liability provisions within the Act.
Environmental Management and Pollution Control Act 1994	*Environment Protection Policy (Air Quality) 2004*, section 17 specifies requirements for planned burning. Clarification of policy is required to avoid possible prosecution for smoke nuisance.
Water Management Act 1999 / State Policy on Water Quality Management 1997	Requirement (section 34 of policy) to comply with Forest Practices Code.
Threatened Species Protection Act 1995	There are situations where a permit is required to 'take' by burning any threatened species known to occur in burning blocks. This will be identified during the planning
Aboriginal Relics Act 1975	Burning will not directly destroy most common Aboriginal sites, but may expose them to other kinds of disturbance. Also the use of machinery in preparatory works has the potential to destroy Aboriginal sites. The planning process must identify when and

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Act	Comments and Possible Issues
	where permits may be required.
State Coastal Policy 1996	Section 1.1.11: 'Fire management, for whatever purpose, shall be carried out in a manner which will maintain ecological processes, geomorphologic processes and genetic diversity of the natural resources located within the coastal zone.' Clarification to enable fuel reduction burning may be required.
Local Government Act 1993	Section 200: Nuisance and abatement are instruments that are currently being used. They could be reviewed in their application, especially on the basis of bushfire risk; however, are largely used at a very localised scale.
Forest Practices Act 1985	Regulation 5(g): The FPA has recognised in writing the environmental impact assessment process used by PWS. Clarification of FPA policy will be required.
National Parks and Reserves Management Act 2002	A standard objective for all classes of reserved land is to protect against, and rehabilitate following, the adverse impacts of fire. Managing authority may do what is necessary to prevent bushfires.
Environment Protection and Biodiversity Conservation Act 1999	Referrals to Commonwealth Government are possible; however this would be identified through the planning process.
Forest Practices Code 2000	Set standards for activities on lands managed for commercial forestry, including conducting of burns.
Tasmanian Electricity Code 2005	The outcomes of the fire protection plans may impact the clearances required in different areas based on bushfire risk.

Implementation Costs

The cost of fuel reduction burning cannot easily be measured as an absolute dollar value. While the forest industry and Parks and Wildlife Service run annualised burning programs, there is no exclusive workforce for program delivery. Rather, staff preparing for a planned burn will simultaneously be engaged in other land management responsibilities, for example supervising harvesting operations or facilities maintenance. This is in part due to the fact that a large part of any burning program is embedded into normal day to day works.

Forestry Tasmania (FT) has contracted out some of their expertise to provide fire management services. Based on records kept for the last ten years, individual burns under that program have been costed. Similarly, Hobart City Council (HCC) investigated the cost of contractors delivering their fire management program. Included in these costs were the following:

- the time and administrative resources required to plan the management of the burn through to its completion;
- managing and paying for machinery and labour to construct or maintain fire boundaries;
- monitoring weather and fuel conditions in the weeks and days leading up to the burn;
- administrative and logistical management of the burn on the day, including the notification of all relevant stakeholders about when and where the burn will occur;
- labour and machinery required to light the burn, including days where those resources were deployed to the site, but conditions weren't suitable to carry out the burn;
- labour and machinery required to suppress and monitor the burn until it is considered safe;

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- recovery costs including monitoring the recovery of the burn site, reporting to stakeholders, cost-recovery, and post-fire review.

The costs were highly variable between each individual burn, in both resourcing requirements and a per hectare dollar value. For example several thousand hectares of remote area button-grass can be burnt with 4 people and 1 helicopter, for less than $50 per hectare. Whereas a 5 hectare burn directly on the urban interface, requiring many fire crews for a minimum of 2 days was estimated at over $1000 per hectare. From this information the relative difference in cost between burning in close to communities versus burning in more remote areas has been expressed in Figure 57 below. It was beyond the scope of this project to undertake a full cost-benefit analysis.

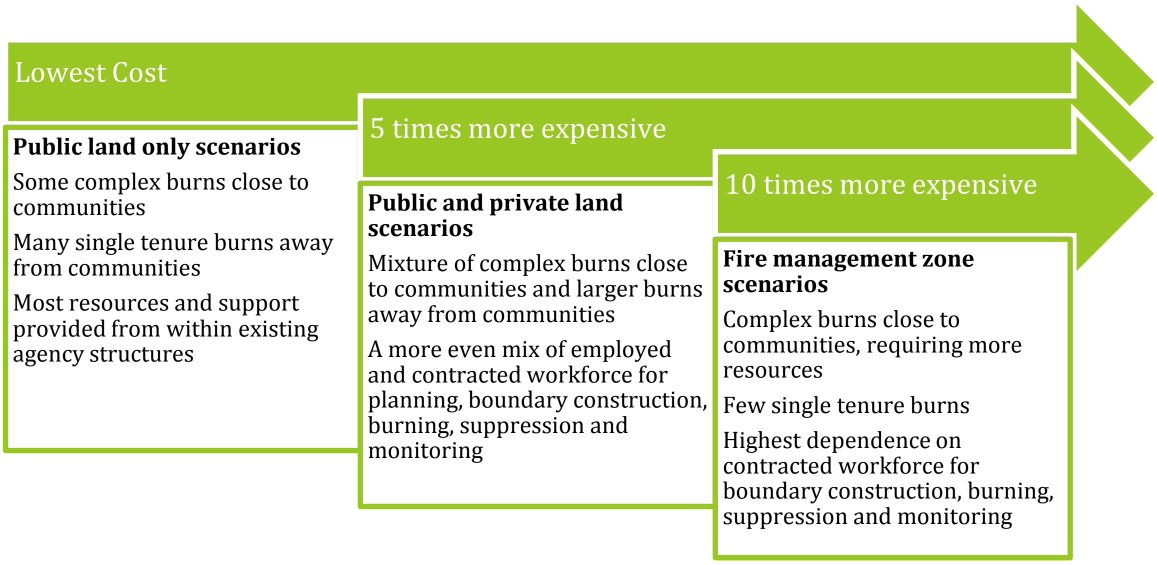

Figure 57: Conceptual diagram of how the resourcing requirements and cost of burning can change based on the complexity of the burn and their proximity to communities. Estimated cost per hectare for each of the fuel reduction burning scenarios was based on fuel reduction burning data and expert opinion on potential resource requirements.

Given the extremely variable costs of burning, we cannot reliably estimate the actual costs associated with implementing each of the different fuel management scenarios. It is possible to estimate cost for a burn on a site by site basis, once the necessary field inspections have occurred. We have however broadly indicated how much more expensive one landscape burning program might cost in comparison to another.

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CONCLUSION AND RECOMMENDATIONS

This analysis demonstrates the importance of a prioritised and strategically targeted fuel reduction burning strategy. Importantly, it shows how bushfire risk analysis is a sensible tool to prioritise activity; where outcomes measure success rather than activities. Whilst a hectare-based target may inspire action, in itself it is not a feasible strategy for reducing risk to communities. The results have demonstrated the importance of approaching risk reduction in a tenure-blind way – that is addressing the highest risk areas regardless of who owns or manages the land. For each scenario the tenure-blind approach provided the greatest reduction in relative risk. It is acknowledged however, that extensive community engagement and consultation is required and encouraged by the State Fire Management Council before any program of this nature is implemented.

The relative risk measure should be used as a means to monitor the benefits of fuel reduction for community safety, and is an appropriate measure of outcomes. Recent experience from Victoria and South Australia has shown that it takes approximately three years to build up the structures and resources required to implement a significantly increased fuel reduction burning program. Given the complexities that are expected when implementing any strategic fuel reduction burning program (for example the management of competing land, ecological and environmental objectives) a challenging target would therefore be a reduction in relative risk to below 80% within the next 8 years. This timeframe includes a build-up period of three years to a fully implemented fuel reduction burning program.

Testing of the fuel treatment strategies using a zoning approach, based on the recommendations from the National Inquiry in Bushfire Management (Ellis, et al., 2004) and research into the effects of fuel on fire severity (Bradstock, et. al., 2010) produced some interesting results. This approach involves all treatable vegetation inside Asset Protection Zones (within 1.05km of human settlement areas) having fuel ages of no more than five years old, by the fifth year of treatment. Further out, half of the treatable vegetation would have a fuel age of less than five years inside the Strategic Fuel Management Zones (between 1.05 and 6.05km from human settlement areas). The Full Fire Management Zone scenario involved treating approximately 100,000 hectares of treatable vegetation each year (on both public and private land) all within 6.05km of settlement areas. At a whole-of-state scale, this approach was the most effective strategy at reducing relative risk on an ongoing basis – though this would be at considerable financial, amenity and ecological cost to communities. In contrast, under the scenario tested, achieving only half this strategy was the least effective method to reduce relative risk at a Statewide scale, even though it still involved treating approximately 50,000 hectares per annum. The modelling has demonstrated the advantages that can be obtained through strategically selecting blocks where the highest risk reduction results can be realised. In 2014 we have developed a more nuanced approached beyond zoning (which certainly have their place in local plans) where the strategic selection of highest risk treatment areas in the landscape can produce a better reduction in relative risk.

Of the scenarios tested, the strategy of burning 31,000 hectares of treatable vegetation on both public and private land, where the treatment blocks were prioritised by risk, presented the most effective fuel reduction option given the relative expense, the reduction in relative risk and the increase in ease of suppression in the broader landscape. SFMC therefore recommends that a tenure-blind fuel reduction burning program is developed to strategically reduce bushfire risk to communities, based on a target of burning 31,000 ha of treatable vegetation each year, measured using a five year rolling average. This equates to total of 155,000 hectares over five years, and allows for variations to occur from year to year.

Based on the fire history records available (which are incomplete for private land), Tasmanian fire and land management agencies have successfully completed burning close to 31,000 hectares in a season

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only once in the last 20 years. However, most of the burning occurred on public land and is unlikely to have been as effective at reducing bushfire risk to communities. This level of burning was undertaken partly to achieve other objectives on public land in very remote areas. The challenge for the future will be to introduce burning into areas of private and public land, increase burning by at least three times the amount that is currently carried out, while effectively managing the complexities and impediments to burning on private land and on multiple tenures.

The bushfire risk assessment that was conducted as part of this report has developed a risk assessment process that has not been used before in Tasmania. SFMC can use this process on an ongoing basis to identify fuel reduction in areas that can achieve the greatest risk reductions. This bushfire risk assessment process is in early stages of development, and the review process will refine strategic selection to further improve potential risk reductions. This body of work has also demonstrated that a tenure-blind approach to risk reduction can achieve better results than restricting burning to public land. By strategically identifying areas that are unconstrained by tenure, fuel reduction can be more targeted and effective by reducing bushfire risk at identified high potential ignition sources, as well as close to vulnerable communities.

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GLOSSARY OF TERMINOLOGY

Airshed – An air shed is a part of the atmosphere that behaves in a coherent way with respect to the dispersion of emissions. It typically forms an analytical or management unit (Australian Bureau of Statistics, 2013)

Analysis Block – A polygon defined spatially using boundaries such as railways, major tracks, watercourses and water bodies. Used to estimate potential burn blocks for modelling fuel treatments.

Asset Protection Zones (APZ) – A class of fire management zone. An area of highest level of strategic protection and fuel management. Regular fuel reduction should be undertaken in this zone (Ellis, et al., 2004; Fire Management Section, Parks and Wildlife Service, 2012)

Asset Zones – A class of fire management zone. The location of assets of high value or importance (Ellis, et al., 2004; Ellis, et al., 2004)

Aurora Energy (Aurora) – Tasmanian government-owned electricity distributor and retailer.

Australasian Fire Authorities Council (AFAC) – The peak representative body for fire, emergency services and land management agencies in the Australasian region. It develops and promotes national standards for the fire industry.

Australasian Inter-service Incident Management System (AIIMS) – A system of incident control used by all Australian fire agencies.

Burn Plan – The plan which is approved for the conduct of planned burning. It contains a map identifying the area to be burnt and incorporates the specifications and conditions under which the operation is to be conducted (Australasian Fire and Emergency Service Authorities Council, 2012).

Burning Window – Period in which fuel reduction burning could potentially occur, based on a simple set of weather parameters defined by planned burning guidelines (Marsden-Smedley, 2009).

Burn-P3 – Simulation model used to evaluate bushfire susceptibility over large fire-prone landscapes, using Prometheus to model fire growth. Developed by the Canadian Forest Service (CFS).

Bushfire Mitigation Planning – The design and implementation of strategies to reduce bushfire risk through hazard treatment.

Bushfire Prone Area – Land that is within the boundary of a bushfire-prone area shown on an overlay on a planning scheme map or where there is no overlay on a planning scheme map, or where the land is outside the boundary of a bushfire-prone area shown on an overlay on such a map, land that is within 100m of an area of bushfire prone vegetation equal to or greater than 1 hectare (Tasmanian Planning Commission, 2012)

Bushfire Risk Assessment Model (BRAM) – Was developed by the Fire Management Section of the Parks and Wildlife Service. The aim of the model is identify bushfire risk at a strategic level as well as to identify the elements driving actual bushfire risk.

Bushland – Land which supports remnant vegetation or land which is disturbed but still retains a predominance of the original floristics and structure (Draper & Richards, 2009).

Communication Strategy – A part of the Tasmanian government project management process to ensure that stakeholders and project managers communicate effectively (Department of Premier and Cabinet, 2011).

Convection – As applied in meteorology, atmospheric motions that are predominantly vertical, resulting in vertical transport and mixing of atmospheric properties (Australasian Fire and Emergency Service Authorities Council, 2012).

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Crown – Land belonging to the state, crown land in Tasmania is managed by various Government agencies.

Curing – A measure of the amount of dryness in fine fuels expressed as a percentage (0% cured=green; 100% cured=totally dry). Used to calculate the Fire Danger Index and predict fire behaviour in grasslands using the McArthur Grassland Fire Danger Meter.

Drought Factor – Is given as a number between 0 and 10 and represents the influence of recent temperatures and rainfall events on fuel availability (Griffiths, 1998).

Ecosystem – The interacting system of a biological community, both plant and animal, and its non-living surroundings.

Ember – Glowing particles cast from the fire (Australasian Fire and Emergency Service Authorities Council, 2012).

Ember Density – Number of embers per square metre for each output cell modelled in phoenix.

Environmental Protection Authority (EPA) – Is Tasmania's principal environmental regulator, administers the Environmental Management and Pollution Control Act 1994 and is an integral part of Tasmania's Resource Management and Planning System.

Fire Access Track – A track constructed and/or maintained expressly for fire management purposes (Australasian Fire and Emergency Service Authorities Council, 2012).

Fire Boundaries – Outer boundary of bushfire or fuel reduction burn usually captured as a polygon which may contain holes to indicate 'islands' of unburnt area.

Fire Break – see Fuelbreak

Fire Danger Rating – A relative number denoting an evaluation of rate of spread, or suppression difficulty for specific combinations of fuel, fuel moisture and wind speed.

Fire Intensity – see Fireline Intensity

Fire Management – All activities associated with the management of fire-prone land, including the use of fire to meet land management goals and objectives.

Fire Management Area – An area of the state declared by notice published in the Gazette to be a Fire Management Area. There are 10 Fire Management Areas declared for Tasmania.

Fire Management Area Committee (FMAC) – A committee established under Section 18 of the Fire Service Act 1979 to coordinate fire management activities within its Fire Management Area, including community education and information and fuel management. Committees are to identify and assess community bushfire risks to prioritise strategic works, captured in an annual Fire Protection Plan.

Fire Management Zone Scenario – A tenure-blind fuel treatment scenario using a combination of fuel reduction burning in the Asset Protection and Strategic Fuel Management Zones.

Fire Regime – The history of fire use in a particular vegetation type or area including the frequency, intensity and season of burning. It may also include proposals for the use of fire in a given area.

Fire Season – The period during which bushfires are likely to occur, spread and do sufficient damage to warrant organised fire control. In Tasmania the length of the season varies from year to year.

Fire Size – Phoenix modelled fire size, defined as any output cells greater with a recorded intensity of greater than 0 kW/m.

Fire Tolerant Vegetation – see Treatable Vegetation

Fire Trail – see Fire Access Track

Fireline Intensity – The rate of energy release per unit length of fire front usually expressed in kilowatts per metre (kW/m) (Australasian Fire and Emergency Service Authorities Council, 2012).

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FireScape – A model for simulation theoretical long-term fire regimes in topographically complex landscapes.

Flame Depth – The depth of the zone within which continuous flaming occurs behind the fire edge (Australasian Fire and Emergency Service Authorities Council, 2012).

Flame Height – The average maximum vertical extension of flames at the leading edge of the fire front (Australasian Fire and Emergency Service Authorities Council, 2012).

FMA Selection method – Process of selecting Analysis Blocks whereby Analysis Blocks in each Fire Management Area are selected proportionally to their total treatable area.

Forecast.IO – A global weather service website that includes a time machine for exploring the weather in the past.

Forest Fire Danger Index (FFDI) – A relative number denoting an evaluation of rate of spread, or suppression difficulty for specific combinations of fuel, fuel moisture and wind speed in dry forest vegetation.

Forest Industries Association of Tasmania – Is an employer body which was formed in 1983 to represent the interest of processors of Tasmanian forest products

Forest Practices Authority – The Forest Practices Authority is an independent statutory body that administers the Tasmanian forest practices system on both public and private land.

Forestry Corporation – see Forestry Tasmania

Forestry Tasmania (FT) – The government business enterprise with statutory responsibility for the management of State forest land.

Fuel Age – A term used to describe fuel build up in response to the amount of time since the last fire occurred.

Fuel – Any material such as grass, leaf litter and live vegetation which can be ignited and sustains a fire. Fuel is usually measured in tonnes per hectare (Australasian Fire and Emergency Service Authorities Council, 2012).

Fuel Hazard – An assessment of fuel arrangement and its effects on bushfire behaviour (Hines, et al., 2010).

Fuel Moisture – The water content of a fuel particle expressed as a percent of the oven dry weight of the fuel particle (%ODW).

Fuel Reduction Burn – The planned use of fire to reduce fuels with the aim of reducing the intensity and spread of bushfires in subsequent years. Fuel-reduction burning is but one form of 'prescribed burning'' (Adams & Attiwill, 2011).

Fuel Treatment – For the purposes of this report, Fuel Treatment is limited to Fuel Reduction burning.

Fuelbreak – A natural or manmade change in fuel characteristics which affects fire behaviour so that fires burning into them can be more readily controlled (Australasian Fire and Emergency Service Authorities Council, 2012).

Generalized Linear Mixed Model (GLMM) – Class of models that incorporates random effects into the linear predictor of a generalized linear model (GLM) (McCulloch & Searle, 2001)

Grazing native vegetation – Land Use Code 2.1.0, as defined by the Australian Land Use and Management Classification. Based on grazing by domestic stock on native vegetation where there has been limited or no deliberate attempt at pasture modification (Department of Agriculture, 2010).

Head Fire Intensity (HFI) – Measured in kW/m and is calculated based on Rate of Spread (m/hr) and Fuel Load.

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Human Settlement Area (HSA) – Defined as where people live or work. For the purposes of this report the spatial extent of Human Settlement Areas are defined in Appendix 3.

Issues Analysis – An examination of any concerns that may impede the project if it is not resolved (Department of Premier and Cabinet, 2011).

Keetch-Byram Drought Index (KBDI) – A numerical value reflecting the dryness of soils, deep forest litter, logs and living vegetation, and expressed as a scale from 0 - 200 where the number represents the amounts of rainfall (mm) to return the soil to saturation (Australasian Fire and Emergency Service Authorities Council, 2012).

Local Government Association of Tasmania – An association that represents 28 of Tasmania's 29 councils which make up Local Government in Tasmania.

Mechanical Fuel Removal – Manipulation or removal of fuels using mechanical methods such as slashing, to reduce the likelihood of ignition and/or to lessen potential damage and resistance to control (Australasian Fire and Emergency Service Authorities Council, 2012).

Moorland Fire Danger Index (MFDI) – A relative number denoting an evaluation of rate of spread, or suppression difficulty for specific combinations of fuel, fuel moisture and wind speed in buttongrass moorland vegetation.

National Parks and Wildlife – see Parks and Wildlife Service

No Fuel Treatment Scenario – Fuel Treatment Scenario whereby no fuel treatment is applied and fuel loads are incremented with age without interruption by bushfire or planned burning.

Orthophoto – An aerial photograph geometrically corrected to remove distortion from topographic relief, lens distortion and camera tilt.

Pandora – Is a Windows application developed by the Canadian Forest Service that can batch-run basic Prometheus simulations without using the Prometheus user interface.

Parks and Wildlife Service (PWS) – The agency within the Department of Primary Industries, Parks, Water and Environment (DPIPWE) responsible for the management of lands reserved under the Nature Conservation Act 2002.

Permanent Timber Production Zone – As defined by the *Forestry Management Bill 2013*, this covers all the land that is now State Forest (except for the majority of forest reserves), plus any Crown land that Parliament determines should be permanent timber production zone land and any land purchased or acquired by the Forestry Corporation.

Permit Period – Time period declared by Tasmania Fire Service, usually during the dry summer period from November to March. It is used to coordinate and monitor controlled burning of vegetation and minimise the risk of fire spreading.

PHOENIX RapidFire (Phoenix) – Is a fire characterisation model developed by the University of Melbourne and Bushfire CRC. It is a deterministic, dynamic, continuous, empirical fire characterization model used to capture the nature of a fire as it spreads across the landscape.

Planned Burning – The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity, and rate of spread required to attain planned resource management objectives. Also known as "Prescribed Burning" or "Planned Fire".

Poisson error distribution – Is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time and/or space if these events occur with a known average rate and independently of the time since the last event (Haight, 1967).

PostgreSQL – Is an open source object-relational database system.

Private Freehold – For the purposes of this report all land not defend as reserve, crown or a Permanent Timber Production Zone.

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Prometheus – Is a deterministic bushfire fire growth simulation model developed by the Canadian Forest Service.

Pseudoreplication – Is a special case of inadequate specification of random factors where both random and fixed factors are present (Hurlbert, 1984).

Public and Private Land Only Scenario – A fuel treatment scenario with selection of Analysis Blocks prioritised by BRAM bushfire risk.

Public Land Only Scenario – A fuel treatment scenario with selection of Analysis Blocks prioritised by BRAM bushfire risk, limited to public land only.

Reserve – Crown land set aside as reserved land under the *Nature Conservation Act 2002*.

Scrub Fire Danger Index (SFDI) – A relative number denoting an evaluation of rate of spread, or suppression difficulty for specific combinations of fuel, fuel moisture and wind speed in scrub vegetation types.

SILO Patched Point Dataset (SILO-PPD) – Is observed meteorological data with missing or suspect values 'patched' with interpolated data, available for some 4600 meteorological stations across Australia.

Soil Dryness Index – A numerical value reflecting the dryness of soils, deep forest litter, logs and living vegetation

Spotting Density – see Ember Density

Stakeholder Analysis – The entities that have an interest in a project are identified and the nature of their interests analysed (Department of Premier and Cabinet, 2011).

State Fire Commission (SFC) – The role of the Commission is to protect life, property and the environment from the impact of fire and other emergencies.

State Fire Management Council (SFMC) – A council appointed under Section 14 of the *Fire Service Act 1979* with the purpose of developing a State vegetation fire management policy to be used as the basis for all fire management planning. And, to provide advice to both the Minister and the State Fire Commission on matters relating to the prevention or mitigation of vegetation fires.

State Selection method – Process of selecting Analysis Blocks whereby Analysis Blocks are selected irrespective of the proportion of total treatable area in each Fire Management Area.

Strategic Fuel Management Zone (SFMZ) – A class of fire management zone. An area of management that will increase the likelihood of controlling a bushfire. Areas strategically located, taking in consideration natural and man-made attributes to provide anchor points. Aims to provide areas of reduced fuel to reduce speed and intensity of bushfires and reduce spot-fire potential (Ellis, et al., 2004; Fire Management Section, Parks and Wildlife Service, 2012)

Suppression – The activities connected with restricting the spread of a fire following its detection and before making it safe (Australasian Fire and Emergency Service Authorities Council, 2012)**.**

Tasmania Fire Service (TFS) – The operational arm of the State Fire Commission, established by the *Fire Service Act 1979*.

Tasmanian Farmers' and Graziers' Association – Is Tasmania's state farmer organisation, representing over 5,000 members who live and work on farm businesses situated across Tasmania.

TASVEG 3.0 – TASVEG is a Tasmania-wide vegetation map produced by the Tasmanian Vegetation Monitoring and Mapping Program (TVMMP). Version 3.0 represents the third major release of the TASVEG layer since 2004.

Tenure-blind – Refers to all land tenure types, i.e. both public and private land.

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Treatable Vegetation – Vegetation that can generally tolerate fuel reduction burning, using Kitchener and Harris (2013) and Pyrke and Marsden-Smedley (2005) as a guide. See Appendix 4 for list of identified treatable vegetation.

Victorian Bushfires Royal Commission (VBRC) – Established after the "Black Saturday" fires of February 2009, where 173 people lost their lives, to inquire into the circumstances of these deaths and to recommend any necessary improvements to fire Management in Victoria (Teague, et al., 2010). 67 recommendations were made and all but 2 of the recommendations were accepted by the Victorian Government.

Works – In the context of a works program defined in the *Land Use Planning and Approvals Act 1993*, includes any change to the natural or existing condition or topography of land including the removal, destruction or lopping of trees and the removal of vegetation or topsoil, but does not include forest practices, as defined in the *Forest Practices Act 1985*, carried out in State forests.

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REFERENCES

Adams, M. & Attiwill, P., 2011. *Burning Issues: Sustainability and Management of Australia's Southern Forests.* Collingwood(Victoria): CSIRO Publishing.

Australasian Fire and Emergency Service Authorities Council, 2012. *Glossaries.* [Online]
Available at: http://www.afac.com.au/services/glossary/bushfire
[Accessed 26 May 2014].

Australian Bureau of Statistics, 2012. *2074.0 - Census of Population and Housing: Mesh Block Counts, 2011.* [Online]
Available at: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2074.0main+features12011
[Accessed 15 May 2014].

Australian Bureau of Statistics, 2013. *1395.0 - Essential Statistical Assets for Australia, 2013.* [Online]
Available at:
http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1395.0Glossary382013?OpenDocument
[Accessed 26 May 2014].

Bates, D., Maechler, M. & Bolker, B., 2013. *lme4: Linear mixed-effects models using S4 classes. R package version 0.999999-2.* [Online]
Available at: http://CRAN.R-project.org/package=lme4
[Accessed 12 May 2014].

Bowman, D., 2003. Bushfires: A Darwinian Perspective. In: G. Cary, D. Lindenmayer & S. Dovers, eds. *Australia Burning: Fire Ecology, Policy and Management Issues.* Collingwood, Victoria: CSIRO Publishing, p. 11.

Bradstock, R. A., Hammill, K. A., Collins, L. & Price, O., 2010. Effects of weather, fuel and terrain on fire severity in topographically diverse landscapes of south-eastern Australia. *Landscape Ecol,* Volume 25, pp. 607-619.

Bureau of Transport Economics, 2001. *Economic Cost of Natural Disasters in Australia,* Canberra: Bureau of Transport Economics.

Cheney, N. P., Gould, J. S. & Catchpole, W. R., 1998. Prediction of Fire Spread in Grasslands. *International Journal of Wildland Fire,* 8(1), pp. 1-13.

Cheney, P. & Sullivan, A., 1997. *Grassfires: Fuel, Weather and Fire Behaviour.* Melbourne: CSIRO Publishing.

Chong, D., Tolhurst, K. & Duff, T., 2012. *PHOENIX RapidFire 4.0's Convective Plume Model,* Melbourne: Bushfire CRC, The University of Melbourne.

CJ White, M. G. S. C. J. B. G. H. L. S. K. M. R. C. S. G. &. N. B., 2010. *Climate Futures for Tasmania: extreme events technical report,* Hobart, Tasmania.: Antarctic Climate and Ecosystems Cooperative Research Centre.

Department of Agriculture, 2010. *The Australian land use and management (ALUM) classification version 7 detailed classification.* [Online]
Available at: http://www.daff.gov.au/abares/aclump/pages/publications.aspx#landuse
[Accessed 26 May 2014].

Department of Environment and Primary Industries, 2013. *Victorian Bushfire Risk Profiles: A Foundational Framework for Strategic Bushfire Risk Assessment,* East Melbourne: Victorian Government, Department of Environment and Primary Industries.

Department of Police and Emergency Management, 2012. *Tasmanian State Natural Disaster Risk Assessment,* Hobart: Department of Police and Emergency Management.

ISBN: 978-0-9925970-0-9

Department of Premier and Cabinet, 2011. *Project Management Guidelines.* Tasmania: Office of eGovernment.

Department of Primary Industries, Parks, Water & the Environment, 2014. *Bushfire Risk Assessment Model: 20/02/14 08:20,* Hobart: Parks & Wildlife Service.

Department of Primary Industries, Water and Environment, 2012. *Northwest Regional Strategic Fire Management Plan,* Hobart: Department of Primary Industries, Water and Environment.

Draper, D. B. & Richards, P. A., 2009. *Dictionary for Managing Trees in Urban Environments.* Collingwood, Victoria: CSIRO Publishing.

Economics, B. o. T., 2001. *Economic Cost of Natural Disasters in Australia - Report 103,* s.l.: Bureau of Transport Economics, Canberra.

Ellis, S., Kanowski, P. & Whelan, R., 2004. *National Inquiry on Bushfire Mitigation and Management,* Canberra: Commonwealth of Australia.

Fire Management Section, Parks and Wildlife Service, 2012. *Northwest Region Strategic Fire Management Plan.* Hobart: Dept. Primary Industries, Parks, Water and Environment.

Forest Fire Management Group, 2012. *National Bushfire Management Policy Statement for Forests and Rangelands,* Canberra: Forest Fire Management Group.

Forthofer, J. M., 2007. *Modeling wind in complex terrain for use in fire spread prediction,* Fort Collins: Colorado State University.

Griffiths, D., 1998. *Improved Formulae for the McArthur Forest Fire,* Melbourne, Victoria: Meteorological Note 214, Bureau of Meteorology.

Haight, F. A., 1967. *Handbook of the Poisson Distributio.* New York: John Wiley & Sons..

Hennessy, K. et al., 2006. *Climate Change Impacts on Fire-Weather in South-East Australia,* Aspendale, Victoria: CSIRO.

Hines, F., Tolhurst, K. G., Wilson, A. A. & McCarthy, G. J., 2010. *Overall fuel hazard assessment guide.* 4th ed. Melbourne: Victorian Government Department of Sustainability and Environment.

Hurlbert, S. H., 1984. Pseudoreplication and the design of ecological field experiments. *Ecological monographs,* 54(2), pp. 187-211.

InsightGIS, 2013. *Tasmanian Bushfire Risk Assessment Model v3.1: Technical Report v1.6,* Hobart: InsightGIS.

Kitchener, A. & Harris, S., 2013. *From Forest to Fjaeldmark: Descriptions of Tasmania's Vegetation.* 2 ed. Hobart(Tasmania): Department of Primary Industries, Parks, Water and Environment.

Luke, R. H. & McArthur, A. G., 1978. *Bushfires in Australia,* Canberra: Australian Government Publishing Service.

Marsden-Smedley, J. B., 2009. *Planned Burning in Tasmania: Operational Guidelines and Review of Current Knowledge,* Hobart: Fire Management Section, Parks and Wildlife Service, Department of Primary Industries, Water and the Environment.

McArthur, A. G., 1962. *Control burning in eucalypt forests,* Canberra: Forest Research Institute, Forestry & Timber Bureau, Commonwealth of Australia.

McArthur, A. G., 1967. *Fire Behavour in Eucalypt Forests,* Canberra: Forest Research Institute, Forestry and Timber Bureau, Commonwealth of Australia.

McArthur, A. G., 1973. *Forest Fire Danger Meter, MkV,* Canberra: Forest Research Institute, Forestry and Timber Bureau, Commonwealth of Australia.

McArthur, A. G., 1978. *Bushfires in Australia,* Canberra: Australian Government Publishing Service.

ISBN: 978-0-9925970-0-9

McCarthy, G. J., Tolhurst, K. G. & Wouters, M., 2003. *Prediction of Firefighting Resources for Suppression Operations in Victoria's Parks and Forests,* East Melbourne: Department of Sustainability and Environment.

McCulloch, C. E. & Searle, S. R., 2001. *Generalized, Linear and Mixed Models.* 1st ed. New York, NY: John Wiley & Sons.

National Emergency Management Committee, 2010. *National Emergency Risk Assessment Guidelines,* Hobart: Tasmanian State Emergency Service.

Noble, I. R., Bary, G. A. V. & Gill, A. M., 1980. McArthur's Fire-Danger Meters Expressed as Equations. *Australian Journal of Ecology,* Volume 5, pp. 201-203.

NRM North; Cradle Coast NRM; NRM South; DPIPWE;, 2009. *Tasmanian Land Use Summer 2009/2010,* Kings Meadows: Department of Primary Industries, Parks, Water and Environment.

Pyrke, A. & Marsden-Smedley, J., 2005. Fire-attributes categories, fire sensitivity, and flammability of Tasmanian vegetation communities. *Tasforests,* December, Volume 16, pp. 35-46.

R Core Team, 2013. *A language and environment for statistical computing.* [Online]
Available at: http://www.R-project.org/
[Accessed 12 May 2014].

Scott, A. B. W. B. S. P. &. A. M., 2014. *Fire on Earth, An Introduction,,* West Sussex: Wiley, Blackwell.

State Fire Management Council, 2012. *State Fire Management Council State Vegetation Fire Management Policy.* Hobart: State Fire Management Council.

State of Victoria, 2012. *Bushfires Royal Commission Implementation Monitor: Final Report,* Melbourne: Victorian Government.

Tasmanian Audit Office, 2011. *Report of the Auditor-General, Special Report No. 99, Bushfire Management,* Hobart: Tasmanian Audit Office.

Tasmanian Bushfire Inquiry , 2013. *Tasmanian Bushfire Inquiry ,* s.l.: s.n.

Tasmanian Liberals, 2014. *Policy.* [Online]
Available at: http://www.tas.liberal.org.au/policy
[Accessed 14 May 2014].

Tasmanian Planning Commission, 2012. *Planning Directive No. 5, Bushfire-Prone Areas Code,* Hobart: Tasmanian Planning Commission.

Teague, B., McLeod, R. & Pascoe, S., 2010. *2009 Victorian Bushfires Royal Commission,* Melbourne: Parliament of Victoria.

Teague, B., Mcleod, R. & Pascoe, S., 2010. *The 2009 Victoria bushfires Royal Commission final report,* Melbourne: Government Printer for the State of Victoria.

Teague, B., Mcleod, R. & Pascoe, S., 2010. *The 2009 Victoria bushfires Royal Commission Final Report,* Melbourne: Government Printer for the State of Victoria.

Tolhurst, K. & Chong, D., 2012. *PHOENIX RapidFire: User Manual - Introduction and Exercise.* Melbourne: University of Melbourne & Department of Sustainability & Environment.

Tolhurst, K., Shields, Brett & Chong, D., 2008. Phoenix: Development and Application of a Bushfire Risk Management Tool. *The Australian Journal of Emergency Management,* 23(4), pp. 47-54.

White, C. J. et al., 2010. *Climate Futures for Tasmania: extreme events technical report,* Hobart, Tasmania: Antarctic Climate and Ecosystems Cooperative Research Centre.

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APPENDIX 1: STATE VEGETATION FIRE MANAGEMENT POLICY 2012

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STATE VEGETATION FIRE MANAGEMENT POLICY 2012

1. INTRODUCTION

The State Fire Management Council (SFMC) is established under Section 14 of the *Fire Service Act 1979* (Tasmania). A principal function of the Council is to develop a State vegetation fire management policy (*Fire Service Act 1979* S. 15 (a)).

SFMC has an independent chair and members are appointed to represent the following organisations:

- Forest Industry Association of Tasmania;
- Forestry Tasmania;
- Local Government Association of Tasmania;
- Parks and Wildlife Service;
- Tasmania Fire Service, and
- Tasmanian Farmers and Graziers Association.

The actions and strategies outlined in this policy reflect the need to balance the often competing demands to protect life and assets, natural and cultural values and to maintain community support for fire management practices. In developing the policy SFMC has taken into account the broader context of:

- The benefits of fire as a land management tool for protecting life and property and for maintaining natural values, and as an accepted practice for control of disease, hazard reduction and vegetation;
- The increasing prevalence of bushfires due to changes in climatic conditions and the increasing trend of people building and living in bushfire prone areas;
- The need to establish community level priorities for action;
- The changes in land use patterns which have increased the number of people living in highly vegetated areas of the State as well as the establishment of new groups of stakeholders;
- The diverse range of community attitudes towards fire and its role in the landscape.
- The need to engage local communities and individuals in fire prevention and management in the face of limited resources, acknowledging the need to build community resilience to bushfires;
- The need to adopt a planned approach to make the best use of available resources to meet future challenges, and
- The development of risk based land use planning principles.

2. PURPOSE OF THE POLICY

To provide a standard and consistent framework for the management of vegetation fire across all land tenures and vegetation types in Tasmania in order to produce the following outcomes:

- Save lives;
- Minimise risks to assets;
- Protect natural and cultural heritage values;
- Increase community capacity and resilience;
- Maximise the level of community engagement and understanding of vegetation fire prevention and management, and
- Encourage the responsible use of fire for the management of land and agricultural systems.

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3. Status and Use of the Policy

This policy represents the position of the State Fire Management Council. The policy is provided for the information of and use by the community through the Minister responsible for the *Fire Service Act 1979*. By agreement, SFMC member bodies should comply with the policy as far as reasonably possible.

The policy applies to both planned use of fire as well as unplanned or bushfire management across Tasmania. It therefore encompasses the urban, agricultural and natural vegetation areas of the State.

This policy can be used as a framework for planning and action by a diverse range of stakeholders across the State responsible for fire and vegetation management activities including but not limited to:

- Parks and Wildlife Service of the Department of Primary Industries, Parks, Water and Environment;
- Forestry Tasmania;
- Tasmania Fire Service;
- Local Government;
- Private forestry companies;
- Farmers and graziers;
- Landholders and managers;
- Community groups, and
- External funding providers (e.g. the Caring for Country or Bushfire Mitigation Fund programs).

This policy can only apply to the extent provided by legislation and other policies and arrangements.

4. Principles that Underpin the Policy

In principle vegetation fire management practices should comply with Australian standards and best practice. Additionally there is a need to draw upon the most up to date scientific data to formulate options for appropriate responses. However there is also a requirement for high level principles. The Council of Australian Governments has endorsed the Recommendations of the ***National Inquiry on Bushfire Mitigation and Management (2004).*** Recommendation 14.1 proposes a set of Indicative National Bushfire Principles which are to be used as the basis for national consultation and adoption. SFMC has adopted the Indicative National Bushfire Principles to underpin this policy, noting that within the Ellis et al. (2004) report planned fires as well as unplanned bushfires were included in the National Bushfire Principles.

The Indicative National Bushfire Principles are:

Bushfires are understood, accepted and respected

Like other natural hazards, bushfires cannot be prevented. In many instances, bushfires are an important tool to assist in achieving land management objectives. The impact of unplanned fires needs to be minimised through effective action based on learning and understanding. This also requires strong self-reliance.

Shared responsibility

A philosophy of responsibility shared between communities and fire agencies underlies our approach to bushfire mitigation and management. Well-informed individuals and communities, with suitable levels

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of preparedness, complement the roles of fire agencies and offer the best way of minimising bushfire risks to lives, property and environmental assets.

Decisions within a risk management framework

No single action will lead to the elimination of bushfire risk. The best approach to minimising risk is to make decisions about bushfire mitigation and management within an integrated risk management framework.

Integration of learning and knowledge

Analysis of fire events is based on operational and scientific evidence and research. This should be informed by extensive and consistent national data, including fire regime mapping. The best results will be achieved by integrating all forms of knowledge, and good information about fire history, with analysis at the local and regional levels.

Manage fire according to the landscape objectives

Australia has a great diversity of climates, environments, land uses and built assets. Fire management objectives and outcomes will vary across landscapes and over time. Clear agreed objectives and an adaptive management approach are required for implementation.

Consistency of purpose and unity of command

There needs to be consistency of purpose during bushfire mitigation and unity of command for all fire response, irrespective of organisational structures.

Protection of lives as the highest consideration

Firefighter and community safety must be at the forefront of bushfire mitigation and management deliberations. Although there should always be a balance between safety, effective response and environmental considerations, it is personal safety that must be the greatest concern.

Monitoring performance

The states, territories and local governments need to regularly review their performance against these principles and other appropriate indicators. Performance review should not be allowed to wait until after a major bushfire event. If the principles are to improve performance and bring about change, they must be monitored on a regular basis.

5. Action Areas and Strategies

The State Vegetation Fire Management Policy encourages the following actions by all stakeholder groups in the Tasmanian community. While some actions will be taken specifically by the State Fire Management Council and the bodies represented on the Council all stakeholder groups are encouraged to use the policy as a framework for their own approach to vegetation fire management.

Action area 5.1 Management of fire in vegetation

Strategies:

Common set of tools

Continue the development and adoption of a common set of tools and terms for fire management by all stakeholder groups as an essential component of effective management of vegetation fire across the State.

Supporting actions may include:

- *Ensure that terms and jargon are based on the AFAC Glossary in all documents, publications and training material.*
- *Continue inter-agency training and workshops to generate consistency of approach where possible.*

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- *Continue use of AIIMS ICS for managing all vegetation fires.*
- *Develop and trial joint fire management tools and templates (e.g. Planned Burning Prescriptions, fuel hazard mapping).*
- *Develop common systems, standards, policies, procedures and guideline (e.g. radio communications networks, standard fire hose couplings, GIS mapping systems, Air Desk procedures, fire trails –specifications, keying, naming and signage)*

Integrated approach

Implement an integrated approach to fire management with all interested parties, especially in boundary areas or where the community impact will be substantial.

Supporting actions may include:

- *Continue the Inter-agency Fire Management Protocol*
- *Continue the Statewide Strategic Fuel Reduction Program.*
- *Use new and emerging research to inform the development of regional/district level fire management plans and to manage risk.*
- *Commit to integrated and cooperative planning across tenures at both the strategic (regional) and tactical (local) levels.*
- *Ensure regional and Statewide risks are identified and prioritised, and agreed among the stakeholders.*

Give due consideration to the recommendations of the 2011 Auditor-General Special Report into Bushfire Management.

Use of zones

Promote the adoption of the fire management zones proposed in Ellis *et al.* (2004) and adopted by the Government of Tasmania and the Council of Australian Governments (COAG) as a minimum standard.

Supporting actions may include:

- *Develop zone definitions, objectives and mitigation criteria appropriate for all tenures.*
- *Broaden the use of zones on public lands to include private lands.*
- *Encourage the use of zones for fire management purposes by providing appropriate training materials.*

Land use planning and management practices

Encourage land use planning and management practices which minimise the potential for loss and damage as a result of unplanned vegetation fire and incorporate contemporary risk based land use planning principles.

Supporting actions may include:

- *Support the need for strong controls over development in bushfire prone areas.*
- *Provide support resources for the development community.*
- *Promote hazard reduction and other effective bushfire safety measures.*
- *Local government authorities and land management agencies should take a risk based approach to land use planning and the placement and management of assets in relation to flammable vegetation.*
- *Provide training on risk based land use planning.*

Fire as a tool to sustain natural values

Promote the use of fire as a means to sustain natural values and maintain biodiversity while appropriately managing fuel hazards.

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Supporting actions may include:

- *Publicise examples of best practice fire management.*
- *Encourage community acceptance of the role of fire in maintaining landscapes and biodiversity.*
- *Promote the development of more cost effective ways of using fire as a hazard management tool.*
- *Continue promoting better knowledge of appropriate fire regimes for the management of Tasmanian vegetation.*

Balancing competing values

Emphasise the net benefits to the community of planned burning and other fuel management activities for the protection of natural values and the minimisation of losses.

Supporting actions may include:

- *Promote a risk management approach in decision making which includes both monetary and non-monetary values as well as short and long term outcomes.*
- *Promote the understanding of the risks which may remain after mitigation activities.*
- *Promote acknowledgement that smoke may have impacts which need to be managed and in some situations cannot be avoided (e.g. short-term visual impacts, road closures).*
- *Develop systems for informing communities of potential impacts from smoke and minimising the impact on public events.*

ACTION AREA 5.2 COMMUNITY AWARENESS AND ENGAGEMENT

Strategies:

Engaging communities and building awareness and capacity

Facilitate community understanding and support of vegetation fire management practices.

Supporting actions may include:

- *Provide opportunities for community members to gain information about current knowledge and to become more aware of the range of fire management options.*
- *Promote access to a range of information resources.*
- *Ensure appropriate community engagement occurs throughout planning processes.*
- *Promote community capacity to manage their own fire risk*.
- *Promote the transformation of awareness into action at the individual, family and community level.*

Identify priorities at the regional or district level

Encourage communities to identify their priority assets and values to guide fire management strategies and actions.

Supporting actions may include:

- *Provide communities with the tools to conduct the priority and valuation assessment process.*

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Empower and support Fire Management Area Committees

Provide resources to enable Fire Management Area Committees to more effectively engage with their communities.

Supporting actions may include:

- *Review the structure and operation of Fire Management Area Committees.*
- *Encourage Fire Management Area Committees to engage with relevant community groups and authorities.*
- *Promote public awareness of the role of Fire Management Area Committees.*

ACTION AREA 5.3 BUILDING THE KNOWLEDGE BASE

Strategies

Identifying knowledge gaps

Identify priorities and opportunities for further fire research relevant to Tasmania.

Supporting actions may include:

- *Identify the fire research needs for Tasmania.*
- *Direct the funding priorities of the Tasmanian Fire Research Fund using identified research needs.*
- *Promote identified research priorities with bodies such as the Bushfire Cooperative Research Centre.*
- *Work with the University of Tasmania to foster research in priority areas.*

Foster appropriate research and disseminate findings

Promote research findings in an accessible format to key stakeholder groups and the community.

Supporting actions may include:

- *Advocate the provision of resources to conduct research appropriate to Tasmania.*
- *Develop a communications plan for the transfer of knowledge.*
- *Promote access to and encourage adoption of authoritative and current research findings.*

6. REVIEW PERIOD FOR THE POLICY

The State Vegetation Fire Management Policy will be reviewed by the Council within two years.

