Spatial distribution of wood heaters and open fires in Tasmania

2017

EPA Tasmania
Department of Primary Industries, Parks, Water and the Environment

Tasmanian Government

Contents

SPATIAL DISTRIBUTION OF WOOD HEATERS AND OPEN FIRES IN TASMANIA

AIM AND SCOPE

The main aim and expected outcome of the project was to produce two sets of spatial, gridded files (raster files), one containing wood heater counts per cell and the second containing open fire counts per cell, covering the main population centres of Tasmania.

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BACKGROUND

The production of two raster files of wood heater counts per 250-m^2 and open fire counts per 250-m^2 was part of a larger Tasmanian Wood Smoke Survey Project, established in 2011 to augment the existing EPA Tasmania wood smoke measurement and monitoring programme, BLANkET (Innis, 2015).

Tasmania's population exposure to known airborne pollutants is mainly from particulate matter as a result of wood burning (Innis, 2015). Elevated wood smoke-derived particulates are experienced in Tasmania, particularly during the autumn and winter seasons, with the main sources: planned burns, associated with either land management or hazard reduction; and the burning of wood for home heating, from either wood heaters or open fires (solid fuel heating) (Innis, 2015).

The Tasmanian Home Heating Survey Project (EPA Tasmania) surveyed domestic heating sources in major population centres in Tasmania. As part of the project, rasters were produced of estimated wood heater and open fire counts in the major population centres.

This report outlines the methods used to produce the two rasters; the wood heater count raster and the open fire count raster.

Monitoring, measurement and modelling of particulates from wood heater use is ongoing at EPA Tasmania, with a number of published technical reports available (Innis, 2015), as well a live data from stationary monitoring sites (http://epa.tas.gov.au/epa/air/monitoring-air-pollution/real-time-air-quality-data-for-tasmania).

METHODS

In order to produce the raster files of wood heater and open fire counts, reliable data were required regarding wood heater and open fire use in population centres, as well as population and housing density. The Tasmanian Home Heating Survey Project was established by EPA Tasmania in 2011 in response to the need for data on wood heater use, with the aim of developing and applying a survey methodology for the collection of home heating data, which would explicitly account for spatial variation in heating choices throughout each population centre. Data were also used from Census 2006 (ABS, 2006) to produce grids of population and housing density to identify population centres to target for the Tasmanian Home Heating Survey Project and to aid in the survey methodology. Processing of the three data sources; the survey data, the population density and the housing density data, resulted in the development of estimated wood heater and open fire rasters at a 250-m resolution. The rasters were combined to form a single raster which was made available on LISTMap (theList, 2017) in 2017.

SPATIALLY-ENABLED HOME HEATING SURVEY PROJECT

Motivation

The Environmental Protection Authority, Tasmania previously conducted atmospheric dispersion modelling to determine the fate of wood smoke emitted from wood heaters and open fireplaces in the Launceston, Hobart and Devonport regions. In each case, the model was provided with appropriate wood smoke emissions data, in a gridded form covering the region in question. The emissions data were derived using the number of occupied dwellings within each grid cell, thus taking into account the spatial variability in occupied dwellings, and an estimate of the proportion of households over the entire modelling domain that warm their homes via wood heating. This latter parameter was determined using data from home heating surveys.

Modelling results obtained using this methodology reflect a poor understanding of the spatial variation in wood heater usage, and show that the assumption of a fixed proportion of wood burning dwellings applied throughout a survey region is clearly inappropriate. Other wood smoke modelling studies, conducted by CSIRO Marine and Atmospheric Research, have reached similar conclusions. Meyer *et al.*, 2008, p ii state …

"Additional areas that could be usefully addressed include: …

Development of methods for determining the spatial distribution of wood heater use and emissions in major air sheds such as Launceston. This is required for accurate dispersion modelling and is currently a significant source of uncertainty."

There was therefore a clear need to obtain survey data on wood heater and open fire usage in Tasmania, in order to better inform future modelling.

Purpose

A survey, designed to obtain information about home heating practices in Tasmanian households, was conducted on behalf of the Environmental Protection Authority Tasmania during the winter months of 2011 in eleven

regions of Tasmania. The main purpose of the project was to find the spatial distribution of wood heaters in the populated urban and rural areas in order to gain a better understanding of health impacts of smoke from wood heaters on the community. Data related to the use of other means for home heating were also collected.

The survey covered over 70% of Tasmanian households in the most densely populated areas of Tasmania; including Hobart, Launceston, Burnie, Devonport and Ulverstone, as well as in some semi-rural areas in the south of Tasmania. The remaining, unsurveyed households were mostly located in sparsely populated or rural areas of Tasmania.

Methods

Survey area and locations

The Spatially-Enabled Home Heating Survey was conducted during the winter months in 2011 to determine the main type of heating respondents used to heat their homes.

It was decided that spatially-enabled home heating surveys would be commissioned for the top ten population centres throughout the state, and also for some smaller regions where there were concerns about smoke concentrations. The resulting eleven survey regions were selected throughout the State, on the basis of the population density and housing density data from the 2006 census (ABS, 2006) (Figure 1):

- Wynyard;
- Burnie/Somerset;
- Ulverstone;
- Devonport/Latrobe;
- Tamar Valley (including the Northern Tamar and Launceston sub-regions);
- New Norfolk;
- Hobart;
- Sorell/Midway Point;
- Kingston/Blackmans Bay;

- Huonville/Ranelagh; and
- Geeveston/Port Huon.

Each survey region was divided into individual strata, with separate results being available for different suburbs or groups of suburbs. This allowed the spatial variation in proportion of wood-burning dwellings to be determined. The location and extent of these strata were based on population and housing density data from the 2006 census (ABS, 2006), as well as Australian Bureau of Statistics boundaries.

