GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Red Hill annual desktop fire regime monitoring: 2019

Version: 2

Approved by: Russell Palmer

Last Updated: 25/8/2020

Custodian: Department of Biodiversity, Conservation and Attractions

Review date:

Version number	Date approved DD/MM/YYYY	Approved by	Brief Description
1	5/8/2020	Russell Palmer	No edits required
1	11/08/2020	Tessa Elvey, Jason Rossendell	Minor edits and formatting
2	25/08/2020	Tessa Elvey, Jason Rossendell	Formatting, additional land systems graphs added, minor edits

Red Hill annual desktop fire regime monitoring: 2019

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August 2020

GOVERNMENT OF WESTERN AUSTRALIA

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July 2020

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The recommended reference for this publication is:
Department Biodiversity, Conservation and Attractions, 2020, *Red Hill annual desktop fire regime monitoring: 2019*, Department of Biodiversity, Conservation and Attractions, Perth.

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Contents

Figures

Tables

Summary

This report addresses the tasks outlined in the document “Scope of Works - DPaW TSOP Fire Regime Monitoring 2019” and includes fire metrics over the Red Hill Land Management Area (LMA) for the time period 1999 – 2019.

The fire metrics contained in this report are listed in Table 1.

Table 1 Fire metrics covered in the report for the period 1999 – 2019

Metric	**Status**
Total area (ha) and proportion burned each year ▪ across entire study area ▪ within land system units ▪ within mapped Northern Quoll (NQ) & Pilbara Olive Python (POP) habitat	Achieved

The project area known as the Red Hill Land Management Area (LMA) is indicated in blue on Figure 1, and indicates the area subject to analysis, the LMA covers 187,708 hectares. In order to understand fires that occur close to or overlap this boundary a 10km buffer area for the provided vector mapping of the fires is delivered for map production use only. The composite land system mapping and fauna habitat areas used in the analysis have been supplied by Rio Tinto (Final Red Hill NQ POP habitat combined_region.shp and 2016_Red Hill_LandSystems_exported.shp).

For information on image processing, fire mapping and satellite imagery please see previous monitoring reports by Chapman and Zdunic (2016). Methodology describing the creation of the fire scar dataset will not be included in this update.