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APPENDIX 2: TASVEG 3.0 VEGETATION TYPES CLASSIFIED AS TREATABLE AND UNTREATABLE FOR FUEL REDUCTION BURNING

Treatable Vegetation Types

Agricultural, urban and exotic vegetation

Marram grassland
Pteridium esculentum fernland
Regenerating cleared land
Weed infestation

Dry eucalypt forest and woodland

Eucalyptus amygdalina - Eucalyptus obliqua damp sclerophyll forest
Eucalyptus amygdalina coastal forest and woodland
Eucalyptus amygdalina forest and woodland on dolerite
Eucalyptus amygdalina forest and woodland on sandstone
Eucalyptus amygdalina forest on mudstone
Eucalyptus amygdalina inland forest and woodland on Cainozoic deposits
Eucalyptus barberi forest and woodland
Eucalyptus delegatensis dry forest and woodland
Eucalyptus globulus dry forest and woodland
Eucalyptus nitida dry forest and woodland
Eucalyptus nitida Furneaux forest
Eucalyptus obliqua dry forest
Eucalyptus ovata forest and woodland
Eucalyptus ovata heathy woodland
Eucalyptus pauciflora forest and woodland not on dolerite
Eucalyptus pauciflora forest and woodland on dolerite
Eucalyptus pulchella forest and woodland
Eucalyptus risdonii forest and woodland
Eucalyptus rodwayi forest and woodland
Eucalyptus sieberi forest and woodland not on granite
Eucalyptus sieberi forest and woodland on granite
Eucalyptus tenuiramis forest and woodland on dolerite
Eucalyptus tenuiramis forest and woodland on granite
Eucalyptus tenuiramis forest and woodland on sediments
Eucalyptus viminalis - Eucalyptus globulus costal forest and woodland
Eucalyptus viminalis Furneaux forest and woodland
Eucalyptus viminalis grassey forest and woodland
Midlands woodland complex

Moorland, sedgeland, rushland and peatland

Buttongrass moorland (undifferentiated)
Buttongrass moorland with emergent shrubs

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Eastern buttongrass moorland
Pure buttongrass moorland
Restionaceae rushland
Sparse buttongrass moorland on slopes
Western buttongrass moorland
Western lowland sedgeland

Native grassland

Coastal grass and herbfield
Lowland grassland complex
Lowland grassy sedgeland
Lowland *Poa labillardierei*
Lowland *Themeda triandra* grassland
Rockplate grassland

Non eucalypt forest and woodland

Allocasuarina littoralis forest
Allocasuarina verticillata forest
Banksia serrata woodland
Busaria - Acacia woodland and scrub

Scrub, heathland and coastal complexes

Acacia longifolia coastal scrub
Coastal heathland
Coastal scrub
Coastal scrub on alkaline sands
Eastern scrub on dolerite
Heathland on calcareous substrates
Kunzea ambigua regrowth scrub
Leptospermum glaucescens heathland scrub
Leptospermum scoparium heathland and scrub
Melaleuca squamea heathland
Scrub complex on King Island
Wet heathland

Untreatable Vegetation Types

Agricultural, urban and exotic vegetation

Agricultural land
Extra-urban miscellaneous
Permanent easements
Plantations for silviculture
Spartina marshland
Unverified plantations for silviculture
Urban areas

Dry eucalypt forest and woodland

Eucalyptus coccifera forest and woodland
Eucalyptus cordata forest
Eucalyptus dalrympleana - Eucalyptus pauciflora forest and woodland
Eucalyptus gunii woodland
Eucalyptus morrisbyi forest and woodland
Eucalyptus perrinana forest and woodland
King Island eucalypt woodland

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Highland and treeless vegetation

Alpine coniferous heathland
Cushion moorland
Eastern alpine heathland
Eastern alpine sedgeland
Eastern alpine vegetation (undifferentiated)
Western alpine heathland
Western alpine sedgeland/herbland

Moorland, sedgeland, rushland and peatland

Alkaline pans
Highland grassy sedgeland
Sphagnum peatland
Subalpine *Diplarrena latifolia* rushland

Native grassland

Highland Poa grassland

Non eucalypt forest and woodland

Acacia dealbata forest
Acacia melanoxylon forest on rises
Acacia melanoxylon swamp forest
Callitris rhomboidea forest
Leptospermum forest
Leptospermum lanigerum - Melaleuca squarrosa swamp forest
Leptospermum scoparium - Acacia mucronata forest
Melaleuca ericifolia swamp forest
Subalpine *Leptospermum nitidum* woodland

Other natural environments

Lichen lithosere
Sand, mud
Water, sea

Rainforest and related scrub

Anthrotaxis cupressoides - Nothofagus gunnii short rainforest
Anthrotaxis cupressoides open woodland
Athrotaxis cupressoides rainforest
Athrotaxis selaginoides - Nothofagus gunnii short rainforest
Athrotaxis selaginoides rainforest
Athrotaxis selaginoides subalpine scrub
Coastal rainforest
Highland low rainforest scrub
Highland rainforest scrub with dead Athrotaxis selaginoides
Lagarostrobos franklinii rainforest and scrub
Nothofagus - Atherosperma rainforest
Nothofagus - Leptospermum short rainforest
Nothofagus - Phyllocladus short rainforest
Nothofagus gunnii rainforest and scrub
Nothofagus rainforest (undifferentiated)
Rainforest fernland

Saltmarsh and wetland

Freshwater aquatic sedgeland and rushland

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- Lacustrine herbland
- Saline aquatic herbland
- Saline sedgeland/rushland
- Saltmarsh (undifferentiated)
- Succulent saline herbland
- Wetland (undifferentiated)

Scrub, heathland and coastal complexes

- *Banksia marginata* wet scrub
- Broad-leaf scrub
- Eastern riparian scrub
- *Leptospermum lanigerum* scrub
- Leptospermum scrub
- Leptospermum with rainforest scrub
- *Melaleuca pustulata* scrub
- *Melaleuca squarrosa* scrub
- Rookery halophytic herbland
- Spray zone coastal complex
- Subalpine heathland
- Western alpine scrub
- Western regrowth complex
- Western wet scrub

Wet eucalypt forest and woodland

- *Eucalyptus brookeriana* wet forest
- *Eucalyptus dalrympleana* forest
- *Eucalyptus delegatensis* forest over Leptospermum
- *Eucalyptus delegatensis* forest over rainforest
- *Eucalyptus delegatensis* forest with broad-leaf shrubs
- *Eucalyptus delegatensis* wet forest (undifferentiated)
- *Eucalyptus globulus* King Island forest
- *Eucalyptus globulus* wet forest
- *Eucalyptus nitida* forest over leptospermum
- *Eucalyptus nitida* forest over rainforest
- *Eucalyptus nitida* wet forest (undifferentiated)
- *Eucalyptus obliqua* forest over Leptospermum
- *Eucalyptus obliqua* forest over rainforest
- *Eucalyptus obliqua* forest with broad-leaf shrubs
- *Eucalyptus obliqua* wet forest (undifferentiated)
- *Eucalyptus regnans* forest
- *Eucalyptus subcrenulata* forest and woodland
- *Eucalyptus viminalis* wet forest

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APPENDIX 3: HUMAN SETTLEMENT AREAS (VERSION 1.2)

SFMC has developed a spatial dataset used to define the extent and name of Human Settlement Areas (HSA) in Tasmania. The term Human Settlement Area is used instead of Community for the purposes of clarity. HSAs are defined as where people live or work.

Dataset Name	HSA_v1_2
Dataset Created	30-01-2014
Data Type	Vector
Data Coverage	Tasmania
Projected Coordinate System	GDA_1994_MGA_Zone_55
Projection	Transverse Mercator

Input Data

- Building point and polygon data from Information and Land Services (ILS), DPIPWE
- Population and Dwelling data from Australian Bureau of Statistics (ABS)
- Cadastral data from ILS
- Localities and Nomenclature data from ILS

Lineage

Version 0 – Beta version made available for comment and feedback to representatives from SFMC, TFS and DPAC (HSA working group).

Version 1 – Minor changes from version 0, based on feedback from HSA working group limited to naming of HSA, no spatial extent changes from version 0.

Version 1.1 – Minor changes from version 1, total HSA count increases from 712 to 715 based on splitting three wrongly dissolved polygons

Version 1.2 (*CURRENT VERSION*) – Minor changes from version 1.1, three polygons had incorrectly identified Suburb and LGA names.

Simplified Model Process

Input Points >>> Weighting >>> Weighted Points >>> Kernel Density >>> Final Output

Methodology

Building polygon data is converted to point (centroid) and merged with building point data to create a continuous building point layer Statewide.

Building points that are deemed not relevant to defining HSAs (as listed below) are removed, percentages are shown for how much of the original (unmodified) merged polygon/point dataset they account for.

- Lighthouses (<0.01%)

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- Public toilets (<0.2%)
- Walking huts (<0.05%)
- Sheds* (14.5%)
- Remote Sheds* (<0.2%)
- Ruins (<0.05%)

  **Whilst sheds and remote sheds are excluded, "Rural small sheds" and "Rural large sheds" have been included*

Furthermore points falling outside the ABS 2011 Mesh Block Statistical Area are removed (less than 0.03% of the dataset). This is predominantly removing a small number of coastal points sitting outside what the ABS defines as land.

The remaining building points are split into two groups:

a) **Group 1** – Residences (66%), Other (0.4%) and Unknown (8.5%)

b) **Group 2** – Community (3.4%), Commercial (1.9%), Industrial (0.8%), Pumphouse (<0.03%), Rural Large Shed (1%), Rural Small Shed (2.8%), Silo (0.3%) and Hothouse (0.1%)

Group 1 is joined with ABS mesh block data, a population field is then calculated by dividing 'Persons Usually Resident' by 'Dwellings" (both fields from ABS data).

ABS defines these two terms as:

Persons Usually Resident: This is the count of people where they usually live, which may or may not be where they were on Census Night. This data is coded from the address supplied to the question "Where does the person usually live?" (Australian Bureau of Statistics, 2012)

Dwellings: A dwelling is a structure which is intended to have people live in it, and which is habitable on Census Night. Some examples of dwellings are houses, motels, flats, caravans, prisons, tents, humpies and houseboats. All occupied dwellings are counted in the Census. Unoccupied private dwellings are also counted with the exception of those in caravan parks, marinas and manufactured home estates. (Australian Bureau of Statistics, 2012)

Before the population field for Group 1 is applied the population and dwelling fields are modified for special cases. In each mesh block if *Dwellings* are equal to zero and *Persons Usually Resident* does not equal zero, then the *Dwelling* field is set to equal one. This is to account for situations like mesh blocks that only include a school, as there are no defined 'dwellings', but we don't want the population field to be assigned a zero value. Another special case is if the *Persons Usually Resident* field equals zero and *Dwellings* does not equal zero, then *the Persons Usually Resident* is set to equal the *Dwellings* field (thereby giving population of 1). The purpose of this is to give weight to dwellings such as in caravan parks that have not been assigned any persons usually resident.

The cadastral dataset is now used to supplement the population weightings whereby all parcels less than or equal to 2.5 hectares (6.18 acres) are selected. From this selection of parcels any building points that are with in this area are selected. For these selected points the minimum population value is raised to the sum of the mean plus two standard deviations of the entire point population dataset. The main purpose of this is to help better capture the shack communities that have high dwelling counts but low population values. As the census is taken in winter, the *Persons Usually Resident* value assigned to mesh blocks is "where people usually live".

Group 2 is now merged back with Group 1 and the population value for Group 2 is set as the previously calculated mean of Group 1. The purpose of this is to weight industrial, community, and commercial areas that might have otherwise received low weighting depending on the cut up of mesh blocks and population figures.

Using the weighted building point population data a kernel density function is run. Kernel density calculates the magnitude per unit area from the point features using a kernel function to fit a

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smoothly tapered surface to each point. In effect the density of point features in a neighbourhood around those features is calculated. Furthermore we use the previously defined population field to further weight those features. The process is run using a cell size of 25m and search radius of 500m.

A cell size of 25m is used as a reasonable compromise between computing processing capability and not over generalising by using too coarse a cell size. Also given a cell size of 25m is a fair approximate of mapping at 1:25,000, this is reasonable for the purposes of this dataset and the input data used. The search radius of 500m was used as it was deemed most appropriate (by repetition of model) for the level of smoothing we required. 500m was also deemed an accurate representative distance when contemplating a radius of defining 'settlement area around a point' i.e. how far to search to build your density layer.

From the resulting output the top 15% of the density surface is taken and converted into a vector polygon dataset. A number of cleaning operations are applied to the dataset, including dropping areas less than 20ha in size. The final dataset is intersected with the existing localities dataset to assign suburb and Local Government area names. Finally a nomenclature name field is added by assigning the closest named nomenclature point to the HSA, from a filtered nomenclature list.

Assumptions, Limitations and Strengths

It is assumed the building point dataset contains a reasonably complete and up to date coverage of the location of buildings across Tasmania. Whilst this is true for some areas of the state it could be considered untrue for others. However one of the strengths of this model to generate the HSA dataset is that if the dataset is missing individual points here and there, it should be reasonably compensated by the complementary methods of weighting. The main weakness is when whole areas of points are missing i.e. an entirely new housing development or another wholesale area is missing from the dataset. For example one such area missing data has already been identified in the North West of the state. ILS has been notified and the building point layer for that area has been updated. Hence, a future version of HSA might include that area depending on the resulting adjusted surface score.

The entire process has been built in a scripted environment; this allows for repetition using different parameters or using updated datasets to generate an updated HSA dataset.

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APPENDIX 4: PHOENIX RAPIDFIRE WEATHER PROFILES

This appendix provides information about the weather profiles that were generated for Phoenix modelling. 45 weather stations were used to generate weather profiles. For each weather station, figures were prepared that compare daily observed meteorological conditions to the synthetic aggregate meteorological variables for the site. In these figures, Temperature (◦C), wind speed (km/h), average wind direction (arrows showing ◦ from north), relative humidity (%) and Forest Fire Danger Index (FFDI) values are represented on the Y axis. The X axis represents time in a 24 hour period from 0:00 to 23:59. The first black vertical line on the X axis indicates 13:00, the next indicates 22:00. Fine lines in the data represent observed daily meteorological records. Bold lines represent the synthetic aggregate meteorological variables, used as weather inputs in Phoenix.

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3.1 92001 Apslawn Weather Station

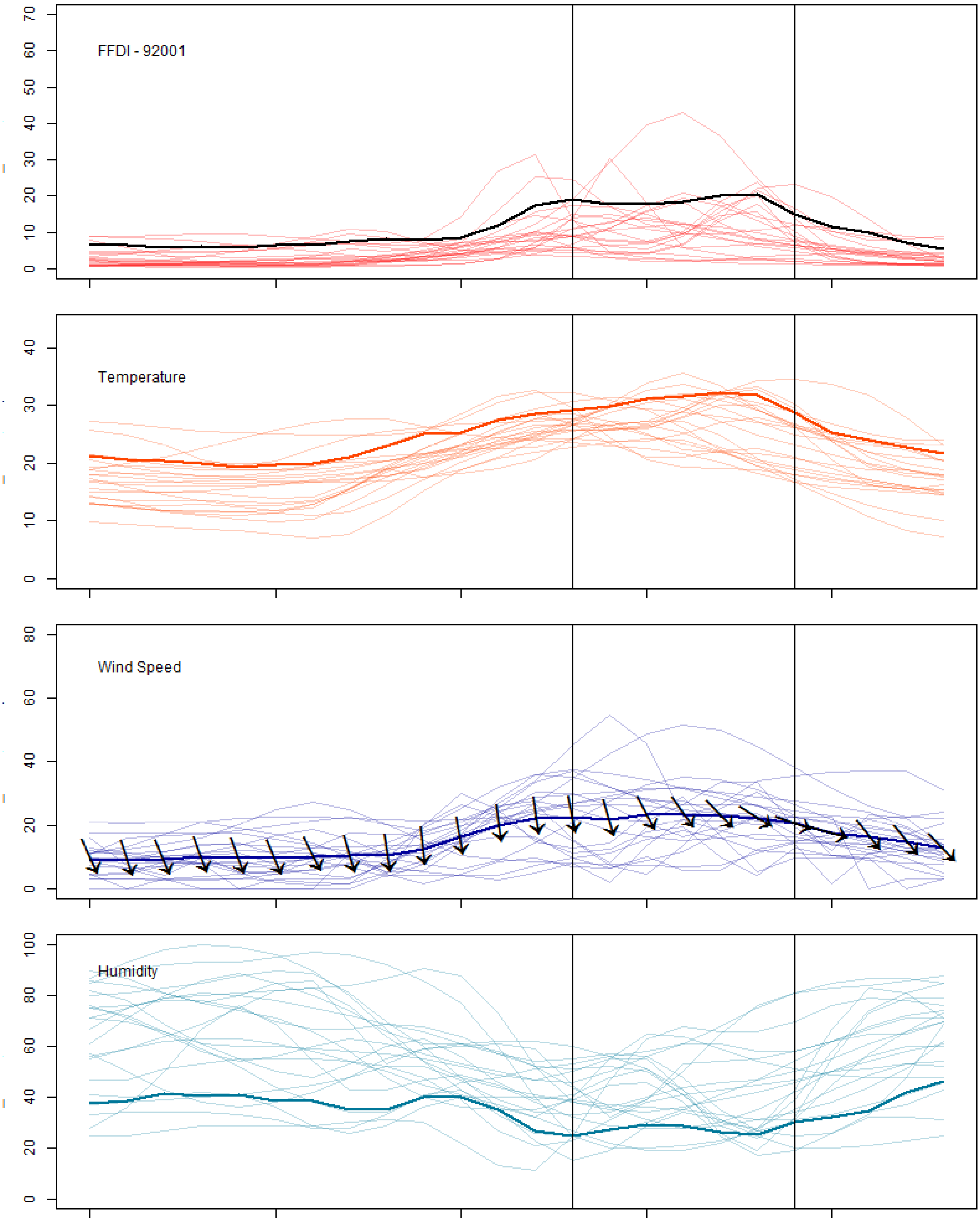

Figure 58: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Apslawn Bureau of Meteorology weather station (no. 92001).

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Figure 59: Estimated Tasmanian land area represented by the Apslawn (no. 92001) weather station (shown in red), adapted from the BRAM HFI Layer (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 9: PHOENIX Rapidfire weather inputs for ignition points located in the Apslawn (no. 92001) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	29.3	25	349	23	8	80	2
14:00	29.9	27.3	344	22	8	80	31
15:00	31.1	29.2	332	23	8	80	27
16:00	31.6	28.9	324	23	8	80	27
17:00	32.2	26.5	316	23	8	80	17
18:00	31.7	25.3	302	22	8	80	0
19:00	28.8	30.2	289	21	8	80	0
20:00	25.2	32.2	286	17	8	80	0
21:00	24	34.5	322	16	8	80	0
22:00	22.8	42.1	321	15	8	80	0

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3.2 92003 Bicheno Council Depot Weather Station

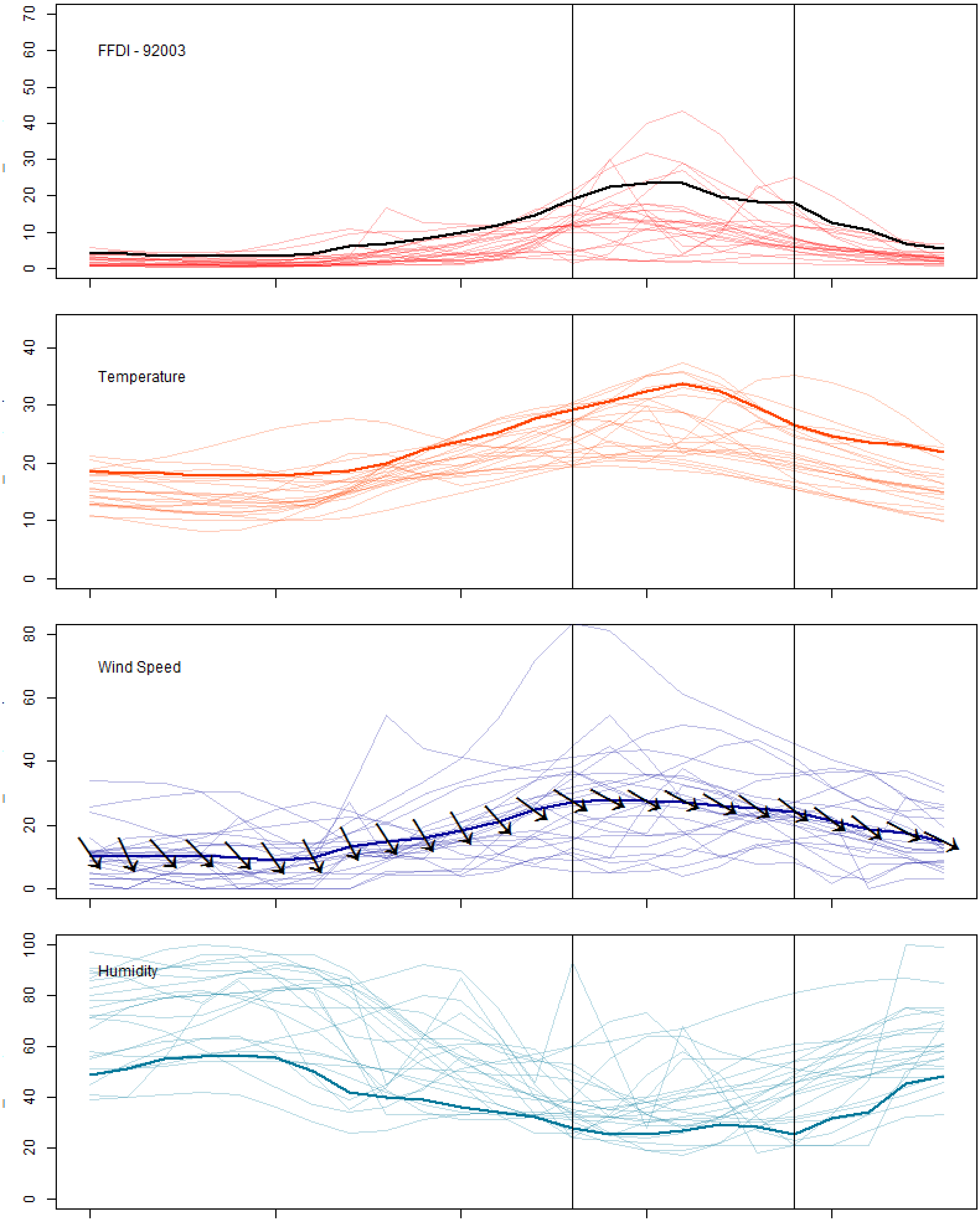

Figure 60: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Bicheno council depot Bureau of Meteorology weather station (no. 92003).

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Figure 61: Estimated Tasmanian land area represented by the Bicheno council depot (no. 92003) weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 10: PHOENIX Rapidfire weather inputs for ignition points located in the Bicheno (no. 92003) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	29.1	27.9	302	27	8	80	0
14:00	30.7	25.3	298	28	8	80	12
15:00	32.4	25.2	299	28	8	80	28
16:00	33.7	26.6	298	27	8	80	31
17:00	32.4	29.3	301	26	8	80	21
18:00	29.7	28.3	306	26	8	80	0
19:00	26.7	25.1	308	24	8	80	0
20:00	24.7	31.6	307	21	8	80	0
21:00	23.7	34.2	308	19	8	80	0
22:00	23.2	45.2	298	18	8	80	0

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3.3 91009 Burnie (Round Hill) Weather Station

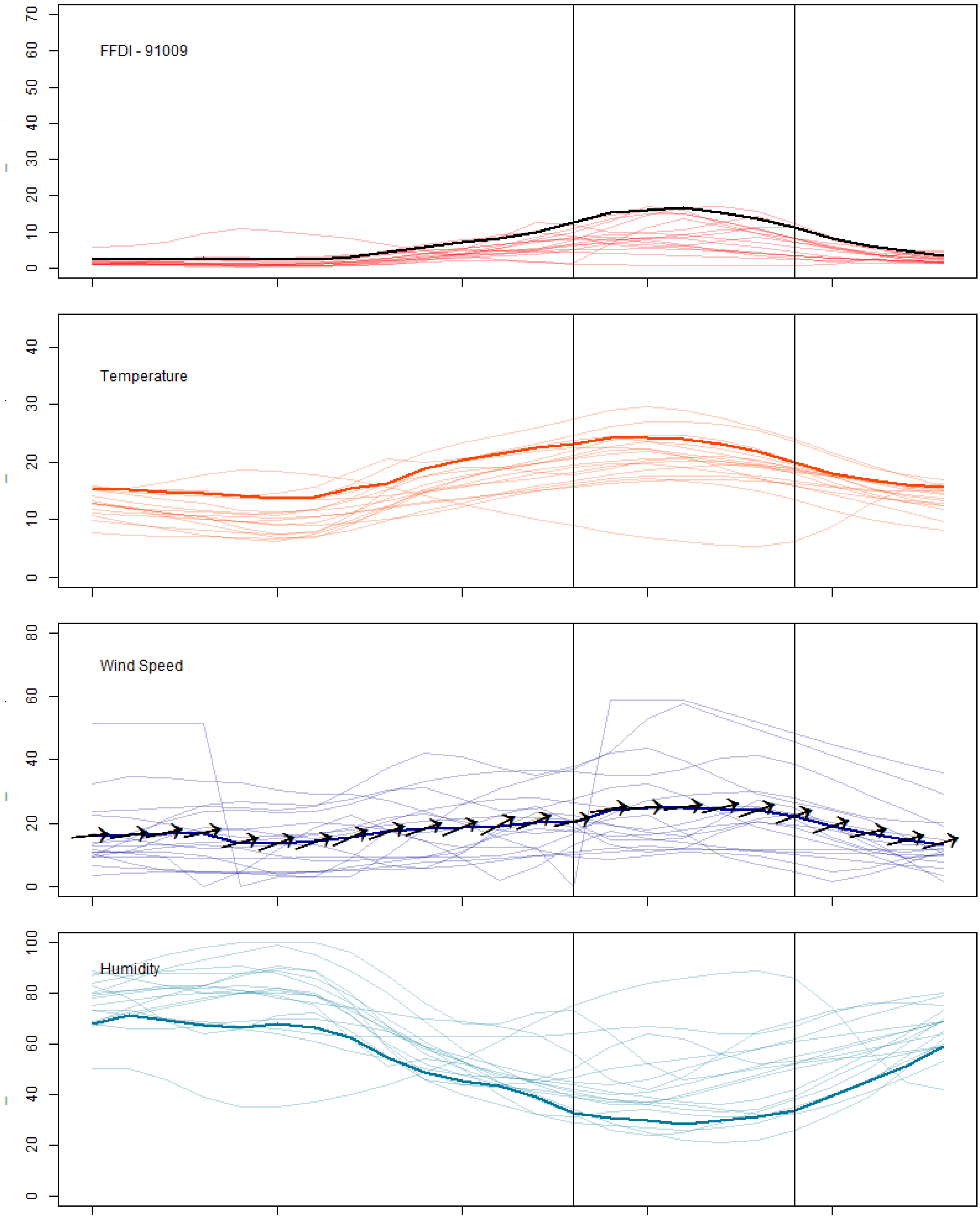

Figure 62: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Burnie (Round Hill) Bureau of Meteorology weather station (no. 91009).

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Figure 63: Estimated Tasmanian land area represented by the Burnie (no. 91009) weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 11: PHOENIX Rapidfire weather inputs for ignition points located in the Burnie weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	23.3	32.8	256	20	8.9	89	0
14:00	24.2	30.6	261	24	8.9	89	3
15:00	24.3	29.8	266	25	8.9	89	1
16:00	24.1	28.4	263	25	8.9	89	3
17:00	23.2	29.8	256	25	8.9	89	4
18:00	21.8	31.4	251	24	8.9	89	0
19:00	20	33.8	249	22	8.9	89	0
20:00	17.9	39.4	251	19	8.9	89	0
21:00	16.9	45.4	257	17	8.9	89	0
22:00	16.1	51.2	255	15	8.9	89	0

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3.4 95003 Bushy Park Weather Station

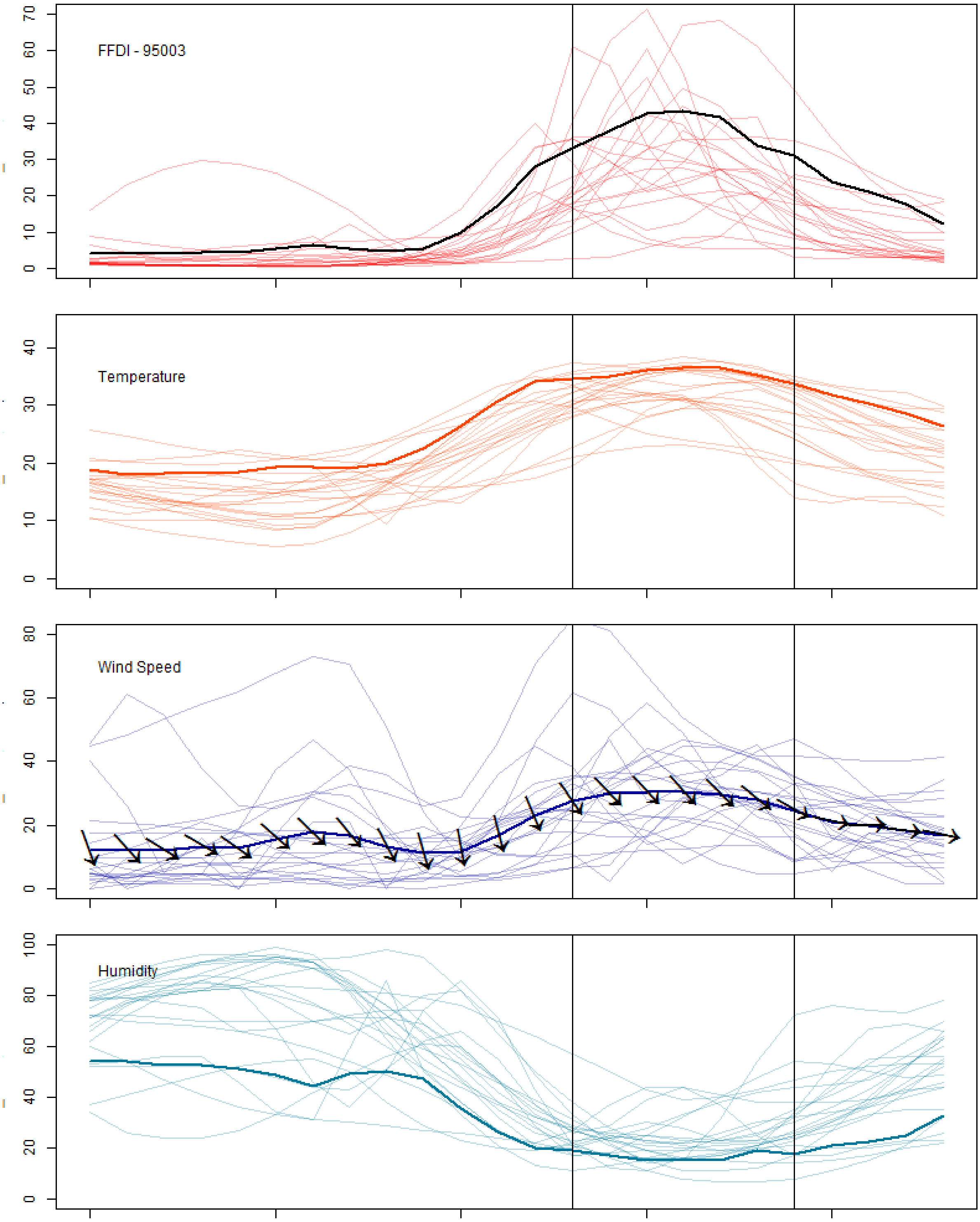

Figure 64: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Bushy Park Bureau of Meteorology weather station (no. 95003).

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Figure 65: Estimated Tasmanian land area represented by the Bushy Park no. 95003 Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 12: PHOENIX Rapidfire weather inputs for ignition points located in the Bushy Park weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	34.6	19.2	325	28	8.3	83	0
14:00	35	17	316	30	8.3	83	0
15:00	36.1	15	317	31	8.3	83	0
16:00	36.6	15	319	30	8.3	83	0
17:00	36.4	15.3	314	30	8.3	83	0
18:00	35.2	19.2	308	28	8.3	83	0
19:00	33.6	17.6	299	25	8.3	83	0
20:00	31.8	21.1	282	21	8.3	83	0
21:00	30.3	22.7	269	20	8.3	83	0
22:00	28.6	24.8	277	18	8.3	83	0

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3.5 94009 Campania Weather Station

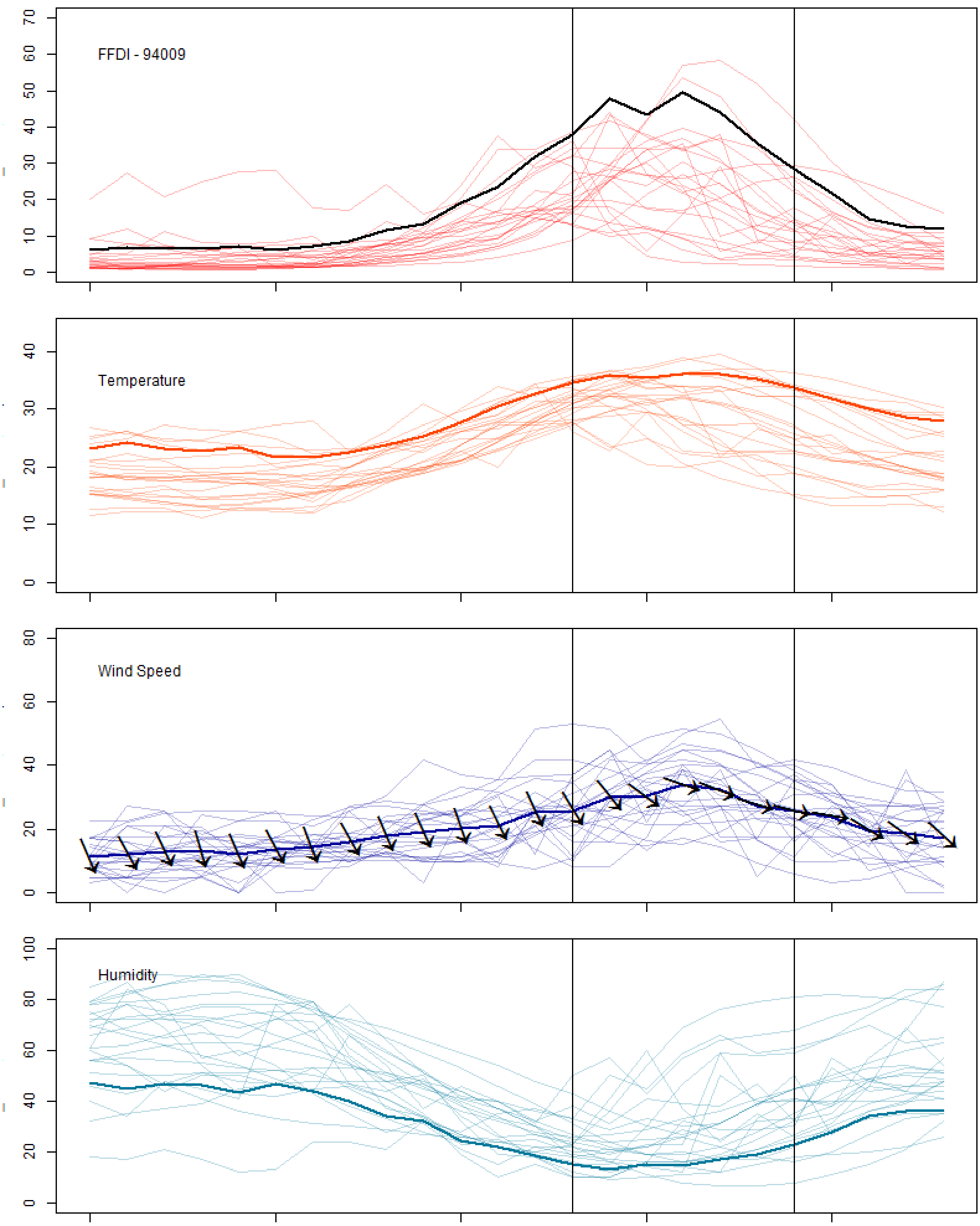

Figure 66: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Campania Bureau of Meteorology weather station (no. 94009).

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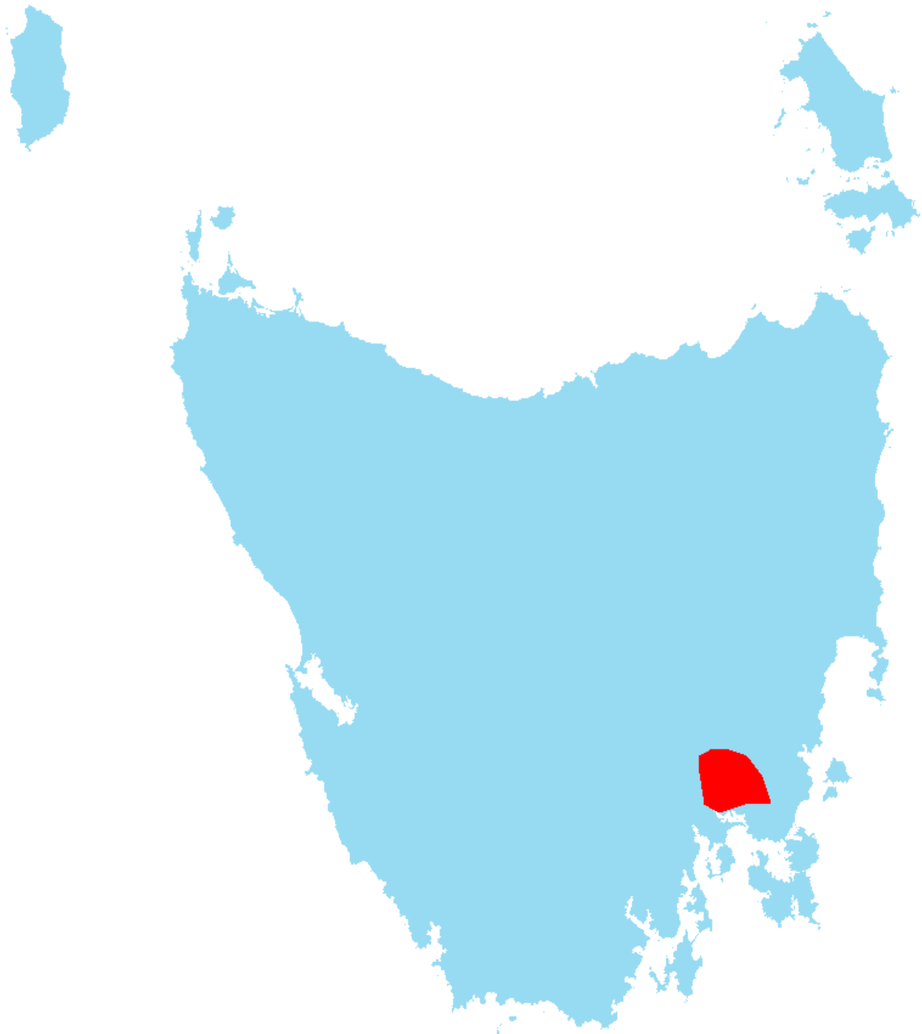

Figure 67: Estimated Tasmanian land area represented by the Campania no. 95003 Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 13: PHOENIX Rapidfire weather inputs for ignition points located in the Campania weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	34.6	15.3	328	26	8.8	88	0
14:00	35.9	12.9	321	30	8.8	88	0
15:00	35.4	15.3	306	30	8.8	88	0
16:00	36.1	14.6	289	34	8.8	88	0
17:00	36.1	17	291	32	8.8	88	0
18:00	35.1	18.9	287	27	8.8	88	0
19:00	33.6	22.9	284	26	8.8	88	0
20:00	31.8	27.6	280	24	8.8	88	0
21:00	30	33.9	301	19	8.8	88	0
22:00	28.6	36.2	306	19	8.8	88	0

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3.6 94010 Cape Bruny Lighthouse Weather Station

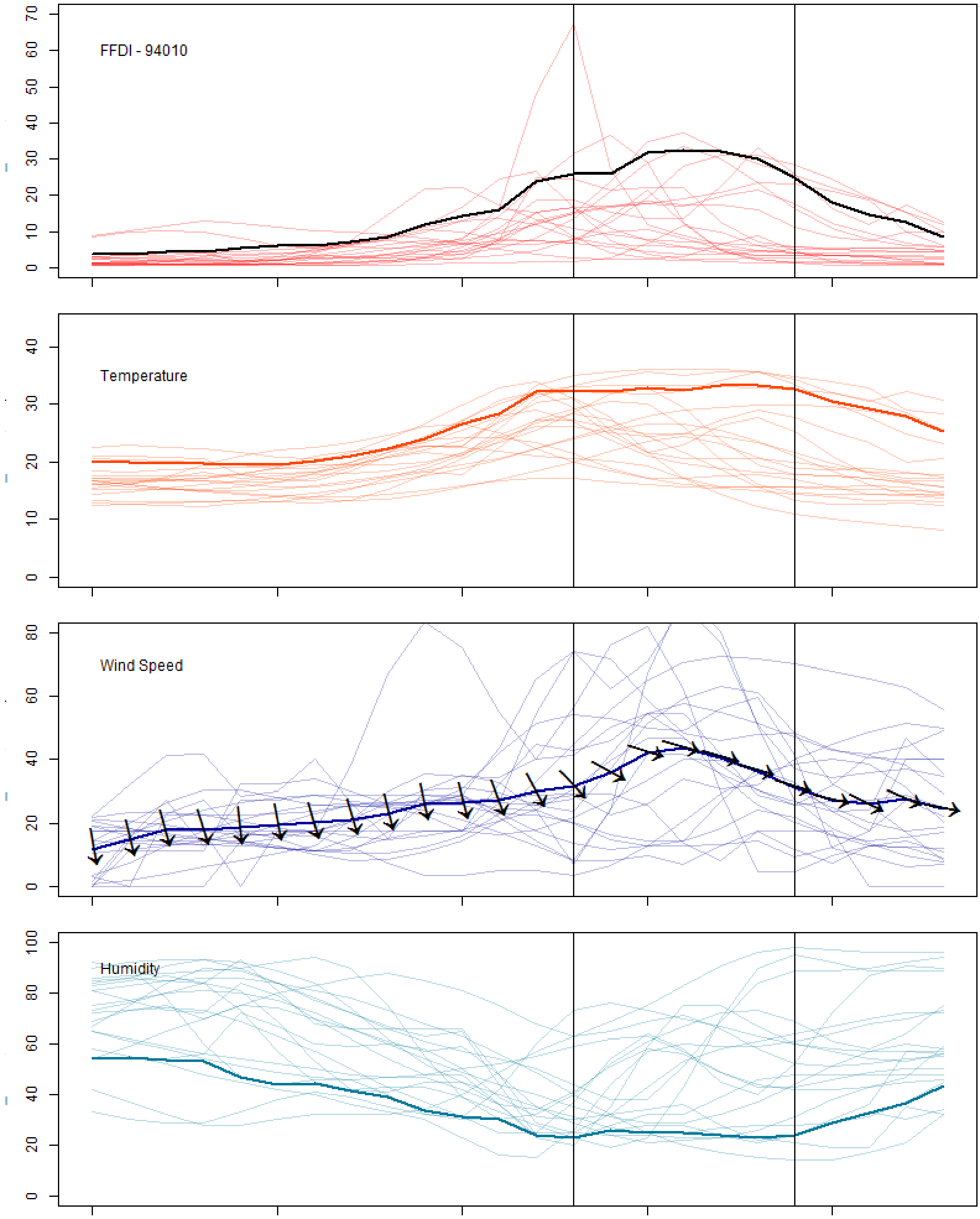

Figure 68: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Cape Bruny Lighthouse Bureau of Meteorology weather station (no. 94010).