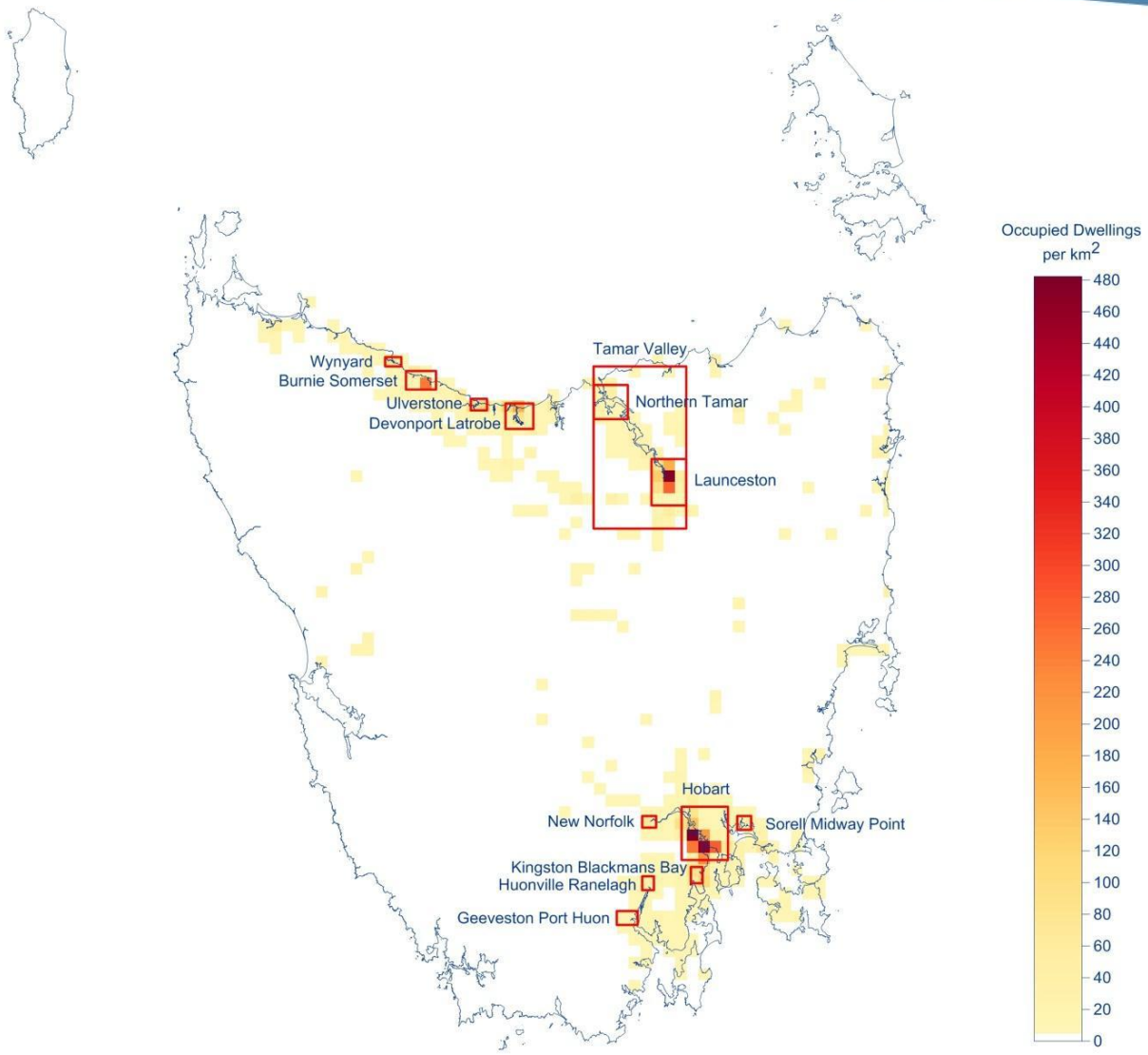

FIGURE 1. AREAS SURVEYED FOR HOME HEATING USE WITHIN RED BOUNDING BOXES. THE COLOURED AREAS INDICATE THE HOUSING DENSITY FROM DATA EXTRACTED FROM THE 2006 CENSUS (ABS, 2006).

Census 2006 housing density

The number of occupied dwellings throughout Tasmania was extracted from the 2006 census mesh-block boundary data (ABS, 2006). This was the most recently available source of housing data. These data were mapped as polygons at the mesh-block level, which is the finest level of data aggregation released by the Australian Bureau of Statistics.

The area of each mesh-block was calculated using the Map Info™ GIS software package, allowing housing density (the number of occupied dwellings per km^2) to be obtained for each mesh-block. Housing density was converted from vector to raster form, by gridding the data onto a 50-m grid covering the

entire state. Adjacent grid cells were subsequently aggregated, using the mean housing density of each block of cells, to form a 250-m housing density raster for Tasmania.

Census 2006 estimate of number of occupied dwellings

The 250-m housing density raster (occupied dwellings/km^2) for each survey region was divided by 16, in order to calculate the number of occupied dwellings within each 250 m by 250 m grid cell. The process of converting housing density from vector form into 50-m raster form, and then aggregating the raster into a 250-m grid, introduced a systematic error in the number of occupied dwellings per grid cell. Where there was a difference in dwelling numbers between census data and gridded data, a correction factor was applied to the occupied dwellings per grid cell raster, to bring the total number of dwellings back to that measured in the census.

Survey Methodology

Request for tender documents were submitted to one Tasmanian and three mainland survey companies, with the tender for all survey regions eventually being awarded to National Field Services (NFS). Interview data were collected using the Computer Aided Telephone Interviewing (CATI) technique. A stratified random sampling approach was used, with each survey region being split into individual 'strata'. These were generally, but not always, based on Australian Bureau of Statistics (ABS) state suburb boundaries. Each stratum was treated as an independent population, and was comprised of adjacent 2006 census mesh-blocks. The number of occupied dwellings from the 2006 census was determined for each stratum area, along with the sample size required to reflect the target population at the 95% confidence level with a 10% confidence interval. Stratum areas were classified and numbered as either residential or agricultural/ rural, according to their mesh block categories.

The Sample Pages directory (www.SamplePages.com.au) was used to draw randomly selected phone numbers from within each stratum area. All phone numbers within the Sample Pages database are accurately geo-referenced, thus allowing samples to be selected from within assigned ABS mesh-blocks.

Households were interviewed during the winter months in 2011 using the CATI technique. This period was specifically chosen to coincide with the home-heating season, when responses would be the most accurate. Interviews were conducted between 16:30 and 20:30 during weeknights, 09:30 and 17:00 on Saturdays, and 10:00 and 17:00 on Sundays. In terms of the home heating survey project, the most important question for the production of the raster files was Question 3:

3. What is the main type of heating you use to heat your home?

- 1. Wood heater
- 2. Open fire
- 3. Gas heater using bottled gas
- 4. Gas heater using mains gas
- 5. Diesel/Oil heater
- 6. Heat pump
- 7. Other electrical heater
- 8. Other (specify)

Responses to this question were used to determine the proportion of wood burning dwellings (wood heaters or open fires) within each stratum area.

Other questions were asked in the survey relating to; what type of heating is used, number and type of heaters, methods of storing firewood, main method of heating the home and other questions relating to housing type (Appendix 1).

ESTIMATED WOOD HEATER AND OPEN FIRE RASTER

Methods

The number of wood heaters within each 250-m grid cell was estimated by multiplying the number of occupied dwellings obtained from the 2006 census

data by the proportion of wood heaters or open fires for each cell obtained from the Spatially-Enabled Home Heating Survey Project results. Small correction factors were applied to ensure that the total number of wood heaters and open fires matched those estimated by the Spatially-Enabled Home Heating Survey Project, prior to the conversion from vector to raster form.

MAIN FINDINGS

Estimated use of wood heaters in Tasmania as a main source of energy for heating is ca. 31% (Table 1). However, the percentage of households using wood heaters varies significantly with the regions from about 16% in Hobart to 51% in Huonville and 59% in Geeveston. Based on the information collected during the survey, the estimated number of wood heaters in Tasmania in 2011 is ca. 60,000 (Table 1, 41,000 wood heaters used, 70% of households covered in survey).

As expected, the distribution of wood heaters is not directly reflected in the distribution of households for the region with consistently larger proportion of households using wood heaters as a main source of heating in rural-classed areas (ca. 63%) than residential-classed areas (ca. 27%) (Table 1).

Open fire use and as a main source of heating was low throughout the regions, with between 0 and 1.7% of respondents in each region using an open fire as a main source of heating their home (Table 1).

Table 1. Summary statistics for each region using both the home home heating survey results and the housing density raster data for wood heaters and open fires. Region defined in sampling method (*region*), number of 250-m^2 grid cells in each region, number of occupied dwellings (*occupied dwellings*), number of households sampled (*sample*), percentage of households using a wood heater as a main source of heating (*woodheater main source*), percentage of households in rural areas using a wood heater as the main source of heating (*rural*), percentage of households in residential areas using a wood heater as the main source of heating (*residential*), total number of wood heaters in the region (derived), percentage of households using an open fire as a main source of heating (*open fire main source*),), total number of open fires in the region (derived) (Source: NFS, 2011)

region	*number of 250-m^2 grid cells*	*occupied dwellings (count)*	*sample (count)*	*wood heater main source (%)*	*rural (%)*	*residential (%)*	*wood heaters total*	*open fire main source (%)*	*open fires total*
Wynyard	448	1900	150	27	45	25	504	0	0
Burnie, Somerset	1664	6001	1235	19	54	16	1131	0.4	21
Ulverstone	560	3327	190	25	n/a	25	826	0	0
Devonport Latrobe	2112	8930	740	24	63	21	2136	0.7	66
Tamar Valley	44800	29695	3517	26	77	23	7594	0.8	242
New Norfolk	480	1696	160	40	65	36	1387	1.7	53
Hobart	7360	39226	3691	16	52	16	6593	0.6	298
Sorell, Midway Point	576	1481	255	31	70	23	686	1.2	29
Kingston, Blackmans Bay	560	5577	351	21	n/a	21	6345	0.7	233
Huonville, Ranelagh	480	986	170	51	75	35	455	1.0	17
Geeveston, Port Huon	864	663	85	59	n/a	59	1181	0	40

The spatial distribution of wood heaters within each region was found to be clustered (Appendix 2: Figures 1:21). In particular, the different between rural and residential area in terms of percent wood heater (Table 1) use was found to give rise to spatial clustering. In the population centres surveyed, there is a derived total of 41,000 woodheaters in use, compared with 1,400 open fires.

RASTER GRID AVAILABLE ON LISTMAP

In 2017, 13 raster grids (Wynyard; Burnie/Somerset; Ulverstone; Devonport/Latrobe; Northern Tamar; Launceston; New Norfolk; Hobart; Sorell/Midway Point; Kingston/Blackmans Bay; Huonville/Ranelagh; and Geeveston/Port Huon) of estimated counts of wood heaters per 250 m^2 were merged to provide one raster grid covering Tasmania using QGIS 2.18.13. The areas of Tasmania that were not sampled for wood heater counts per 250 m^2 in the 2011 survey were assigned a 'no data' value for that cell. The raster was made available on LISTMap (TheList, 2017) in 2017.