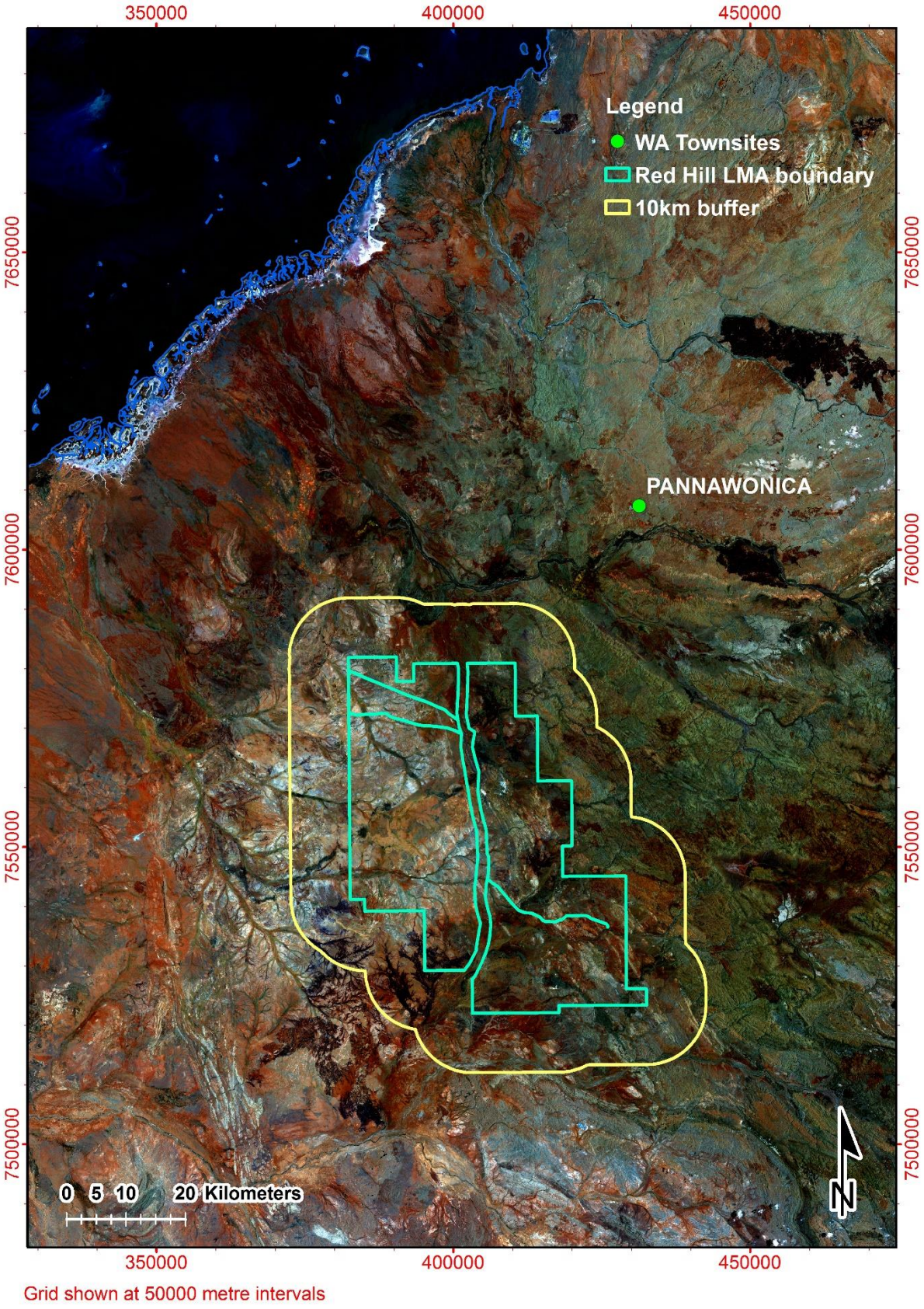

Figure 1 Red Hill Land Management Area, the background image is a Landsat 8 satellite image.

1 Data

Fire metrics were calculated using a combination of datasets provided by Rio Tinto and the Department of Biodiversity, Conservation and Attractions (DBCA). Table 2 displays the datasets used.

Table 2 Datasets used in the Red Hill fire metric analysis.

Dataset	Source	Description
Final Red Hill NQ POP habitat combined_region.shp	Rio Tinto	Northern Quoll and Pilbara Olive Python habitat extent
2016_Red Hill_LandSystems_exported.shp	Rio Tinto	Land system boundaries
Red Hill Station_exported.shp	Rio Tinto	Red Hill LMA boundary
Pilbara_fires_Z50_1999.shp	DBCA	Fire scar boundaries
Pilbara_fires_Z50_2001.shp	DBCA	Fire scar boundaries
Pilbara_fires_Z50_2003.shp	DBCA	Fire scar boundaries
Pilbara_fires_Z50_2004.shp	DBCA	Fire scar boundaries
Pilbara_fires_Z50_2006.shp	DBCA	Fire scar boundaries
Pilbara_fires_Z50_2007Oct.shp	DBCA	Fire scar boundaries
Pilbara_fires_Z50_2008.shp	DBCA	Fire scar boundaries
Pilbara_fires_Z50_2009.shp	DBCA	Fire scar boundaries
114075_2010-2011_FireScars.shp	DBCA	Fire scar boundaries
114075_2011-2012_FireScars.shp	DBCA	Fire scar boundaries
11475_2012-2013_FireScars.shp	DBCA	Fire scar boundaries
Fortescue_and_Offshore_Fires_2013_2014.shp	DBCA	Fire scar boundaries
Fortescue_River_Catchment_fire_mapping_2015.shp	DBCA	Fire scar boundaries
201516_Pilbara_Fire_Mapping_mga50.shp	DBCA	Fire scar boundaries
201617_114075_afed.shp	DBCA	Fire scar boundaries
114075_dec16_to_dec17_rio_2017_update.shp	DBCA	Fire scar boundaries
114075_160918_060119_mga50.shp	DBCA	Fire scar boundaries
RedHill_fires_201920_10kmbuff.shp	DBCA	Fire scar boundaries

1.1 Land Systems mapping

The land systems mapping dataset was provided by Rio Tinto. This dataset was used to calculate area based statistics for land systems within the Red Hill LMA. The total areas and the description for each land system are listed in Table 3 Figure 2 displays a map of Red Hill LMA and the supplied mapping.