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Figure 69: Estimated Tasmanian land area represented by the Cape Bruny Lighthouse no. 95003 Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 14: PHOENIX Rapidfire weather inputs for ignition points located in the Cape Bruny Lighthouse weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	32.4	23	317	32	7.4	74	7.65
14:00	32.2	25.7	299	36	7.4	74	21.85
15:00	32.9	24.9	288	42	7.4	74	22.95
16:00	32.4	24.7	286	44	7.4	74	0
17:00	33.3	23.9	286	41	7.4	74	0
18:00	33.2	22.9	287	36	7.4	74	0
19:00	32.6	24	287	31	7.4	74	0
20:00	30.6	29	283	27	7.4	74	0
21:00	29.1	32.7	296	26	7.4	74	0
22:00	27.9	36.7	293	28	7.4	74	0

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3.7 91011 Cape Grim (Woolnorth) Weather Station

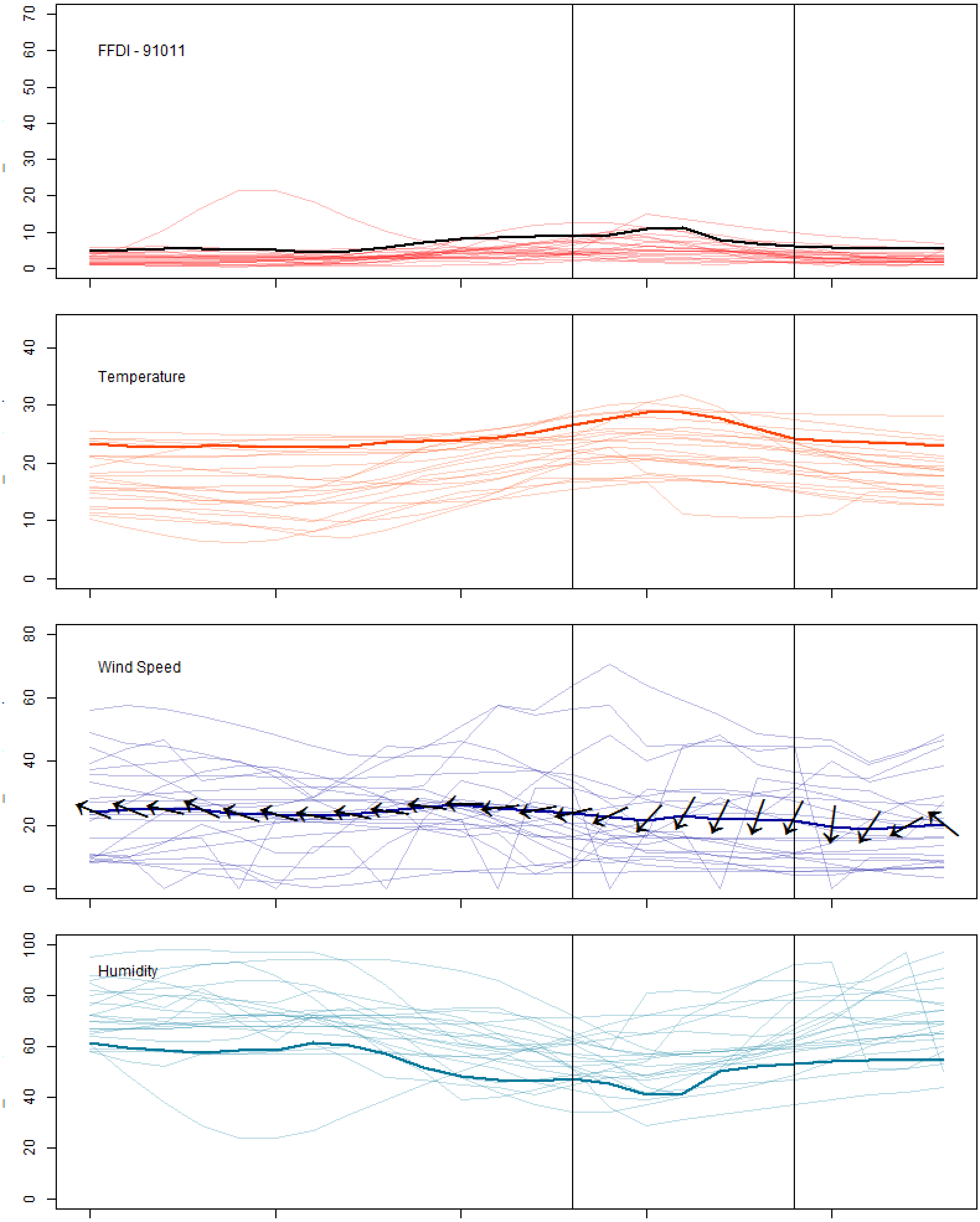

Figure 70: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Cape Grim Bureau of Meteorology weather station (no. 91011).

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Figure 71: Estimated Tasmanian land area represented by the Cape Grim (no. 91011) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 15: PHOENIX Rapidfire weather inputs for ignition points located in the Cape Grim (no. 91011) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	26.6	47.3	77	24	8.3	83	0
14:00	27.6	45.5	65	23	8.3	83	0
15:00	28.8	41.2	43	22	8.3	83	15.05
16:00	28.7	41.3	29	23	8.3	83	0
17:00	27.7	50	26	22	8.3	83	0
18:00	25.9	52.2	19	22	8.3	83	1.65
19:00	24.2	53	27	22	8.3	83	2.25
20:00	23.9	54.2	7	20	8.3	83	0
21:00	23.6	54.5	33	19	8.3	83	0
22:00	23.3	54.6	61	19	8.3	83	0

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3.8 91022 Cressy Research Station Weather Station

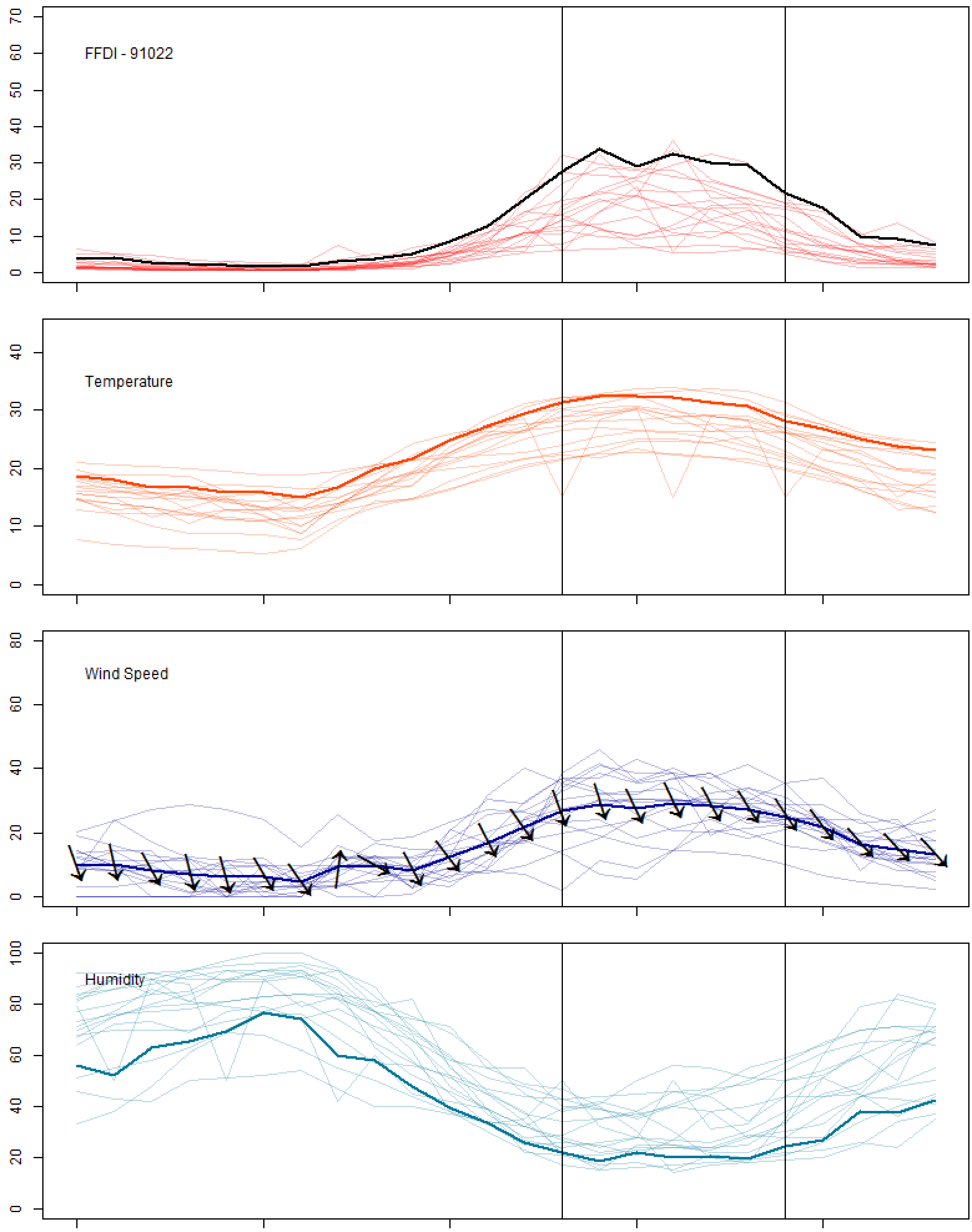

Figure 72: Comparison of daily meteorological records and synthetic aggregate meteorological variables for Cressy Research Station weather station (no. 91022).

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Figure 73: Estimated Tasmanian land area represented by the Cressy Research Station (no. 91022) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 16: PHOENIX Rapidfire weather inputs for ignition points located in the Cressy Research Station (no. 91022) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	31.4	21.8	340	27	8.8	88	0
14:00	32.4	18.6	343	29	8.8	88	0
15:00	32.5	21.8	334	28	8.8	88	0
16:00	32.2	19.8	335	29	8.8	88	0
17:00	31.4	20.4	332	28	8.8	88	0
18:00	30.6	19.4	327	27	8.8	88	0
19:00	28.2	24.4	326	25	8.8	88	0
20:00	26.7	26.8	323	22	8.8	88	0
21:00	25	38	319	16	8.8	88	0
22:00	23.7	37.6	317	15	8.8	88	0

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3.9 98001 Currie Weather Station

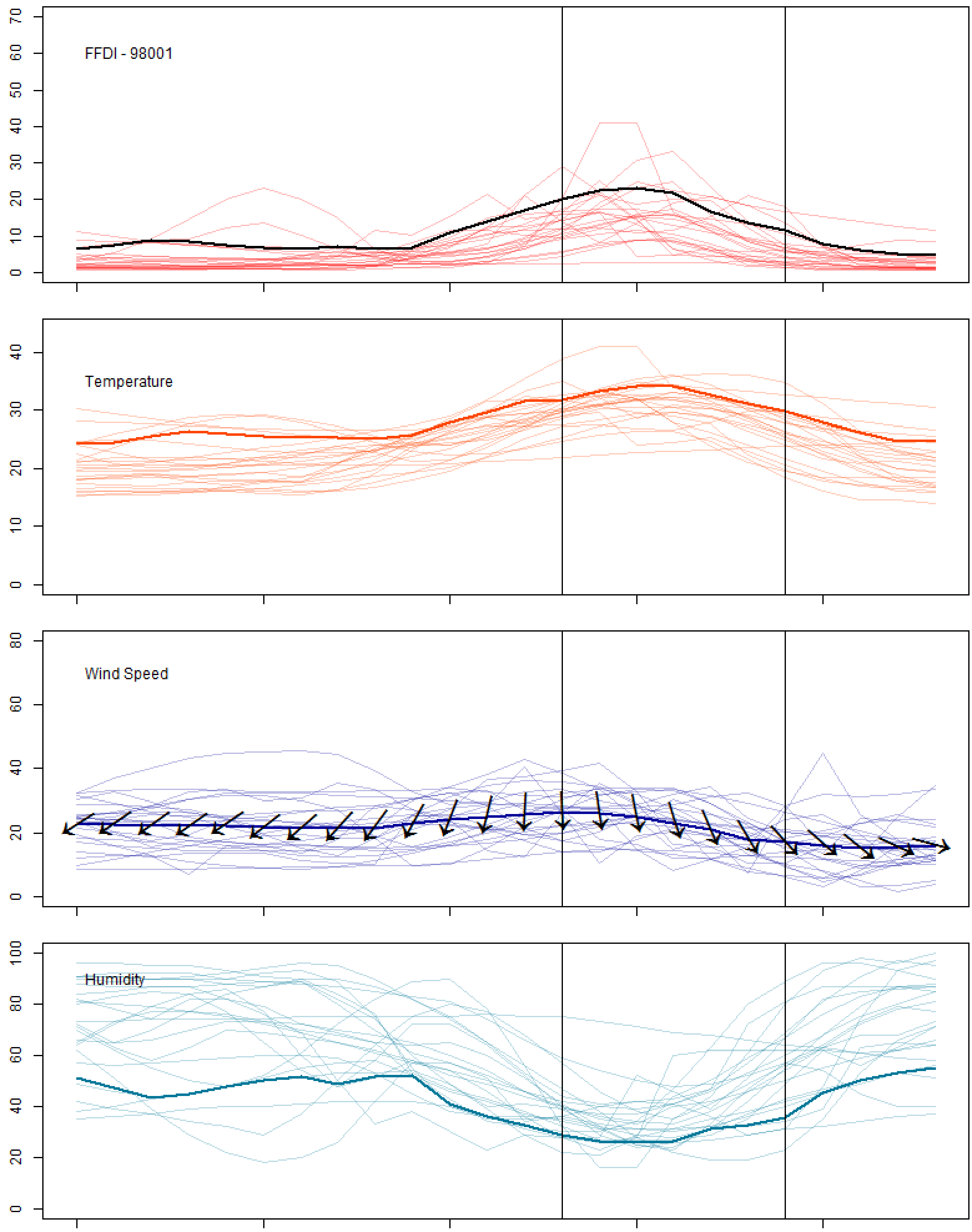

Figure 74: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Currie weather station (no. 98001).

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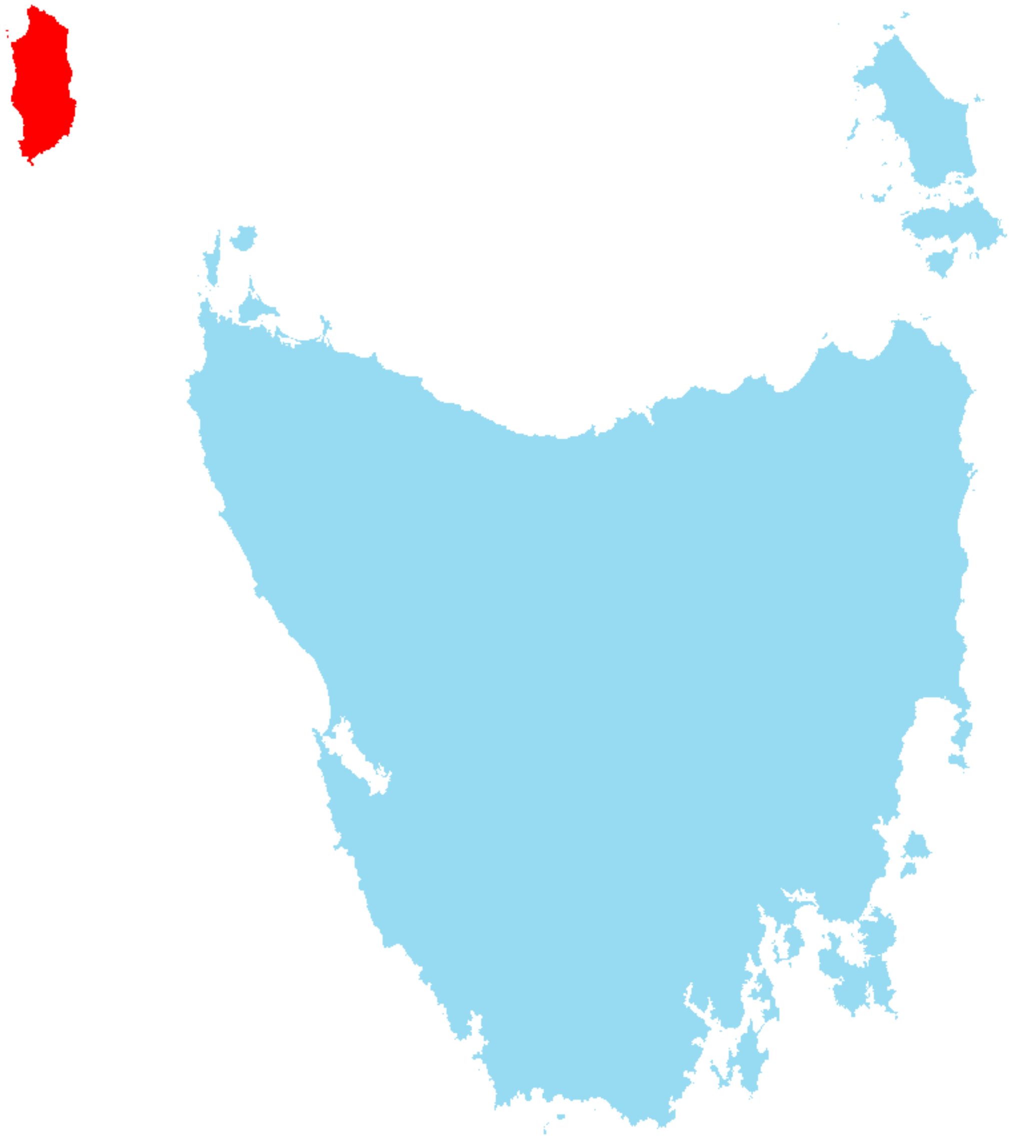

Figure 75: Estimated Tasmanian land area represented by the Currie (no. 98001) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 17: PHOENIX Rapidfire weather inputs for ignition points located in the Currie (no. 98001) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	31.9	28.6	357	26	7.9	79	0
14:00	33.4	26.3	352	26	7.9	79	0
15:00	34.2	25.6	349	25	7.9	79	0
16:00	34.2	26.3	344	23	7.9	79	0
17:00	32.6	31	337	21	7.9	79	0
18:00	31	32.9	330	18	7.9	79	0
19:00	29.8	35.8	318	17	7.9	79	0
20:00	27.9	45.3	311	16	7.9	79	0
21:00	26.3	50	309	15	7.9	79	0
22:00	24.7	53	295	15	7.9	79	0

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3.10 91126 Devonport Airport Weather Station

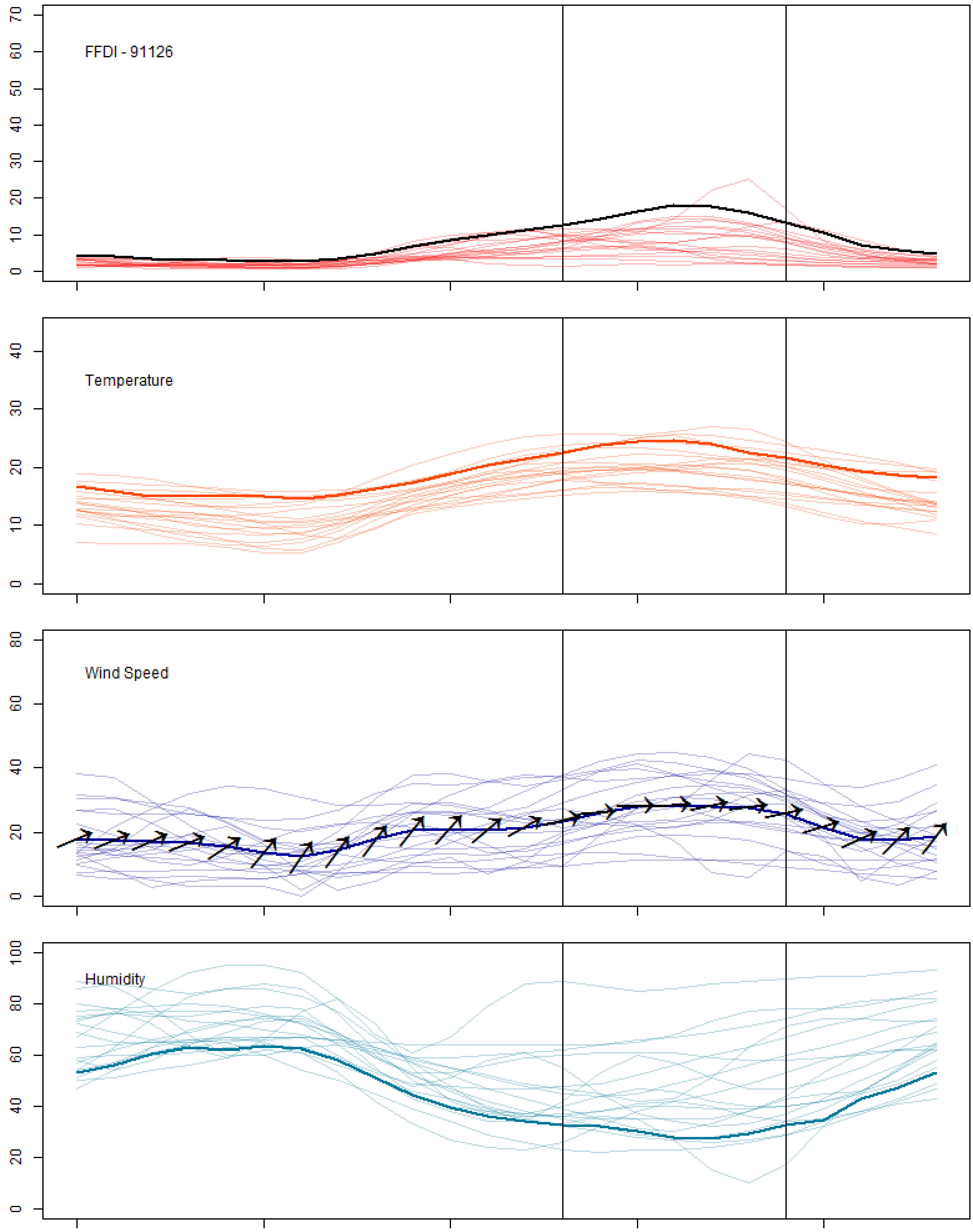

Figure 76: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Devonport Airport weather station (no. 91126).

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Figure 77: Estimated Tasmanian land area represented by the Devonport Airport (no. 91126) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 18: PHOENIX Rapidfire weather inputs for ignition points located in the Devonport Airport (no.91126) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	22.6	32.7	256	23	8.5	85	28.1
14:00	23.8	32	265	26	8.5	85	30.1
15:00	24.6	30.4	269	28	8.5	85	31
16:00	24.6	27.7	266	28	8.5	85	31
17:00	24	27.4	258	28	8.5	85	31
18:00	22.6	29.1	263	28	8.5	85	5.6
19:00	21.8	32.5	258	26	8.5	85	30.7
20:00	20.4	34.7	253	22	8.5	85	30.4
21:00	19.2	42.9	246	18	8.5	85	0
22:00	18.8	47.2	225	18	8.5	85	30

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3.11 94020 Dover Weather Station

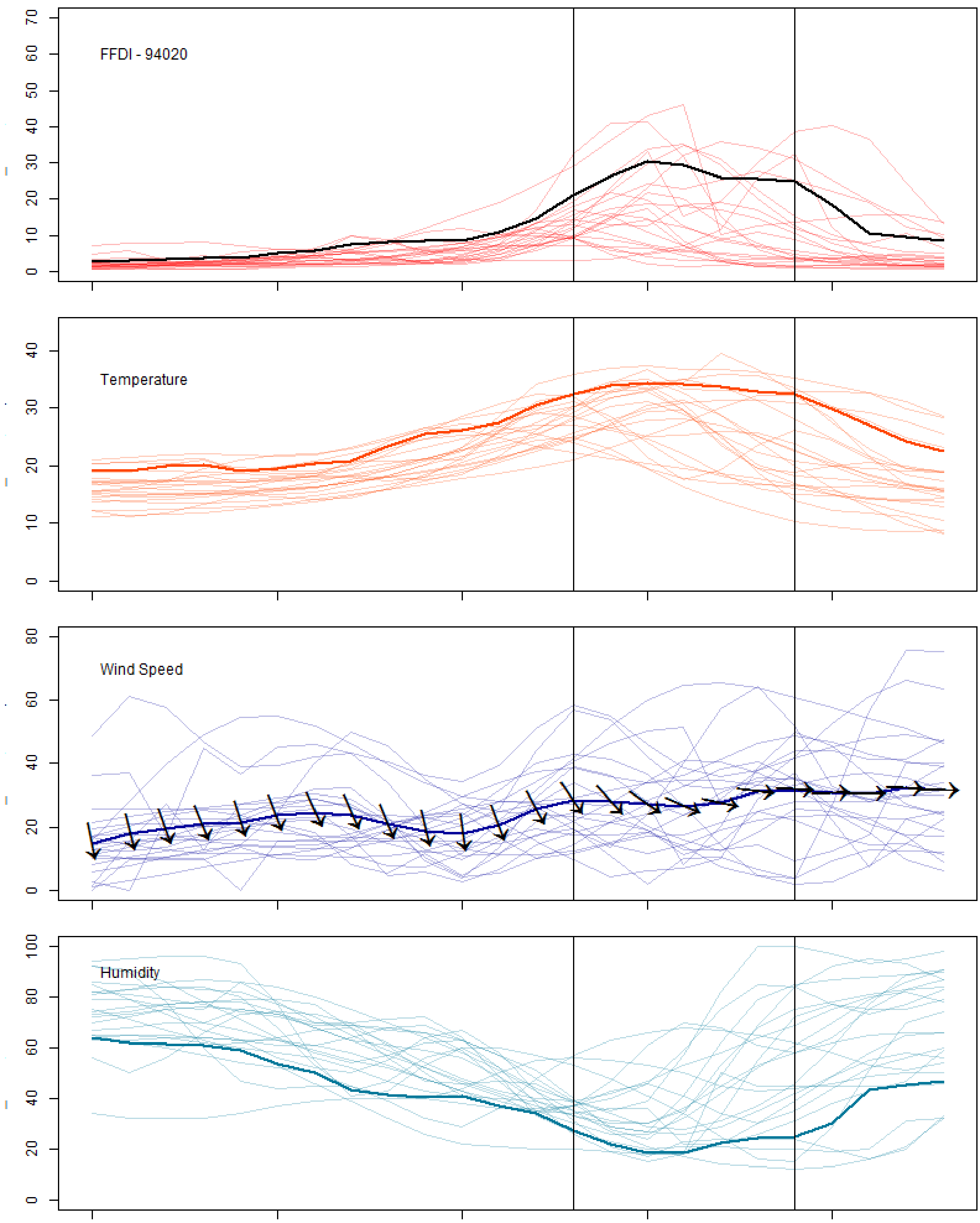

Figure 78: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Dover weather station (no. 94020).

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Figure 79: Estimated Tasmanian land area represented by the Dover (no. 94020) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 19: PHOENIX Rapidfire weather inputs for ignition points located in the Dover (no.94020) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	32.4	27.5	326	28	7.6	76	0
14:00	33.8	22.2	318	28	7.6	76	0
15:00	34.4	18.3	305	27	7.6	76	0
16:00	34.2	18.5	294	27	7.6	76	0
17:00	33.7	22.3	282	28	7.6	76	0
18:00	32.8	24.3	277	31	7.6	76	0
19:00	32.5	25.1	273	32	7.6	76	0
20:00	29.8	30.4	267	31	7.6	76	0
21:00	27.1	43.3	270	30	7.6	76	0
22:00	24.2	45.3	273	32	7.6	76	0

ISBN: 978-0-9925970-0-9

3.12 92045 Eddystone Point Weather Station

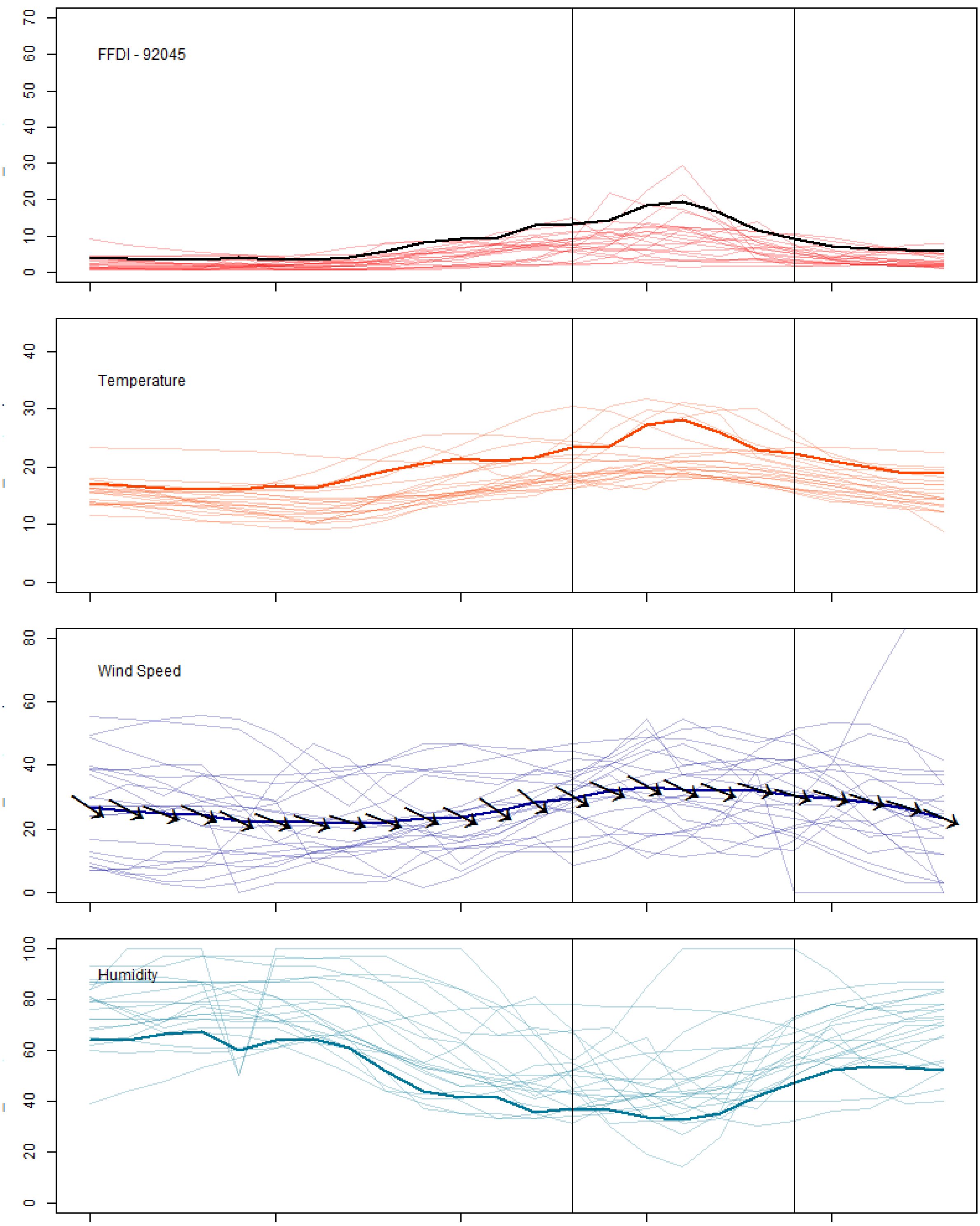

Figure 80: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Eddystone Point weather station (no. 92045).

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Figure 81: Estimated Tasmanian land area represented by the Eddystone Point (no. 92045) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 20: PHOENIX Rapidfire weather inputs for ignition points located in the Eddystone Point (no.92045) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	23.5	37	300	30	8.7	87	0
14:00	23.7	36.5	294	32	8.7	87	0
15:00	27.3	33.6	298	33	8.7	87	0
16:00	28.1	32.5	296	32	8.7	87	3.6
17:00	25.9	35.2	292	32	8.7	87	0
18:00	22.9	42.2	287	32	8.7	87	0
19:00	22.3	47.5	287	30	8.7	87	0
20:00	21	52.3	288	30	8.7	87	0
21:00	19.9	53.5	287	28	8.7	87	0
22:00	18.9	53	287	27	8.7	87	0

ISBN: 978-0-9925970-0-9

3.13 91074 Edith Creek Weather Station

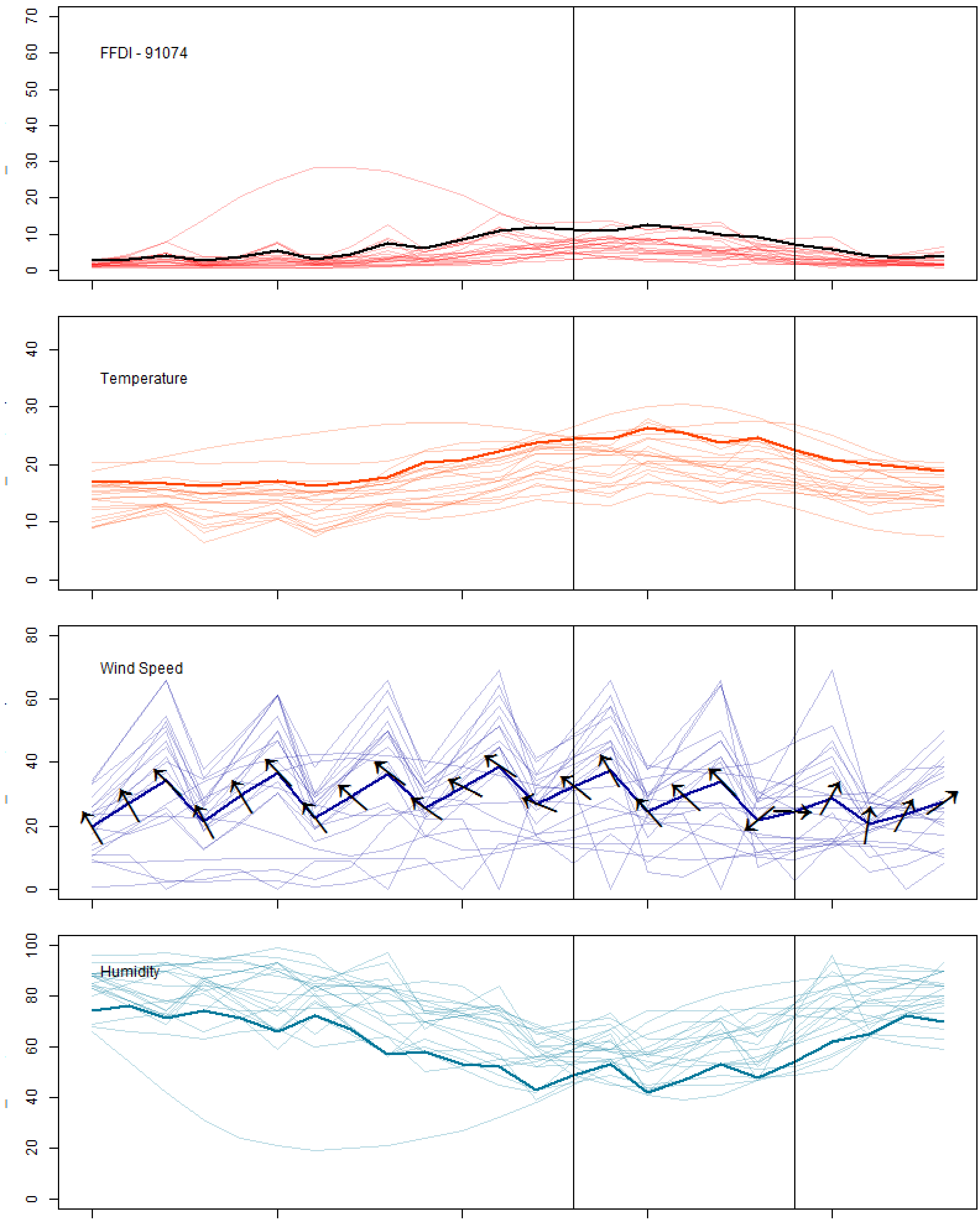

Figure 82: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Edith Creek weather station (no. 91074).

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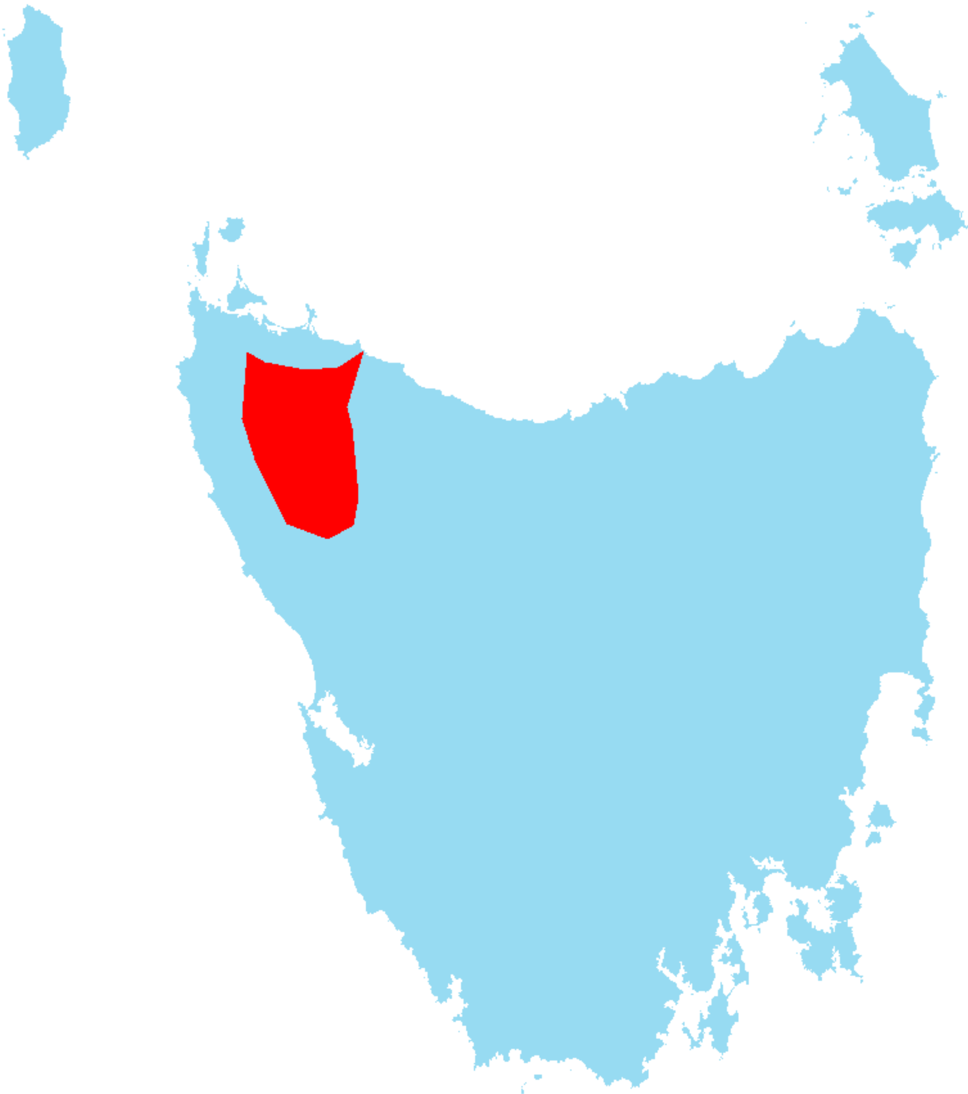

Figure 83: Estimated Tasmanian land area represented by the Edith Creek (no. 91074) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 21: PHOENIX Rapidfire weather inputs for ignition points located in the Edith Creek (no.91074) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	24.4	49	128	32	10	100	0
14:00	24.4	53	150	38	10	100	0
15:00	26.4	42	139	24	10	100	0
16:00	25.5	47	133	30	10	100	0
17:00	23.9	53	135	34	10	100	0
18:00	24.6	48	50	22	10	100	0
19:00	22.5	54	273	25	10	100	0
20:00	20.9	62	210	29	10	100	0
21:00	20.2	65	189	21	10	100	0
22:00	19.4	72	209	24	10	100	0

ISBN: 978-0-9925970-0-9

3.14 92012 Fingal (Legge Street) Weather Station

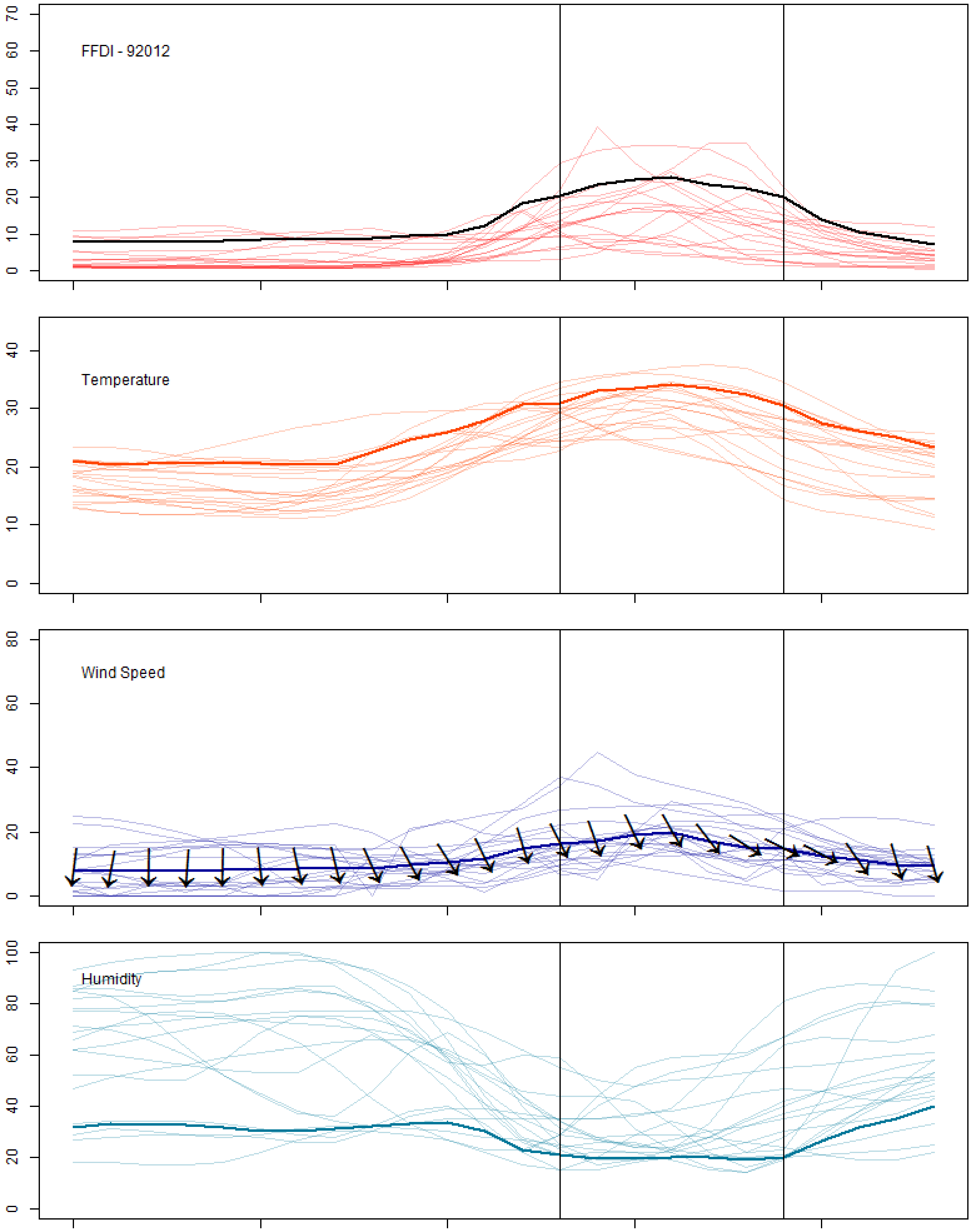

Figure 84: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Fingal (Legge Street) weather station (no. 92012).

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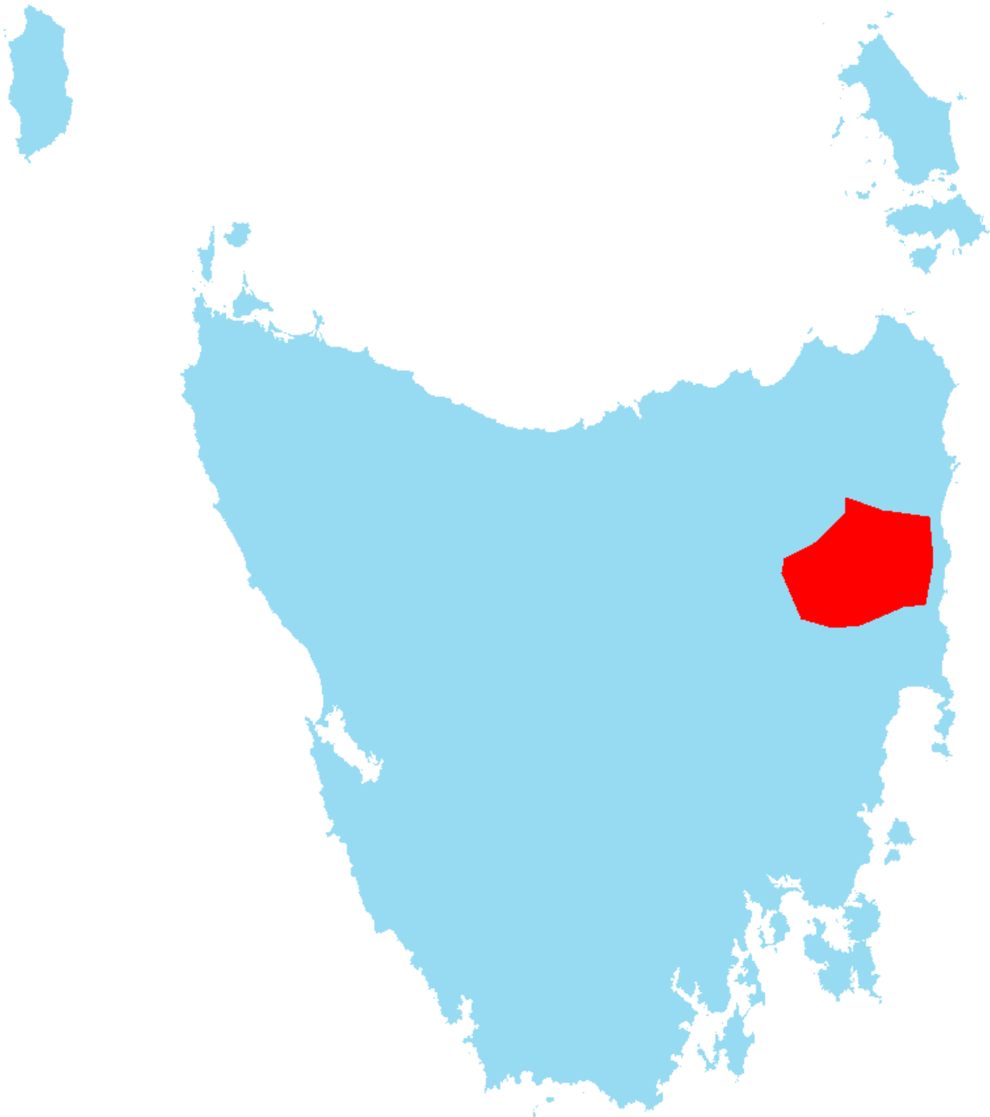

Figure 85: Estimated Tasmanian land area represented by the Fingal (Legge Street) (no. 92012) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 22: PHOENIX Rapidfire weather inputs for ignition points located in the Fingal (Legge Street) (no.92012) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	30.8	21	333	16	8.2	82	0
14:00	33.2	19.7	340	17	8.2	82	5
15:00	33.5	19.7	335	19	8.2	82	9.9
16:00	34.2	20	331	20	8.2	82	7.1
17:00	33.5	20	322	17	8.2	82	4.7
18:00	32.5	18.8	303	15	8.2	82	0
19:00	30.5	20	296	15	8.2	82	0
20:00	27.6	26.1	298	13	8.2	82	0
21:00	26.1	31.9	326	11	8.2	82	0
22:00	25	34.9	343	10	8.2	82	0

ISBN: 978-0-9925970-0-9

3.15 99005 Flinders Island Airport Weather Station

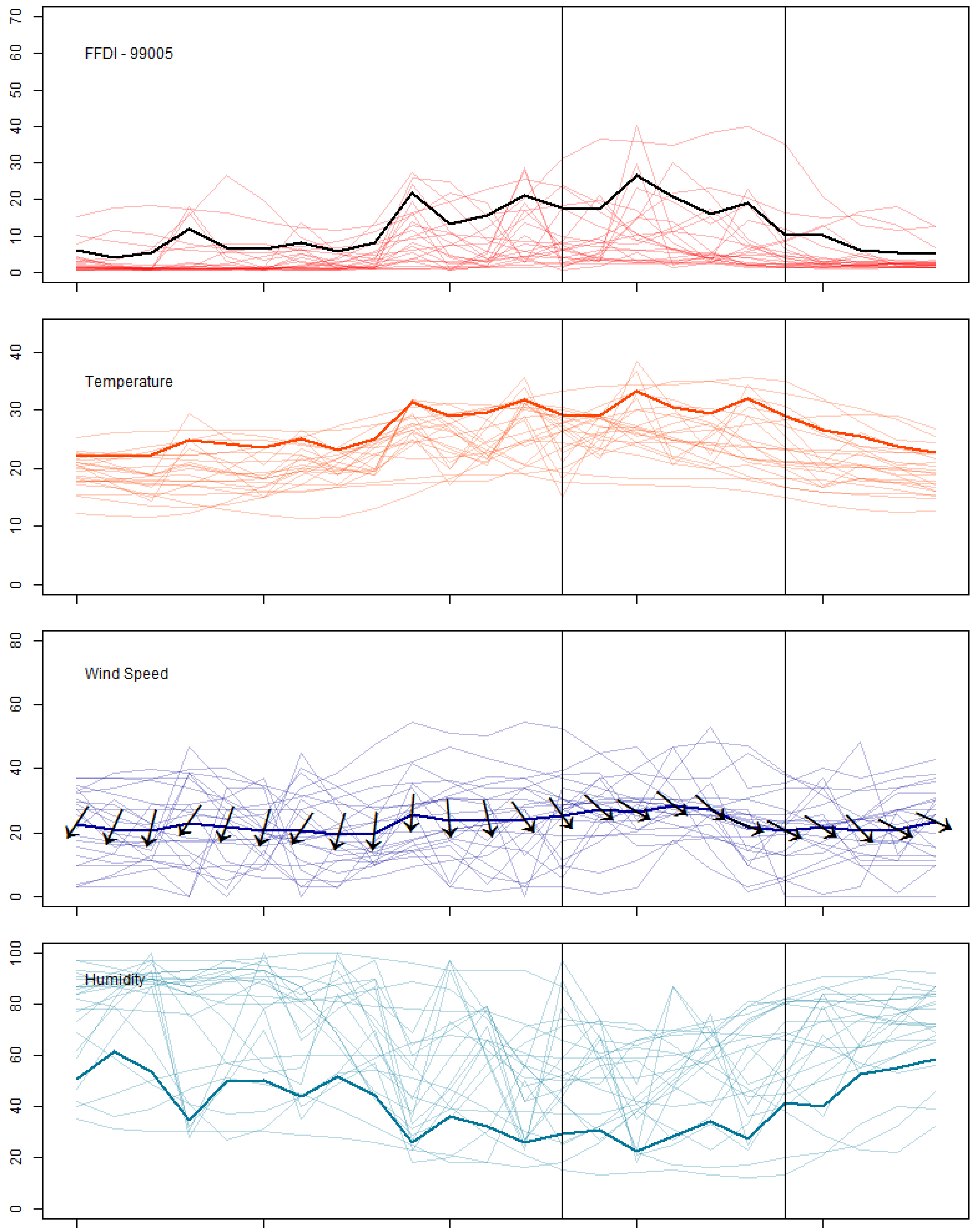

Figure 86: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Flinders Island Airport weather station (no. 99005).