APPENDICES

Appendix 1: Home Heating Questionnaire

1. Phone Number	2. Address (Street & Number)	3. Date	
4. Postcode	5. Stratum area code	6. SSC_Code_2006	7. Mesh Block Number

Good afternoon/evening,

This is ..... from the market research firm..... Today we are conducting a study regarding home heating practices in your region on behalf of the EPA Division. Could I please speak to an adult living in the household?

REPEAT IF NECESSARY TO RELEVANT PERSON

The survey will take about 3 minutes and all answers are confidential. The information collected by the survey is very important for addressing air quality issues in your region and will benefit the residents of the area. Would you be willing to help?

ARRANGE A CALL BACK IF NECESSARY OTHERWISE PROCEED

1. What types of heating do you use to heat your home? MULTIPLE RESPONSES POSSIBLE PROBE WITH "ANY OTHER TYPES OF HEATING?"	Wood heater Open fire Gas heater using bottled gas Gas heater using mains gas Diesel/Oil heater Heat pump Other electrical heater Other (specify)
2. How many heaters of each type do you use? MULTIPLE RESPONSES POSSIBLE (OBTAIN NUMBER FOR EACH HEATER TYPE)	Wood heater Open fire Gas heater using bottled gas Gas heater using mains gas Diesel/Oil heater Heat pump Other electrical heater Other (specify)
3. What is the main type of heating you use to heat your home?	Wood heater Open fire Gas heater using bottled gas Gas heater using mains gas

	Diesel/Oil heater Heat pump Other electrical heater Other (specify)
4. Your main cooking stove uses …	Wood Gas Electricity Other
If the home heating and cooking options mentioned in Questions 1 and 4 DO NOT include those that emit air pollution then go to QUESTIONS about the HOUSEHOLD. ie. If Options 1 to 5 ('wood heater'; 'open fire'; 'gas heater' (any type); 'diesel/oil heater') are NOT mentioned in Question 1, AND Options 1 or 2 ('wood'; 'gas') are not mentioned in Question 4 THEN go to QUESTIONS about the HOUSEHOLD.	
5. If you use gas heating in your household, is the heater … MULTIPLE RESPONSES POSSIBLE	Flued Unflued Not sure
6. If you use firewood, **has it been split and dried for several months or more?**	Never Sometimes Always Not sure
7. If you use firewood, do you ever store firewood uncovered in the open?	Always Sometimes Never
QUESTIONS about the HOUSEHOLD Could you please answer two questions about the place you live in now?	
8. Do you live in a …	Separate house Flat, unit, apartment Semi-detached row or terrace/town house 4. Other
9. Is the place you are living in …	Rented (public) Rented (other) Owned by you Other

ASK ALL RESPONDENTS

10. Finally, if I could please have your first name for audit purposes?	
Thank you for helping. Just to remind you that my name is ..... from the research firm ..... conducting this survey for the EPA Division. If you have any questions about the survey my supervisor can be reached on xxxxxxxxxx.	
.....INTERVIEWER.....DATE	
.....TIME COMPLETED.....TIME TAKEN (MINUTES)	

Appendix 2: Estimated spatial distribution of wood heaters and open fires rasters

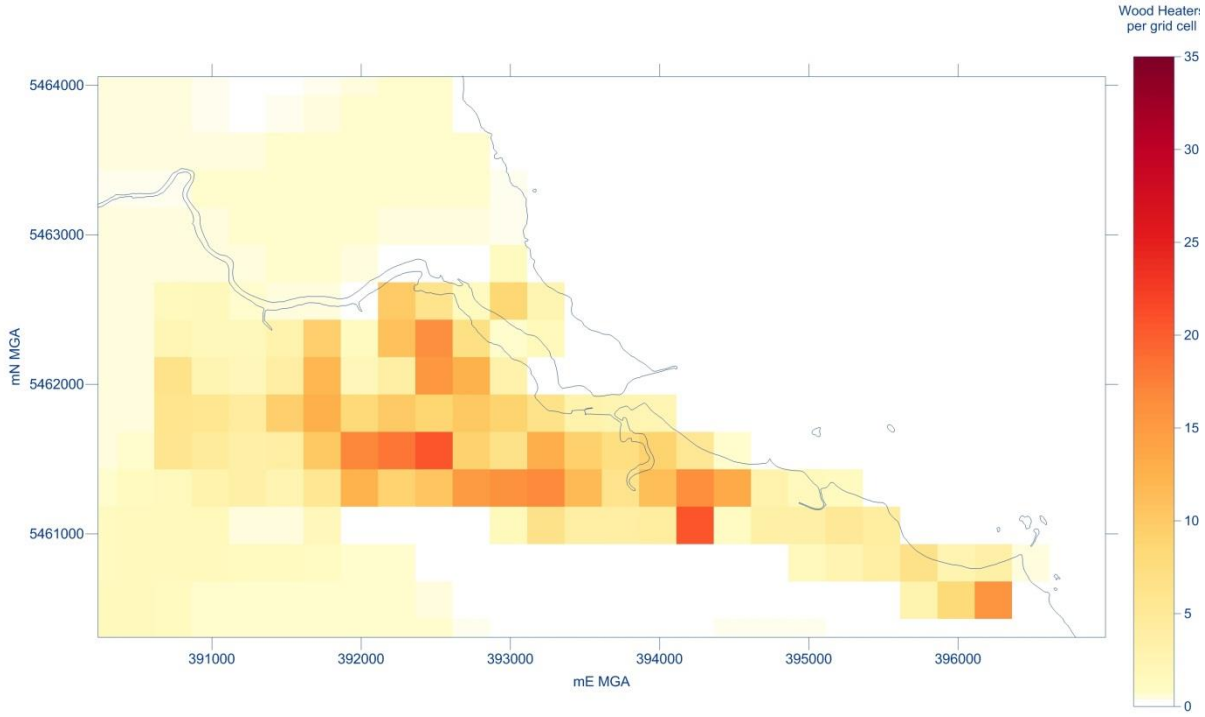

FIGURE 1. THE ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE WYNYARD SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 20.7 WOOD HEATERS PER 250 M GRID CELL. THERE ARE 710 WOOD HEATERS WITHIN THE DISPLAYED REGION.

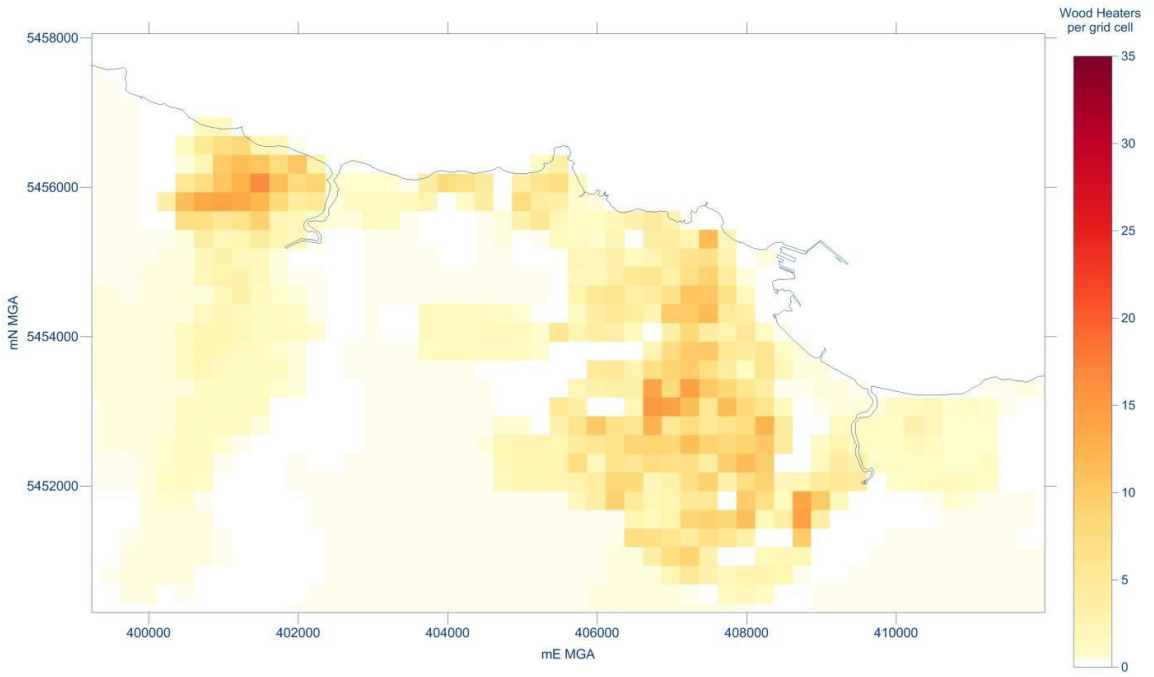

FIGURE 2. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE BURNIE/SOMERSET SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 16.5 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 1,750 WOOD HEATERS WITHIN THE DISPLAYED REGION.