Table 3 Land systems and area statements over the Red Hill Land Management Area.

Land system ID	Description	Area (hectares)
HOT	Houndstooth Land System	23,913.62
NNT	Nanutarra Land System	3,786.18
UAR	Uaroo Land System	10,457.67
DOR	Dollar Land System	8,743.59
SRK	Sherlock Land System	2,284.83
CPN	Capricorn Land System	31,381.91
RIV	River Land System	1,829.99
ROB	Robe Land System	12,587.46
BGD	Boolgeeda Land System	9,637.77
URY	Urandy Land System	11,172.49
STT	Stuart Land System	65,308.43
NEW	Newman Land System	807.88
ROC	Rocklea Land System	5,253.46
CAL	Calcrete Land System	542.02

1.2 Northern Quoll and Pilbara Olive Python boundary

An ESRI shapefile with the habitat extent of the Northern Quoll (NQ) and Pilbara Olive Python (POP) was provided by Rio Tinto. Mapped habitat for both NQ and POP is based on land system mapping (van Vreeswyk et al., 2004) and represents a coarse estimate of available habitat within the LMA. The total area of the fauna habitat covers 53,630 hectares of Red Hill LMA. Figure 2 displays a map of the fauna habitat within Red Hill LMA. Throughout this document the habitat area for the fauna will be referred to as the NQ and POP habitat.