ISBN: 978-0-9925970-0-9

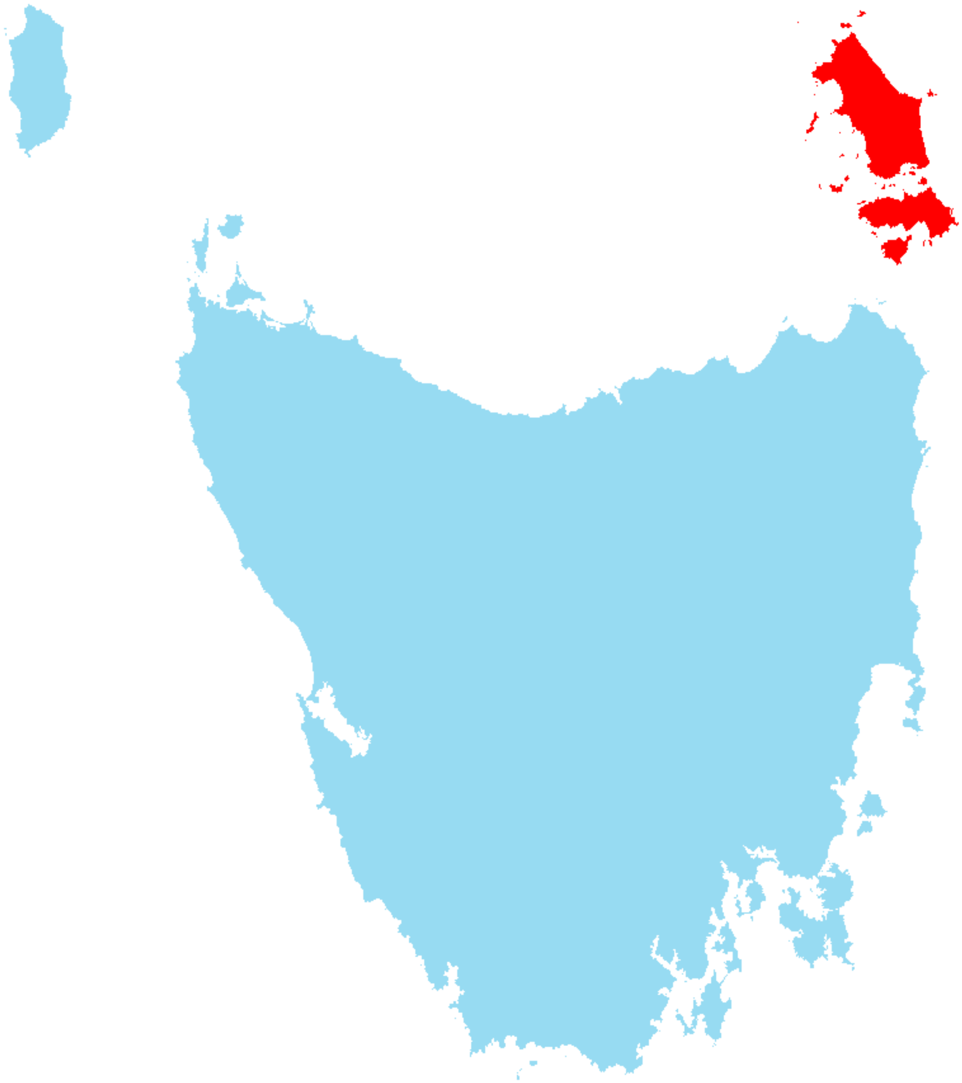

Figure 87: Estimated Tasmanian land area represented by the Flinders Island Airport (no. 99005) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 23: PHOENIX Rapidfire weather inputs for ignition points located in the Flinders Island Airport (no.99005) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	29.2	29.3	324	25	8.1	81	0
14:00	28.9	30.6	312	27	8.1	81	0
15:00	33.2	22.3	301	26	8.1	81	31
16:00	30.6	28.2	308	29	8.1	81	9.3
17:00	29.4	33.9	310	27	8.1	81	0
18:00	32.1	27.4	292	22	8.1	81	0
19:00	28.9	41.5	298	21	8.1	81	0
20:00	26.6	40.2	304	22	8.1	81	0
21:00	25.4	52.9	316	21	8.1	81	0
22:00	23.7	55.1	297	21	8.1	81	0

ISBN: 978-0-9925970-0-9

3.16 94137 Geeveston (Cemetery Road) Weather Station

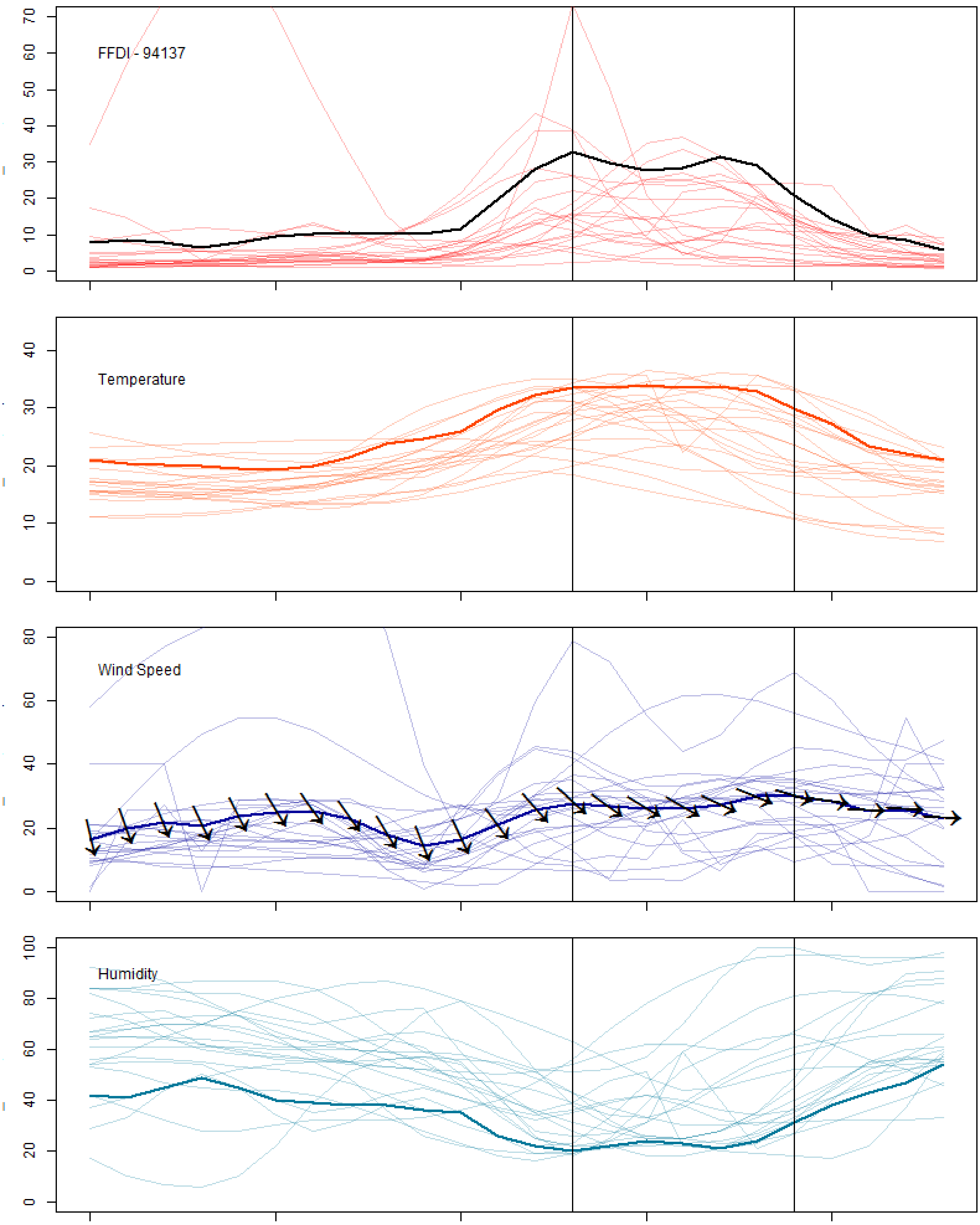

Figure 88: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Geeveston (Cemetery Rd) weather station (no. 94137).

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Figure 89: Estimated Tasmanian land area represented by the Geeveston (Cemetery Rd) (no. 94137) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 24: PHOENIX Rapidfire weather inputs for ignition points located in the Geeveston (Cemetery Rd no. 94137) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	33.5	20	312	28	8.8	88	0
14:00	33.6	22	306	27	8.8	88	0
15:00	33.8	24	301	26	8.8	88	0
16:00	33.5	23	300	26	8.8	88	0
17:00	33.6	21	295	27	8.8	88	0
18:00	32.8	24	291	30	8.8	88	0
19:00	29.8	31	286	30	8.8	88	0
20:00	27.2	38	278	28	8.8	88	0
21:00	23.3	43	273	25	8.8	88	0
22:00	22.2	47	274	26	8.8	88	0

ISBN: 978-0-9925970-0-9

3.17 94027 Hastings Chalet Weather Station

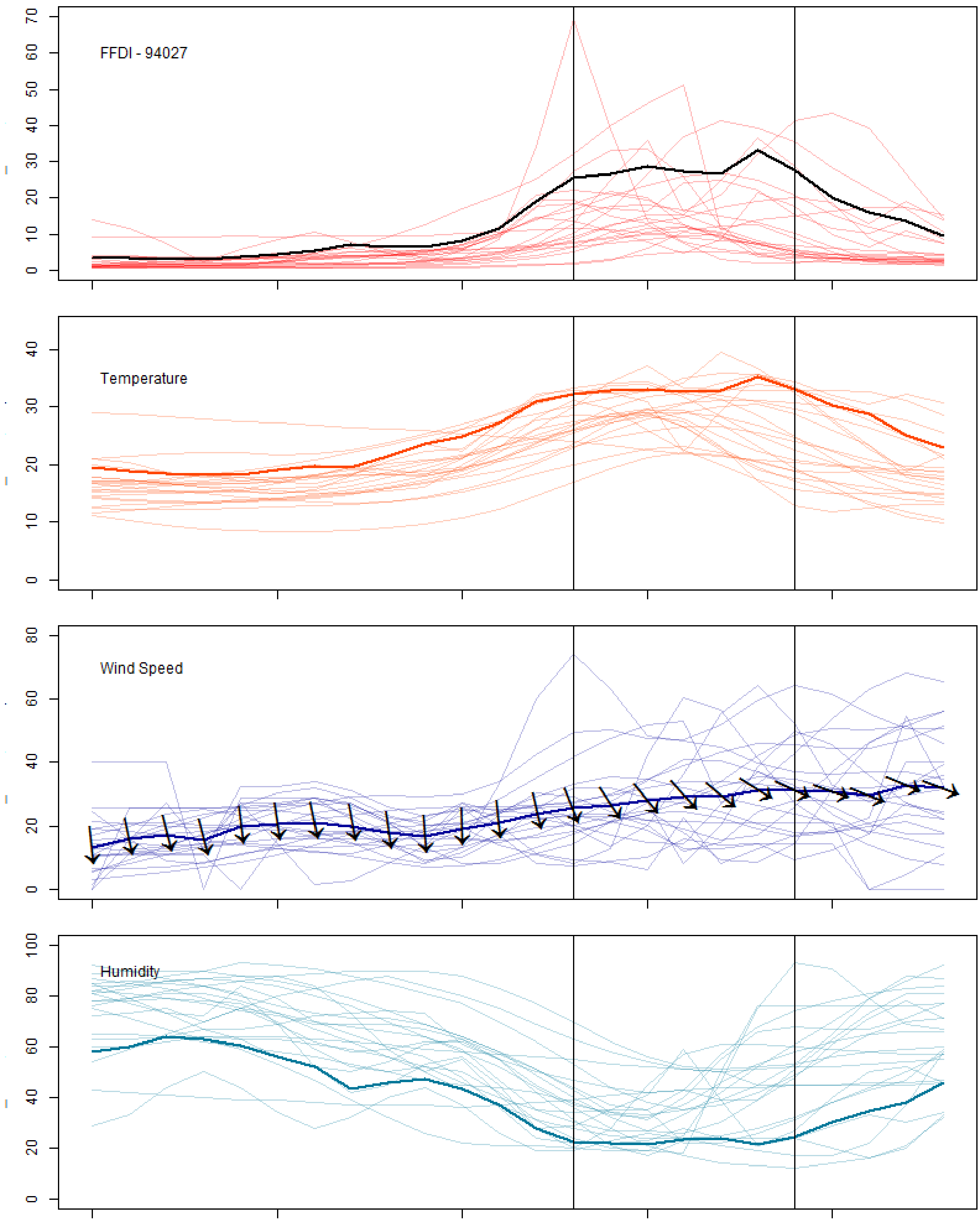

Figure 90: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Hastings Chalet weather station (no. 94027).

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Figure 91: Estimated Tasmanian land area represented by the Hastings Chalet (no. 94027) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 25: PHOENIX Rapidfire weather inputs for ignition points located in the Hastings Chalet (no. 94137) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	32.2	22.3	338	26	8.1	81	0
14:00	32.9	22.2	327	27	8.1	81	0
15:00	33.1	21.3	321	28	8.1	81	0
16:00	32.7	23.2	318	29	8.1	81	0
17:00	32.9	24	310	29	8.1	81	0
18:00	35.3	21.5	302	31	8.1	81	0
19:00	33.1	24.5	294	31	8.1	81	0
20:00	30.3	30.4	289	31	8.1	81	0
21:00	28.7	34.5	292	29	8.1	81	0
22:00	25.2	38.2	292	33	8.1	81	0

ISBN: 978-0-9925970-0-9

3.18 94029 Hobart (Ellerslie Rd) Weather Station

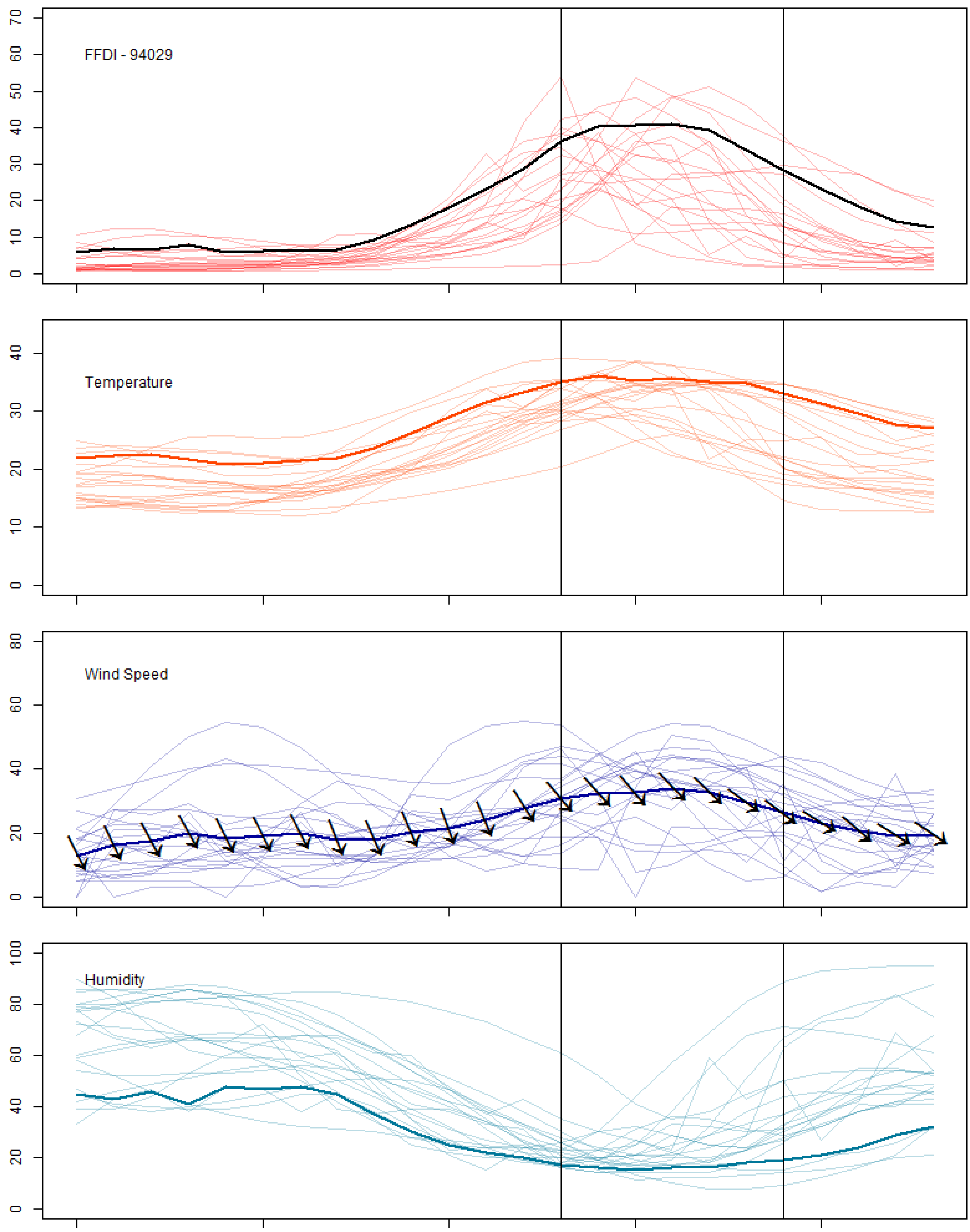

Figure 92: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Hobart (Ellerslie Rd) weather station (no. 94029).

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Figure 93: Estimated Tasmanian land area represented by the Hobart (Ellerslie Rd) (no. 94029) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 26: PHOENIX Rapidfire weather inputs for ignition points located in the Hobart (Ellerslie Rd) (no. 94029) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	35	17	320	31	7.8	78	0
14:00	36.1	16	318	32	7.8	78	0
15:00	35.2	15	320	33	7.8	78	0
16:00	35.6	16	317	34	7.8	78	0
17:00	35	16	314	33	7.8	78	0
18:00	34.8	18	306	30	7.8	78	0
19:00	33	19	307	26	7.8	78	0
20:00	31.4	21	302	23	7.8	78	0
21:00	29.5	24	311	20	7.8	78	0
22:00	27.8	29	302	19	7.8	78	0

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3.19 91045 JETSONVILLE (MUSKFIELD) WEATHER STATION

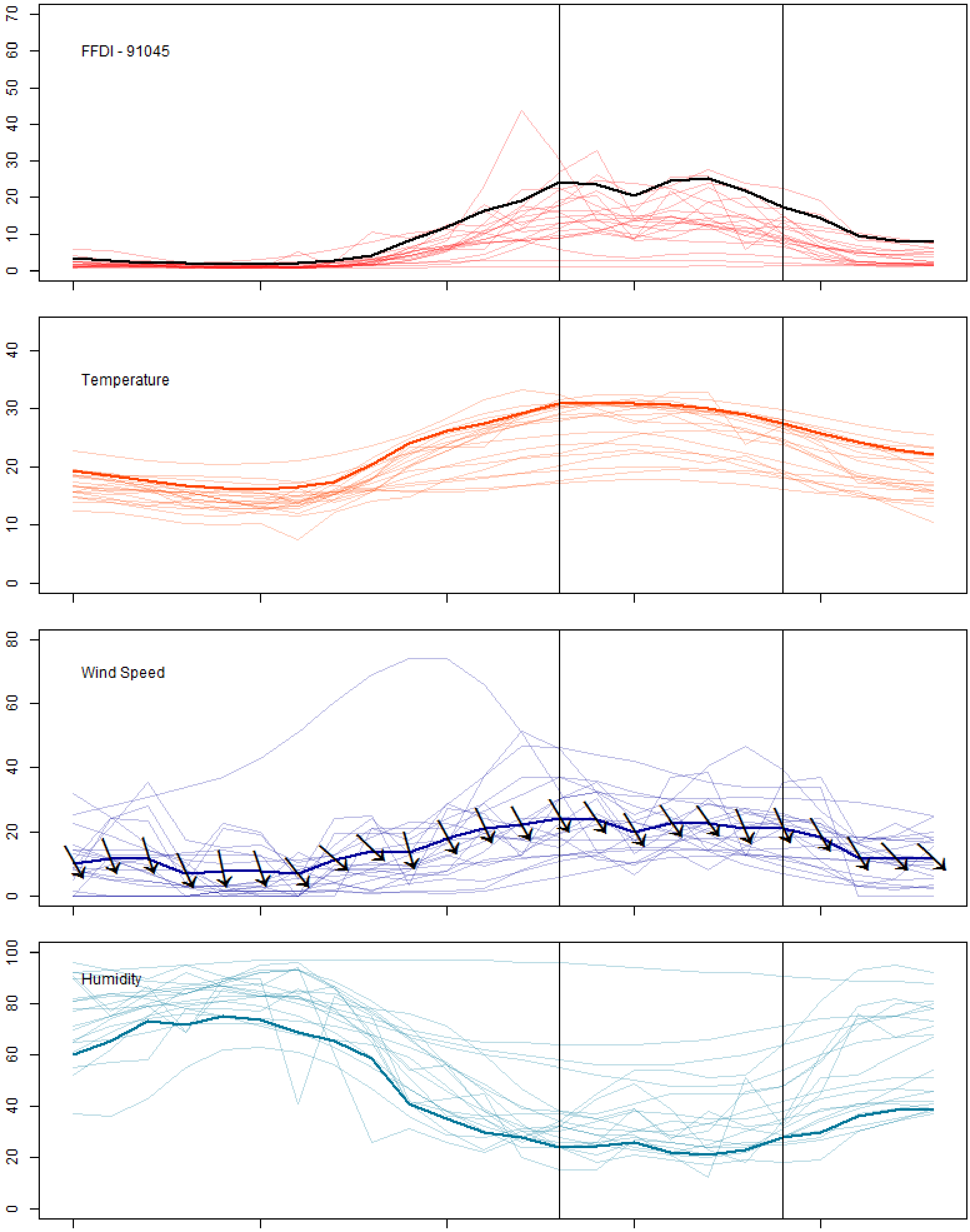

Figure 94: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Jetsonville (Muskfield) weather station (no. 91045).

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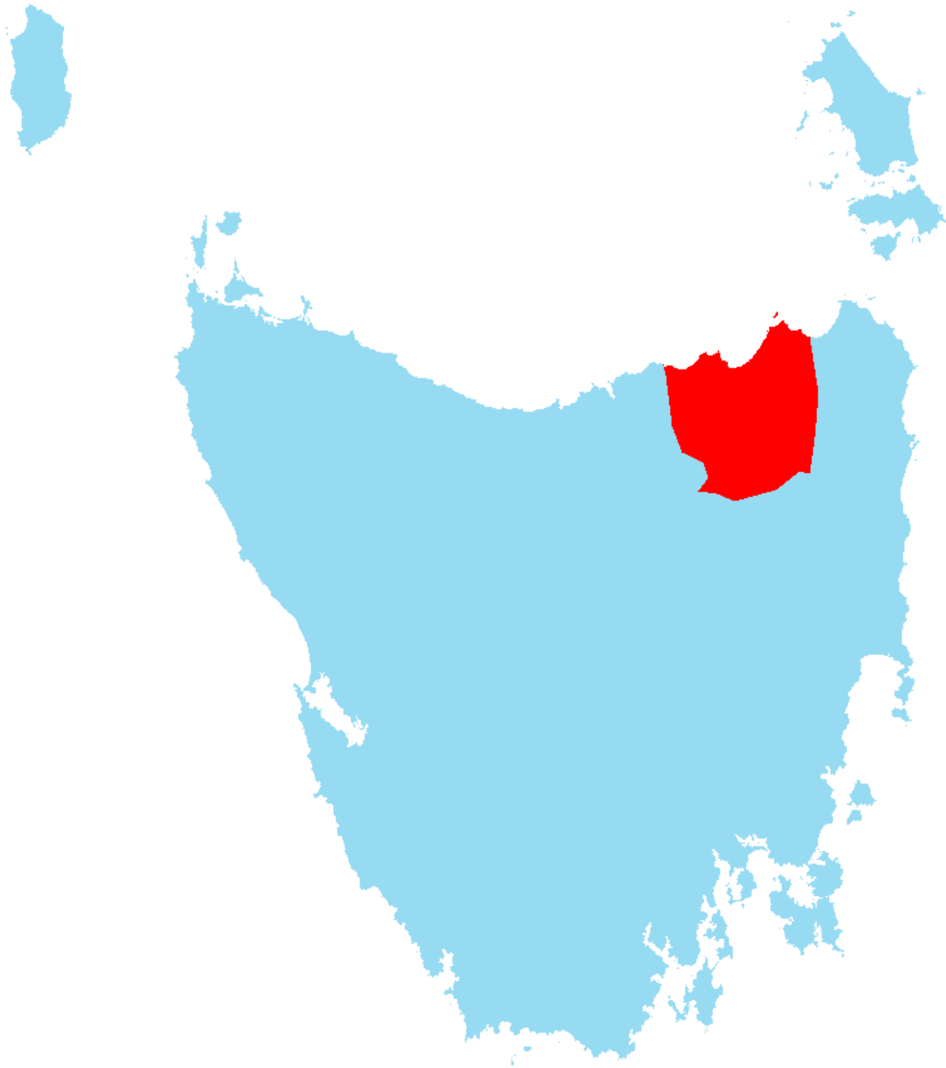

Figure 95: Estimated Tasmanian land area represented by the Jetsonville (Muskfield) (no. 91045) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 27: PHOENIX Rapidfire weather inputs for ignition points located in the Jetsonville (Muskfield) (no. 91045) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	31	24	330	24	8.9	89	0
14:00	31	24.4	326	24	8.9	89	0
15:00	30.9	25.7	329	20	8.9	89	10.25
16:00	30.7	21.9	326	23	8.9	89	0
17:00	30.1	20.9	324	23	8.9	89	0
18:00	28.9	22.9	337	21	8.9	89	0
19:00	27.5	27.7	335	21	8.9	89	0
20:00	25.7	29.7	329	18	8.9	89	0
21:00	24.2	36.3	329	12	8.9	89	0
22:00	22.9	38.4	317	12	8.9	89	0

ISBN: 978-0-9925970-0-9

3.20 92019 Lake Leake (Elizabeth River) Weather Station

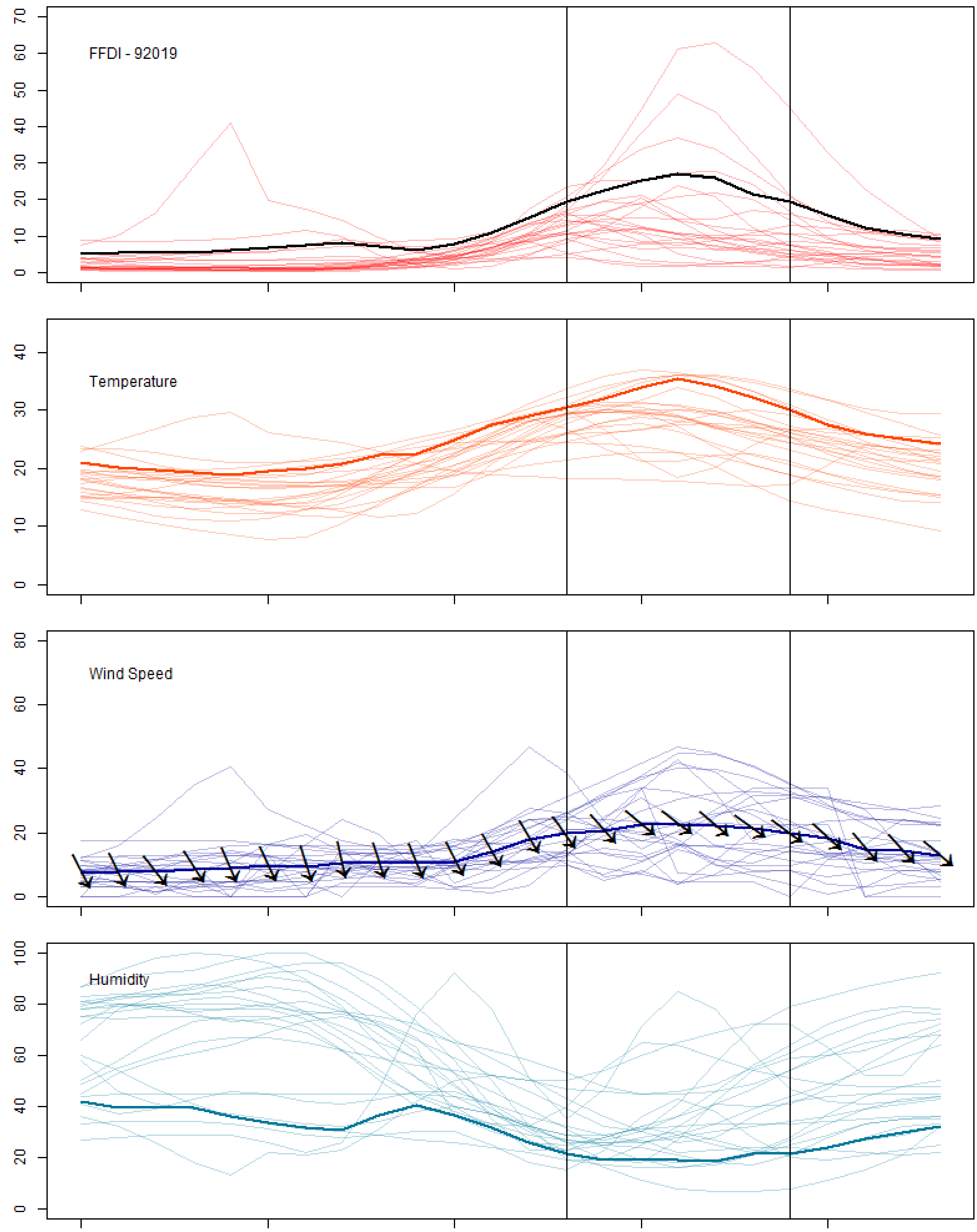

Figure 96: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Lake Leake (Elizabeth River) weather station (no. 92019).

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Figure 97: Estimated Tasmanian land area represented by the Lake Leake (Elizabeth River) (no. 92019) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 28: PHOENIX Rapidfire weather inputs for ignition points located in the Lake Leake (Elizabeth River no. 92019) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	30.5	21.3	325	20	7.4	74	0
14:00	32	19	319	21	7.4	74	2
15:00	33.9	19	310	23	7.4	74	2
16:00	35.4	18.9	308	23	7.4	74	2
17:00	34.2	18.3	310	22	7.4	74	2.6
18:00	32.3	21.3	306	22	7.4	74	0
19:00	30.1	21.3	306	20	7.4	74	0
20:00	27.6	24	312	18	7.4	74	0
21:00	26	27.3	320	15	7.4	74	0
22:00	25	29.9	318	14	7.4	74	0

ISBN: 978-0-9925970-0-9

3.21 91072 Launceston (Kings Meadows) Weather Station

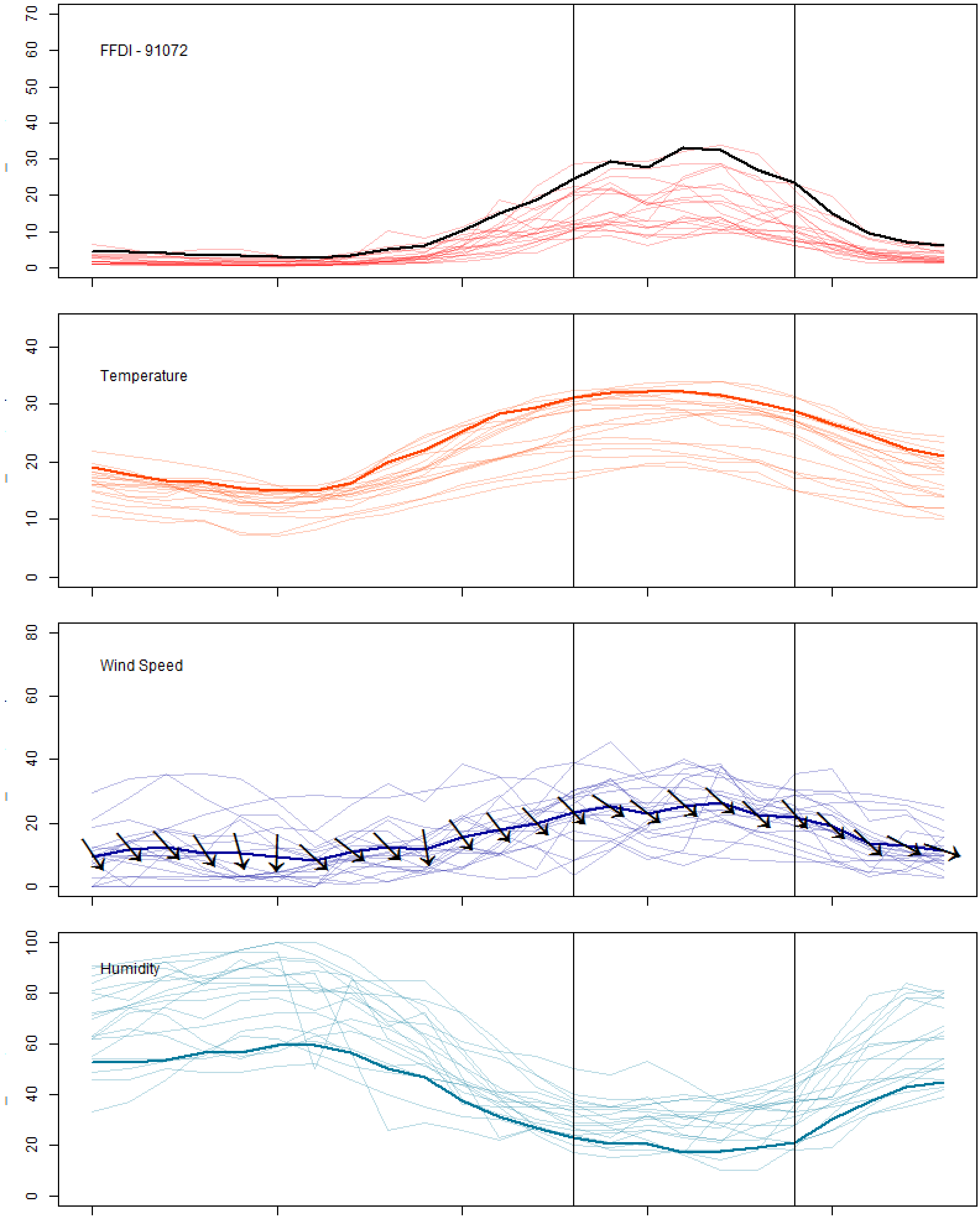

Figure 98: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Launceston (Kings Meadows) weather station (no. 91072).

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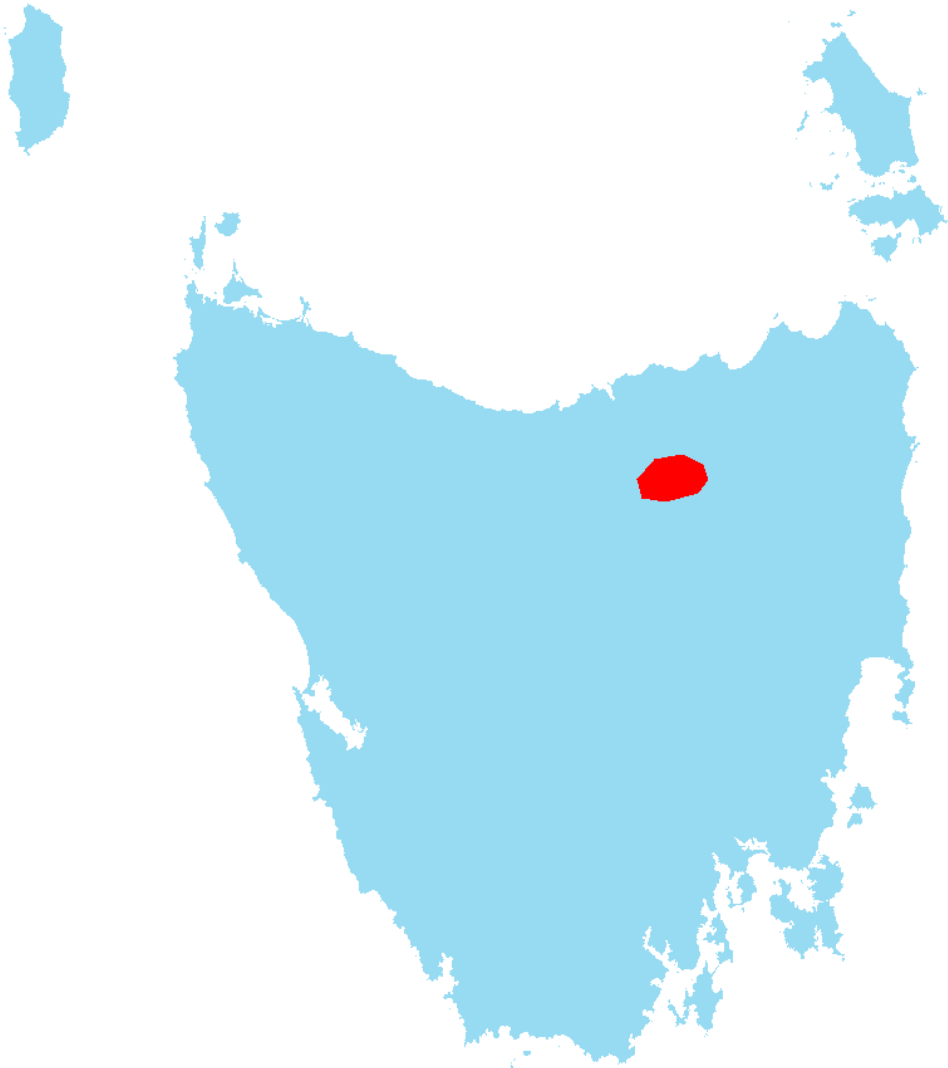

Figure 99: Estimated Tasmanian land area represented by the Launceston (Kings Meadows) (no.91072) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 29: PHOENIX Rapidfire weather inputs for ignition points located in the Launceston (Kings Meadows no. 91072) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	31.1	23	316	23	8.9	89	0
14:00	32.1	20.4	304	25	8.9	89	0
15:00	32.2	20.7	308	23	8.9	89	0
16:00	32.2	17	312	25	8.9	89	0
17:00	31.5	17.7	312	26	8.9	89	0
18:00	30.4	19	314	22	8.9	89	0
19:00	28.7	21	319	22	8.9	89	0
20:00	26.7	30.2	314	19	8.9	89	0
21:00	24.6	37.1	313	13	8.9	89	0
22:00	22.3	43.1	298	13	8.9	89	0

ISBN: 978-0-9925970-0-9

3.22 91104 Launceston Airport Comparison Weather Station

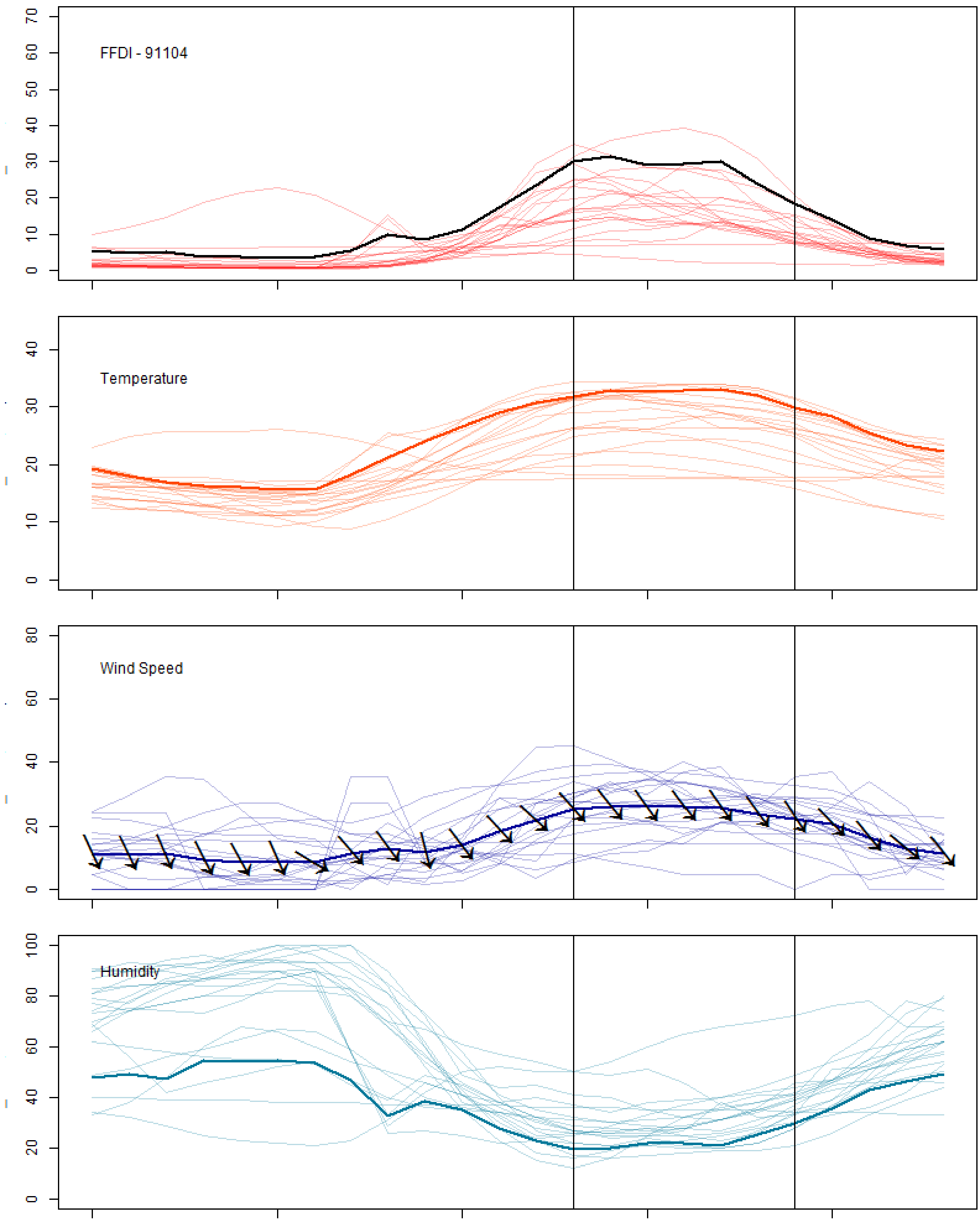

Figure 100: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Launceston Airport Comparison weather station (no. 91104).