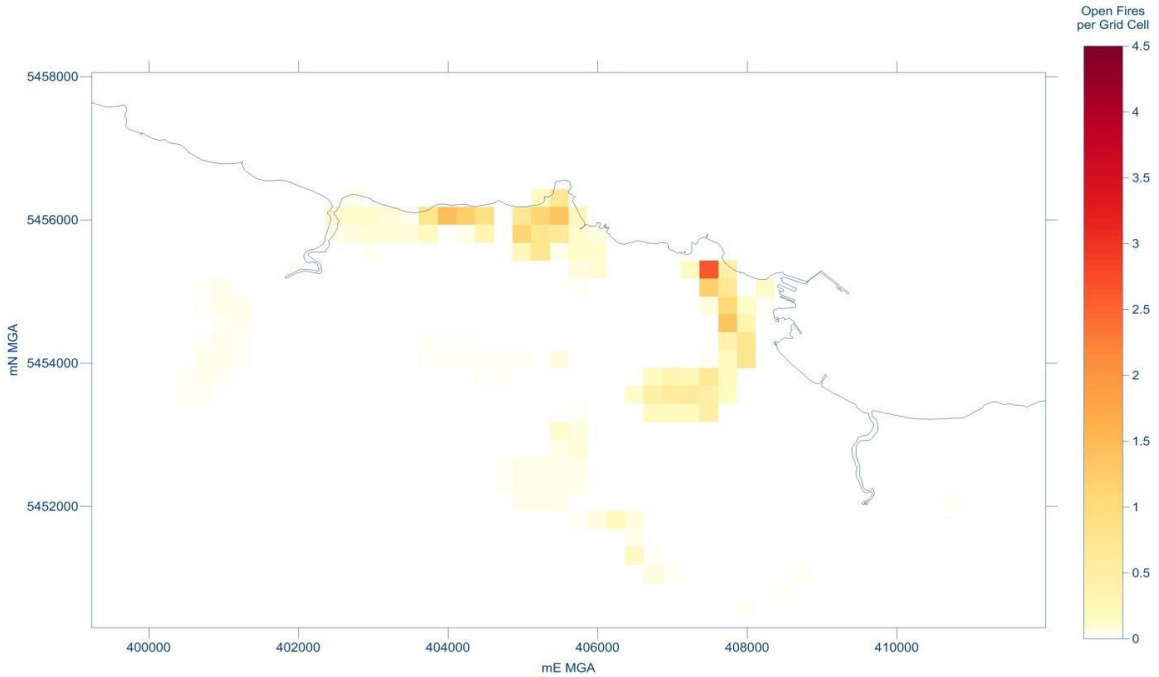

FIGURE 3. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE BURNIE/SOMERSET SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 2.6 OPEN FIRES PER 250-M GRID CELL, WHICH OCCURS IN BATTERY POINT. THERE ARE 35 OPEN FIRES WITHIN THE DISPLAYED REGION.

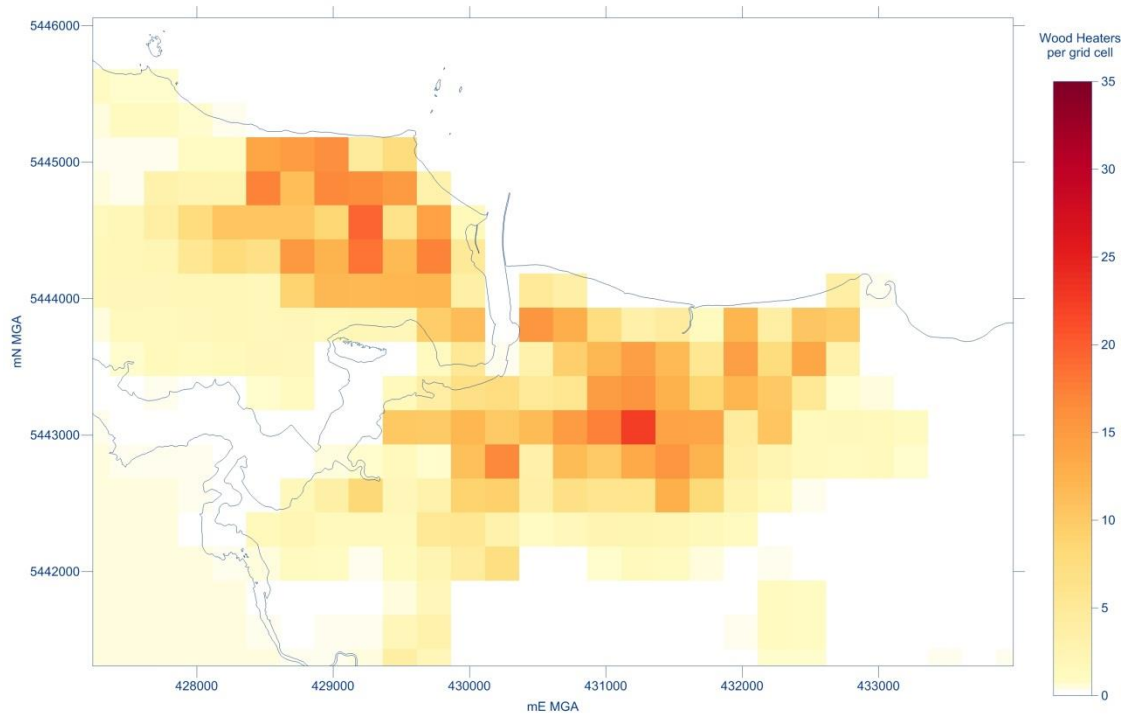

FIGURE 4. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE ULVERSTONE SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 22.6 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 1,190 WOOD HEATERS WITHIN THE DISPLAYED REGION.

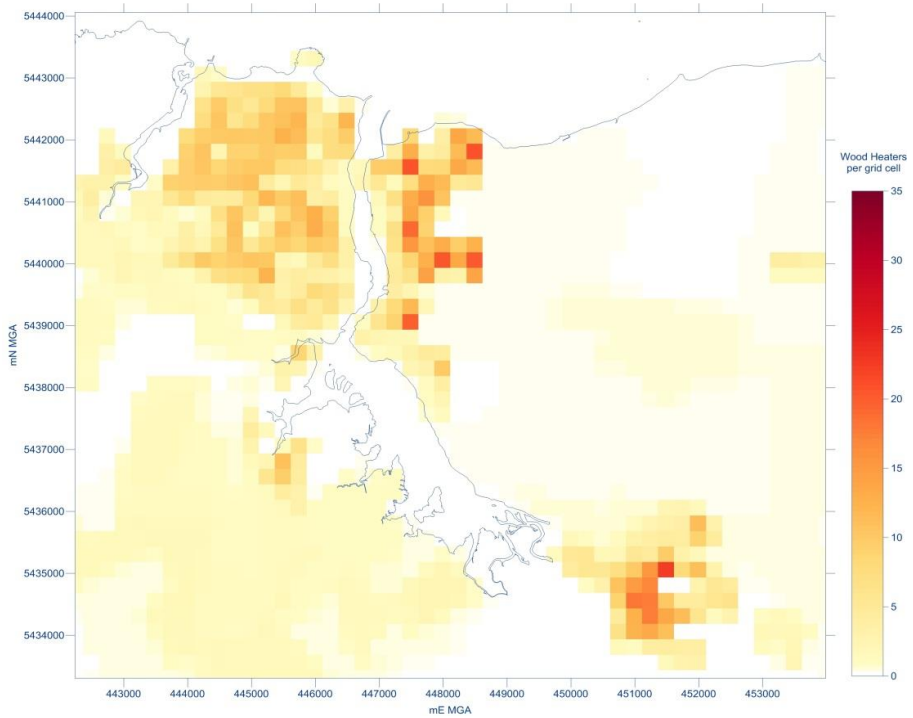

FIGURE 5. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE DEVONPORT LATROBE SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 22.6 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 2,910 WOOD HEATERS WITHIN THE DISPLAYED REGION.