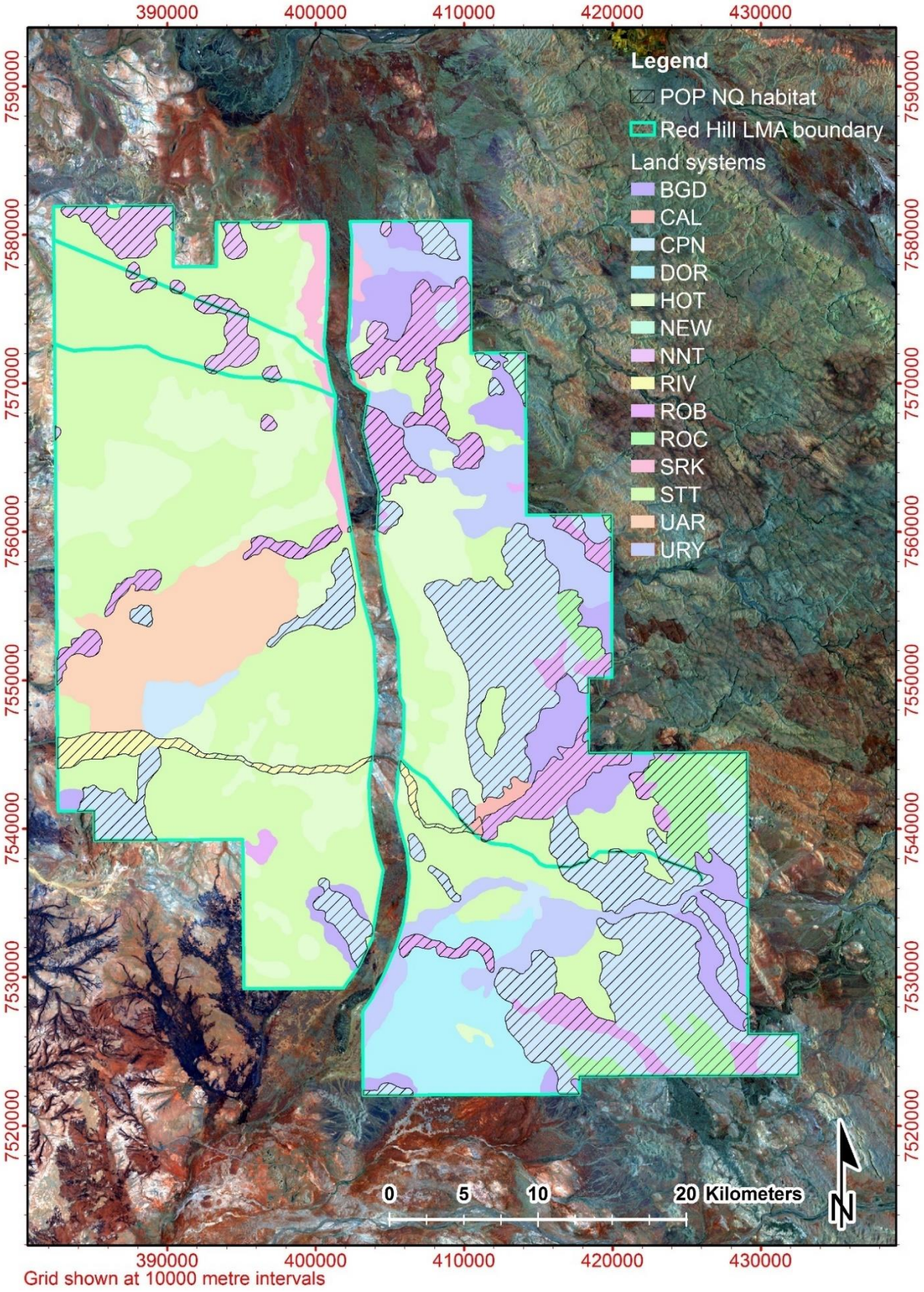

Figure 2 Red Hill Land Management Area with land systems and Northern Quoll and Pilbara Olive Python habitat boundary, the background image is a Landsat 8 satellite image.

2 Methodology

The methodology describes the calculation of the fire metrics.

2.1 Fire metrics

Metrics were derived from the fire scar datasets using ArcGIS 10.6.1. This software is geographic information systems software that allows the viewing, analysis and storage of spatial data.

2.1.1 Vector data cleaning

Fire scar vectors were examined for errors in the data, which might cause errors in the area statistics. Duplicate polygons can sometimes occur when the same fire is mapped more than once, this is more common around the edges of Landsat scene boundaries. To find duplicate polygons within each year of fire scar mapping the “Count Overlapping Polygons” toolbox in ArcGIS was used (Honeycutt, 2012). Duplicate polygons were then deleted. Part of the cleaning process was to ensure all data were in the same coordinate system and that all datasets had been repaired using the “Repair Geometry” tool in ArcGIS.

Once all the individual years of fire scar datasets were cleaned they were merged into one shapefile and clipped to the Red Hill LMA 10km buffer shapefile using the “Clip” tool in ArcGIS. This dataset was further clipped to the Red Hill LMA area of interest.

2.1.2 Graphing fire metrics

Graphs were produced using the statistical package R. This enables repeatability in the graphing as a script has been produced for each graph set up and annual updates require the latest data to be entered (R Core Team, 2017).

3 Results

The results address the fire metrics requested and listed in Table 1. The results are structured according to Table 4

Table 4 Structure of the fire metrics results.

Metric	**Category**	**Graphs/ tables**
3.1 Total area (ha) and proportion burned each year.	3.1.1 Across entire study area	Table 6 Figure 4 and Figure 5
	3.1.1 Within mapped NQ & POP habitat	Table 6 and Table 7 and Figure 5
	3.1.2 Within land systems	Table 7 and Table 8 Figure 6 and Figure 7 Alternative style graphs: Figure 8 and Figure 9 Individual land systems graphs: Figures 10 - 23

To provide context of each variable across the Red Hill LMA the area of the study site, POP and NQ habitat and land systems that fire metrics were calculated for are displayed in Table 5.