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Figure 101: Estimated Tasmanian land area represented by the Launceston Airport Comparison (no. 91104) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 30: PHOENIX Rapidfire weather inputs for ignition points located in the Launceston Airport Comparison (no. 91104) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	31.7	19.6	319	25	9	90	0
14:00	32.8	19.9	321	26	9	90	0
15:00	32.7	21.9	324	26	9	90	0
16:00	32.9	21.9	322	26	9	90	0
17:00	33	20.9	324	26	9	90	0
18:00	31.9	25.4	324	24	9	90	0
19:00	29.9	29.7	327	22	9	90	0
20:00	28.4	35.7	316	21	9	90	0
21:00	25.4	42.8	320	16	9	90	0
22:00	23.5	46.3	310	13	9	90	0

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3.23 96004 Liawenee HEC Weather Station

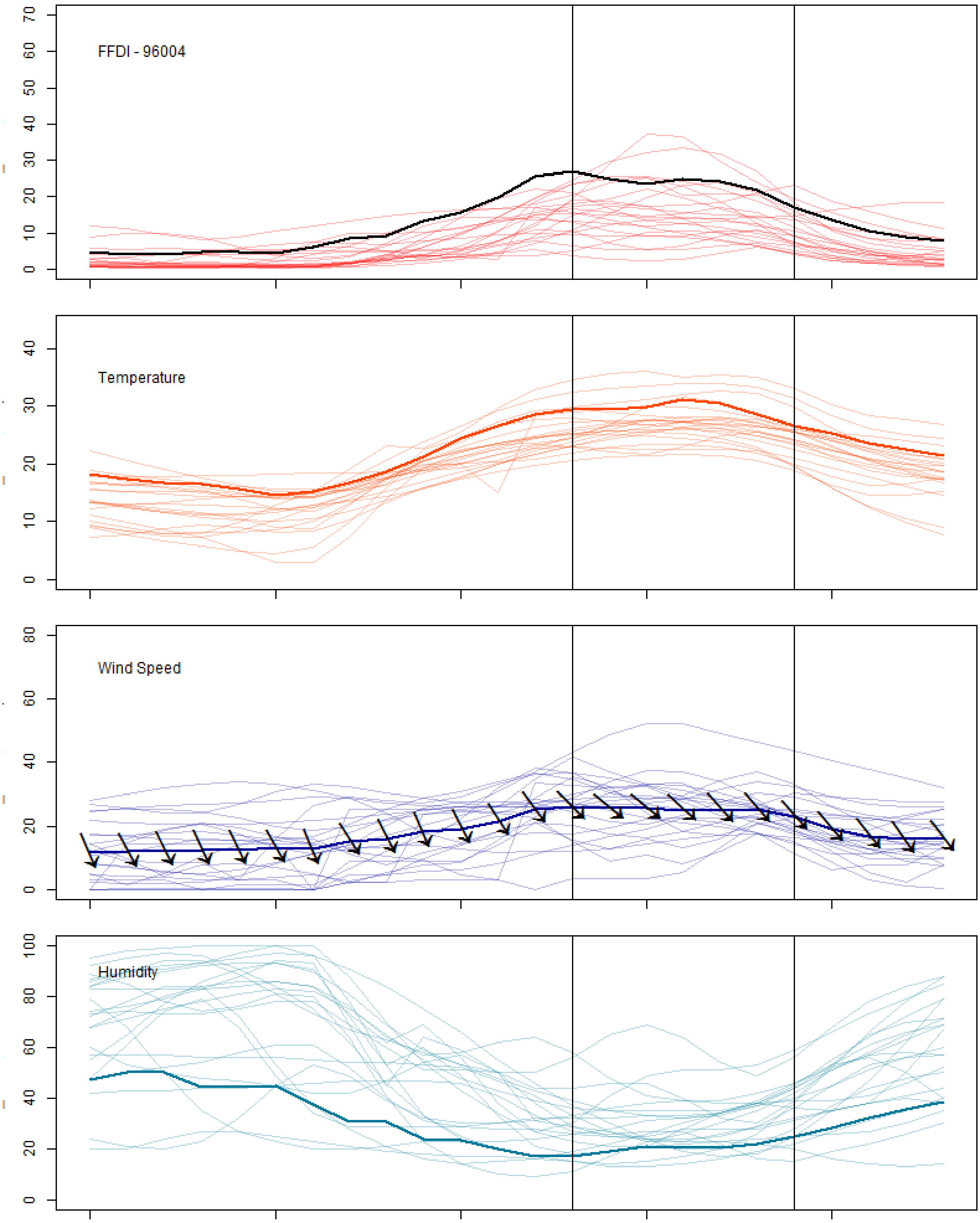

Figure 102: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Liawenee HEC weather station (no. 96004).

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Figure 103: Estimated Tasmanian land area represented by the Liawenee HEC (no. 96004) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 31: PHOENIX Rapidfire weather inputs for ignition points located in the Liawenee HEC (no. 96004) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	29.4	17.2	315	26	7.8	78	0.9
14:00	29.4	19	309	26	7.8	78	6.9
15:00	29.9	21	309	26	7.8	78	0.9
16:00	31.2	20.3	313	25	7.8	78	6.45
17:00	30.5	20.3	318	25	7.8	78	6.15
18:00	28.6	22	319	25	7.8	78	0
19:00	26.6	25	319	23	7.8	78	0
20:00	25.3	28.2	320	19	7.8	78	0
21:00	23.6	32.1	322	17	7.8	78	0
22:00	22.5	35.8	325	16	7.8	78	0

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3.24 91057 Low Head (Comparison) Weather Station

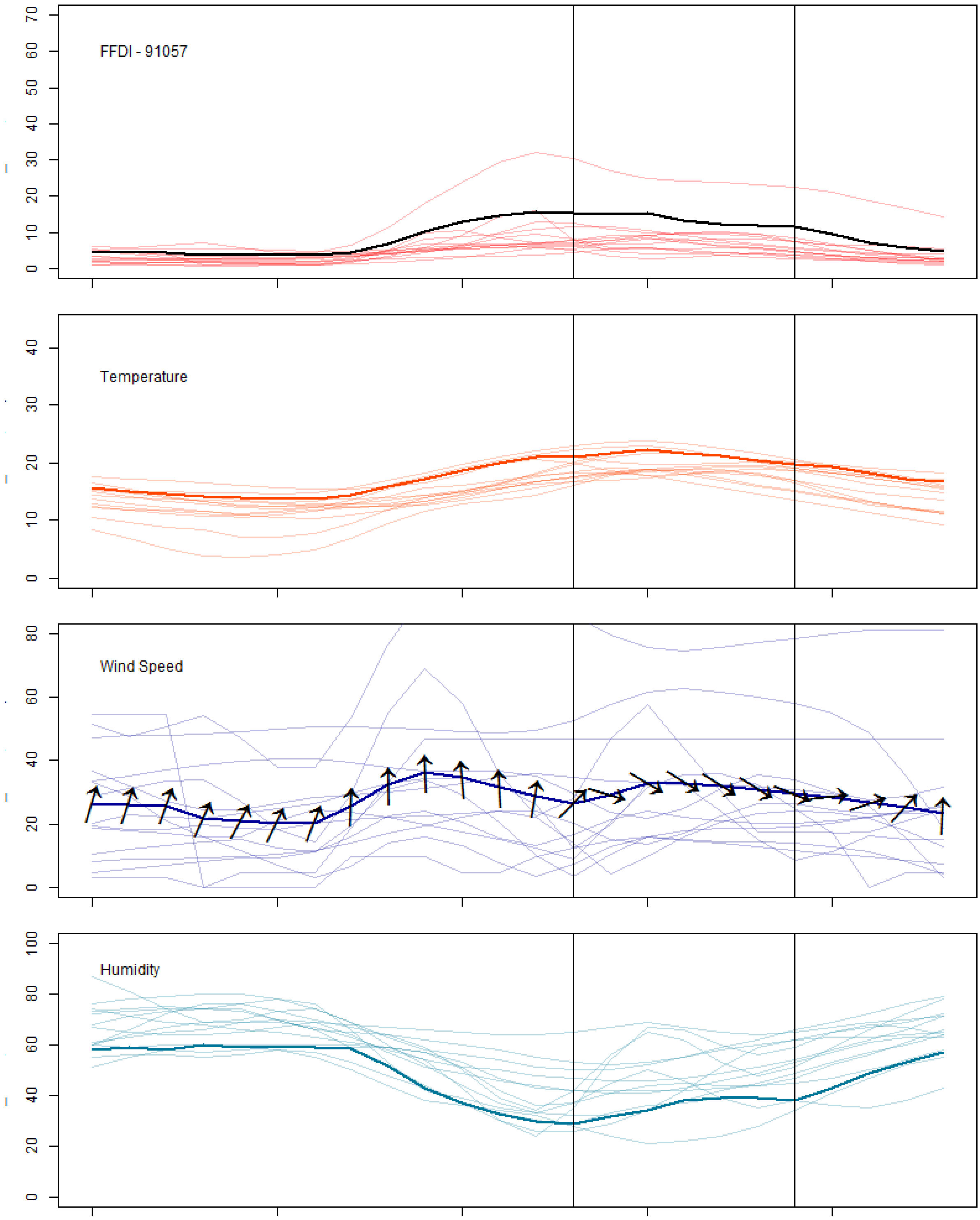

Figure 104: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Low Head (Comparison) weather station (no. 91057).

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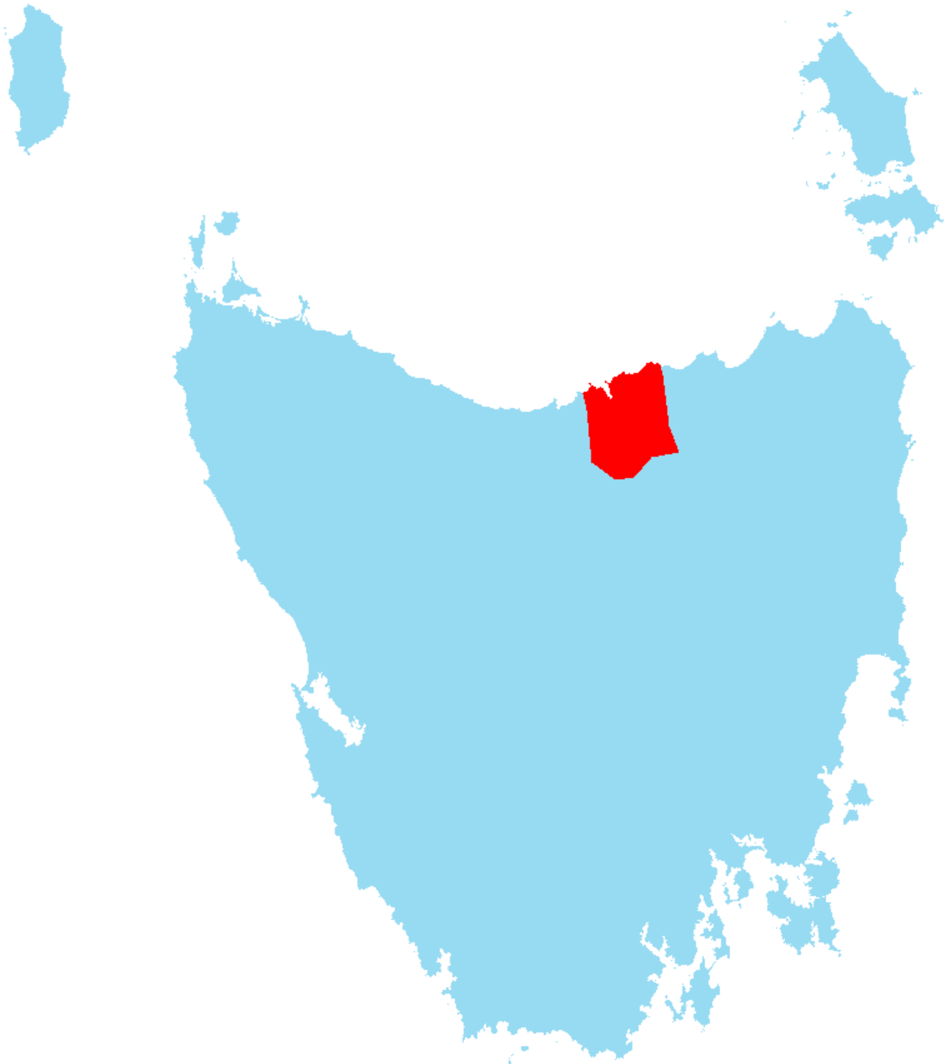

Figure 105: Estimated Tasmanian land area represented by the Low Head (Comparison) (no. 91057) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 32: PHOENIX Rapidfire weather inputs for ignition points located in the Low Head (Comparison) (no. 91057) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	21	29	224	27	8.8	88	30.9
14:00	21.6	31.9	286	29	8.8	88	30.95
15:00	22.3	34	300	33	8.8	88	31
16:00	21.7	38	302	33	8.8	88	29
17:00	21.2	39	302	32	8.8	88	26
18:00	20.4	38.8	302	31	8.8	88	0
19:00	19.8	38	291	30	8.8	88	0
20:00	19.4	42.9	264	29	8.8	88	0
21:00	18.2	48.9	251	27	8.8	88	0
22:00	17.3	53	223	25	8.8	88	0

ISBN: 978-0-9925970-0-9

3.25 94041 Maatsuyka Island Lighthouse Weather Station

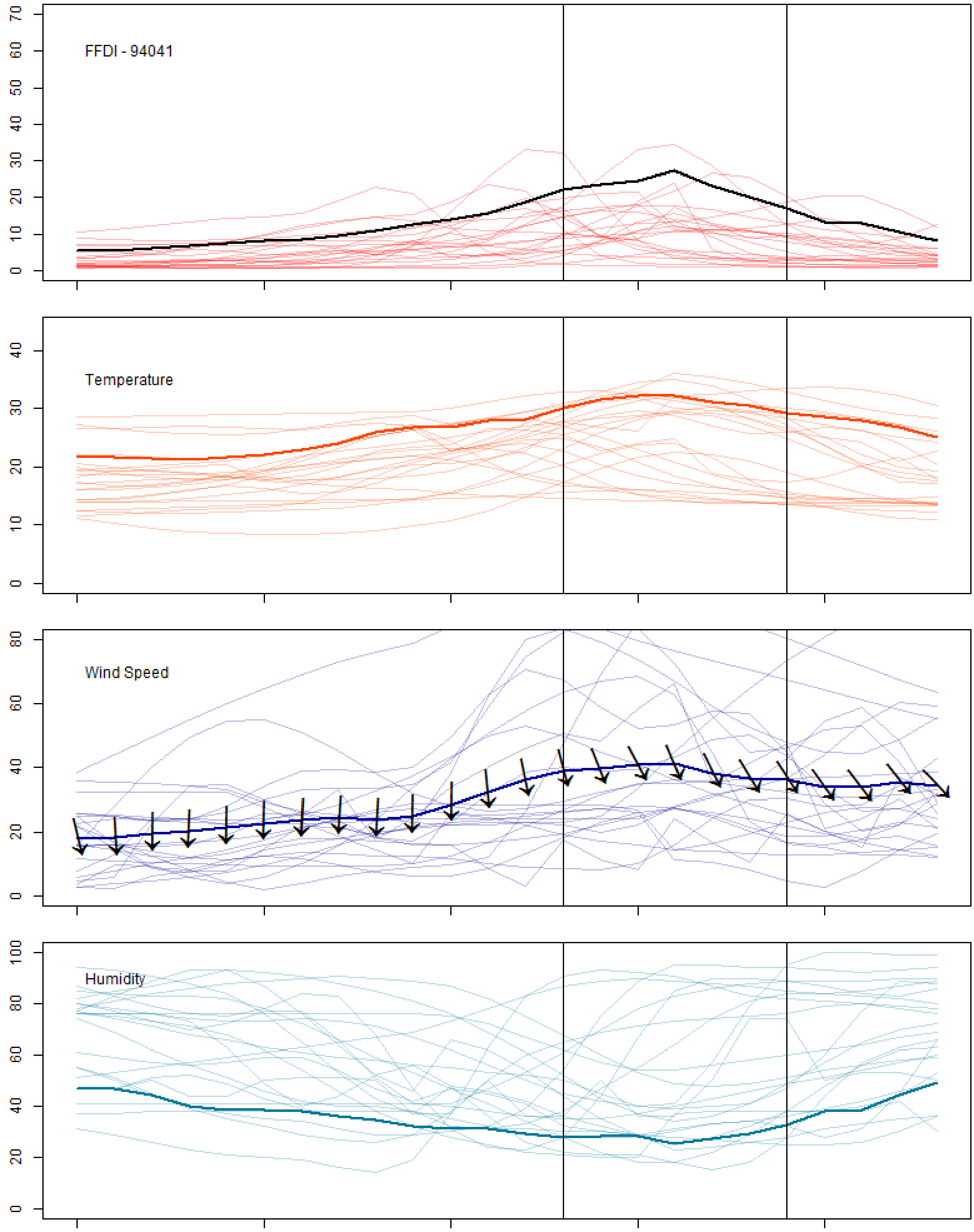

Figure 106: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Maatsuyka Island Lighthouse weather station (no. 94041).

ISBN: 978-0-9925970-0-9

Figure 107: Estimated Tasmanian land area represented by the Maatsuyka Island Lighthouse (no. 94041) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 33: PHOENIX Rapidfire weather inputs for ignition points located in the Maatsuyka Island Lighthouse (no. 94041) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	30.1	28	345	39	6.8	68	0
14:00	31.6	28.3	338	40	6.8	68	21.75
15:00	32.2	28.2	332	41	6.8	68	0
16:00	32.1	25.5	338	41	6.8	68	0
17:00	31.1	27.2	334	38	6.8	68	0
18:00	30.5	29.5	329	37	6.8	68	0
19:00	29.1	32.6	327	36	6.8	68	0
20:00	28.6	38	325	34	6.8	68	0
21:00	28	38.3	323	34	6.8	68	0
22:00	26.9	44.2	322	36	6.8	68	0

ISBN: 978-0-9925970-0-9

3.26 91223 Marrawah Weather Station

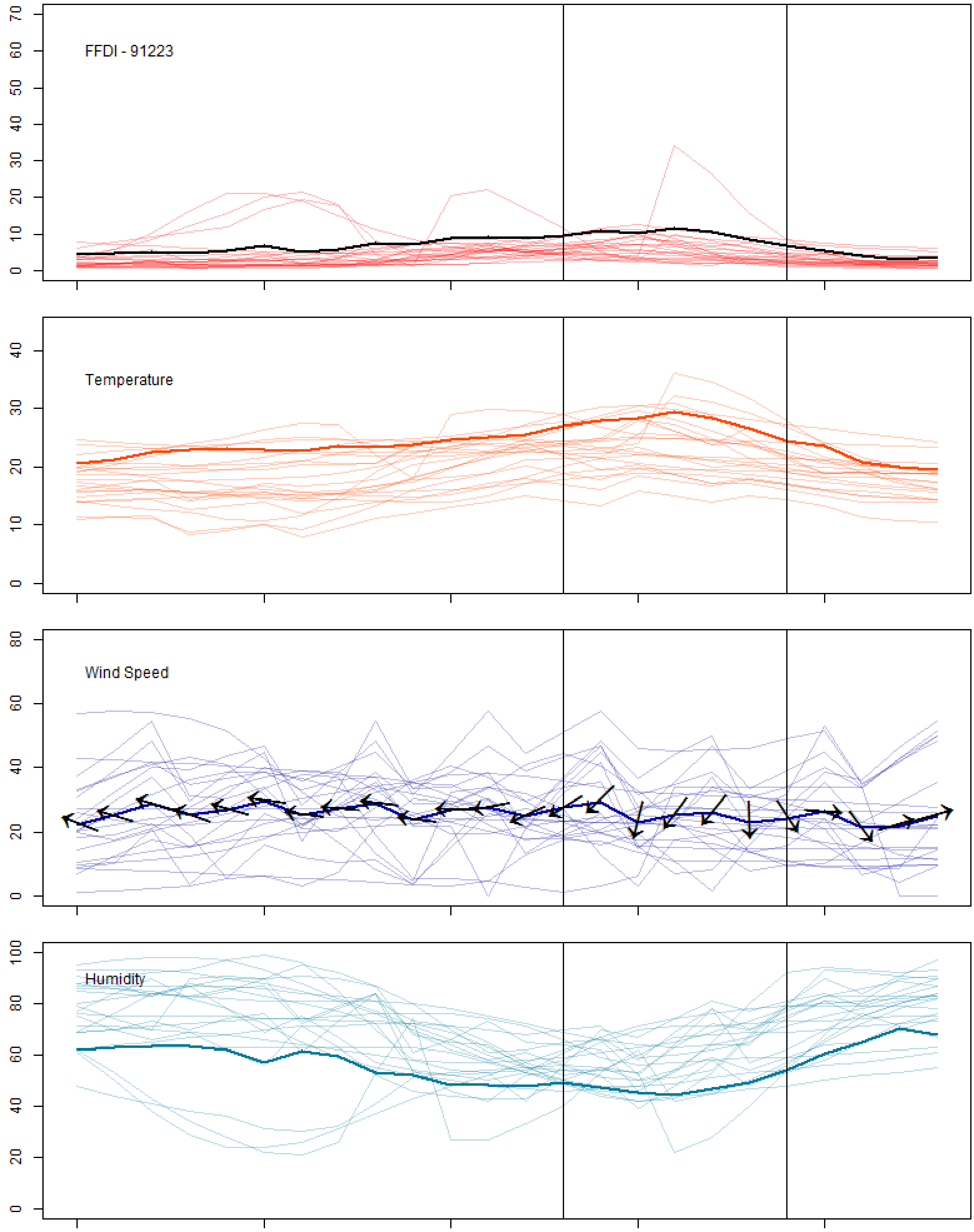

Figure 108: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Marrawah weather station (no. 91223).

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Figure 109: Estimated Tasmanian land area represented by the Marrawah (no. 91223) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 34: PHOENIX Rapidfire weather inputs for ignition points located in the Marrawah (no. 91223) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	27	49.2	58	28	8.9	89	0
14:00	27.8	47.2	45	29	8.9	89	0
15:00	28.4	45.2	14	23	8.9	89	0
16:00	29.5	44.2	36	25	8.9	89	0
17:00	28.3	46.8	39	26	8.9	89	0
18:00	26.5	49.2	358	23	8.9	89	0.15
19:00	24.4	54.3	327	24	8.9	89	0.15
20:00	23.5	60.6	274	26	8.9	89	0
21:00	20.9	65	323	21	8.9	89	0
22:00	20	70.2	253	22	8.9	89	0

ISBN: 978-0-9925970-0-9

3.27 95011 Maydena Weather Station

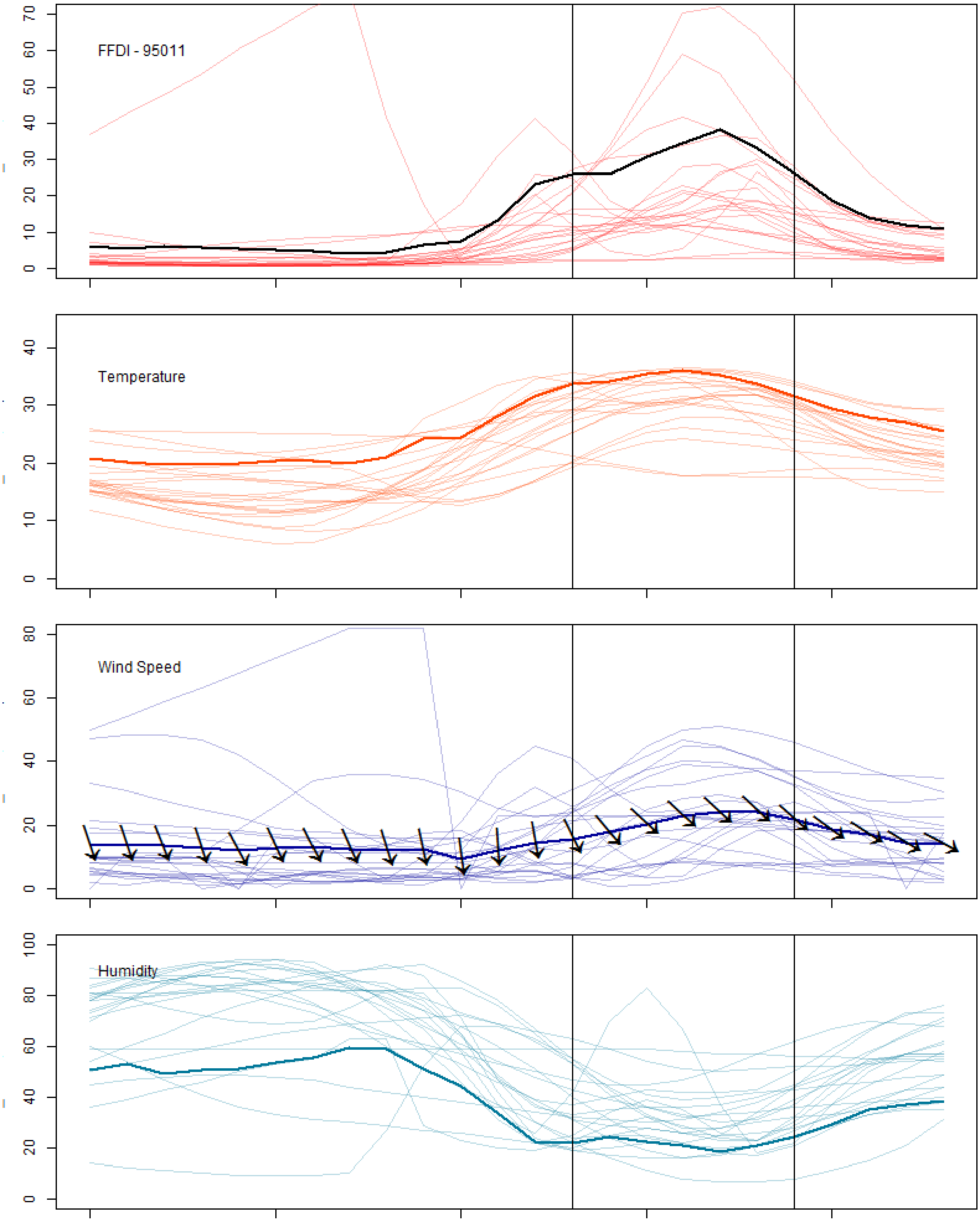

Figure 110: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Maydena weather station (no. 95011).

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Figure 111: Estimated Tasmanian land area represented by the Maydena (no. 95011) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 35: PHOENIX Rapidfire weather inputs for ignition points located in the Maydena (no. 95011) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	33.7	22.2	334	16	10	100	0
14:00	34.1	24.2	320	18	10	100	0
15:00	35.4	22.3	313	20	10	100	0
16:00	36	21.2	313	23	10	100	0
17:00	35.3	18.3	313	24	10	100	0
18:00	33.7	21	313	24	10	100	0
19:00	31.6	24.2	312	22	10	100	0
20:00	29.4	29.5	306	19	10	100	0
21:00	27.9	35	303	17	10	100	0
22:00	27	37.3	301	14	10	100	0

ISBN: 978-0-9925970-0-9

3.28 94140 Melton Mowbray (Lovely Banks) Weather Station

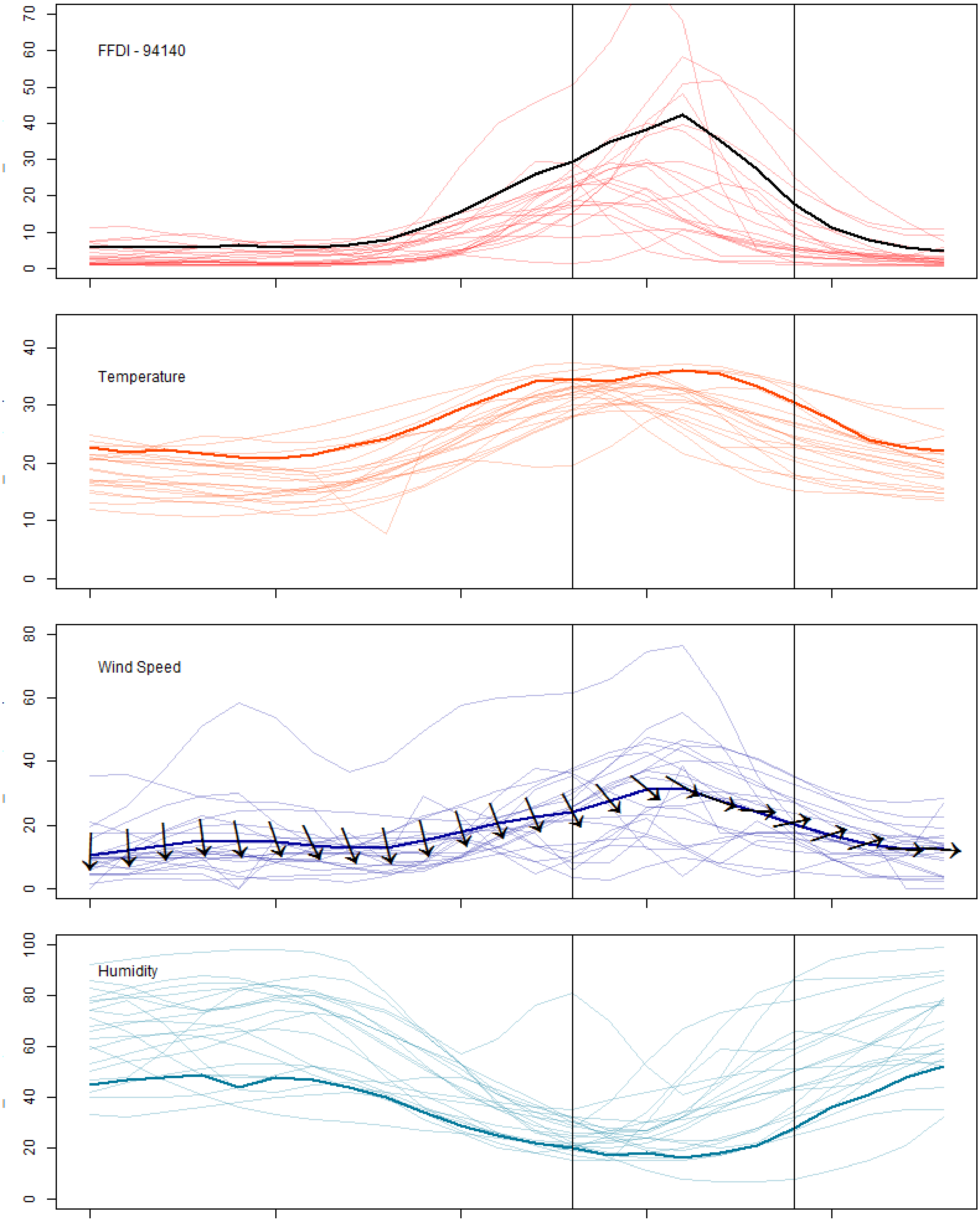

Figure 112: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Melton Mowbray (Lovely Banks) weather station (no. 94140).

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Figure 113: Estimated Tasmanian land area represented by the Melton Mowbray (Lovely Banks) (no. 94140) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 36: PHOENIX Rapidfire weather inputs for ignition points located in the Melton Mowbray (no. 94140) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	34.5	20	332	24	8.3	83	0
14:00	34.1	17	320	28	8.3	83	0
15:00	35.4	18	309	31	8.3	83	0
16:00	36.1	16	301	32	8.3	83	0
17:00	35.3	18	290	28	8.3	83	0
18:00	33.3	21	274	24	8.3	83	0
19:00	30.5	28	258	20	8.3	83	0
20:00	27.5	36	252	17	8.3	83	0
21:00	24.1	41	253	14	8.3	83	0
22:00	22.8	48	274	12	8.3	83	0

ISBN: 978-0-9925970-0-9

3.29 94066 Mt Wellington (The Springs) Weather Station

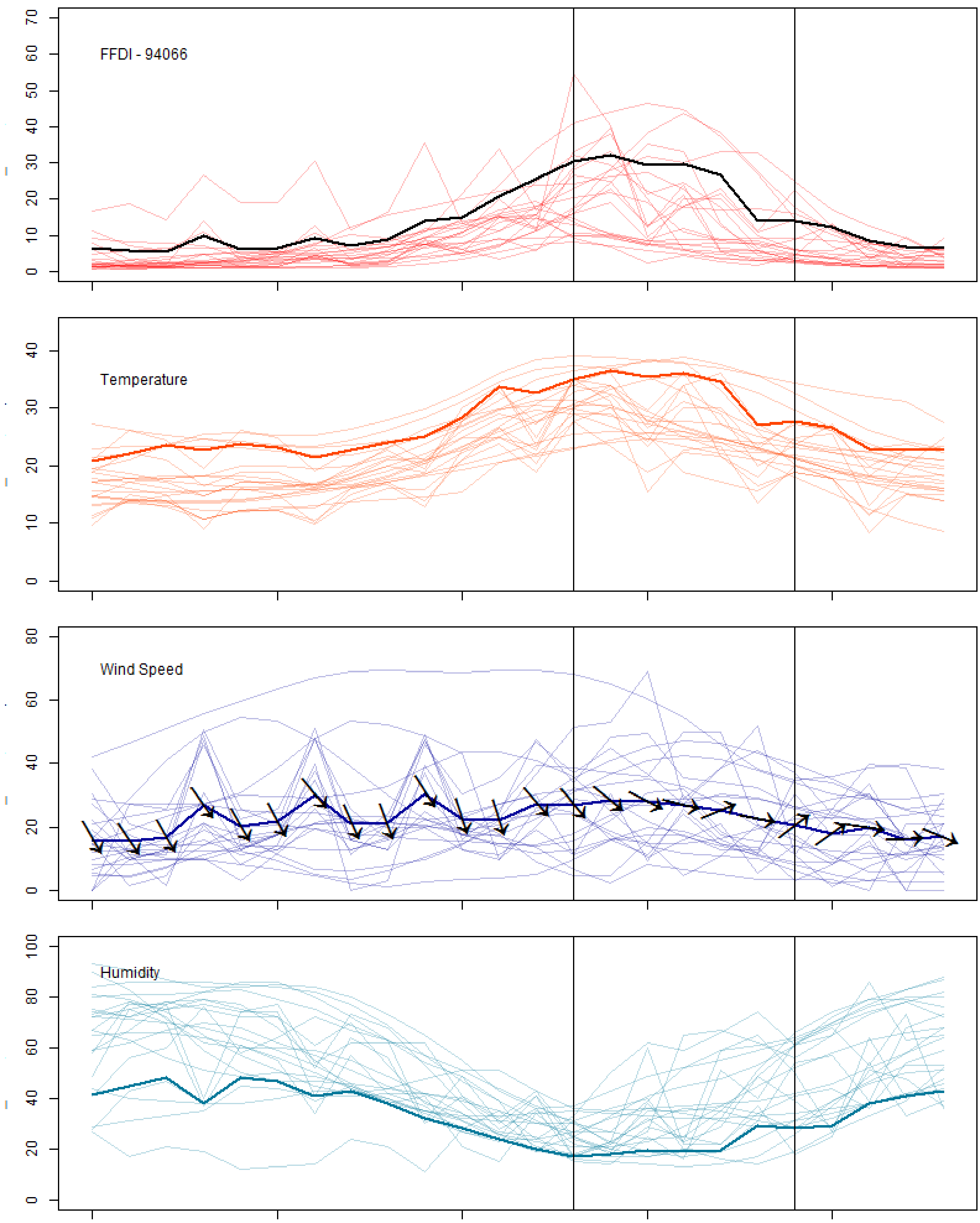

Figure 114: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Mt Wellington (The Springs) weather station (no. 94066).

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Figure 115: Estimated Tasmanian land area represented by the Mt Wellington (The Springs) (no. 94066) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 37: PHOENIX Rapidfire weather inputs for ignition points located in the Mt Wellington (The Springs) (no. 94066) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	35	17.2	321	27	7.2	72	0
14:00	36.6	18.2	309	28	7.2	72	0
15:00	35.4	19.6	297	28	7.2	72	0
16:00	36.1	19.2	284	27	7.2	72	0
17:00	34.6	19.5	248	25	7.2	72	0
18:00	27.1	29.3	281	22	7.2	72	0
19:00	27.7	28.2	233	20	7.2	72	0
20:00	26.5	29.5	235	18	7.2	72	0
21:00	23	38	278	20	7.2	72	0
22:00	22.8	41.2	267	16	7.2	72	0

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3.30 92027 Orford (Aubin Court) Weather Station

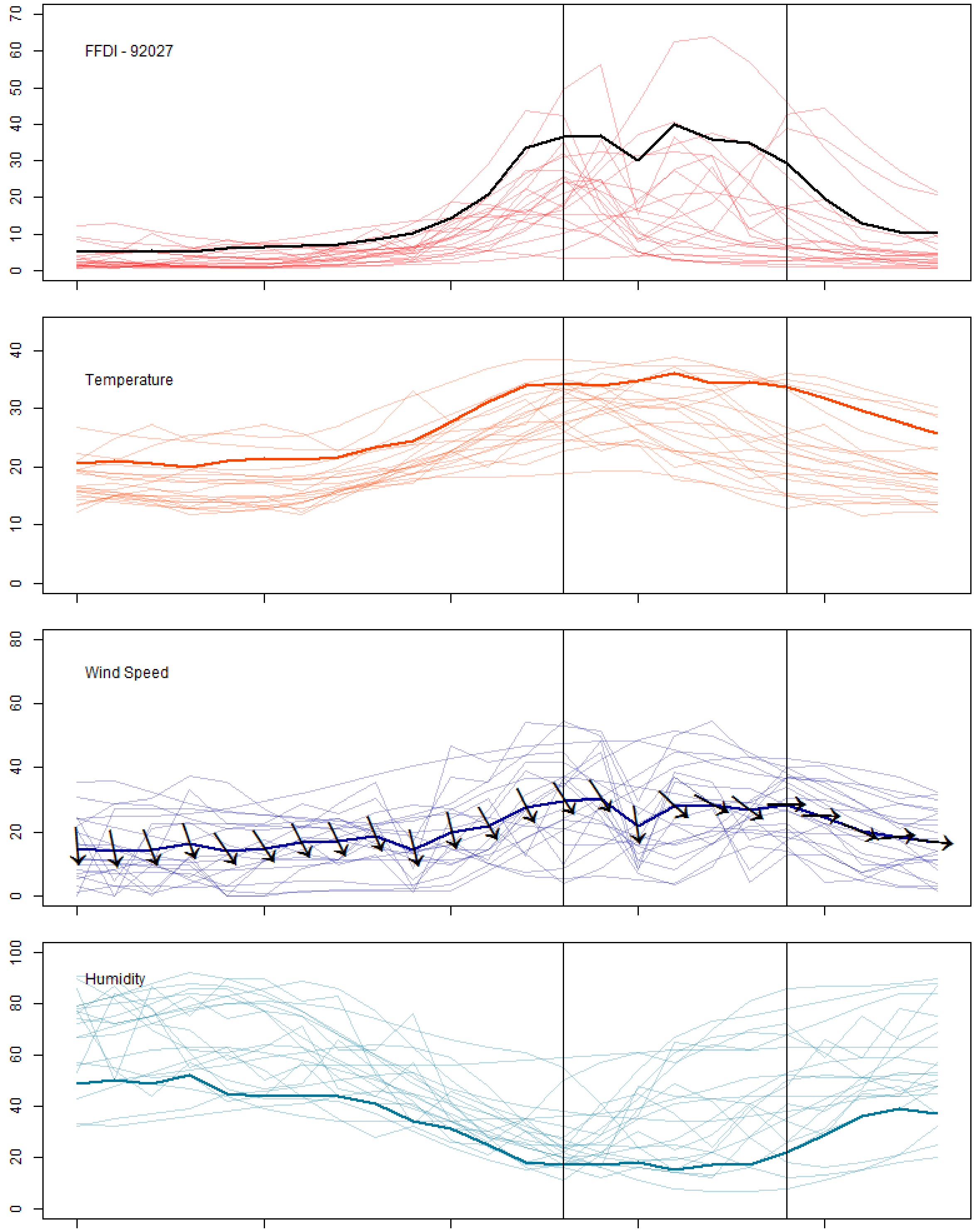

Figure 116: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Orford (Aubin Court) weather station (no. 92027).

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Figure 117: Estimated Tasmanian land area represented by the Orford (Aubin Court) (no. 92027) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 38: PHOENIX Rapidfire weather inputs for ignition points located in the Orford (Aubin Court) (no. 92027) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	34.4	17	327	29	8.3	83	0
14:00	33.9	17	327	30	8.3	83	0
15:00	34.8	18	351	22	8.3	83	0
16:00	36.1	15	313	28	8.3	83	0
17:00	34.4	17	297	28	8.3	83	0
18:00	34.5	17	307	27	8.3	83	0
19:00	33.7	22	270	28	8.3	83	0
20:00	31.7	29	271	25	8.3	83	0
21:00	29.7	36	293	20	8.3	83	0
22:00	27.8	39	264	18	8.3	83	0

ISBN: 978-0-9925970-0-9

3.31 95012 Ouse (Millbrook) Weather Station

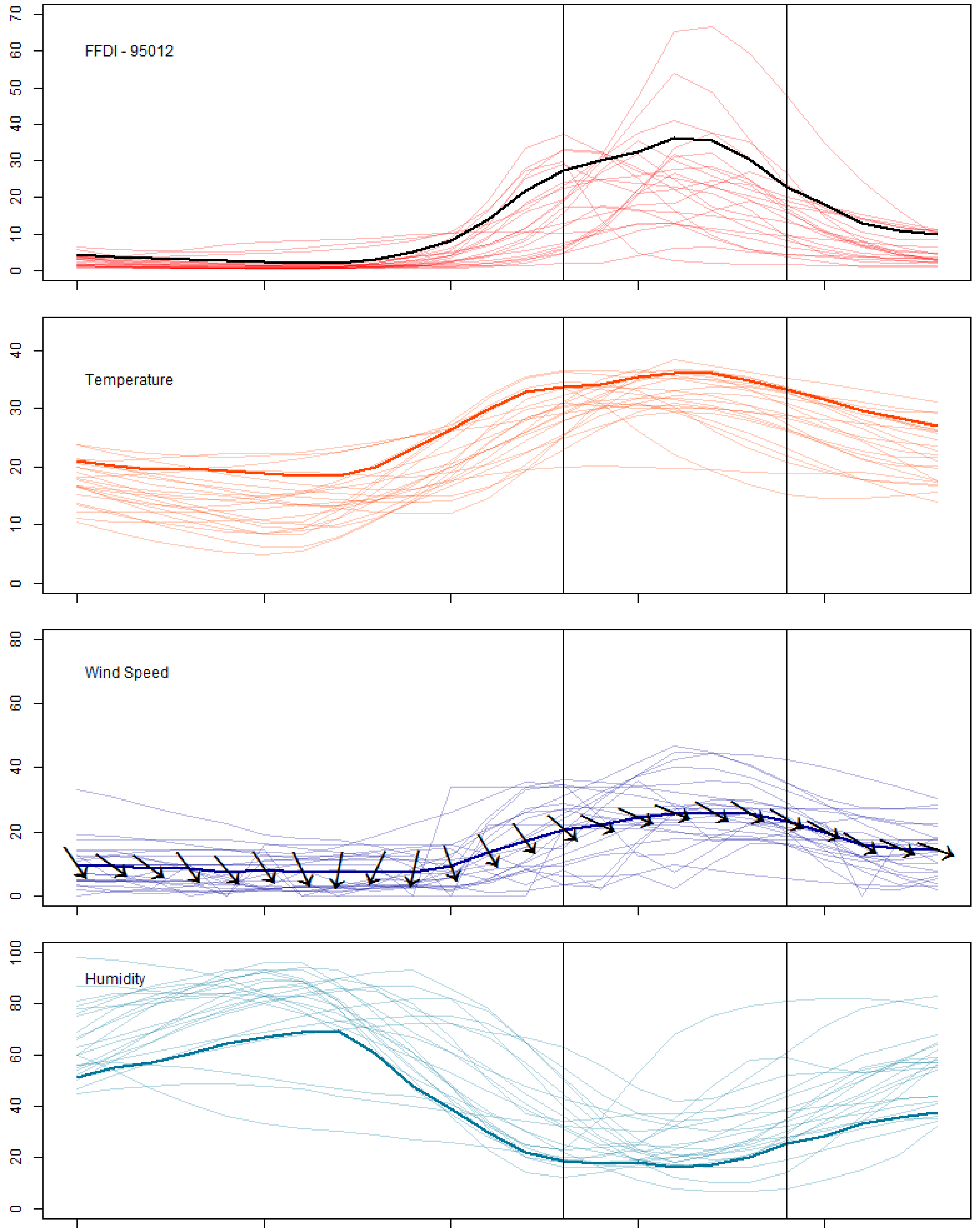

Figure 118: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Ouse (Millbrook) weather station (no. 95012).