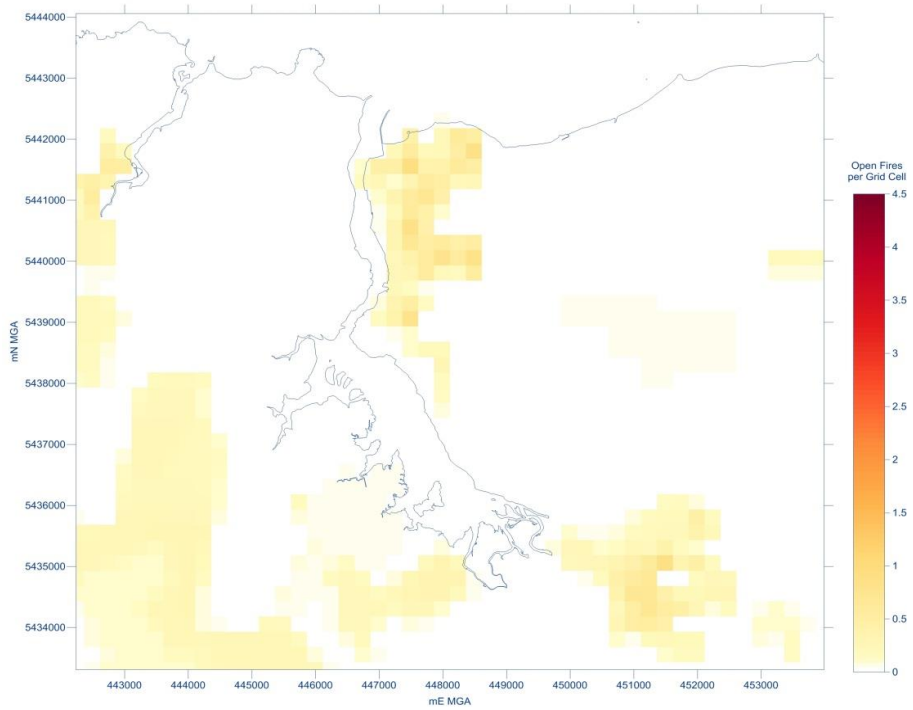

FIGURE 6. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE DEVONPORT LATROBE SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 0.9 OPEN FIRES PER 250-M GRID CELL, WHICH OCCURS IN EAST DEVONPORT. THERE ARE 90 OPEN FIRES WITHIN THE DISPLAYED REGION.

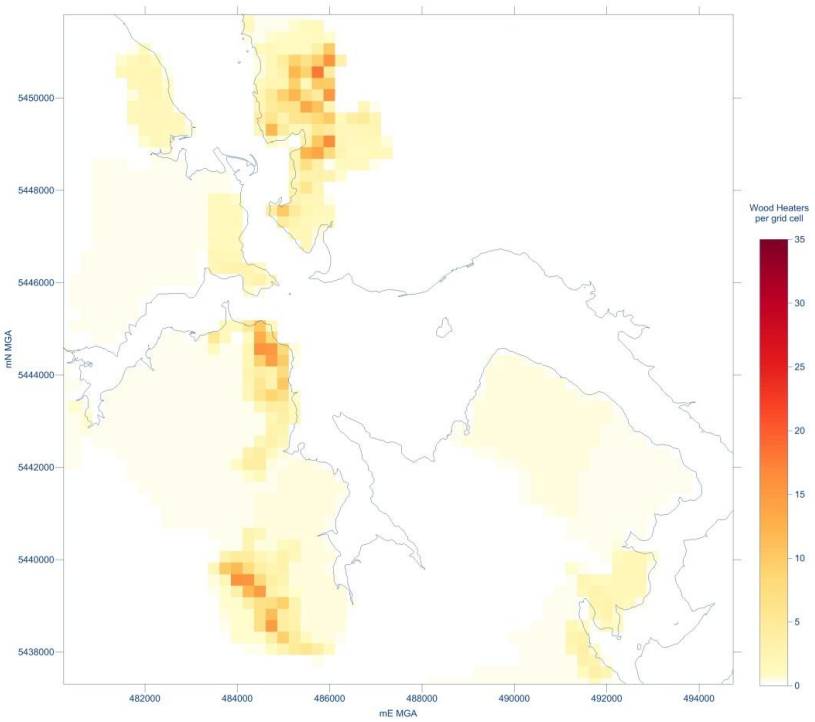

FIGURE 7. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE NORTHERN TAMAR SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 18 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 1,390 WOOD HEATERS WITHIN THE DISPLAYED REGION.

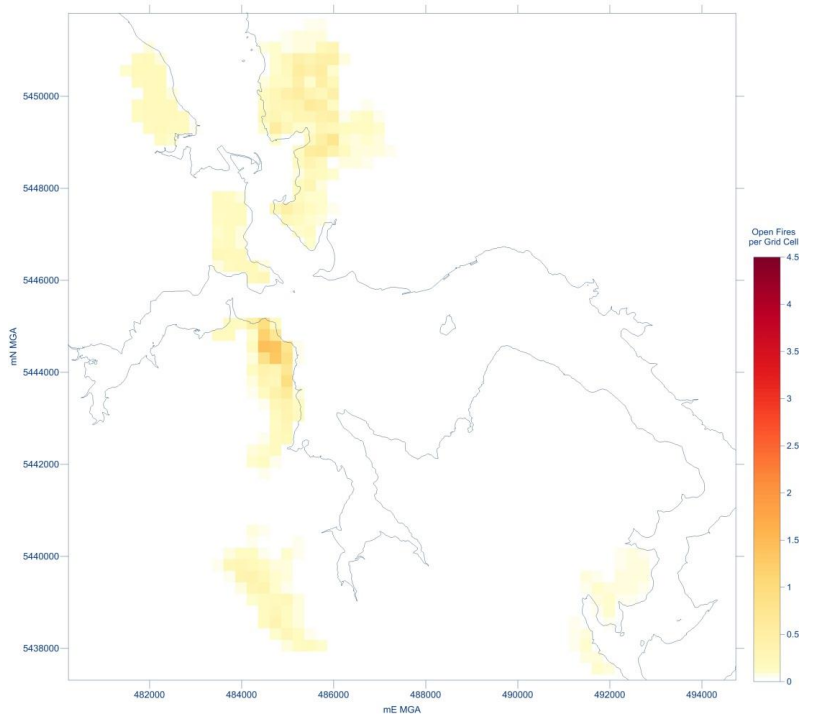

FIGURE 8. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE NORTHERN TAMAR SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 1.4 OPEN FIRES PER 250-M GRID CELL, WHICH OCCURS IN BEAUTY POINT. THERE ARE 55 OPEN FIRES WITHIN THE DISPLAYED REGION.

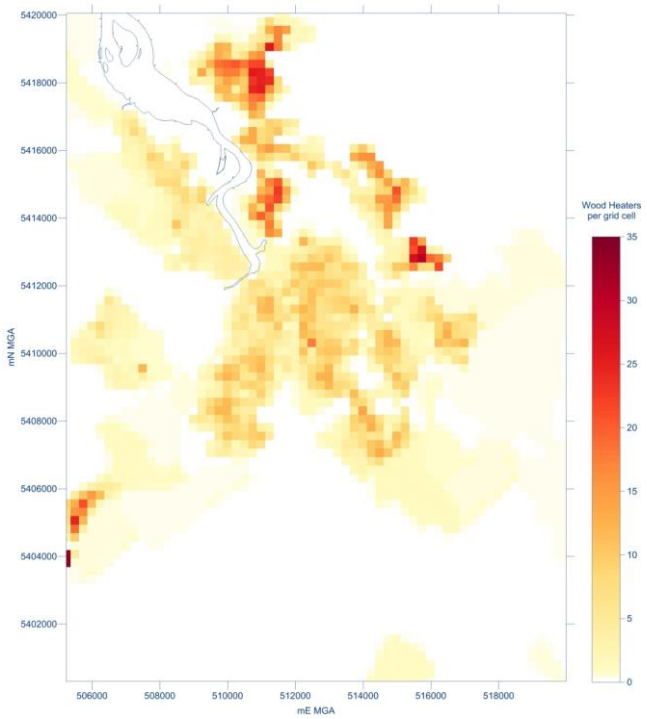

FIGURE 9. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE LAUNCESTON SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 33.1 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 6,590 WOOD HEATERS WITHIN THE DISPLAYED REGION.