Table 5 Area statistics for each zone; area statements were used to calculate metrics based on these zones.

Zone	Total area (ha)	% of study area
Red Hill LMA	187,707.80	100
POP NQ Habitat	53,629.72	28.57
HOT	23,913.62	12.74
NNT	3,786.18	2.02
UAR	10,457.67	5.57
DOR	8,743.59	4.66
SRK	2,284.83	1.22
CPN	31,381.91	16.72
RIV	1,829.99	0.97
ROB	12,587.46	6.71
BGD	9,637.77	5.13
URY	11,172.49	5.95
STT	65,308.43	34.79
NEW	807.88	0.43
ROC	5,253.46	2.80
CAL	542.02	0.29

3.1 Total area and proportion burned in each fire mapping year

The following statistics show total area burnt in hectares for each year of available fire mapping. A variety of graphs and tables are presented for each fire metric to allow for different options to be explored. Metrics calculated are provided as;

Total area (ha) and proportion burned each year:

- across the entire study area
- within mapped NQ and POP habitat
- within land systems

Fires that occurred on Red Hill station and within a 10km buffer are shown in Figure 3.

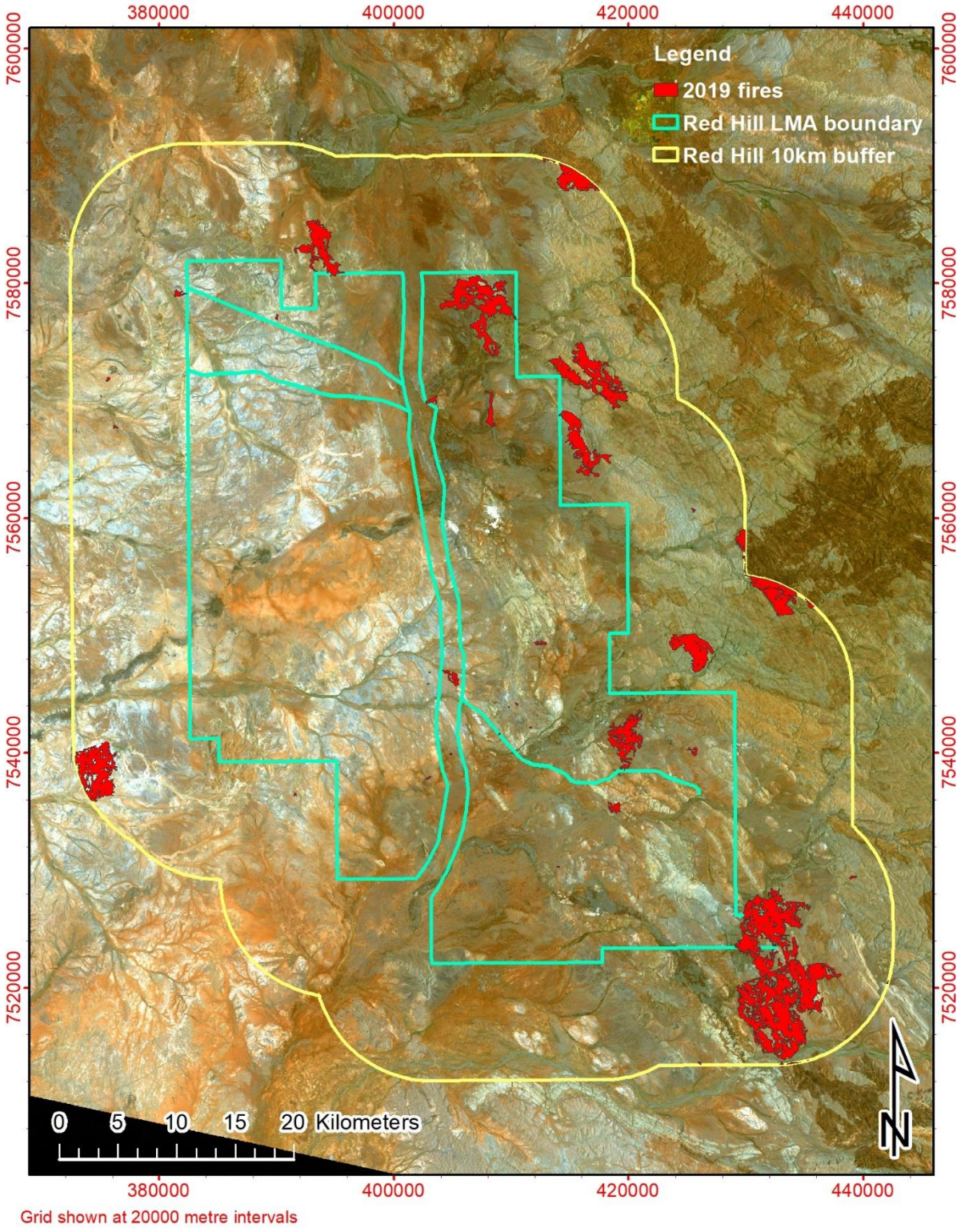

Figure 3 Fires that occurred on Red Hill Station and within a 10 km buffer in 2019, the background image is a Landsat 8 satellite image, the image date is 24th December 2019 and was used to map the 2019 fires.