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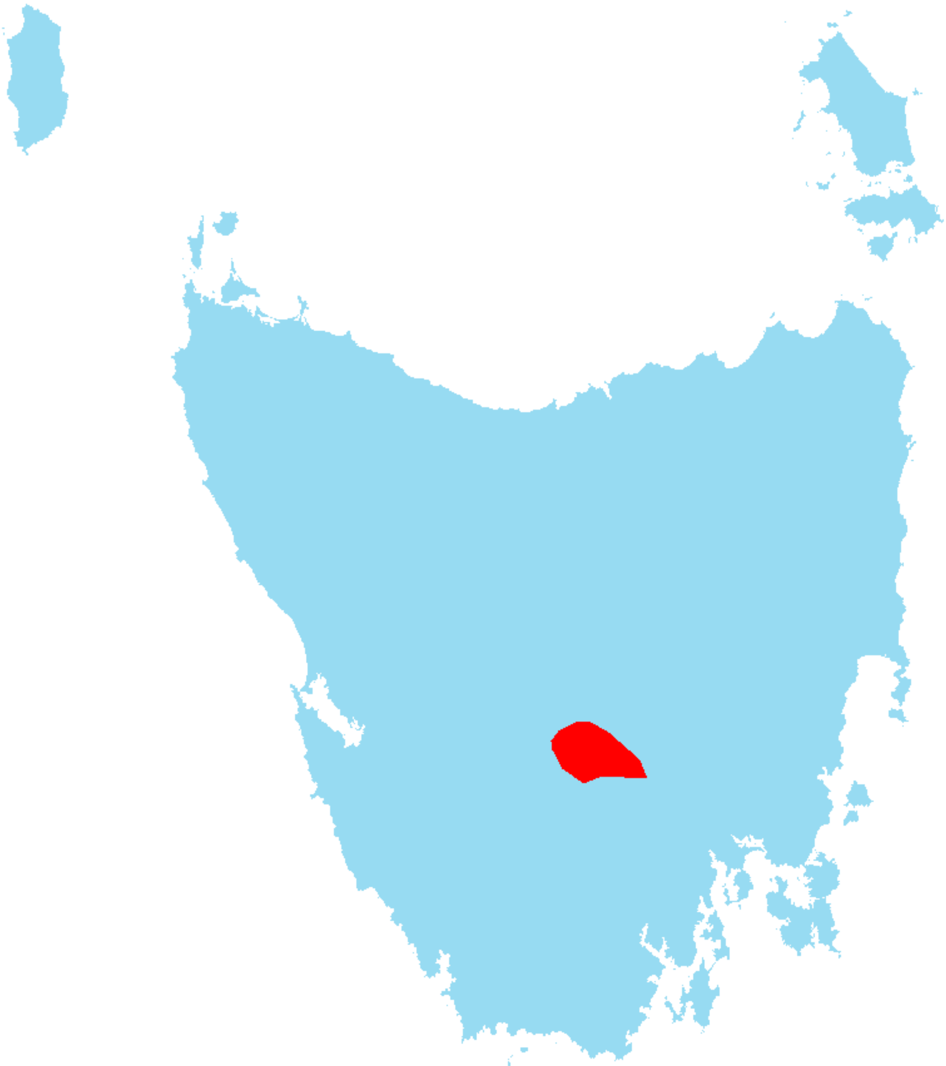

Figure 119: Estimated Tasmanian land area represented by the Ouse (Millbrook) (no. 95012) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 39: PHOENIX Rapidfire weather inputs for ignition points located in the Ouse (Millbrook) (no. 95012) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	33.7	18.3	312	21	8.2	82	0
14:00	34.2	17.3	296	22	8.2	82	0
15:00	35.4	18	294	25	8.2	82	0
16:00	36.1	16.3	292	26	8.2	82	0
17:00	36.1	17	300	26	8.2	82	0
18:00	34.8	20	302	26	8.2	82	0
19:00	33.3	25.3	301	24	8.2	82	0
20:00	31.6	28.3	299	20	8.2	82	0
21:00	29.6	33.3	302	16	8.2	82	0
22:00	28.3	35.6	293	15	8.2	82	0

ISBN: 978-0-9925970-0-9

3.32 97073 Rosebery (HEC Substation) Weather Station

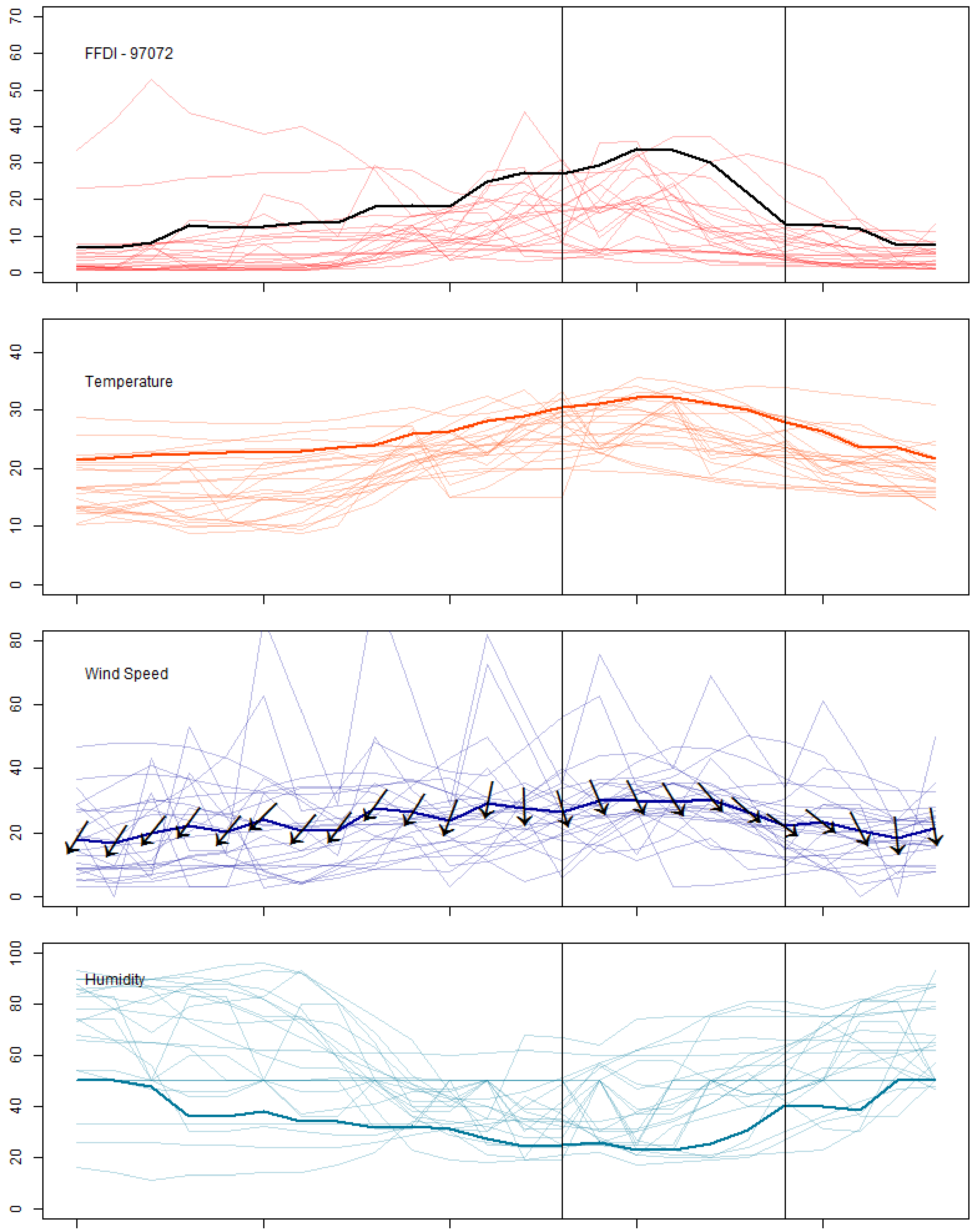

Figure 120: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Rosebery (HEC Substation) weather station (no. 97073).

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Figure 121: Estimated Tasmanian land area represented by the Rosebery (HEC Substation) (no. 97073) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 40: PHOENIX Rapidfire weather inputs for ignition points located in the Rosebery (HEC Substation) (no. 97073) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	28.6	30.3	335	25	10	100	0
14:00	29.4	30.2	319	25	10	100	0
15:00	29.6	33.3	318	25	10	100	0
16:00	29.1	35.3	311	25	10	100	0
17:00	27.9	41	304	25	10	100	0
18:00	27.8	37	316	24	10	100	0
19:00	27.1	34.5	316	21	10	100	0
20:00	25.7	42.3	315	20	10	100	0
21:00	23.2	46.5	318	20	10	100	0
22:00	22.7	50	323	17	10	100	0

ISBN: 978-0-9925970-0-9

3.33 93025 Ross (Macquarie River) Weather Station

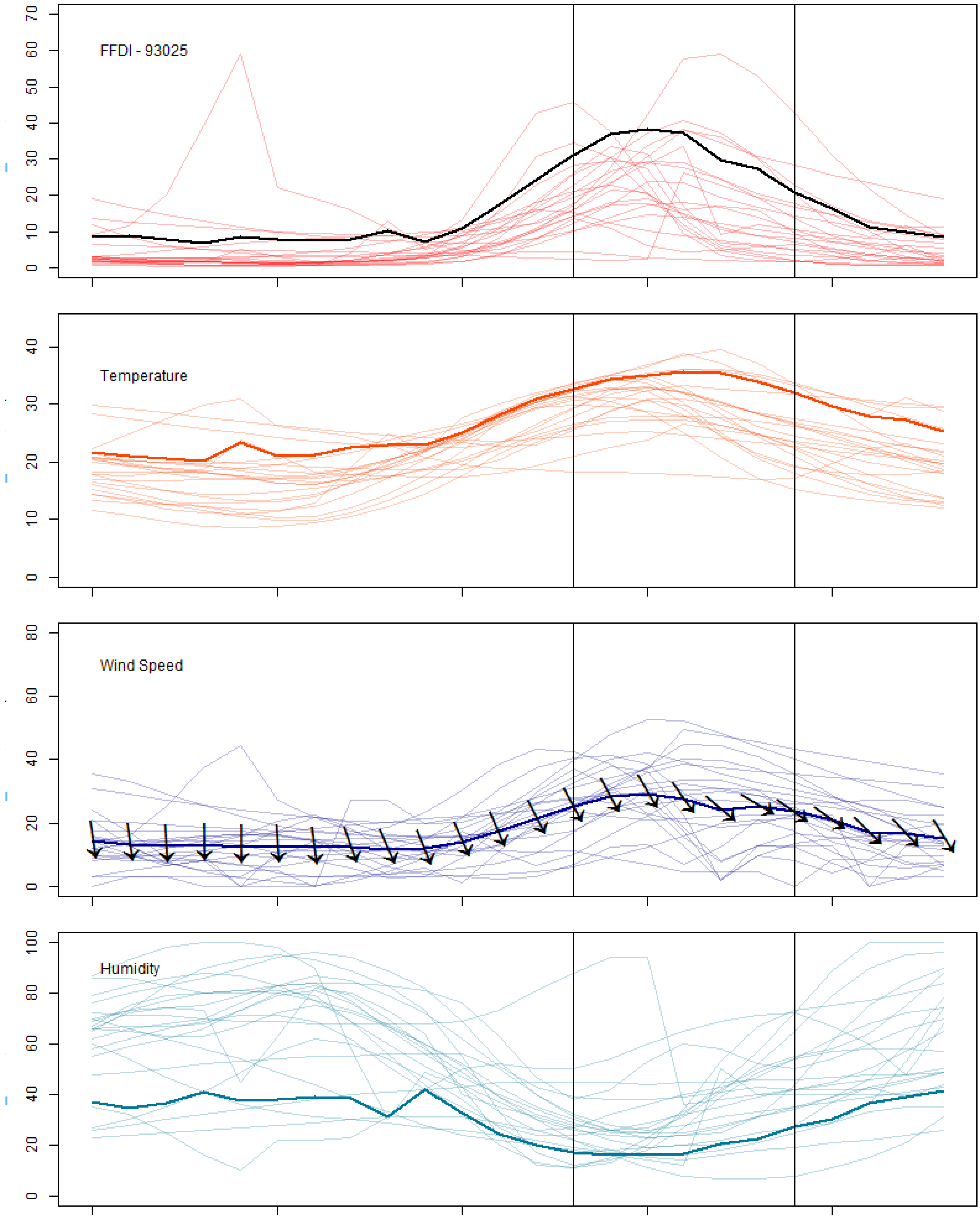

Figure 122. Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Ross (Macquarie River) weather station (no. 93025).

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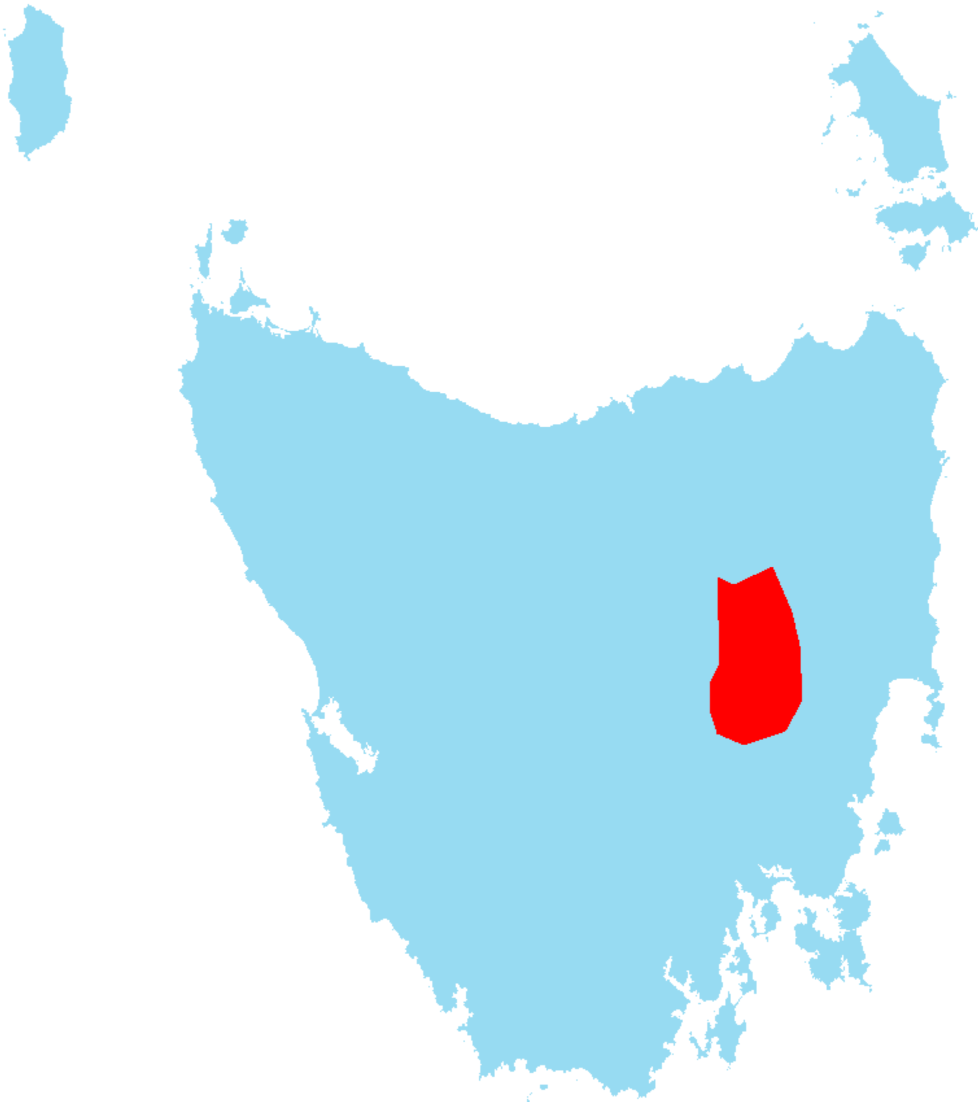

Figure 123: Estimated Tasmanian land area represented by the Ross (Macquarie River) (no. 93025) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 41: PHOENIX Rapidfire weather inputs for ignition points located in the Ross (Macquarie River) (no. 93025) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	32.6	17.2	332	25	8.4	84	0
14:00	34.4	16	331	28	8.4	84	1.2
15:00	35	16.3	330	29	8.4	84	0
16:00	35.7	16.6	325	28	8.4	84	0
17:00	35.4	20.3	310	24	8.4	84	0
18:00	34	22.5	301	25	8.4	84	0
19:00	32	27.2	305	24	8.4	84	0
20:00	29.6	30.2	305	21	8.4	84	0
21:00	27.8	36.5	315	17	8.4	84	0
22:00	27.3	39.2	317	17	8.4	84	0

ISBN: 978-0-9925970-0-9

3.34 91091 Sheffield Weather Station

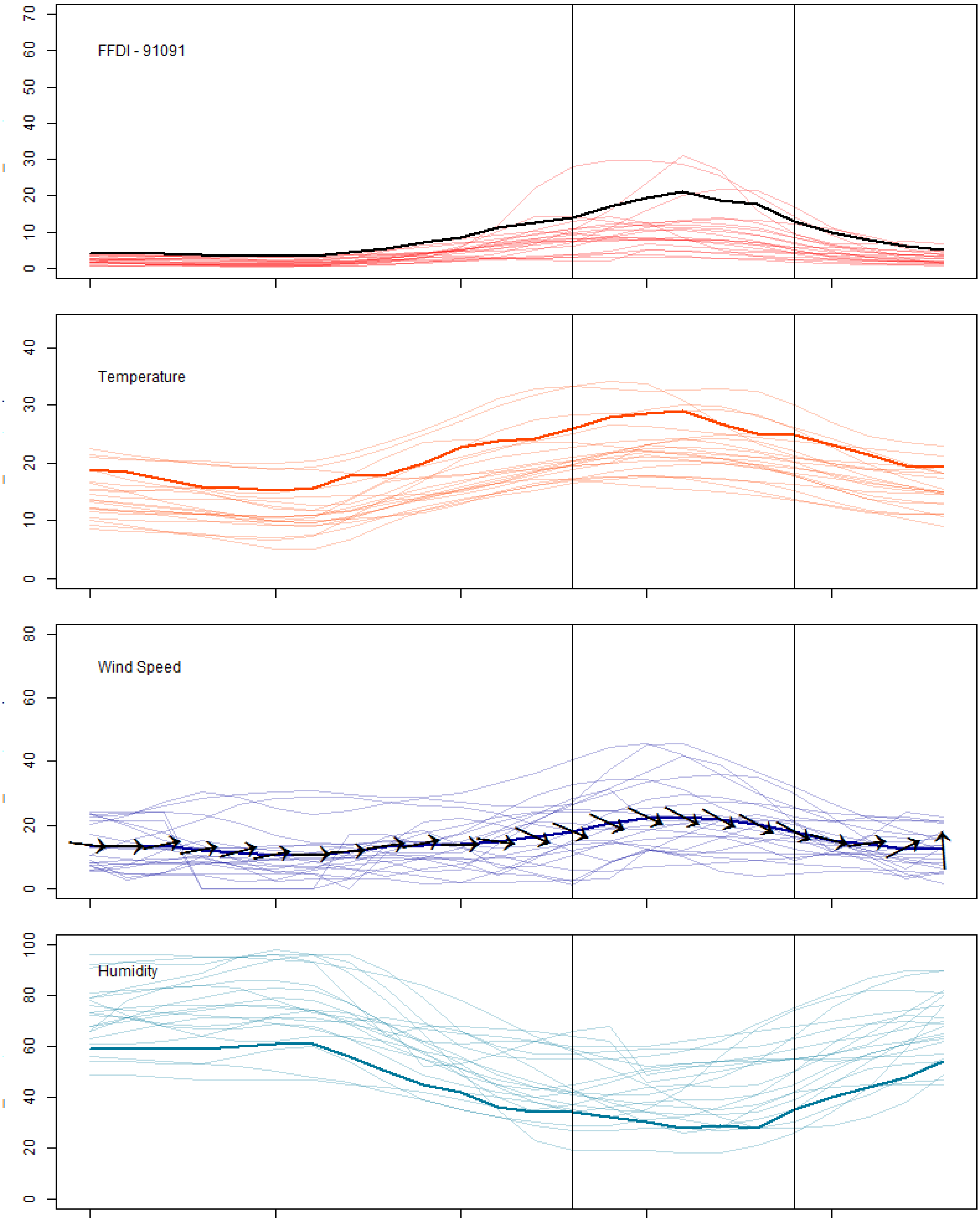

Figure 124: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Sheffield weather station (no. 91091).

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Figure 125: Estimated Tasmanian land area represented by the Sheffield (no. 91091) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 42: PHOENIX Rapidfire weather inputs for ignition points located in the Sheffield (no. 91091) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	26.1	34	293	18	10	100	8
14:00	27.8	32	295	21	10	100	8
15:00	28.5	30	295	22	10	100	13
16:00	28.9	28	298	23	10	100	20
17:00	26.9	29	299	22	10	100	21
18:00	25.2	28	298	20	10	100	0
19:00	24.9	35	298	18	10	100	0
20:00	23.2	40	284	15	10	100	0
21:00	21.5	44	263	14	10	100	0
22:00	19.6	48	243	13	10	100	0

ISBN: 978-0-9925970-0-9

3.35 91092 Smithton (Grant Street) Weather Station

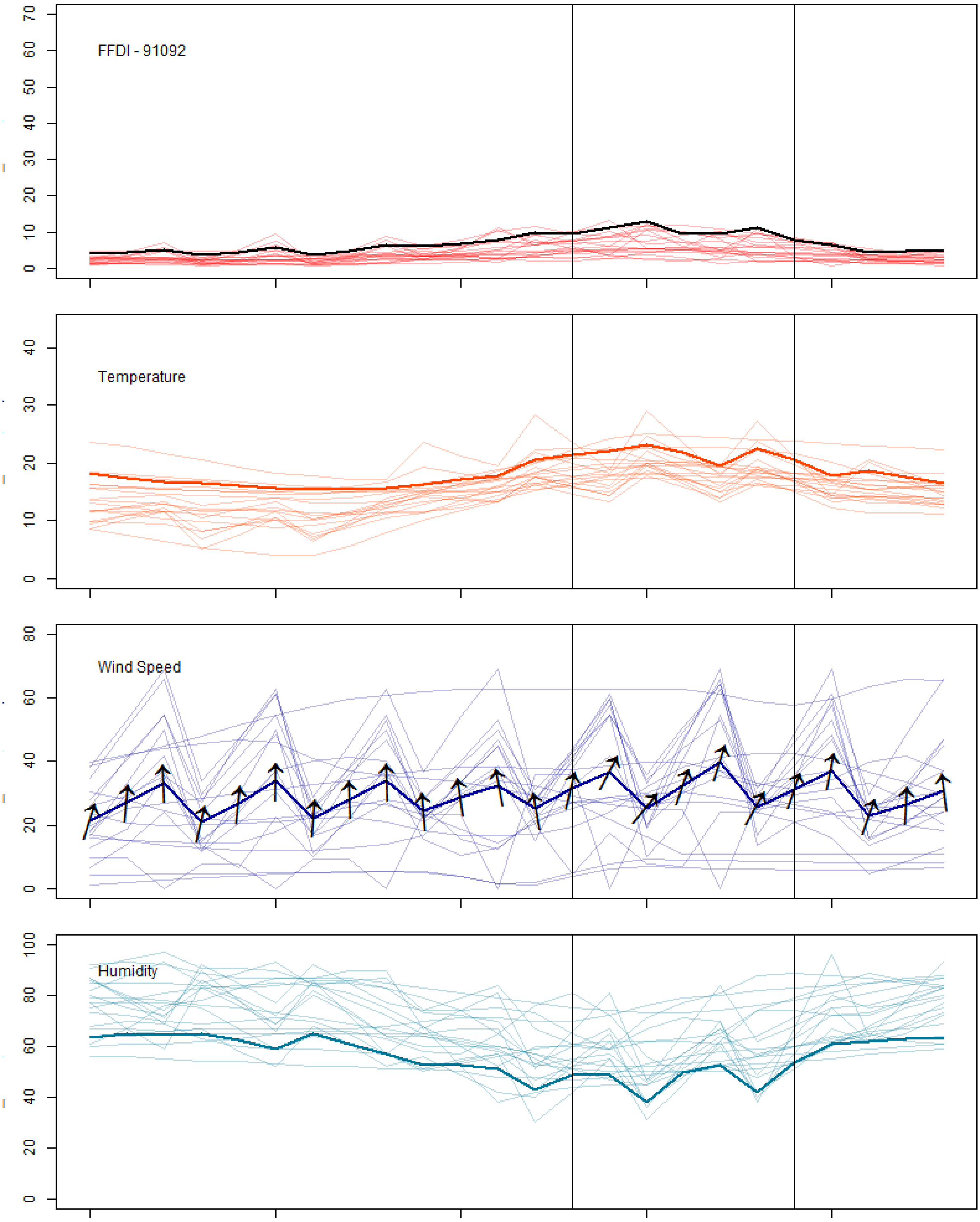

Figure 126: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Smithton (Grant Street) weather station (no. 91092).

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Figure 127: Estimated Tasmanian land area represented by the Smithton (Grant Street) (no. 91092) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 43: PHOENIX Rapidfire weather inputs for ignition points located in the Smithton (Grant Street) (no. 91092) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	21.4	48.7	194	31	9.7	97	0
14:00	22	48.9	208	37	9.7	97	0
15:00	23.1	38	220	25	9.7	97	26.35
16:00	21.9	49.9	199	33	9.7	97	22.1
17:00	19.5	52.9	198	40	9.7	97	0
18:00	22.6	42	210	26	9.7	97	0
19:00	20.5	53.9	199	31	9.7	97	0
20:00	17.9	60.9	191	37	9.7	97	0
21:00	18.6	62	199	23	9.7	97	0
22:00	17.6	62.9	183	27	9.7	97	0

ISBN: 978-0-9925970-0-9

3.36 94062 Snug Primary School Weather Station

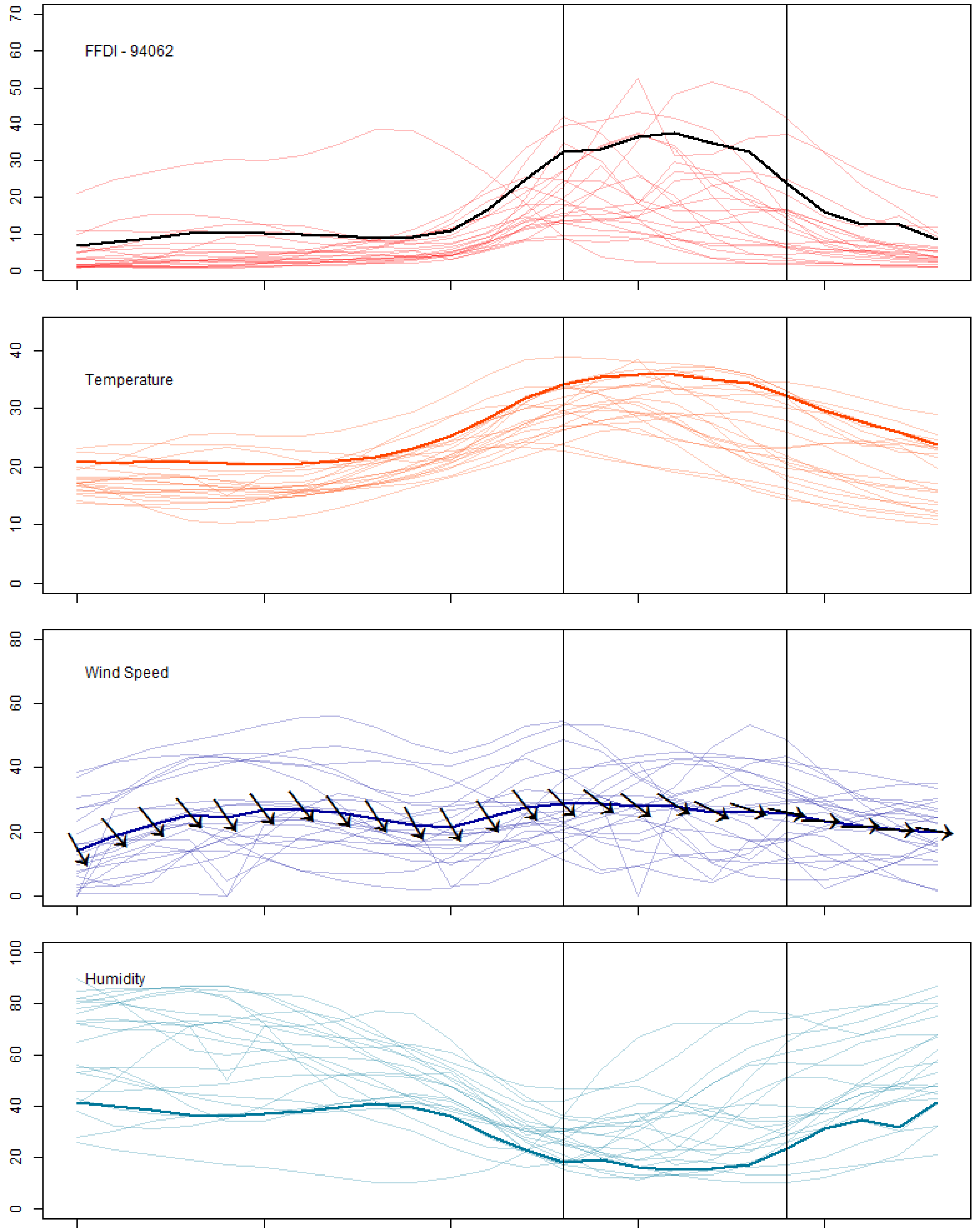

Figure 128: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Snug Primary School weather station (no. 94062).

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Figure 129: Estimated Tasmanian land area represented by the Snug Primary School (no. 94062) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 44: PHOENIX Rapidfire weather inputs for ignition points located in the Snug Primary School (no. 94062) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	34	18.2	315	29	7.9	79	0
14:00	35.4	19.2	308	29	7.9	79	0
15:00	35.9	16	308	28	7.9	79	0
16:00	35.9	15.3	302	28	7.9	79	0
17:00	35.1	15.5	297	26	7.9	79	0
18:00	34.4	17.2	288	26	7.9	79	0
19:00	32.2	23.5	281	26	7.9	79	0
20:00	29.6	31	272	23	7.9	79	0
21:00	27.8	34.5	268	22	7.9	79	0
22:00	25.9	31.8	273	21	7.9	79	0

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3.37 92033 St Helens Post Office Weather Station

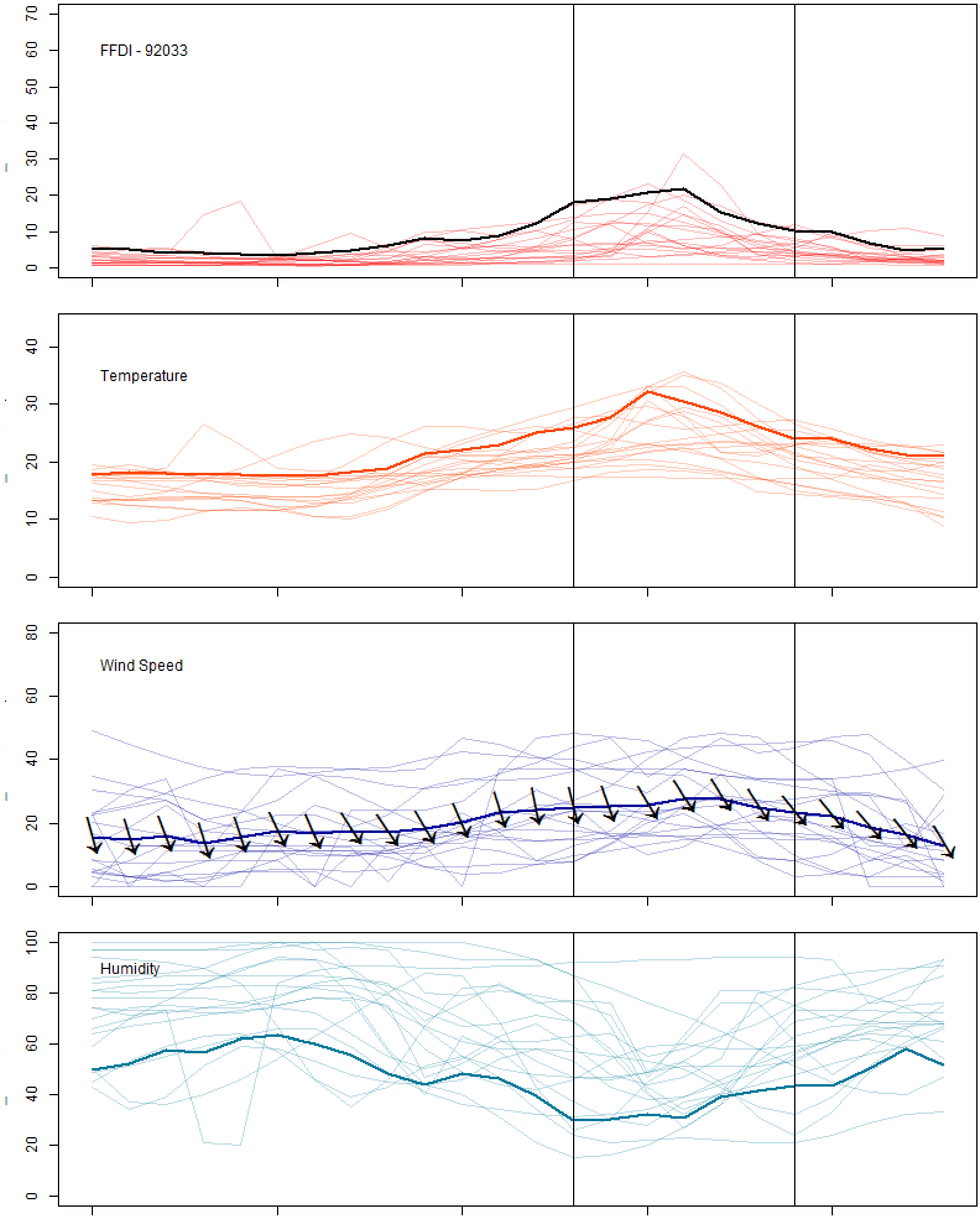

Figure 130: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the St Helens Post Office weather station (no. 92033).

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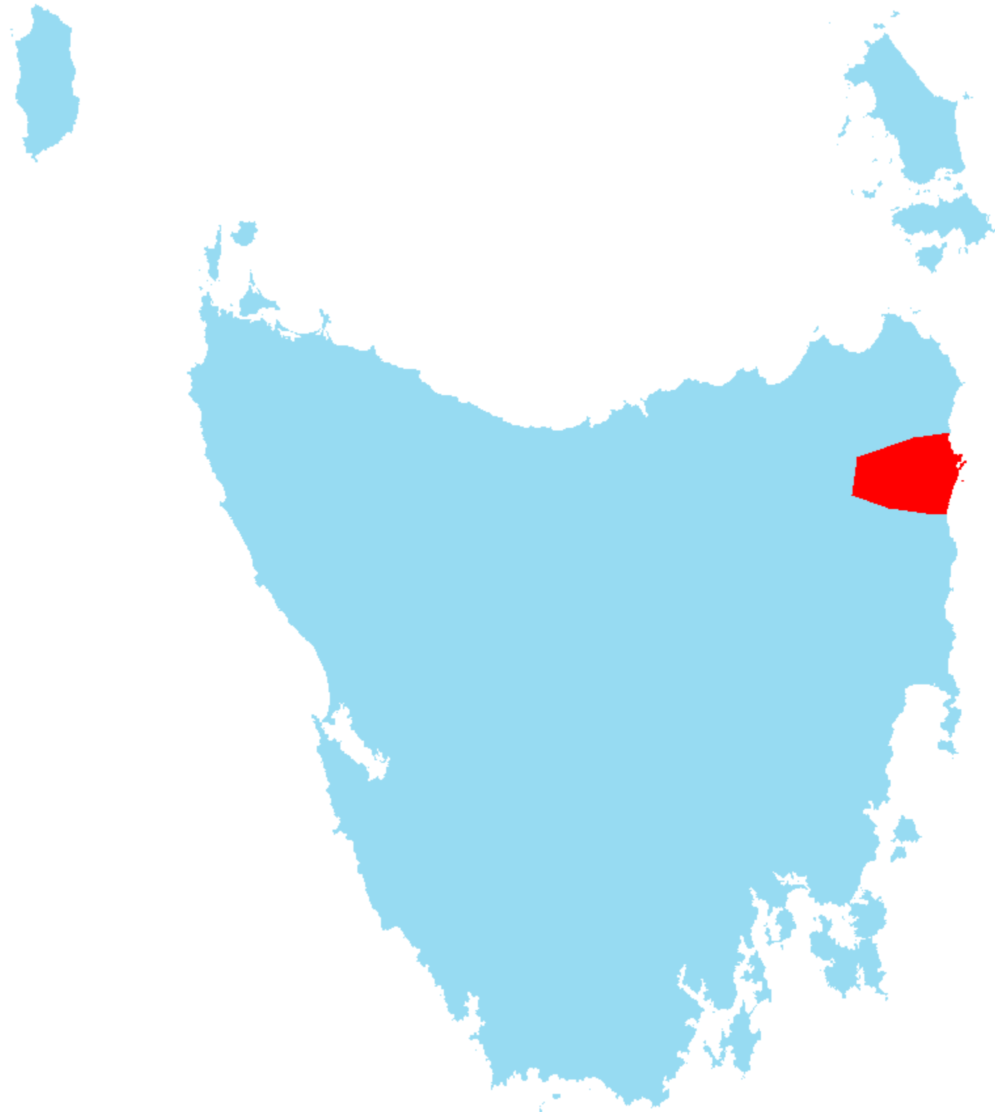

Figure 131: Estimated Tasmanian land area represented by the St Helens Post Office (no. 92033) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 45: PHOENIX Rapidfire weather inputs for ignition points located in the St Helens Post Office (no. 92033) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	25.9	29.5	346	25	9.4	94	0
14:00	27.8	30	340	25	9.4	94	0
15:00	32.3	32.2	329	26	9.4	94	1.4
16:00	30.5	30.5	328	28	9.4	94	0.7
17:00	28.5	38.8	328	28	9.4	94	0
18:00	26.1	41.3	327	25	9.4	94	0
19:00	24	43.2	321	23	9.4	94	0
20:00	24	43.2	321	22	9.4	94	0
21:00	22.2	50.4	319	19	9.4	94	0
22:00	21.2	58	322	16	9.4	94	0

ISBN: 978-0-9925970-0-9

3.38 97072 Strahan Aerodrome Weather Station

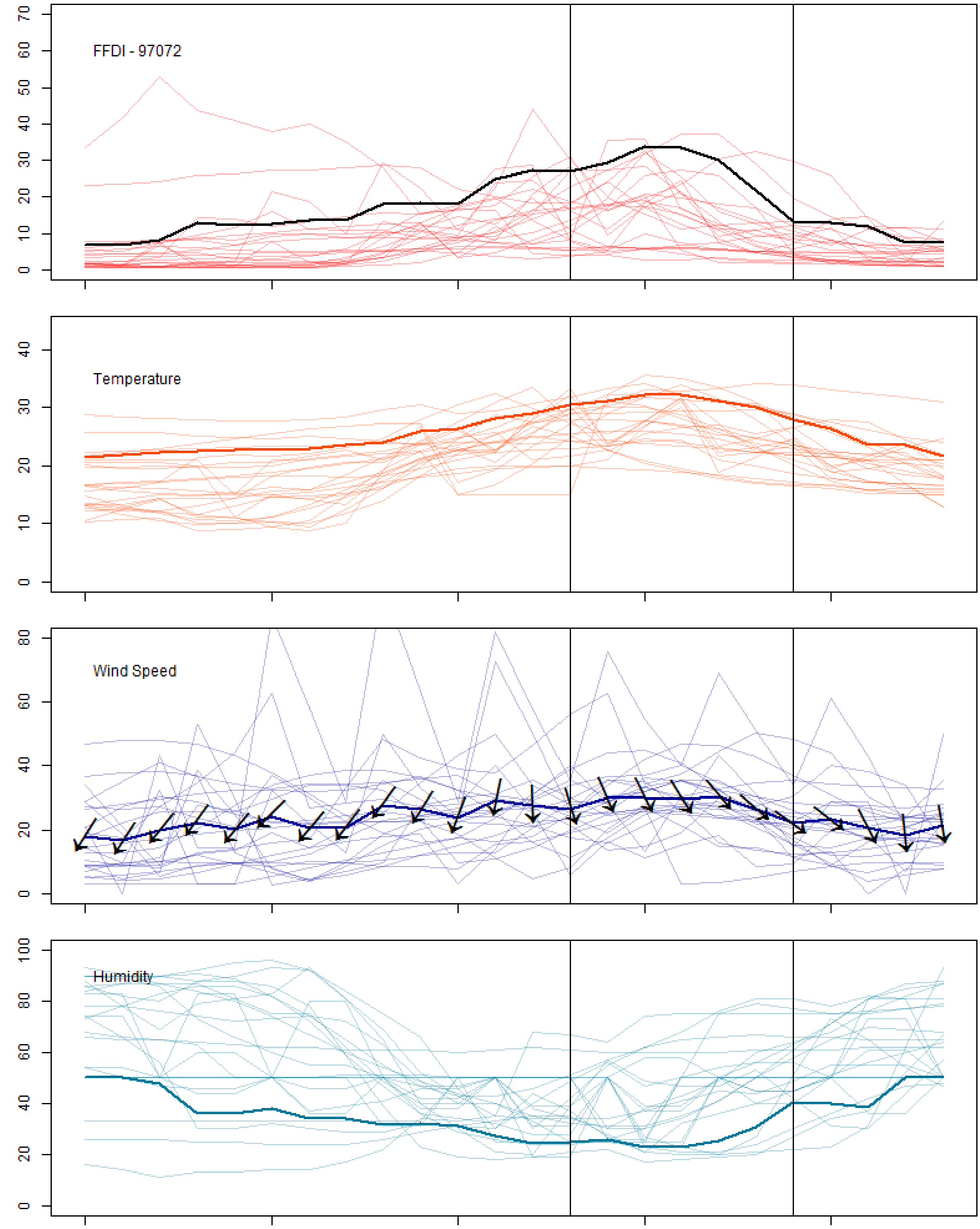

Figure 132: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Strahan Aerodrome weather station (no. 97072).

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Figure 133: Estimated Tasmanian land area represented by the Strahan Aerodrome (no. 97072) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 46: PHOENIX Rapidfire weather inputs for ignition points located in the Strahan Aerodrome (no. 97072) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	30.4	25	343	26	10	100	0
14:00	31.1	26	337	30	10	100	0
15:00	32.2	23	334	30	10	100	0
16:00	32.2	23	328	30	10	100	0
17:00	31.2	25.5	320	30	10	100	0
18:00	30	30.9	310	26	10	100	0
19:00	27.9	40.6	306	22	10	100	0
20:00	26.5	40.2	308	23	10	100	0
21:00	23.7	38.5	333	21	10	100	0
22:00	23.7	50	354	18	10	100	0

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3.39 97053 Strathgordon Village Weather Station

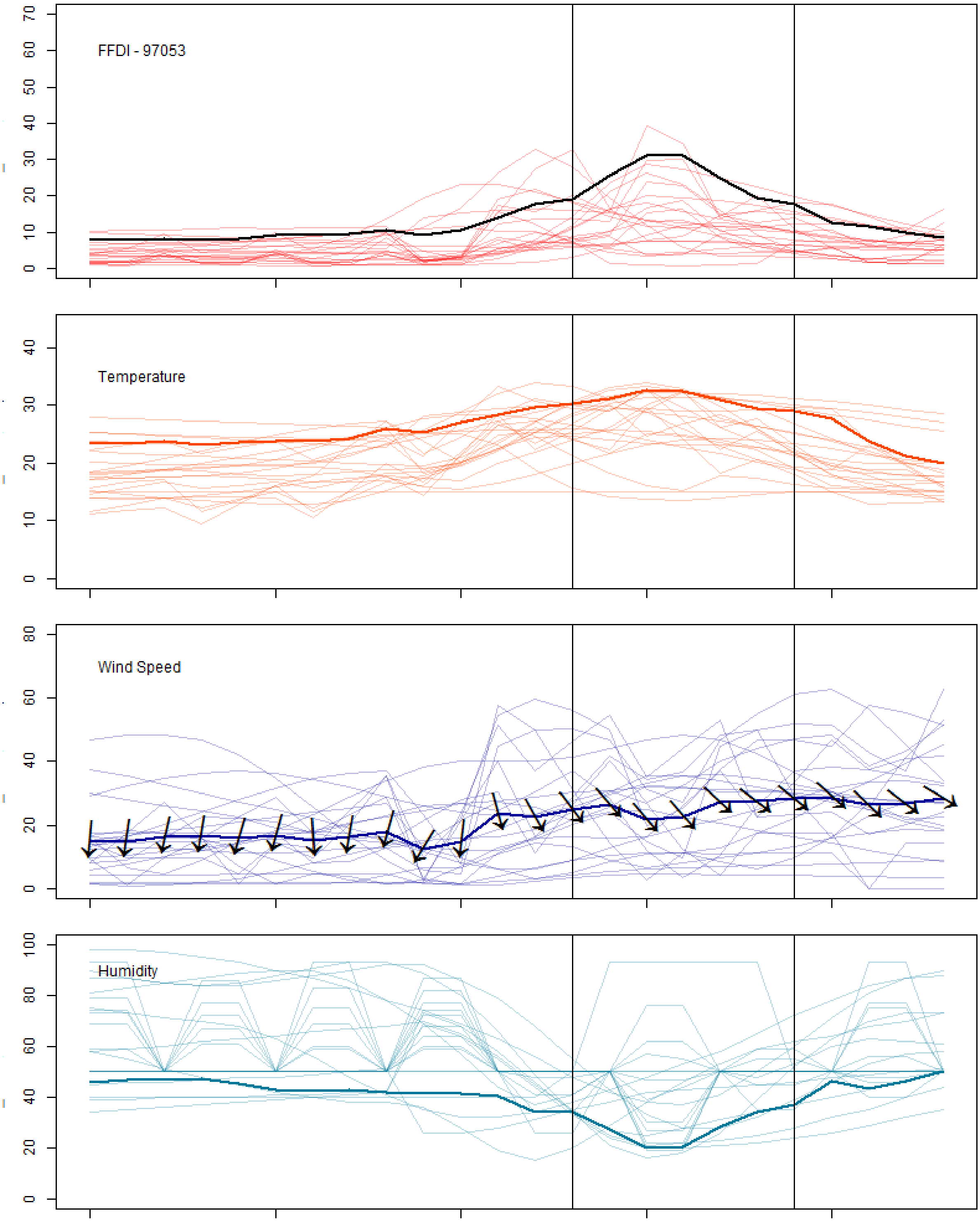

Figure 134: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Strathgordon Village weather station (no. 97053).