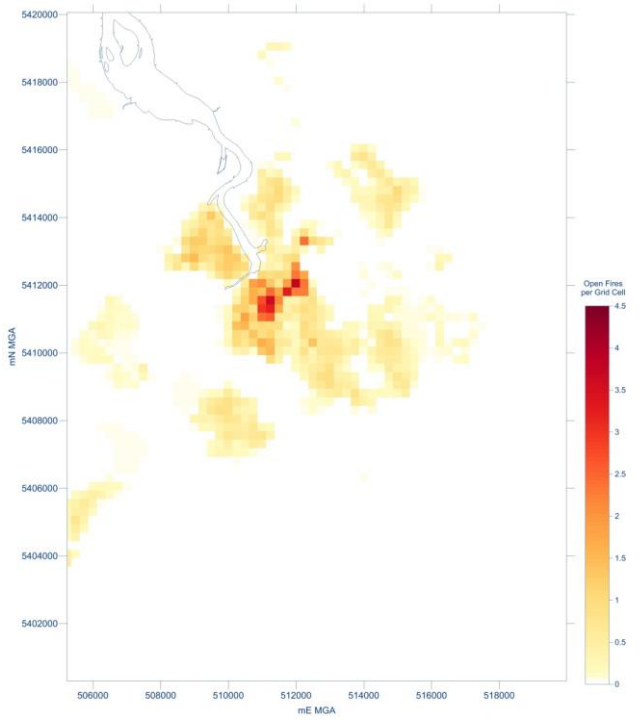

FIGURE 10. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE LAUNCESTON SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 3.8 OPEN FIRES PER 250-M GRID CELL. THERE ARE 300 OPEN FIRES WITHIN THE DISPLAYED REGION.

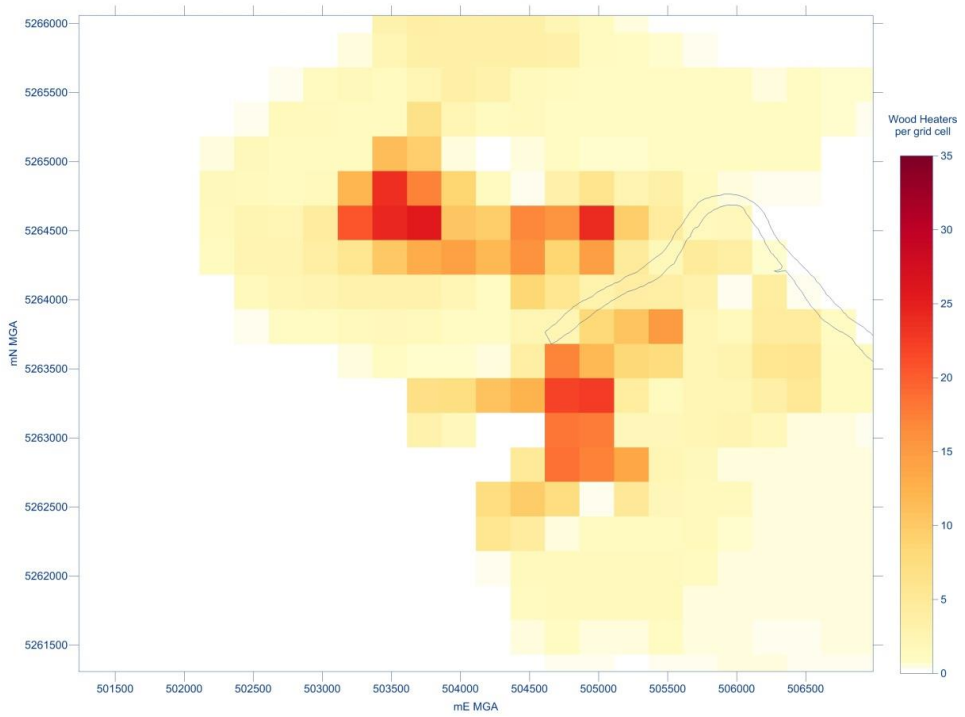

FIGURE 11. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE NEW NORFOLK SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 25.8 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 950 WOOD HEATERS WITHIN THE DISPLAYED REGION.

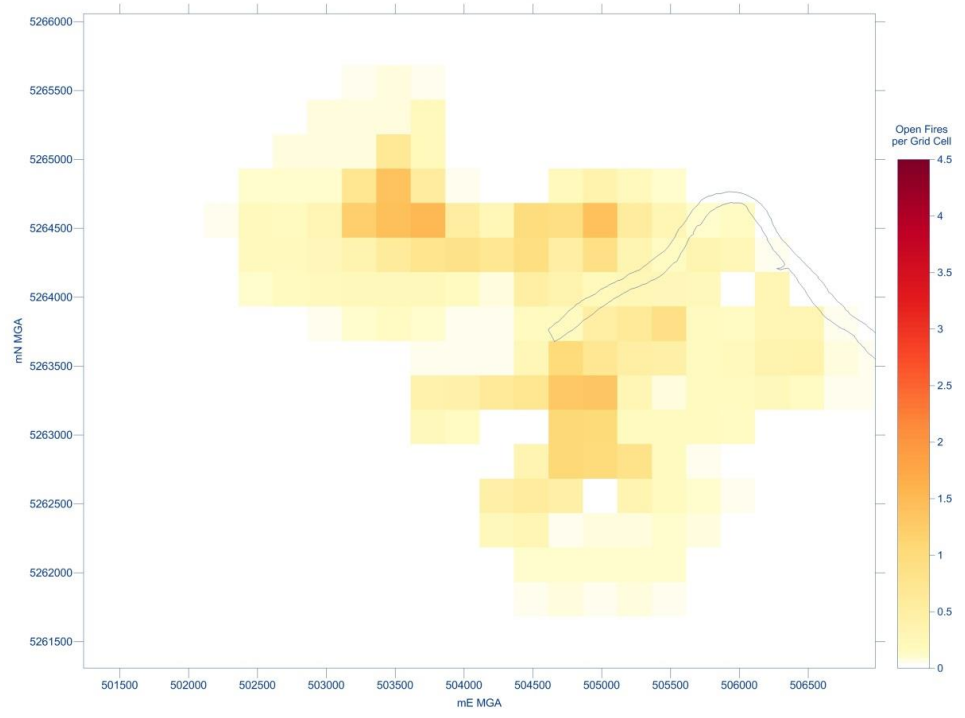

FIGURE 12. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE NEW NORFOLK SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 1.5 OPEN FIRES PER 250 M GRID CELL. THERE ARE 45 OPEN FIRES WITHIN THE DISPLAYED REGION.

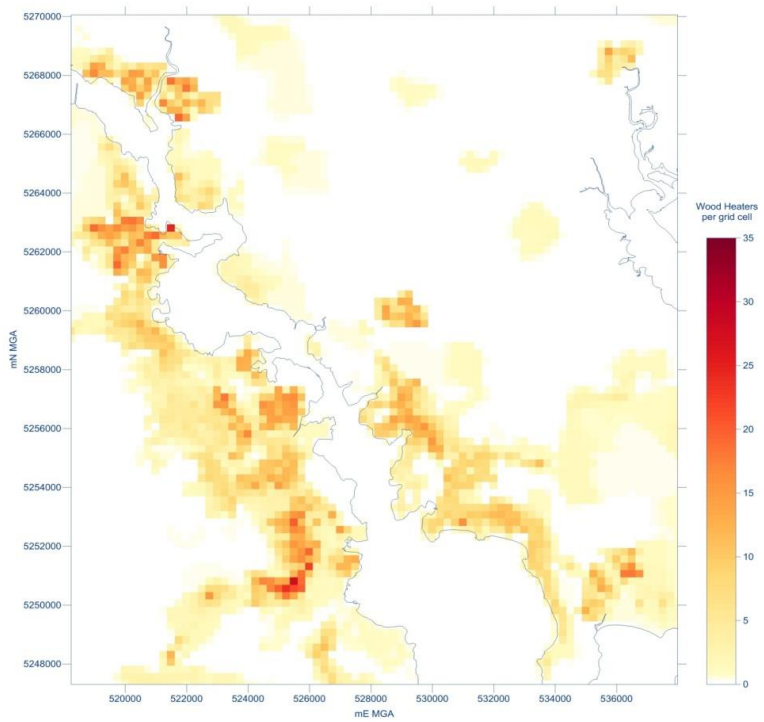

FIGURE 13. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE HOBART SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 27.8 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 9,210 WOOD HEATERS WITHIN THE DISPLAYED REGION.