3.1.1 Across Red Hill LMA and mapped NQ & POP habitat

The NQ and POP habitat and total Red Hill area metrics have been combined in both the tables and figures as the NQ and POP habitat is a subset of the total area and this reduces the number of tables, graphs and figures. Table 6 displays the total area of land mapped as burnt over Red Hill and the NQ and POP habitat. The percentages based on these area figures are also displayed in Table 6. Graphs of the area statements are displayed in Figure 4 and percentages values are displayed in Figure 5.

Table 6 Total area and percentage of land burnt (ha) over Red Hill LMA and NQ & POP habitat for each year of available fire mapping.

YEAR	1999	2001	2003	2004	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
TOTAL AREA BURNT (HA)	4,490	55,748	18,367	296	20,384	3,305	2,062	19,456	391	1,719	2,524	10,524	8,154	9,875	11,524	3,129	19,053	2,681
% BURNT	2	30	10	<1	11	2	1	10	<1	1	1	6	4	5	6	2	10	1
TOTAL AREA NQ/POP HABITAT BURNT (HA)	1,130	20,238	1,867	31	2,234	1,916	431	8,101	0	347	1,185	1,330	2,709	6,540	4,919	922	3,218	1,250
% BURNT	2	38	3	0	4	4	1	15	0	1	2	2	5	12	9	2	6	2