ISBN: 978-0-9925970-0-9

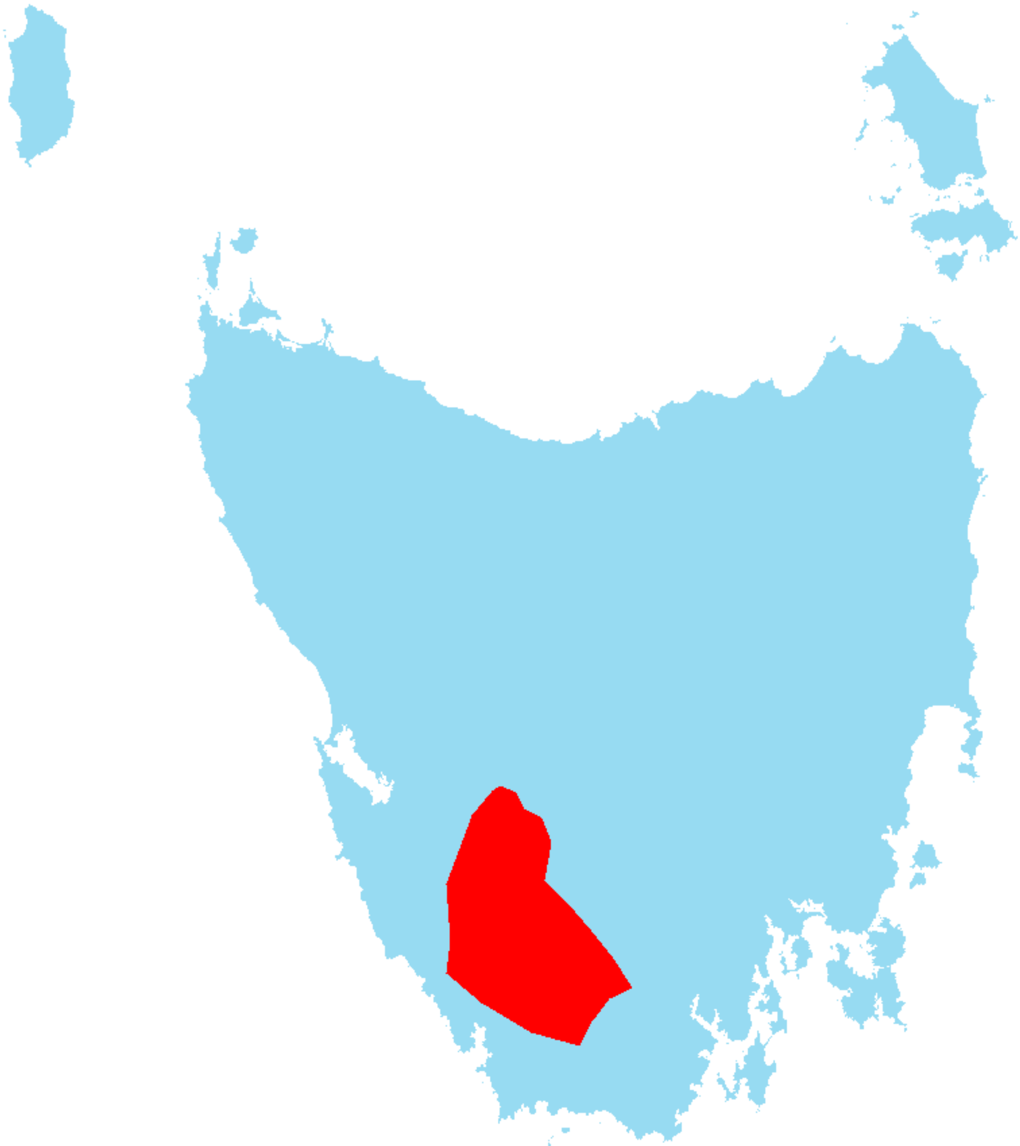

Figure 135: Estimated Tasmanian land area represented by the Strathgordon Village (no. 97053) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 47: PHOENIX Rapidfire weather inputs for ignition points located in the Strathgordon Village (no. 97053) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	30.3	34	322	25	10	100	0
14:00	31.2	27	318	26	10	100	0
15:00	32.7	20	319	21	10	100	0
16:00	32.3	22	319	22	10	100	0
17:00	30.1	28	311	27	10	100	0
18:00	29.3	34	305	27	10	100	0
19:00	28.9	37	307	28	10	100	0
20:00	28.4	46	311	29	10	100	0
21:00	23.9	43	313	26	10	100	0
22:00	20.6	46	306	27	10	100	0

ISBN: 978-0-9925970-0-9

3.40 92038 Swansea Post Office

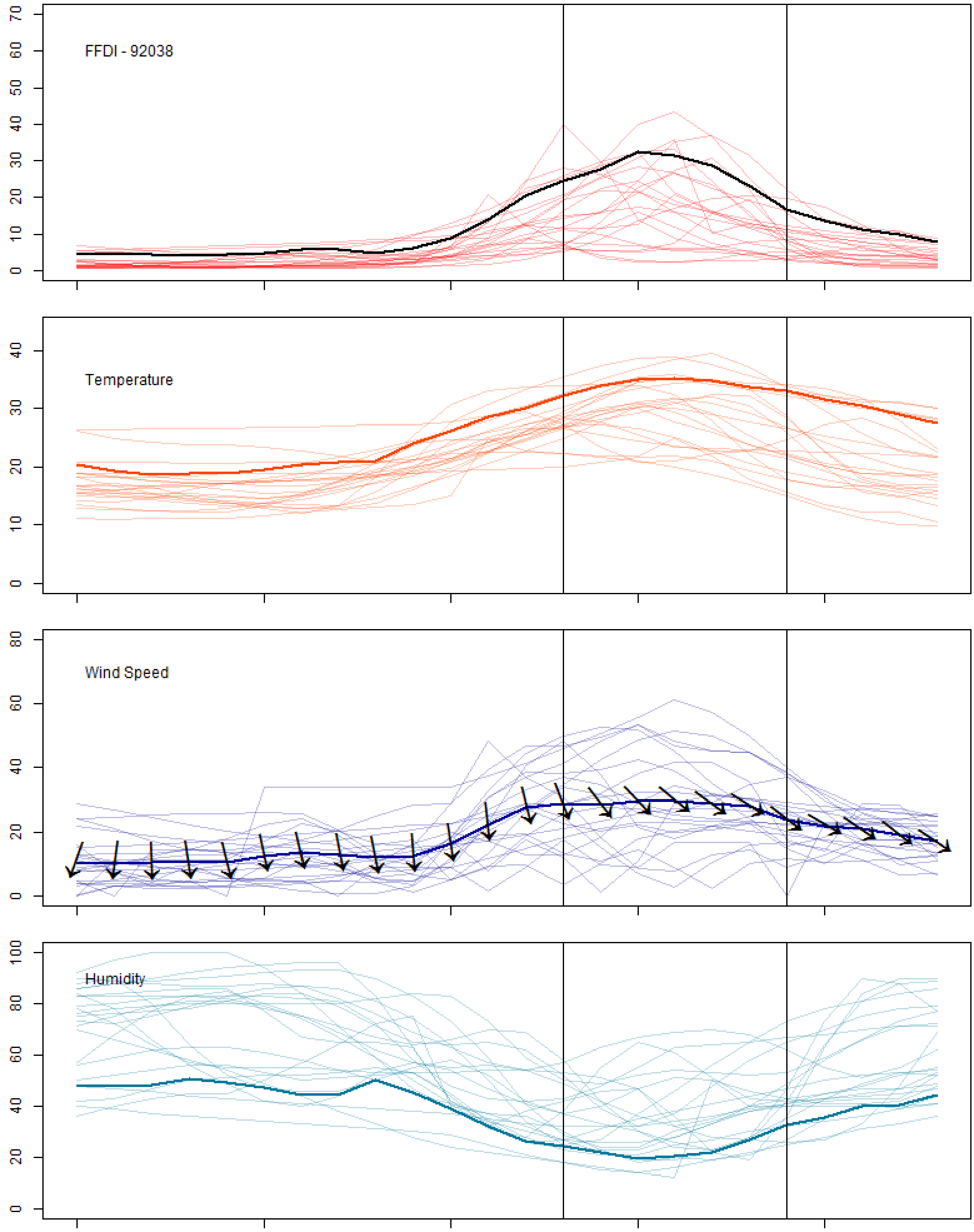

Figure 136: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Swansea Post Office weather station (no. 92038).

ISBN: 978-0-9925970-0-9

Figure 137: Estimated Tasmanian land area represented by the Swansea Post Office (no. 92038) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 48: PHOENIX Rapidfire weather inputs for ignition points located in the Swansea Post Office (no. 92038) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	32.1	24.2	339	29	7.8	78	15.05
14:00	33.9	22.2	322	28	7.8	78	29
15:00	35.1	19.3	316	29	7.8	78	27.6
16:00	35.3	20.6	310	29	7.8	78	31
17:00	34.7	22.2	306	29	7.8	78	31
18:00	33.8	27	302	28	7.8	78	0
19:00	33	32.5	308	24	7.8	78	0
20:00	31.5	35.8	300	22	7.8	78	0
21:00	30.5	40.2	304	21	7.8	78	0
22:00	28.9	40.3	308	19	7.8	78	0

ISBN: 978-0-9925970-0-9

3.41 95018 Tarraleah Village Weather Station

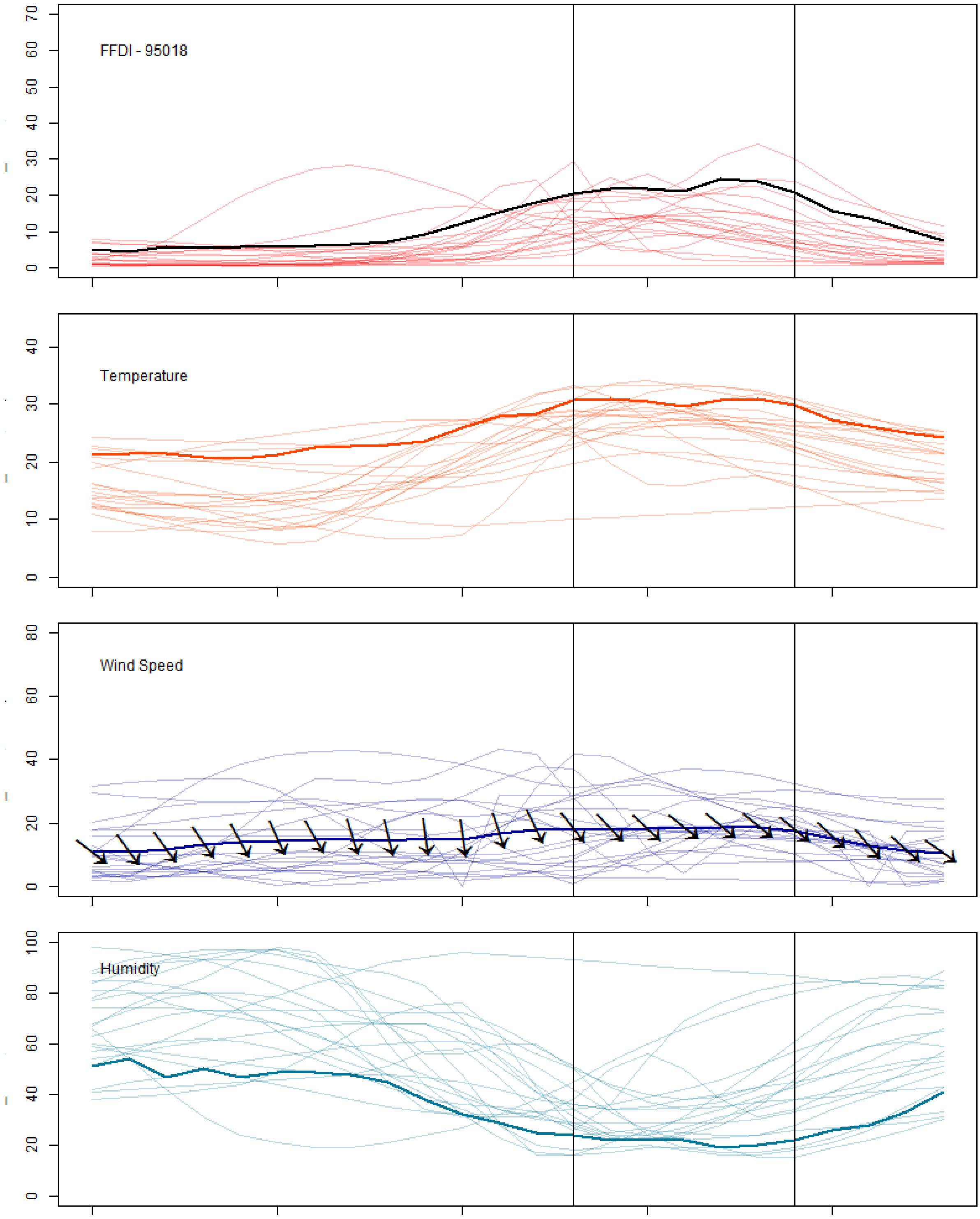

Figure 138: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Tarraleah Village weather station (no. 95018).

ISBN: 978-0-9925970-0-9

Figure 139: Estimated Tasmanian land area represented by the Tarraleah Village (no. 95018) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 49: PHOENIX Rapidfire weather inputs for ignition points located in the Tarraleah Village (no. 95018) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	30.8	24	322	18	8.7	87	0
14:00	30.9	22	316	18	8.7	87	0
15:00	30.6	22	313	18	8.7	87	0
16:00	29.6	22	309	18	8.7	87	0
17:00	30.8	19	310	19	8.7	87	0
18:00	30.8	20	309	19	8.7	87	0
19:00	29.7	22	310	18	8.7	87	0
20:00	27.2	26	313	15	8.7	87	0
21:00	26.2	28	320	13	8.7	87	0
22:00	25.2	33	312	11	8.7	87	0

ISBN: 978-0-9925970-0-9

3.42 94075 Tasman Island Lighthouse

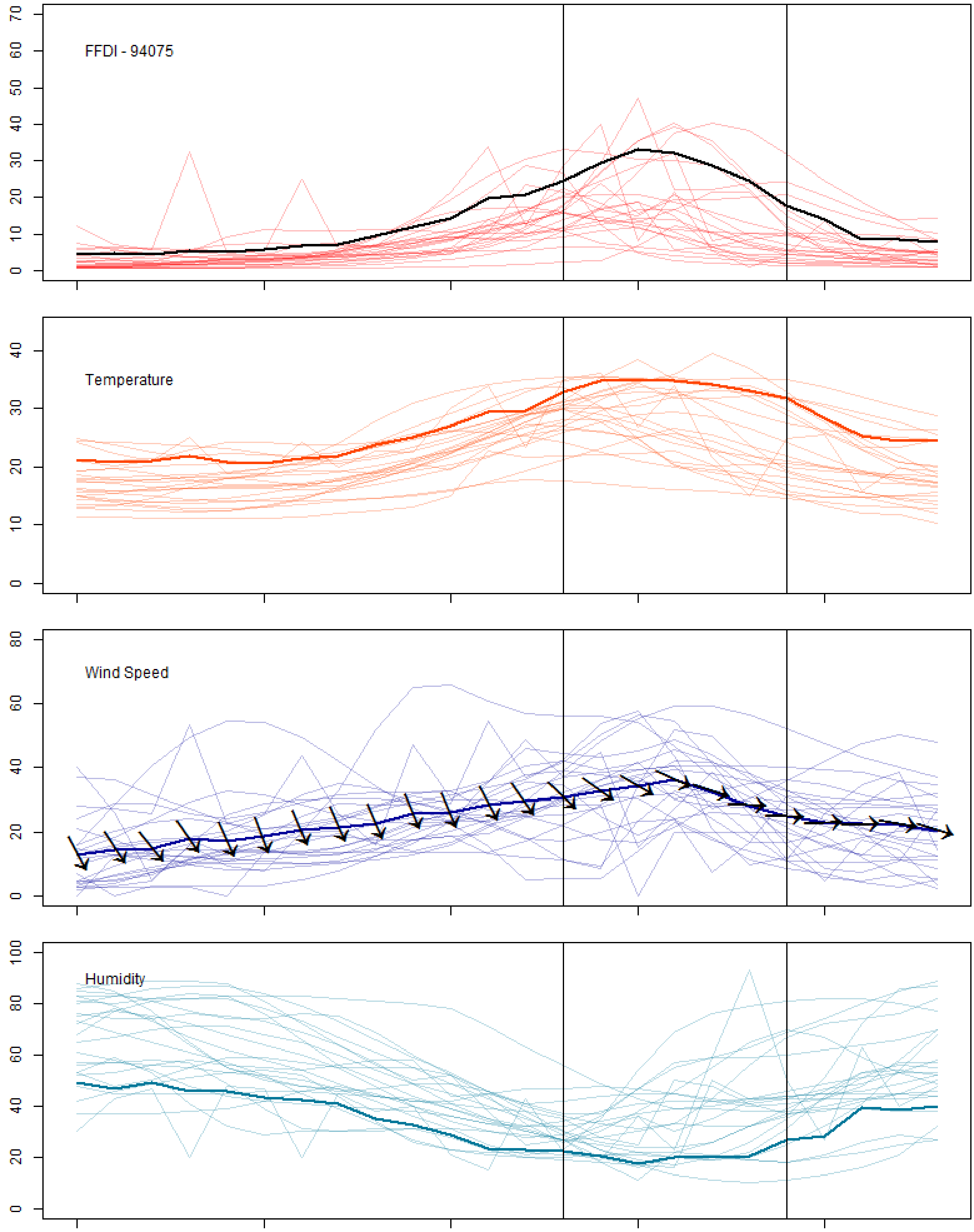

Figure 140: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Tasman Island Lighthouse weather station (no. 94075).

ISBN: 978-0-9925970-0-9

Figure 141: Estimated Tasmanian land area represented by the Tasman Island Lighthouse (no. 94075) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 50: PHOENIX Rapidfire weather inputs for ignition points located in the Tasman Island Lighthouse (no. 94075) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	32.9	22.3	314	31	6.8	68	0
14:00	34.7	20.3	305	33	6.8	68	0
15:00	34.7	17.6	300	34	6.8	68	0
16:00	34.7	20	295	36	6.8	68	0
17:00	34.1	20	288	32	6.8	68	9.6
18:00	33.1	20.6	273	28	6.8	68	0
19:00	31.9	26.8	272	25	6.8	68	0
20:00	28.3	28.5	267	23	6.8	68	2.4
21:00	25.4	39.6	269	23	6.8	68	6.6
22:00	24.5	38.6	280	22	6.8	68	1.2

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3.43 94067 Tunnack Post Office Weather Station

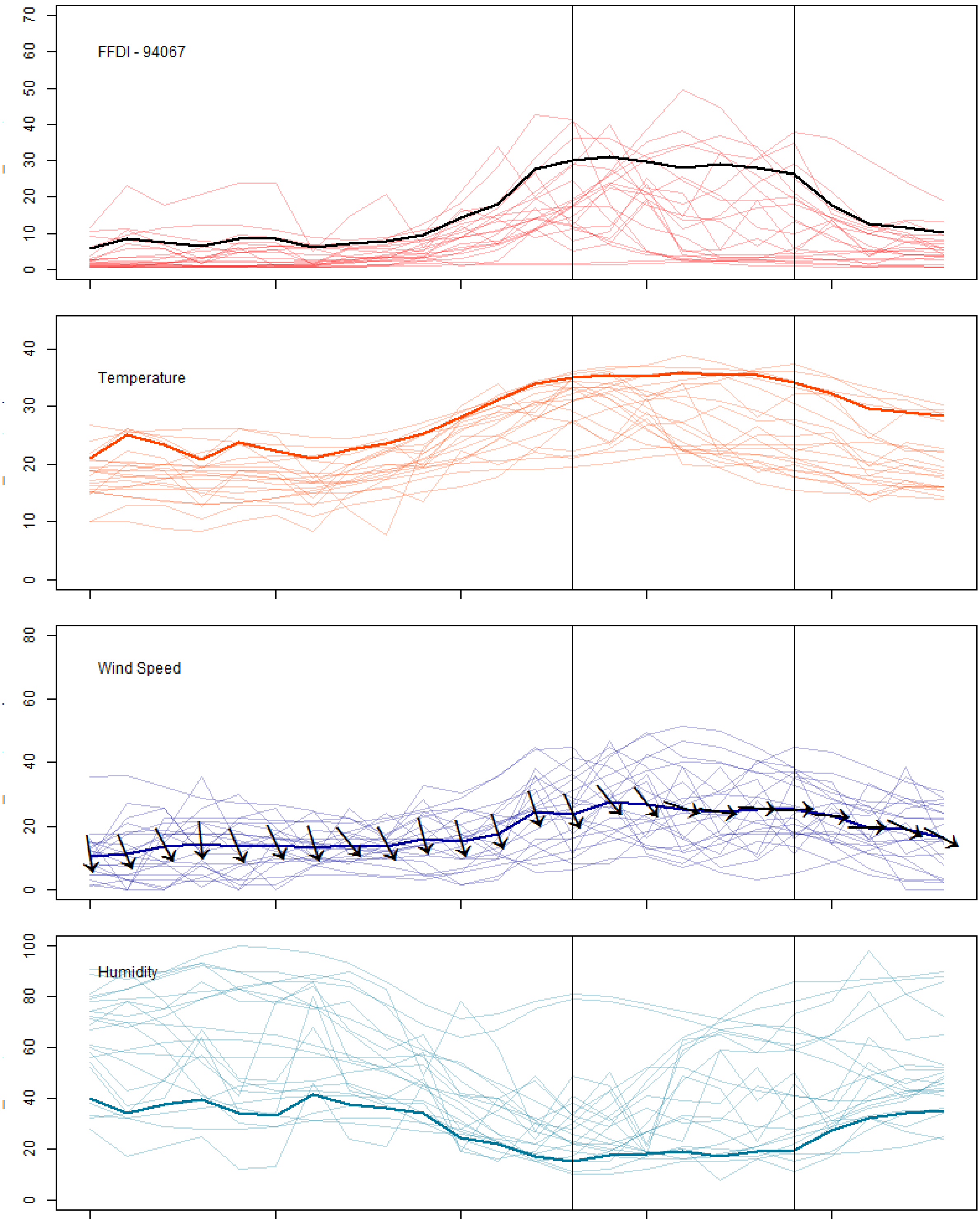

Figure 142: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Tunnack Post Office weather station (no. 94067).

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Figure 143: Estimated Tasmanian land area represented by the Tunnack Post Office (no. 94067) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 51: PHOENIX Rapidfire weather inputs for ignition points located in the Tunnack Post Office (no. 94067) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	34.9	15.3	335	24	7.2	72	0
14:00	35.3	17.3	320	28	7.2	72	0
15:00	35.1	18	322	27	7.2	72	0
16:00	35.9	19.2	288	25	7.2	72	0
17:00	35.4	17.2	278	24	7.2	72	0
18:00	35.5	19	274	25	7.2	72	0
19:00	34.1	19.5	268	25	7.2	72	0
20:00	32.2	27.3	275	23	7.2	72	0
21:00	29.6	32.2	269	20	7.2	72	0
22:00	29	34.2	295	19	7.2	72	0

ISBN: 978-0-9925970-0-9

3.44 91107 Wynyard Airport Weather Station

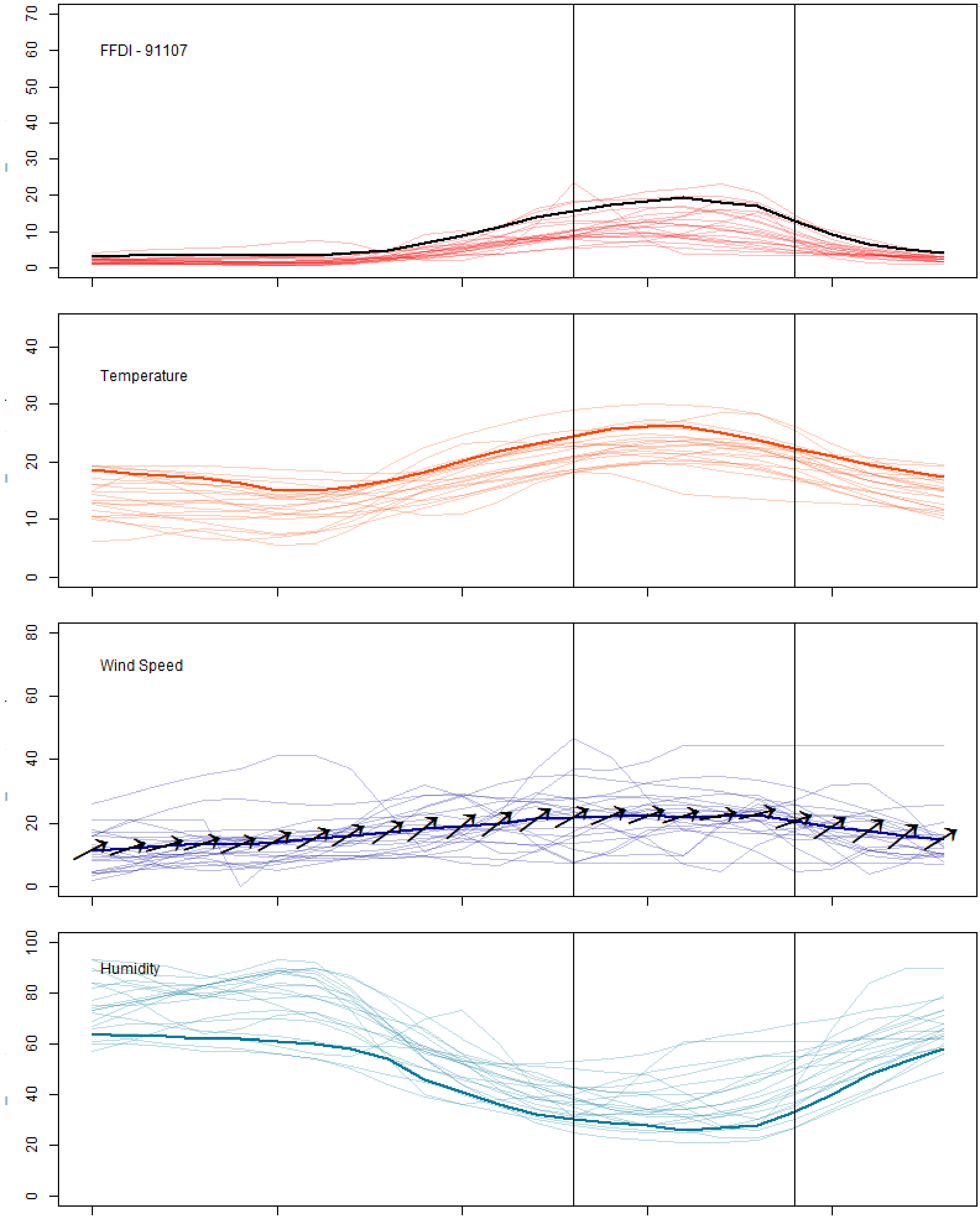

Figure 144: Comparison of daily meteorological records and synthetic aggregate meteorological variables for the Wynyard Airport weather station (no. 91107).

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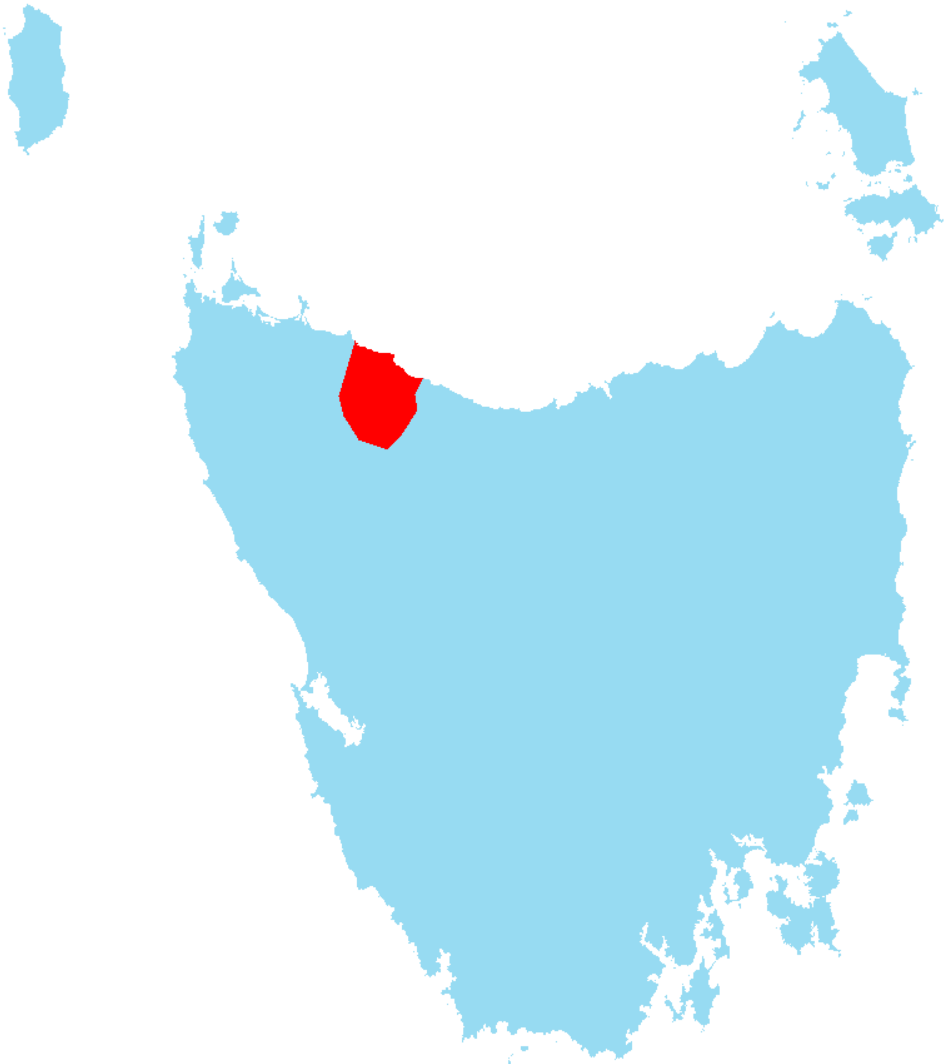

Figure 145: Estimated Tasmanian land area represented by the Wynyard Airport (no. 91107) Bureau of Meteorology weather station (shown in red) (Department of Primary Industries, Parks, Water & the Environment, 2014).

Table 52: PHOENIX Rapidfire weather inputs for ignition points located in the Wynyard Airport (no. 91107) weather station area.

Time	Temperature (◦C)	Relative Humidity (%)	Wind Direction (◦)	Wind Speed (km/h)	Drought Factor	Curing (%)	Cloud Cover (%)
13:00	24.4	30	240	22	9.5	95	0
14:00	25.8	29	247	22	9.5	95	13
15:00	26.2	28	249	23	9.5	95	12
16:00	26.2	26	252	22	9.5	95	17
17:00	25.1	27	259	22	9.5	95	22
18:00	23.8	28	256	23	9.5	95	0
19:00	22.4	33	251	21	9.5	95	0
20:00	21	40	237	19	9.5	95	0
21:00	19.6	48	233	18	9.5	95	0
22:00	18.4	53	231	16	9.5	95	0

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APPENDIX 5: HYPOTHETICAL FIVE YEAR BURNING PROGRAMS

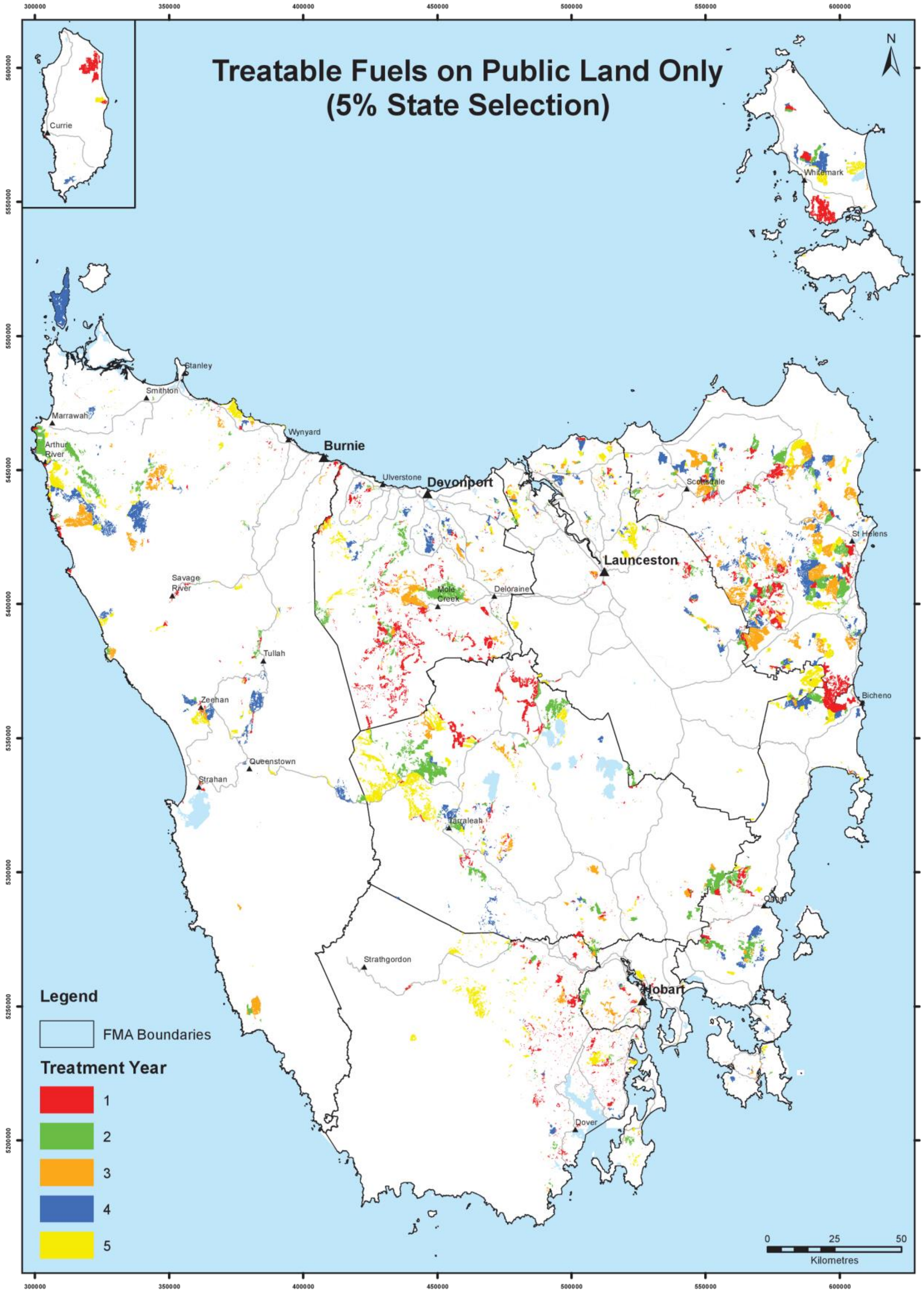

Figure 146: Five year hypothetical burning program for the Public Land Only scenario, burning 5% of treatable fuels on public land each year. Selection of burn areas was based on treatment of bushfire risk at the Statewide scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

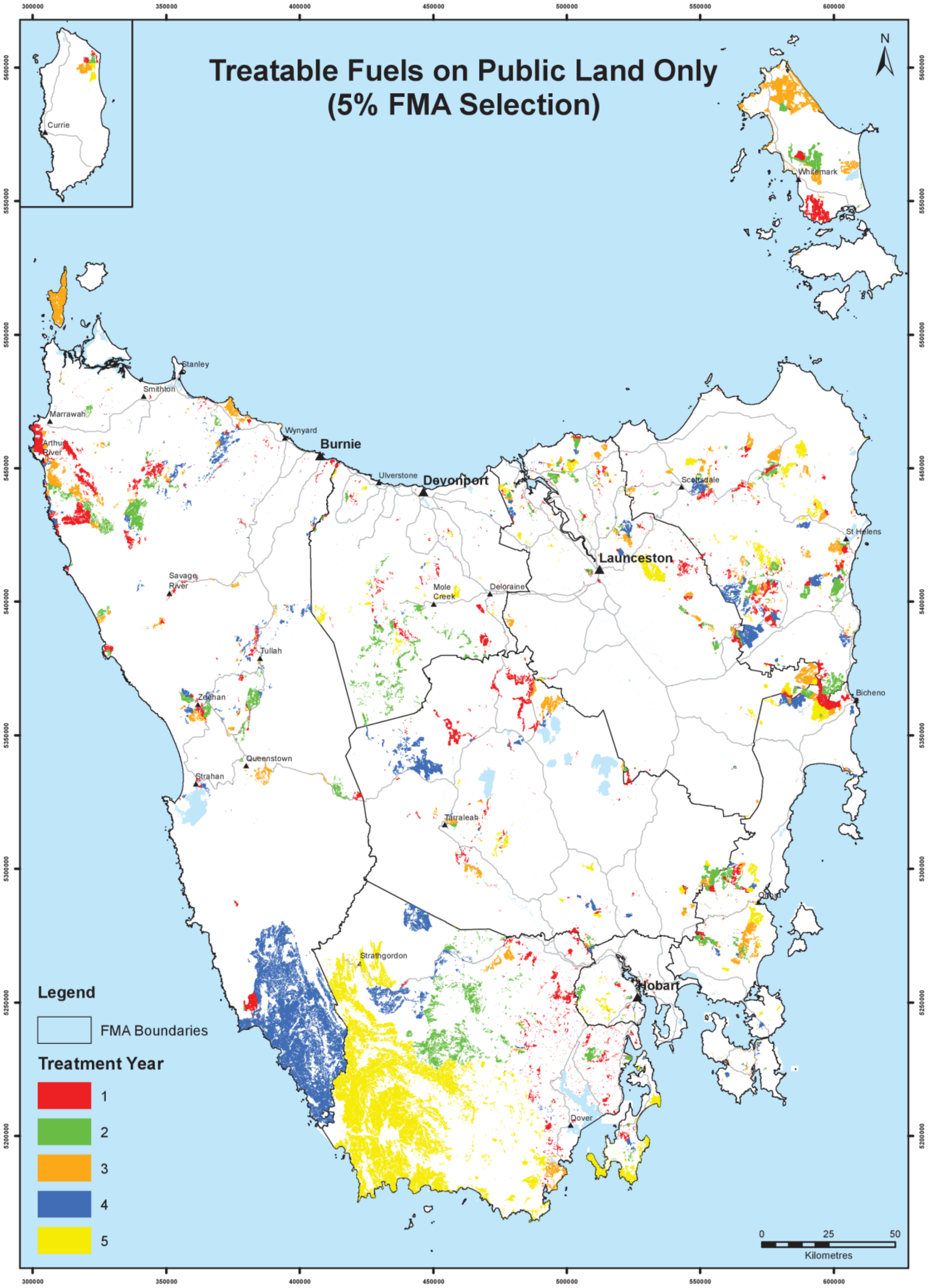

Figure 147: Five year hypothetical burning program for the Public Land Only scenario, burning 5% of treatable fuels on public land each year. Selection of burn areas was based on treatment of bushfire risk at the Fire Management Area scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

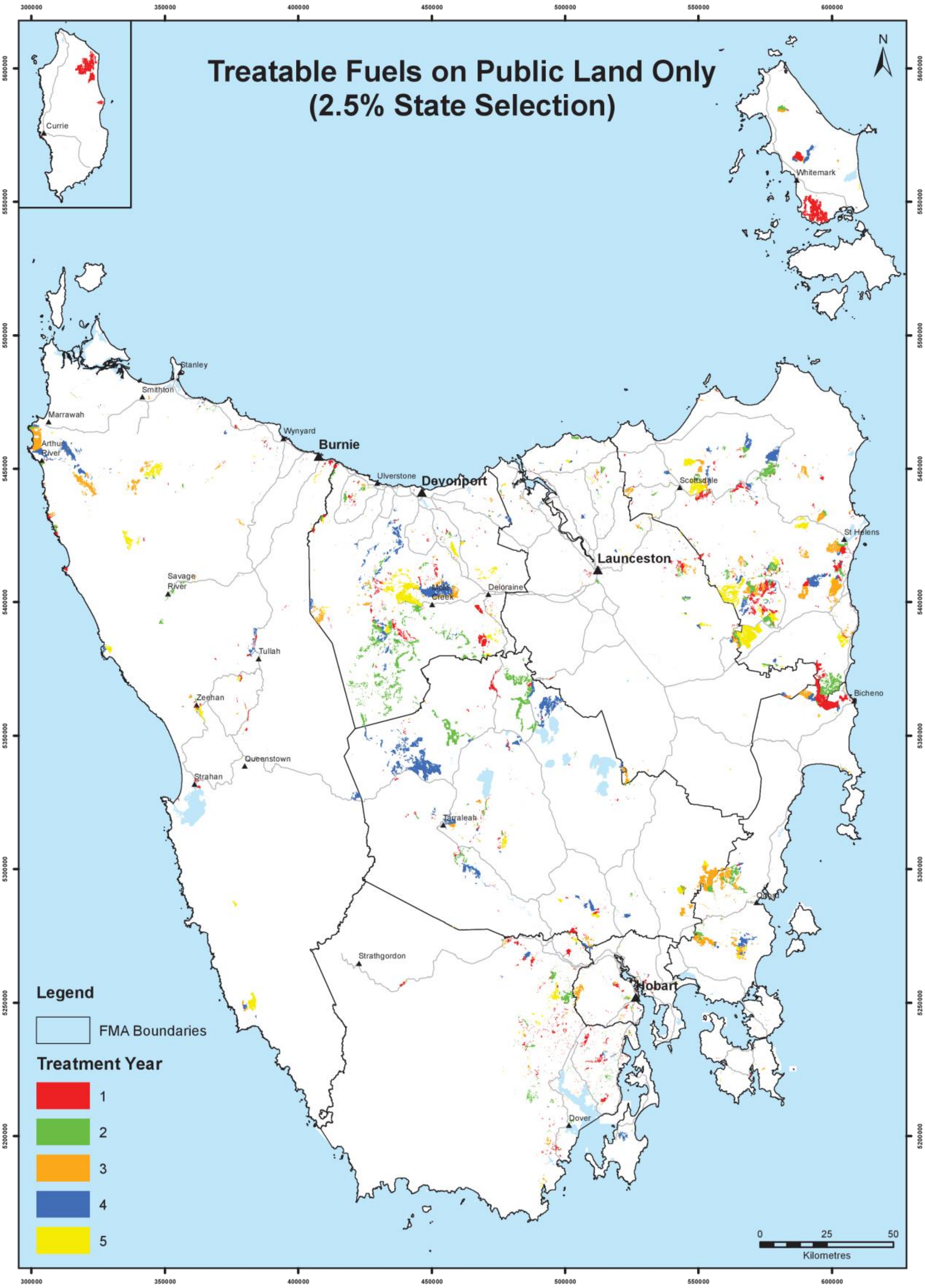

Figure 148: Five year hypothetical burning program for the Public Land Only scenario, burning 2.5% of treatable fuels on public land each year. Selection of burn areas was based on treatment of bushfire risk at the Statewide scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

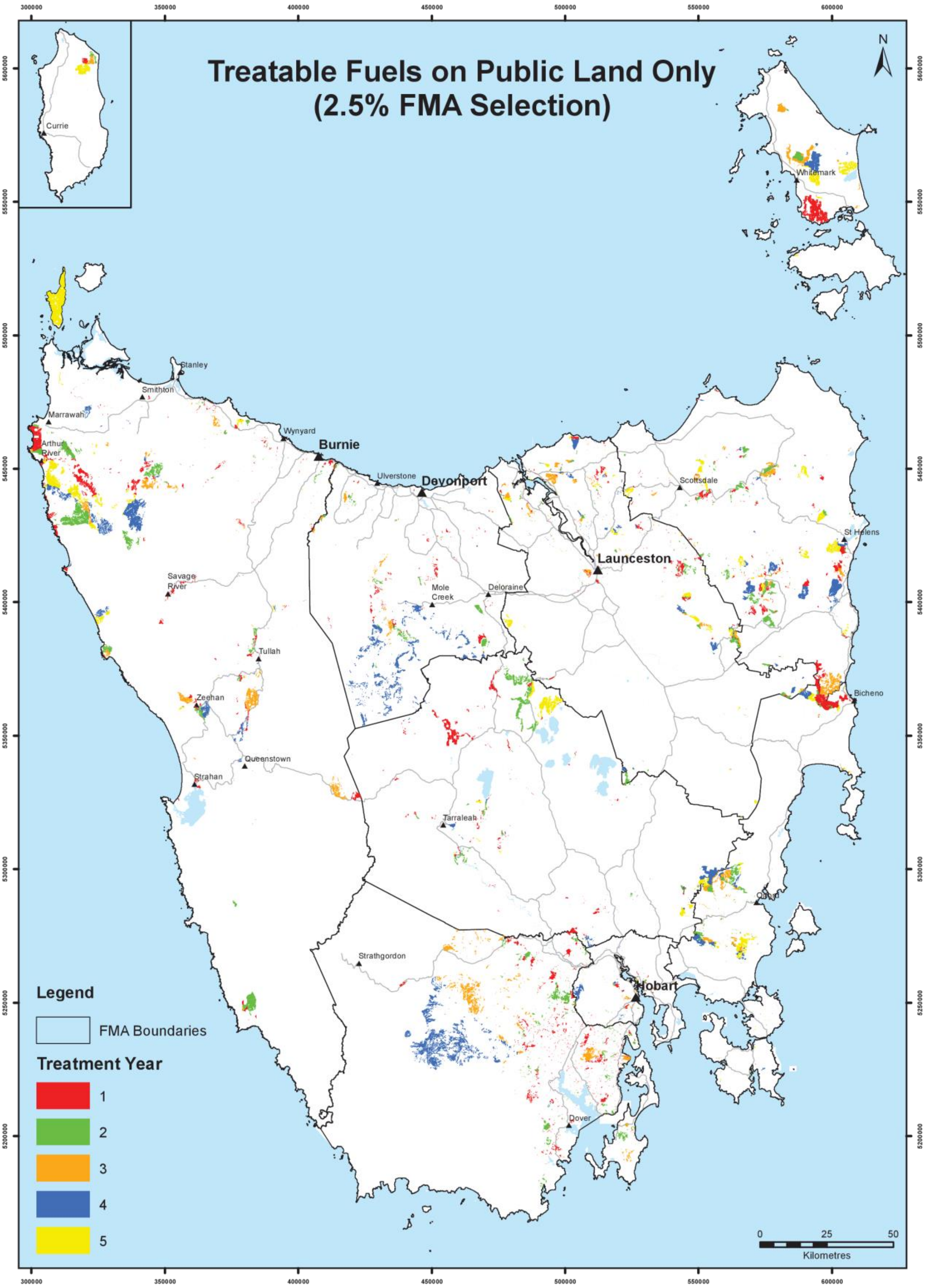

Figure 149: Five year hypothetical burning program for the Public Land Only scenario, burning 2.5% of treatable fuels on public land each year. Selection of burn areas was based on treatment of bushfire risk at the Fire Management Area scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