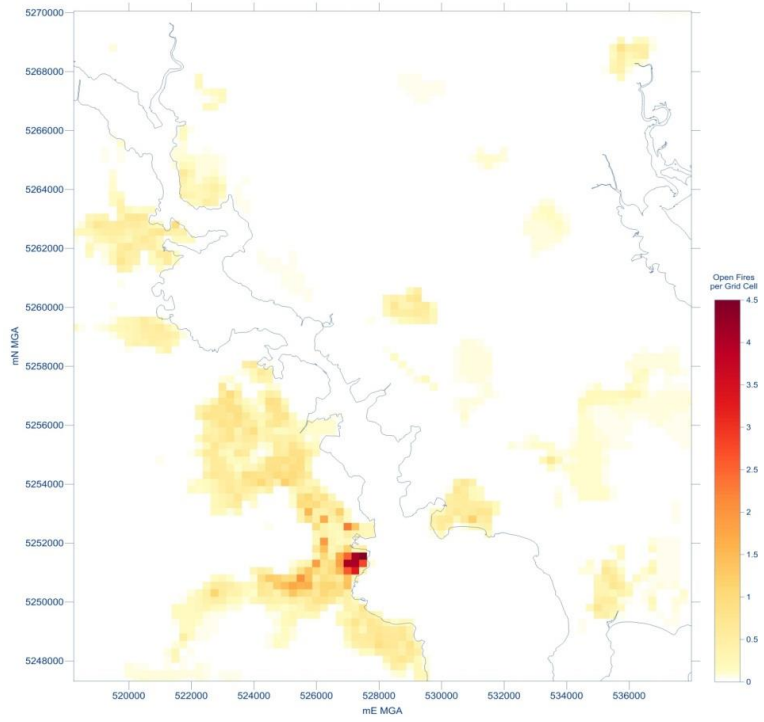

FIGURE 14. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE HOBART SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 4.5 OPEN FIRES PER 250-M GRID CELL, WHICH OCCURS IN BATTERY POINT. THERE ARE 385 OPEN FIRES WITHIN THE DISPLAYED REGION.

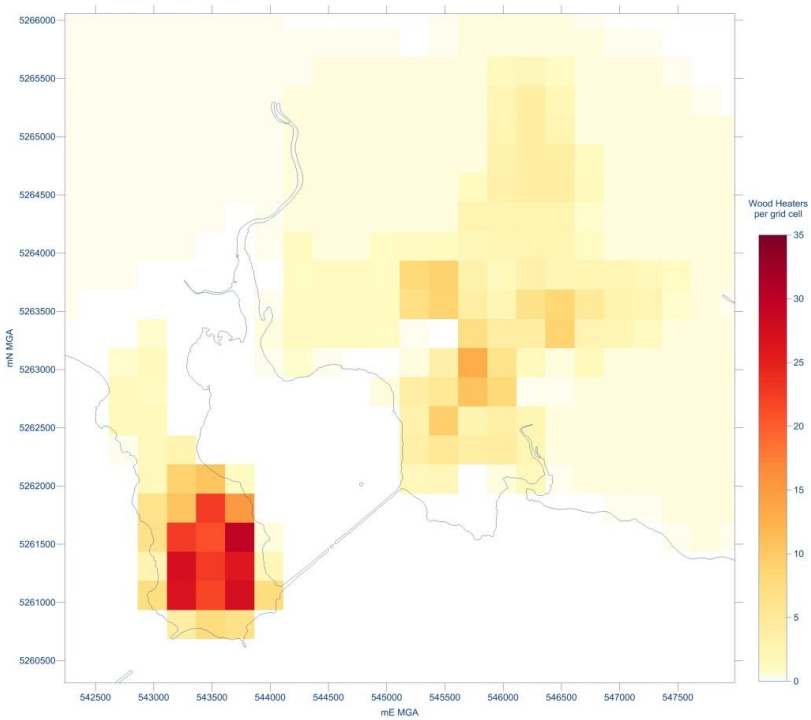

FIGURE 15. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE SORELL MIDWAY POINT SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 29.7 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 690 WOOD HEATERS WITHIN THE DISPLAYED REGION.

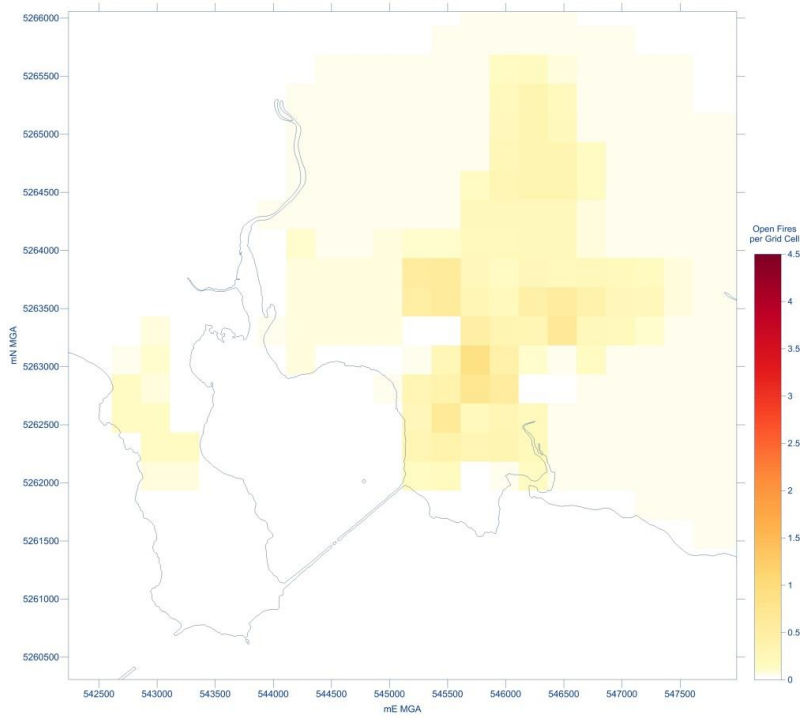

FIGURE 16. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE SORELL MIDWAY POINT SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 0.9 OPEN FIRES PER 250-M GRID CELL, WHICH OCCURS IN BATTERY POINT. THERE ARE 25 OPEN FIRES WITHIN THE DISPLAYED REGION.

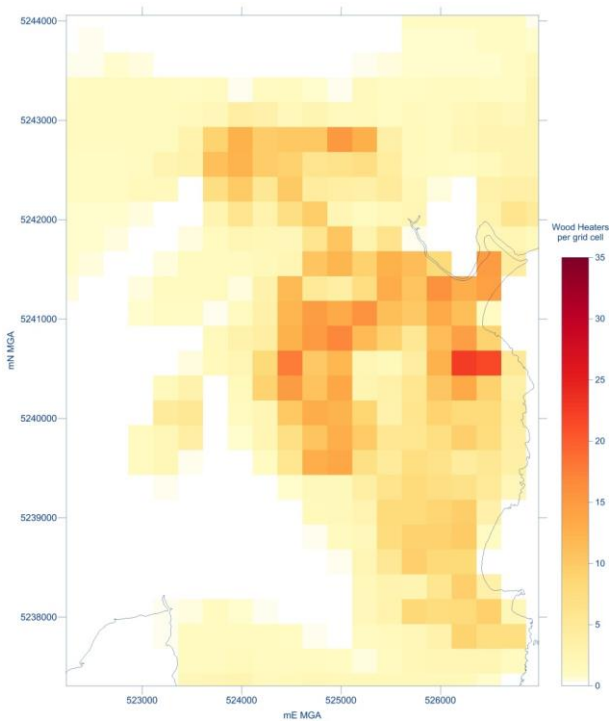

FIGURE 17. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE KINGSTON BLACKMANS BAY SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 22.7 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 1,570 WOOD HEATERS WITHIN THE DISPLAYED REGION.

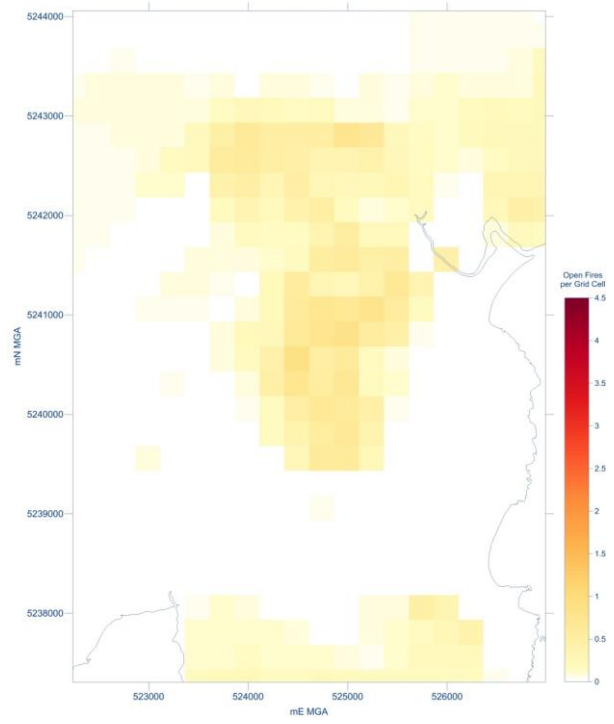

FIGURE 18. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE KINGSTON BLACKMANS BAY SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 0.9 OPEN FIRES PER 250-M GRID CELL, WHICH OCCURS IN BATTERY POINT. THERE ARE 50 OPEN FIRES WITHIN THE DISPLAYED REGION.