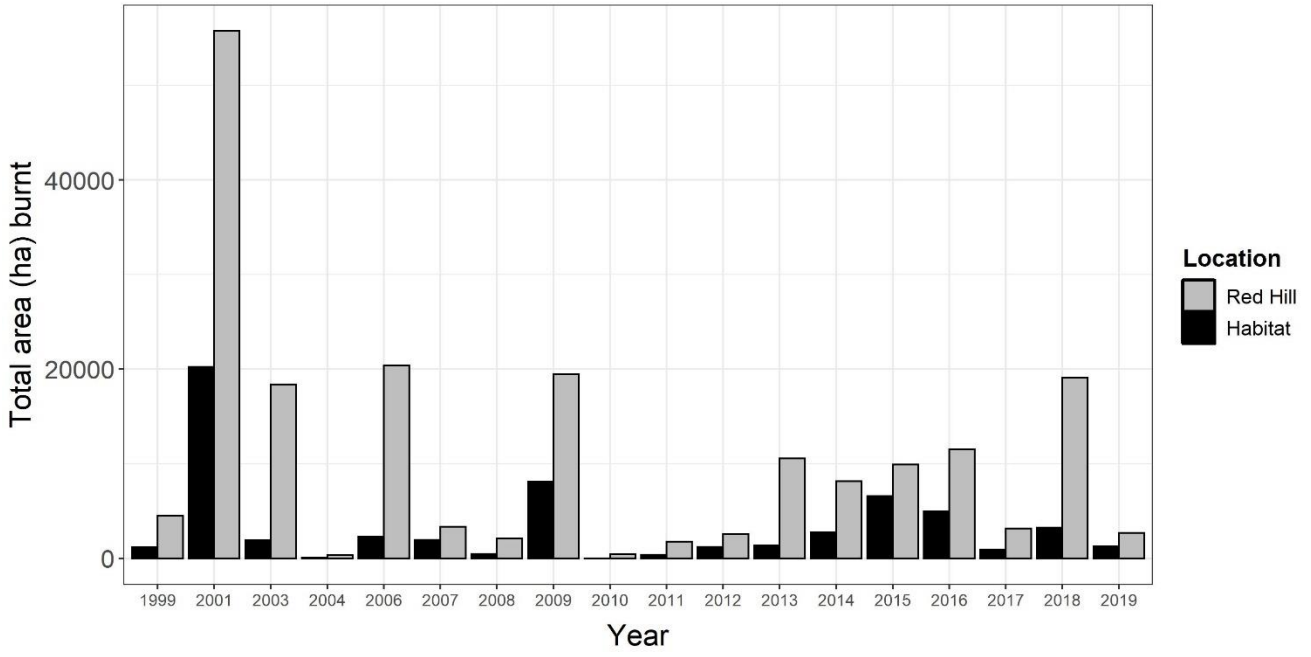

Figure 4 Total area (ha) burnt per year across Red Hill LMA and NQ & POP habitat.

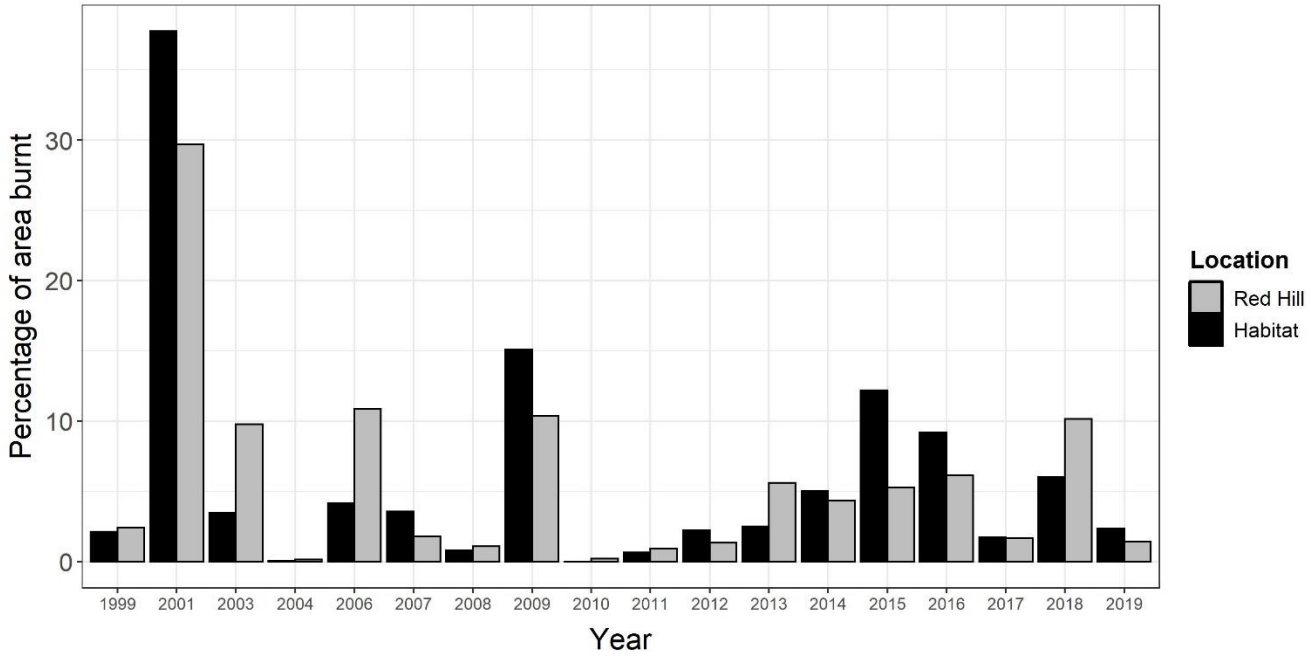

Figure 5 Total percentage burnt per year across Red Hill LMA and NQ & POP habitat range.