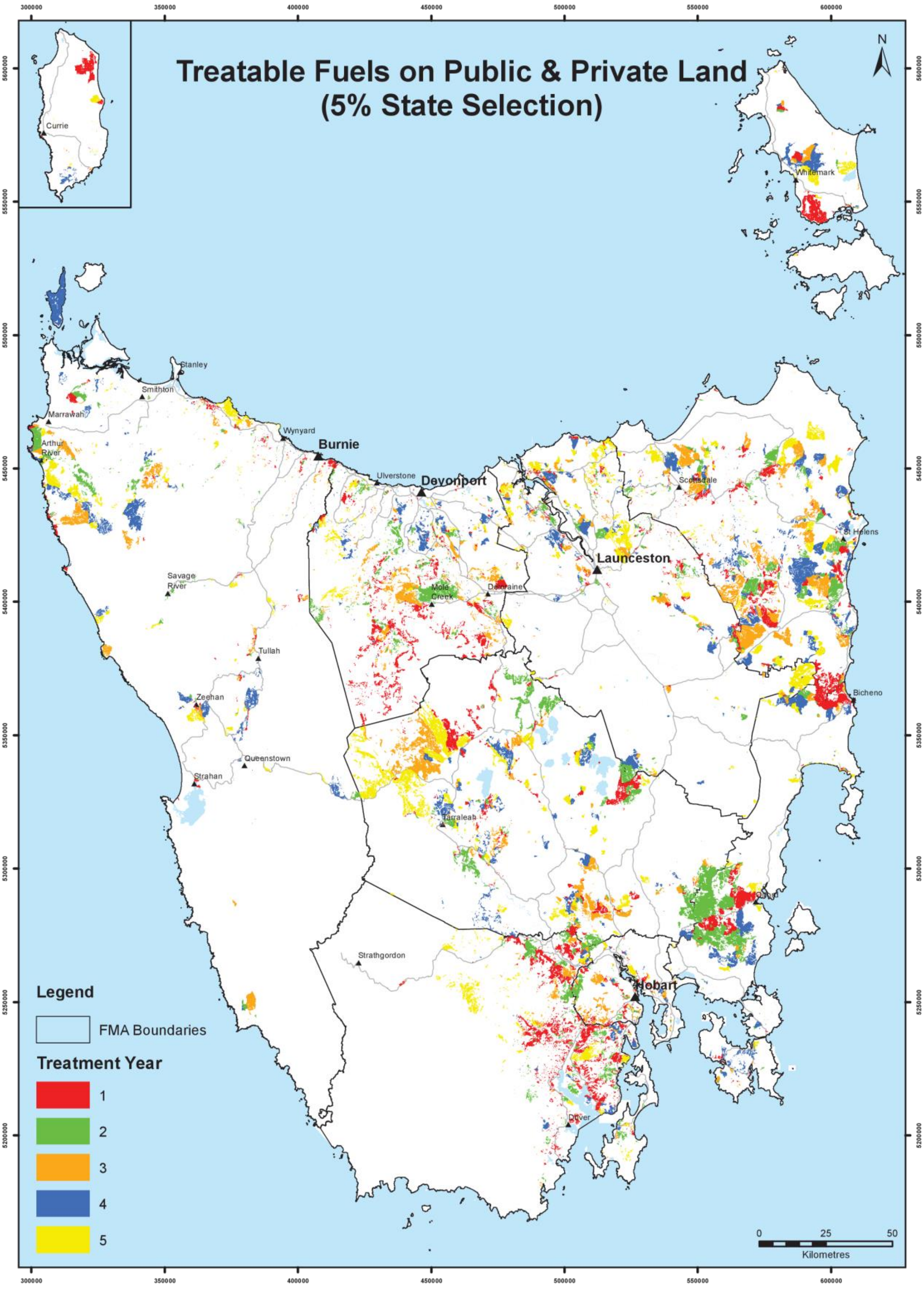

Figure 150: Five year hypothetical burning program for the Public and Private Land scenario, burning 5% of treatable fuels on public and private land each year. Selection of burn areas was based on treatment of bushfire risk at the Statewide scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

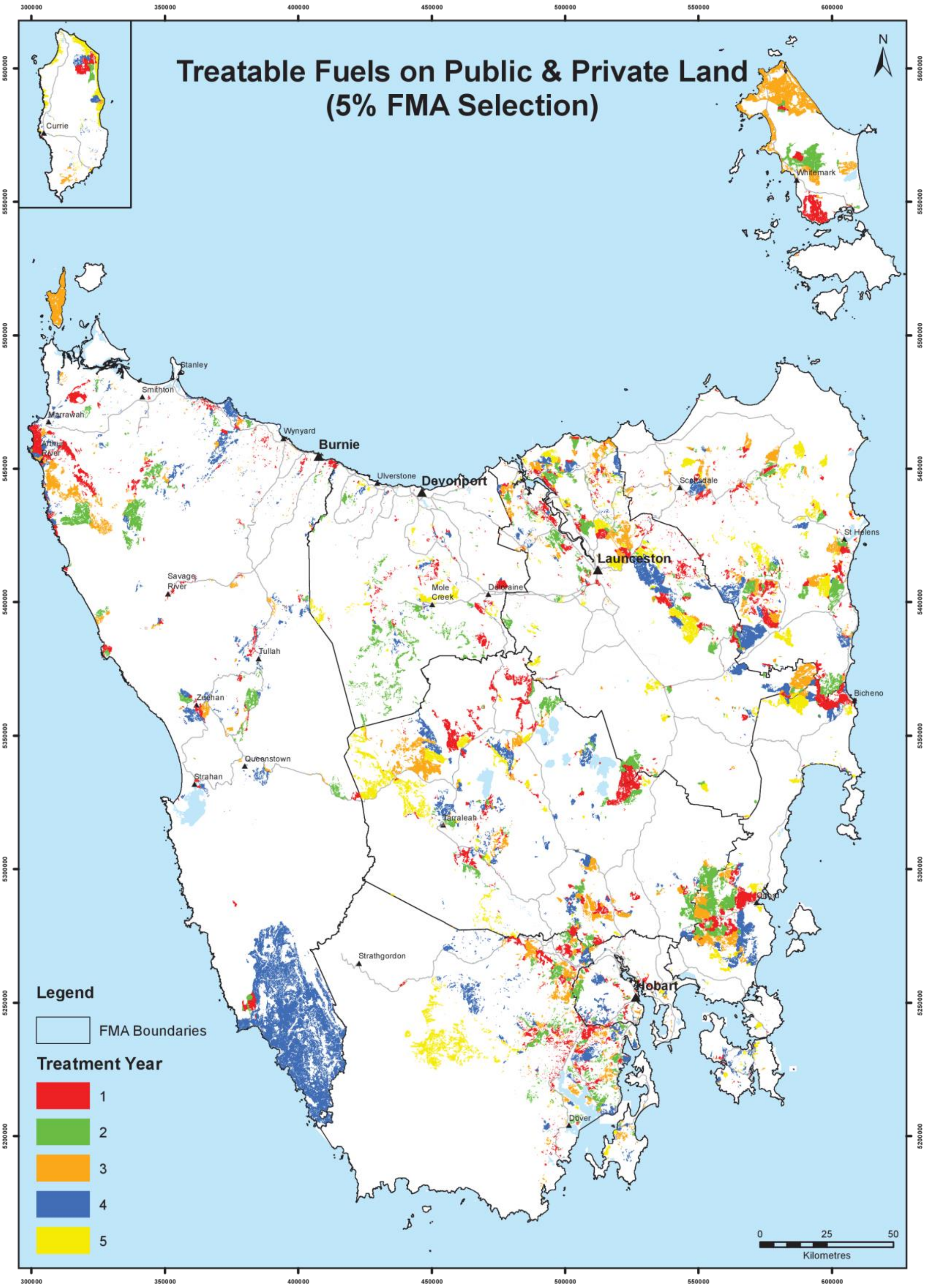

Figure 151: Five year hypothetical burning program for the Public and Private Land scenario, burning 5% of treatable fuels on public and private land each year. Selection of burn areas was based on treatment of bushfire risk at the Fire Management Area scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

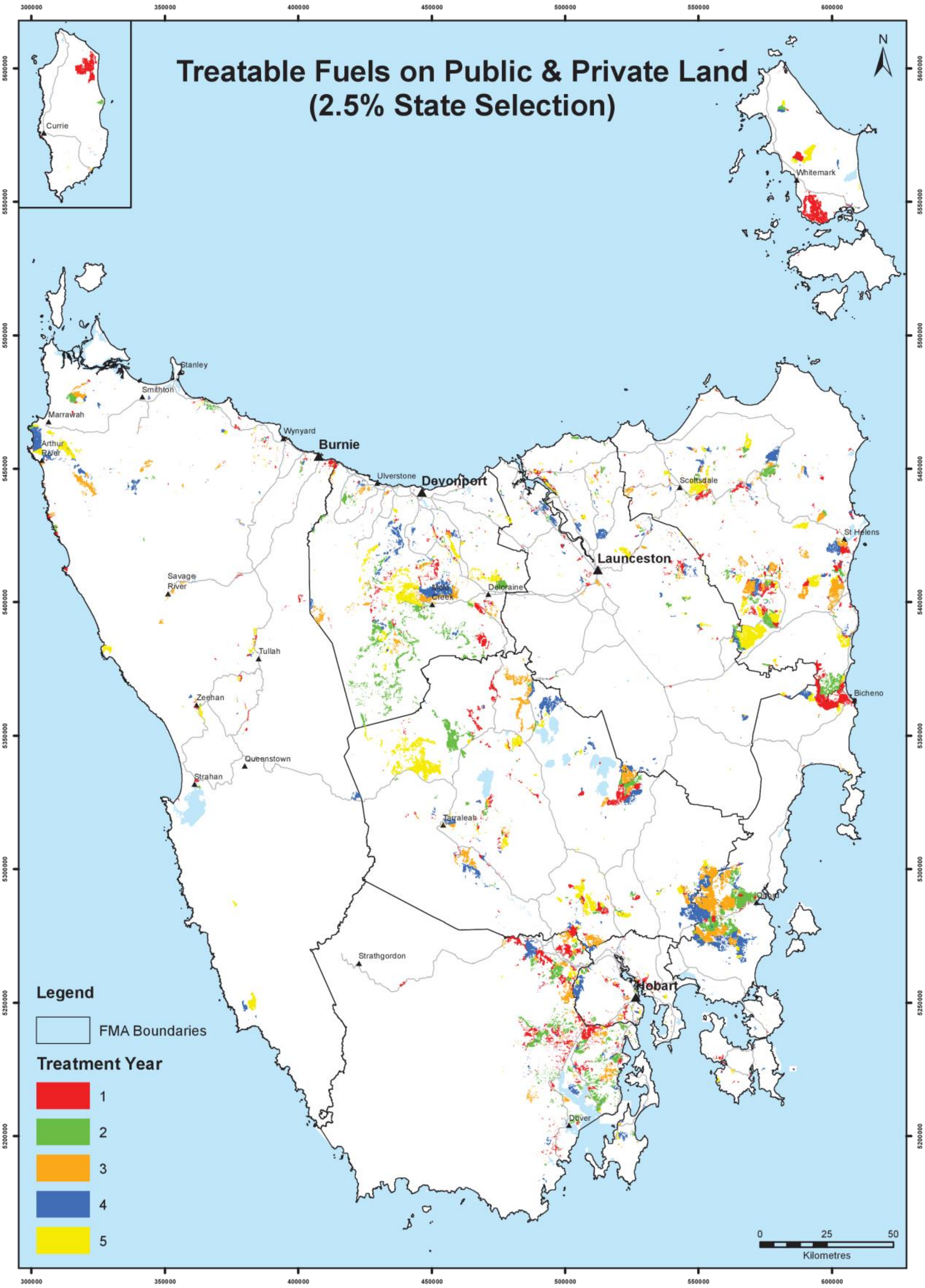

Figure 152: Five year hypothetical burning program for the Public and Private Land scenario, burning 2.5% of treatable fuels on public and private land each year. Selection of burn areas was based on treatment of bushfire risk at the Statewide scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

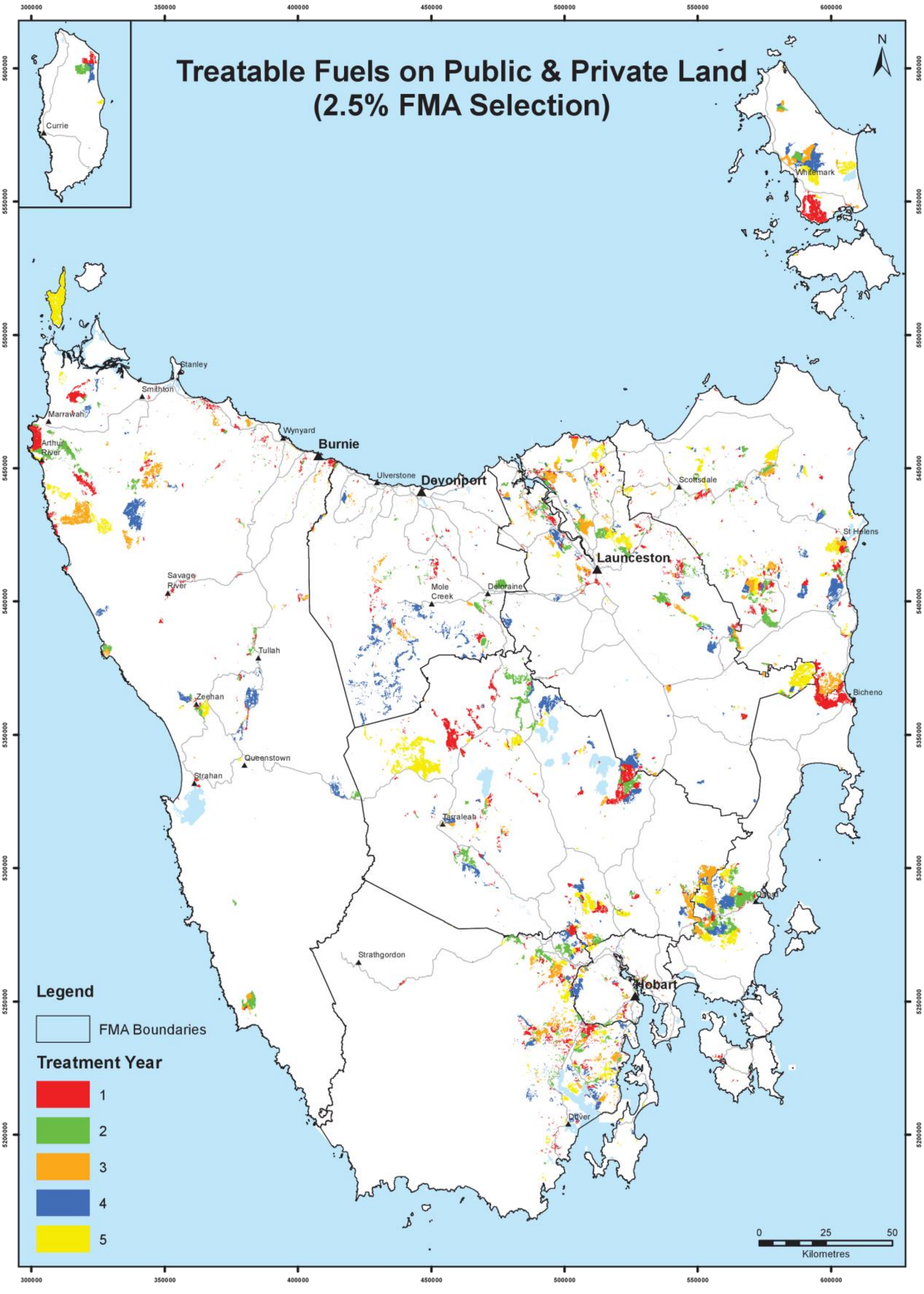

Figure 153: Five year hypothetical burning program for the Public and Private Land scenario, burning 2.5% of treatable fuels on public and private land each year. Selection of burn areas was based on treatment of bushfire risk at the Fire Management Area scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

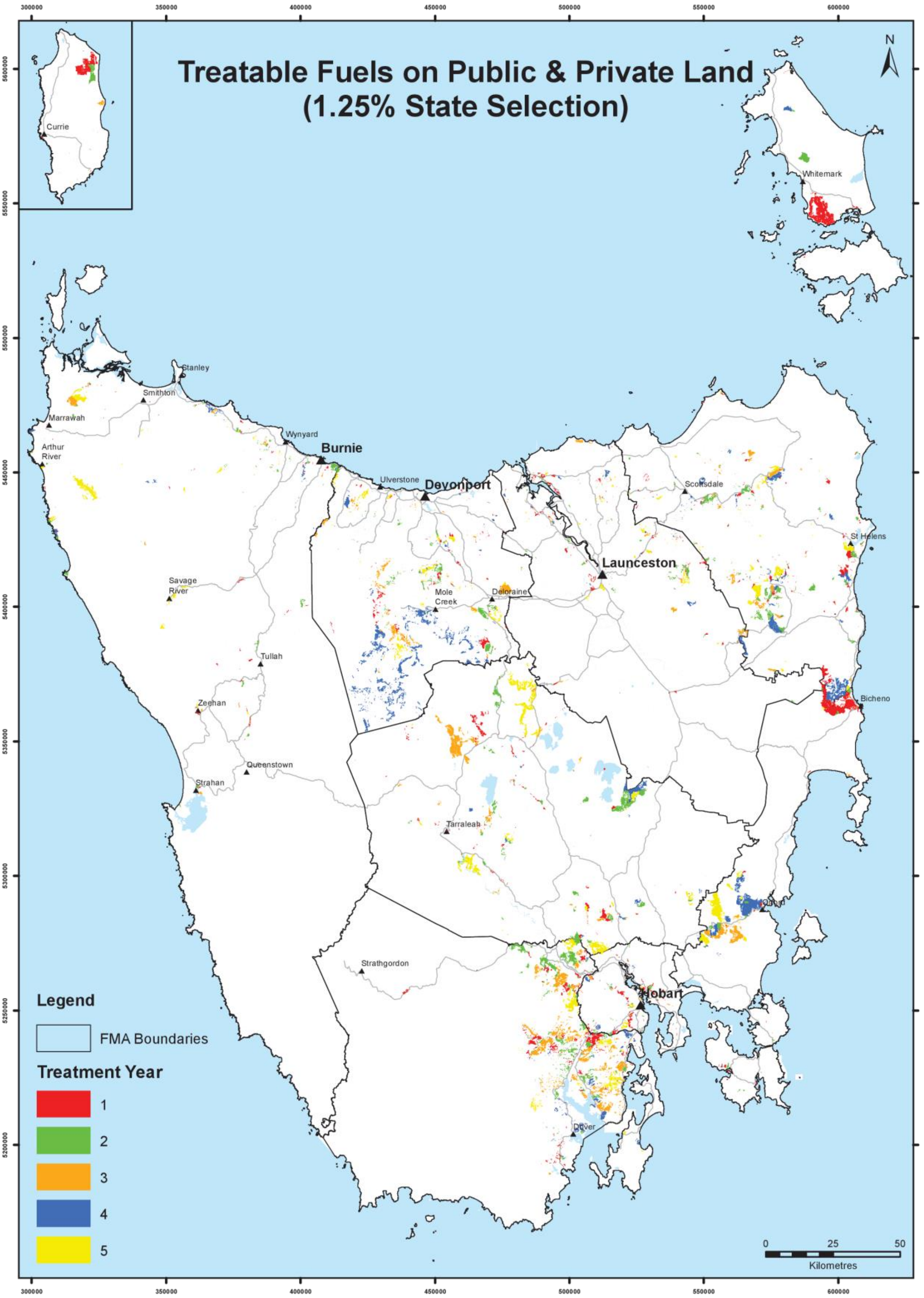

Figure 154: Five year hypothetical burning program for the Public and Private Land scenario, burning 1.25% of treatable fuels on public and private land each year. Selection of burn areas was based on treatment of bushfire risk at the Statewide scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

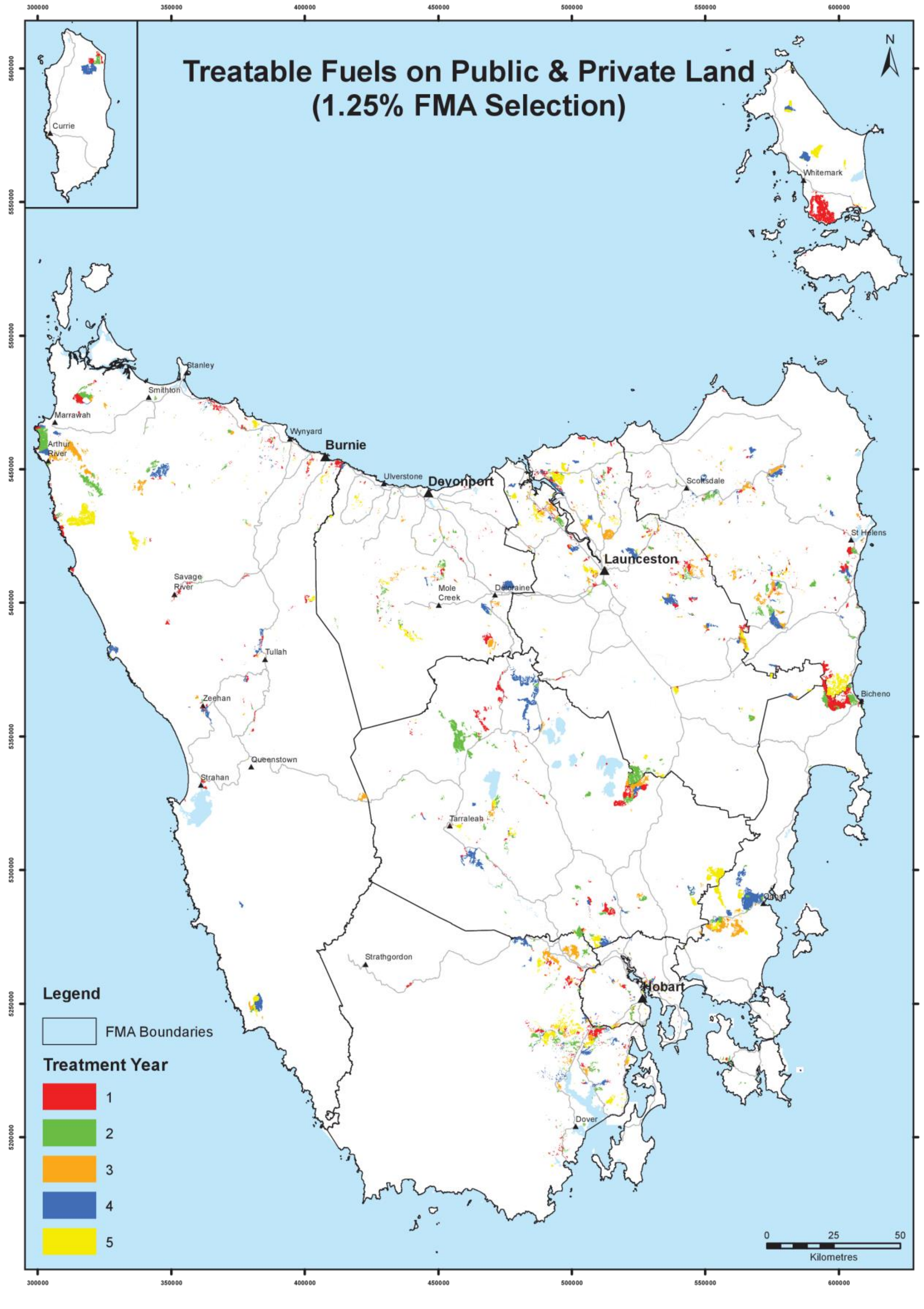

Figure 155: Five year hypothetical burning program for the Public and Private Land scenario, burning 1.25% of treatable fuels on public and private land each year. Selection of burn areas was based on treatment of bushfire risk at the Fire Management Area scale using the BRAM Bushfire Risk output.

ISBN: 978-0-9925970-0-9

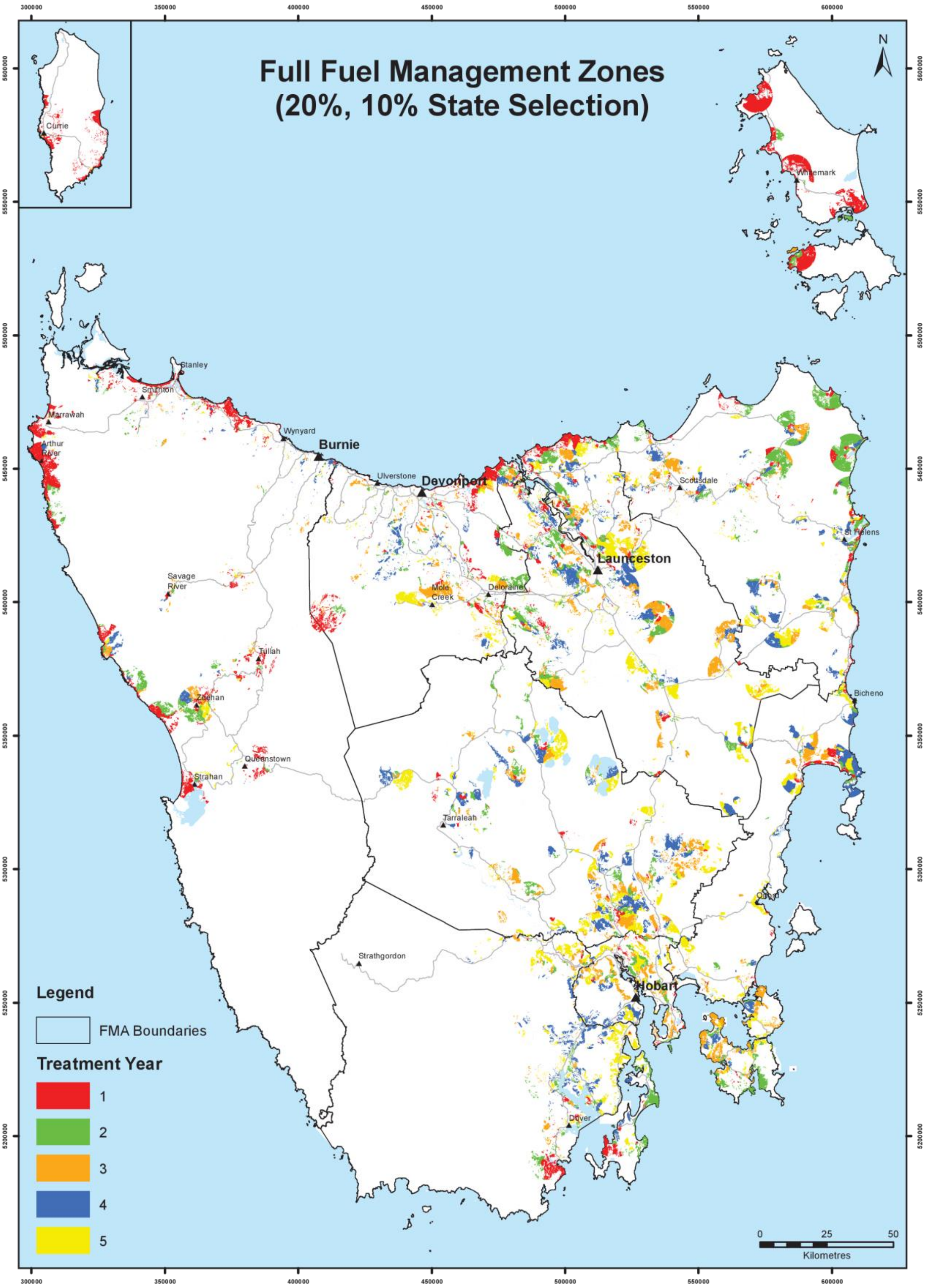

Figure 156: Five year hypothetical burning program for the Full Fire Management Zone scenario. Selection of burn areas was based on treatment of bushfire risk at the Statewide scale using BRAM HFI.

ISBN: 978-0-9925970-0-9

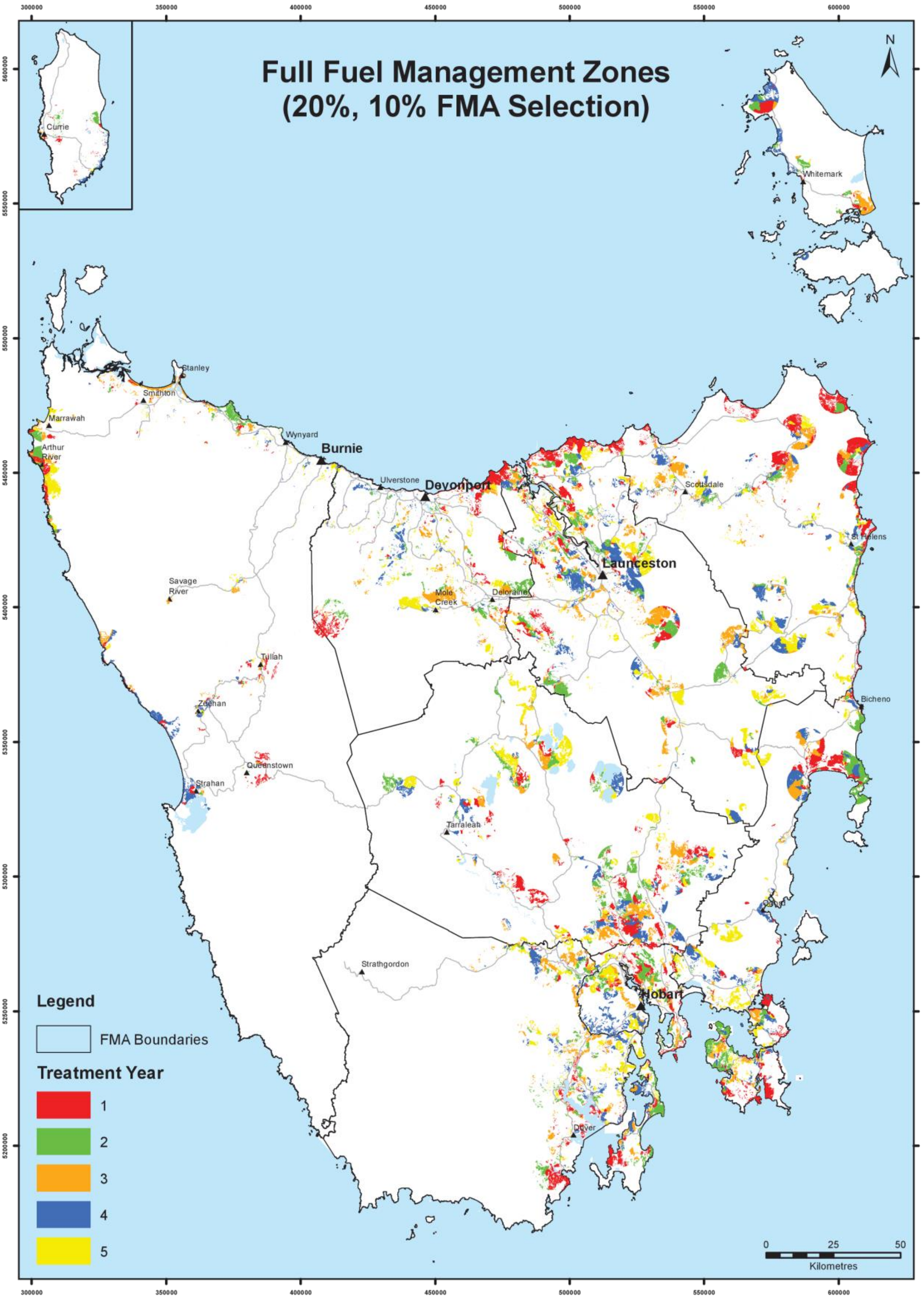

Figure 157: Five year hypothetical burning program for the Full Fire Management Zone scenario. Selection of burn areas was based on treatment of bushfire risk at the Fire Management Area scale using the BRAM HFI.

ISBN: 978-0-9925970-0-9

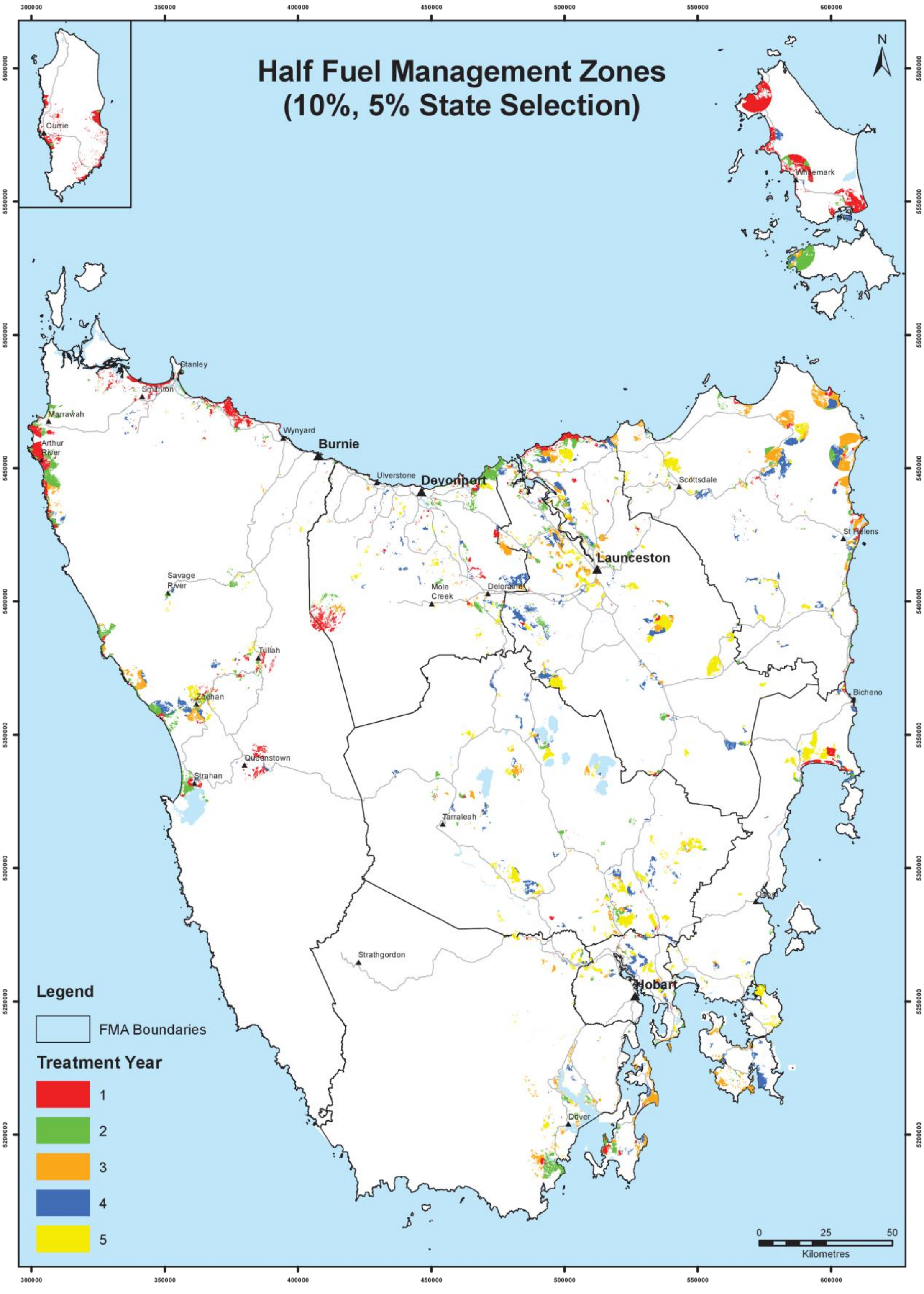

Figure 158: Five year hypothetical burning program for the Half Fire Management Zone scenario. Selection of burn areas was based on treatment of bushfire risk at the Statewide scale using BRAM HFI.

ISBN: 978-0-9925970-0-9

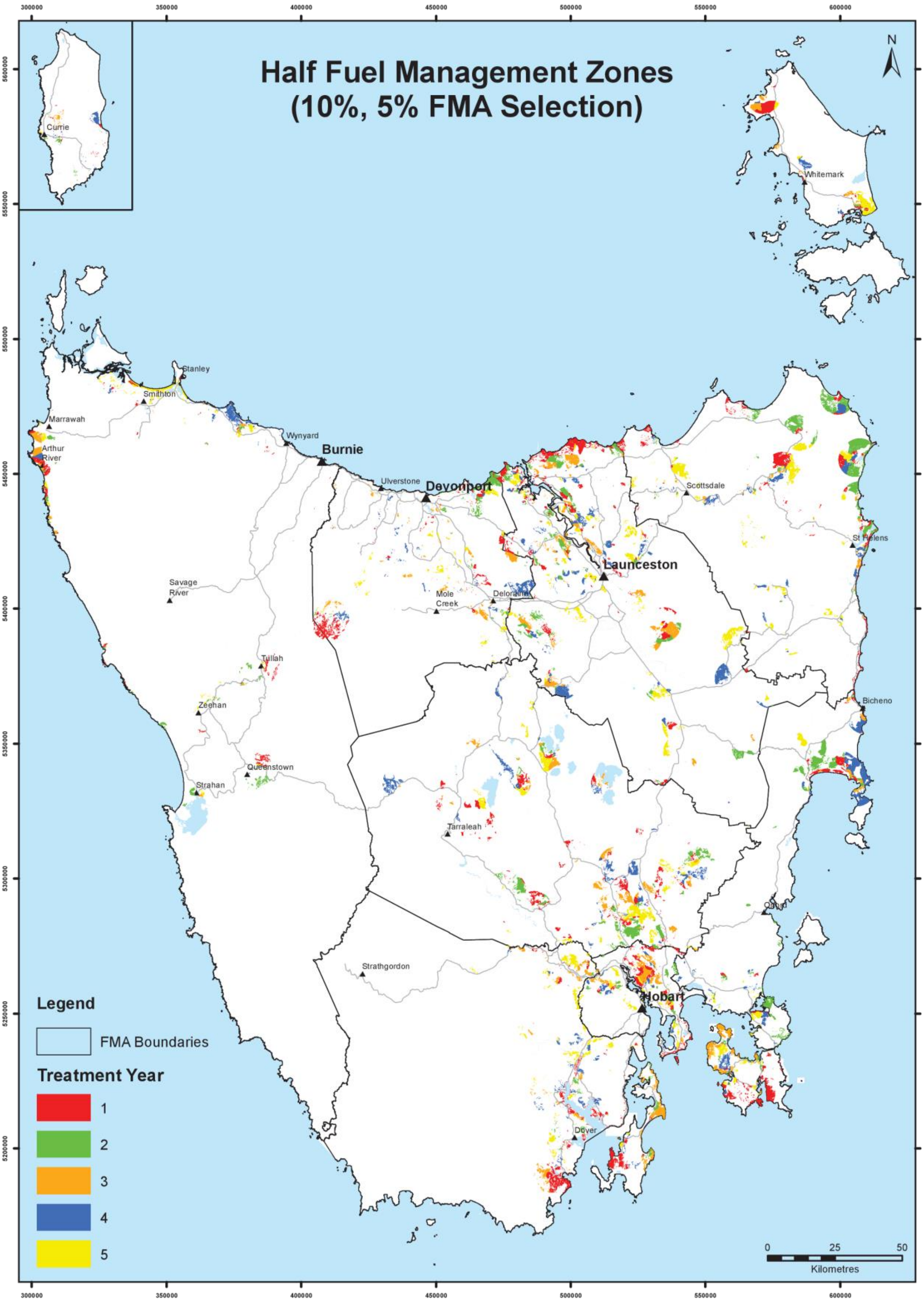

Figure 159: Five year hypothetical burning program for the Half Fire Management Zone scenario. Selection of burn areas was based on treatment of bushfire risk at the Fire Management Area scale using BRAM HFI.

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APPENDIX 6: THE PHOENIX RAPIDFIRE SYSTEM, TERMS OF USE, LIBRARIES AND SOURCES

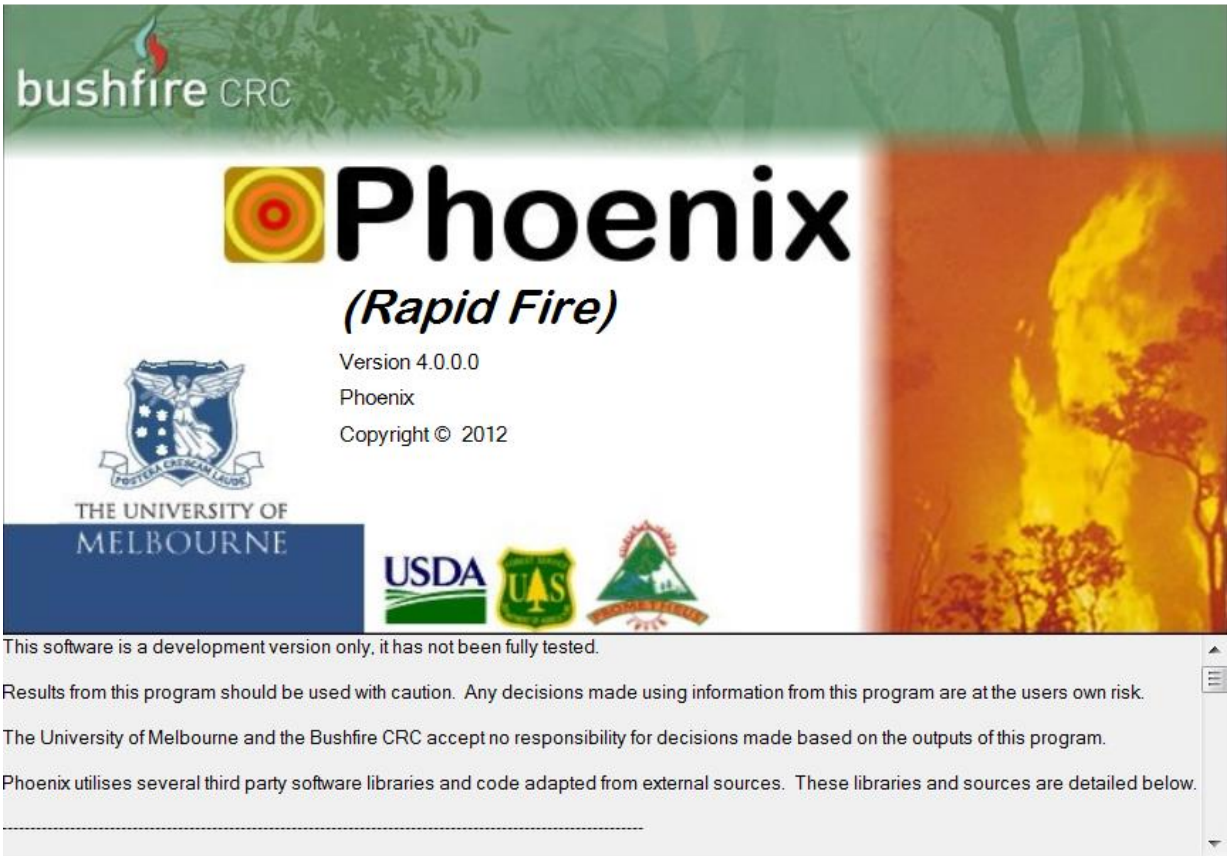

Figure 160. PHOENIX RapidFire: Opening page listing disclaimer and terms of use.

THE LIBRARIES AND SOURCES DETAILED IN PHOENIX V 4.0.0.0

SiroFire - N_GROW.PAS library (John Coleman -Version 1.167 June 1992)

Perimeter propogation mechanism within Phoenix is based on code within this library. Specifically, the method of determining positions of points on a new perimeter, which is described in detail on page 75-77 in this paper.

Knight I, Coleman J (1993) A Fire Perimeter Expansion Algorithm-Based on Huygens Wavelet Propagation. International Journal of Wildland Fire 3 , 73–84.

License and disclaimer pending....

ISBN: 978-0-9925970-0-9

Phoenix forest fine fuel mositure model has been adapted from Python script provided by Stuart Matthews - CSIRO which implements the model described in the paper below.

Matthews S, Gould J, McCaw L (2010) Simple models for predicting dead fuel moisture in eucalyptus forests. International Journal of Wildland Fire 19, 459–467.

License and disclamer pending....

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solrad.xls (version 1.0)

A solar position and radiation calculator for Microsoft Excel/VBA

Phoenix solar radiation functions have been derived from functions in this spreadsheet.

Greg Pelletier

Washington State Department of Ecology, Olympia, WA

The solar position calculations in this Excel/VBA application are a translation of NOAA's JavaScript solar position calculator. Documentation of the solar position calculations is available at NOAA's web page:

http://www.srrb.noaa.gov/highlights/sunrise/azel.html

ISBN: 978-0-9925970-0-9

Solar radiation calculations are based on the following publications:

Bird and Hulstrom's model from the publication "A Simplified Clear Sky model for Direct and Diffuse Insolation on Horizontal Surfaces" by R.E. Bird and R.L Hulstrom, SERI Technical Report SERI/TR-642-761, Feb 1991. Solar Energy Research Institute, Golden, CO.

Bras, R.L. 1990. Hydrology. Addison-Wesley, Reading, MA.

Ryan, P.J. and K.D. Stolzenbach. 1972. Engineering aspects of heat disposal from power generation, (D.R.F. Harleman, ed.). R.M. Parson Laboratory for Water Resources and Hydrodynamics, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA.

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NetCDF 3.6.1(http://www.unidata.ucar.edu/software/netcdf/)

VB.Net wrapper by (Wieczorrek, C.; J. Planar Chromatogr. 18 (2005) 181-187 (http://www.mn-net.com/tabid/10845/default.aspx)

Used to interrogate netCDF weather grids supplied from the Bureau Of Meterology

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ISBN: 978-0-9925970-0-9

Shapelib V1.2.10 (http://shapelib.maptools.org/)

Used to export simulation results (isochrones, grid cells), fires as points, and generate ignition grid

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DotNetZip Library 1.9.1.5 (http://dotnetzip.codeplex.com/)

Used to generate and read Phoenix data files, compress batch simulation results, compress google earth outputs from .kml to .kmz

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Proj.Net 1.2

http://projnet.codeplex.com/

Use to reproject coordinates into Lat/Lon for Google Earth and solar radiation calculation

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