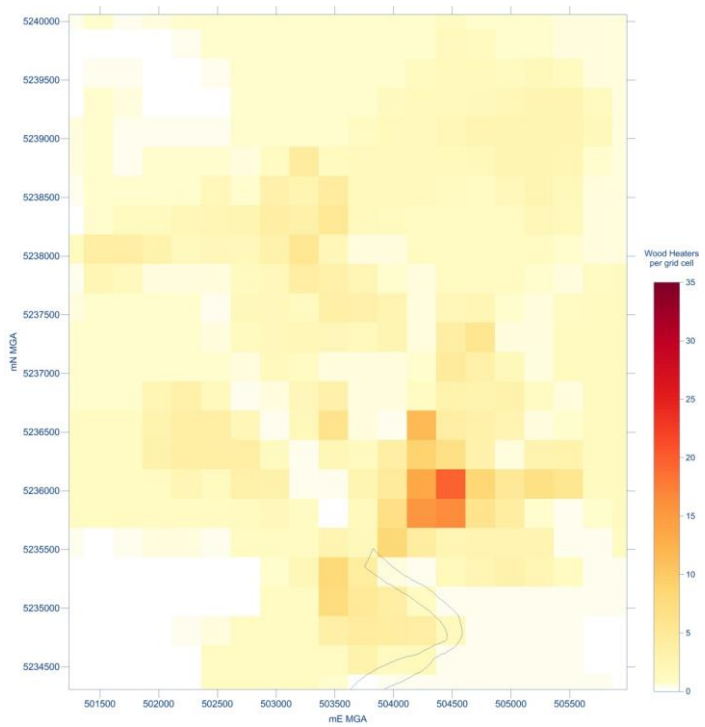

FIGURE 19. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE HUONVILLE RANELAGH SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 19.7 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 620 WOOD HEATERS WITHIN THE DISPLAYED REGION.

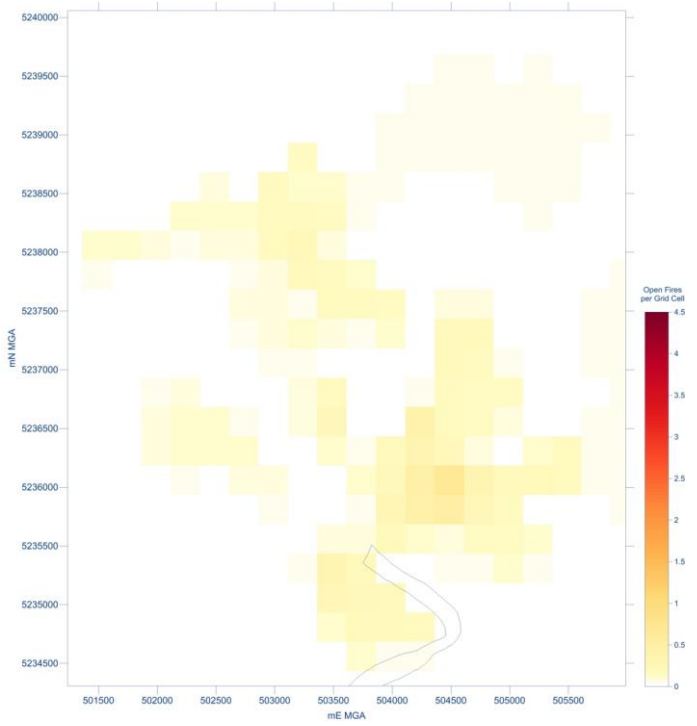

FIGURE 20. ESTIMATED SPATIAL DISTRIBUTION OF OPEN FIRES THROUGHOUT THE HUONVILLE RANELAGH SURVEY REGION. THE MAXIMUM OPEN FIRE DENSITY IS 0.7 OPEN FIRES PER 250-M GRID CELL, WHICH OCCURS IN BATTERY POINT. THERE ARE 15 OPEN FIRES WITHIN THE DISPLAYED REGION.

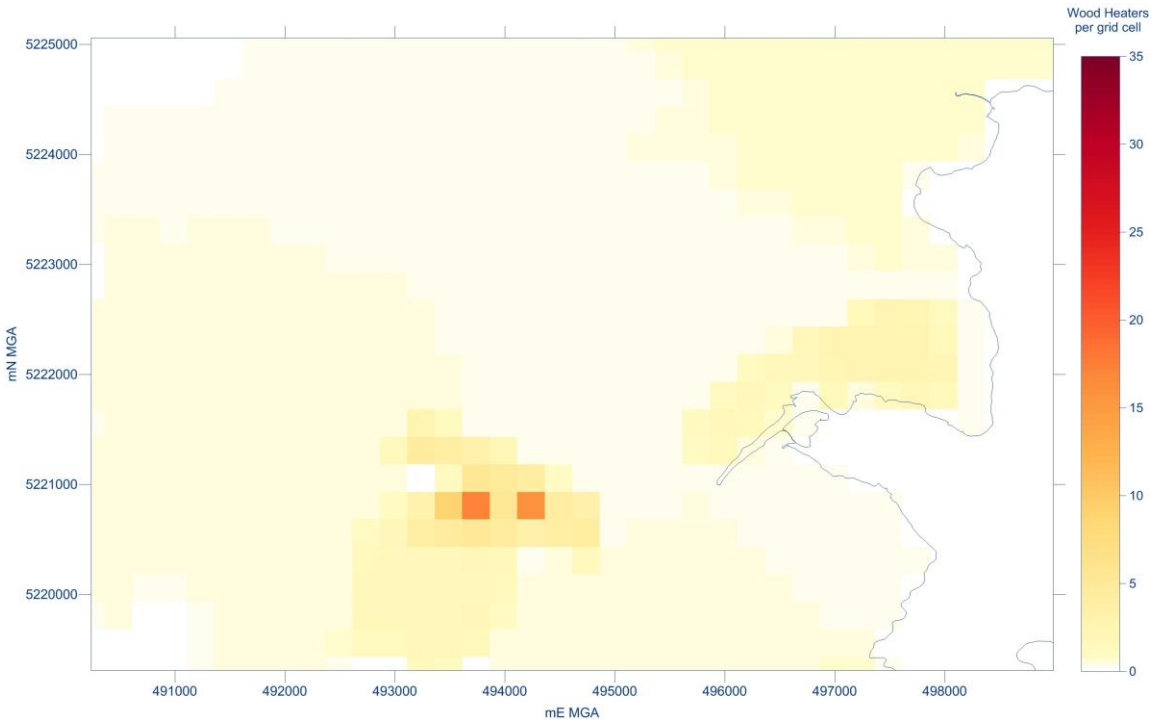

FIGURE 21. ESTIMATED SPATIAL DISTRIBUTION OF WOOD HEATERS THROUGHOUT THE GEEVESTON PORT HUON SURVEY REGION. THE MAXIMUM WOOD HEATER DENSITY IS 17.2 WOOD HEATERS PER 250-M GRID CELL. THERE ARE 390 WOOD HEATERS WITHIN THE DISPLAYED REGION.

REFERENCES

Australian Bureau of Statistics (2006), Mesh Blocks (Draft) Digital Boundaries, Australia. Cat. No. 1209.0.30.001, ABS: Canberra, Australian Capital Territory.

Innis, J.L. (2015), *Overview of the BLANkET smoke monitoring network: Development and operation, 2009-2015*. BLANkET Technical Report 31, EPA Tasmania: Air Section, Hobart, Tasmania.

Meyer, C.P., Luhar, A., Gillett, R. and Keywood, M. (2008), *Measurement of real-world PM10 emission factors and emission profiles from woodheaters by in situ source monitoring and atmospheric verification methods.* Final Report of Clean Air Research Project 16 for Australian Commonwealth Department of the Environment Water Heritage and the Arts, Aspendale, Victoria.

National Field Services (2011), *Spatially Enabled Home Heating Survey - Main Reports, 2011*. NFS: Melbourne, Victoria.

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