3.1.2 Land systems

Table 7 displays the total area of land mapped as burnt across the different land system units. The percentages based on these area figures are displayed in Table 8. Graphs of the area statements are displayed in Figure 6 and percentages of those figures are displayed in Figure 7. Alternative graphs for displaying the metrics for the land systems across Red Hill LMA are displayed in Figure 8 and Figure 9. These display the same data but give an alternative visual representation.

Table 7 Total area in hectares of area burnt over Red Hill LMA within the land systems for each year of available fire mapping.

YEAR	1999	2001	2003	2004	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HOT	276	5,830	2,673	27	3,858	0	841	503	0	152	943	1,252	1,795	194	1,696	179	3,141	20
NNT	0	1,259	912	0	133	0	0	786	0	323	0	0	168	0	34	3	43	3
UAR	339	43	0	0	1,149	0	0	2,971	0	0	0	1,686	4	3	107	<1	3,821	0
DOR	0	5,071	0	0	0	27	80	0	0	0	0	1,296	88	0	0	<1	789	0
SRK	6	69	1,329	0	248	0	2	148	129	48	0	0	313	0	584	0	299	0
CPN	94	11,457	231	1	1,589	757	102	2,511	0	20	1,153	1,165	2,124	5,701	2,035	766	1,371	809
RIV	0	25	0	0	123	0	7	315	0	0	0	0	0	50	208	19	127	0
ROB	996	3,627	506	29	481	455	319	4,087	0	3	0	870	418	232	915	136	1,170	366
BGD	619	3,659	1,100	0	202	670	24	1,099	0	62	0	579	93	1,315	999	447	598	500
URY	200	5,581	1,194	239	1,000	0	317	2,648	261	5	86	1,095	281	1,074	284	13	1,052	499
STT	1,920	15,080	10,166	0	11,355	691	423	3,768	0	1,105	310	2,291	2,870	710	2,932	1,559	6,186	396
NEW	0	415	42	0	13	1	0	307	0	0	0	0	0	139	357	0	0	2
ROC	40	3611	206	0	235	703	0	207	0	0	32	23	0	400	1,360	0	455	72
CAL	0	21	7	0	0	0	26	25	0	0	0	268	0	58	14	6	0	14

Table 8 Total percentage of area burnt over Red Hill LMA within the land systems for each year of available fire mapping.

YEAR	1999	2001	2003	2004	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HOT	1	24	11	<1	16	0	4	2	0	1	4	5	8	1	7	1	13	<1
NNT	0	33	24	0	4	0	0	21	0	9	0	0	4	0	1	<1	1	<1
UAR	3	<1	0	0	11	0	0	28	0	0	0	16	<1	<1	1	<1	37	0
DOR	0	58	0	0	0	<1	1	0	0	0	0	15	1	0	<1	<1	9	0
SRK	<1	3	58	0	11	0	<1	6	6	2	0	0	14	0	26	0	13	0
CPN	<1	37	1	<1	5	2	<1	8	0	0	4	4	7	18	6	2	4	3
RIV	0	1	0	0	7	0	<1	17	0	0	0	0	0	3	11	1	7	0
ROB	8	29	4	<1	4	4	3	32	0	<1	0	7	3	2	7	1	9	3
BGD	6	38	11	0	2	7	<1	11	0	1	0	6	1	14	10	5	6	5
URY	2	50	11	2	9	0	3	24	2	<1	1	10	3	10	3	<1	9	4
STT	3	23	16	0	17	1	1	6	0	2	<1	4	4	1	4	2	9	1
NEW	0	51	5	0	2	<1	0	38	0	0	0	0	0	17	44	0	0	<1
ROC	1	69	4	0	4	13	0	4	0	0	1	<1	0	8	26	0	9	1
CAL	0	4	1	0	0	0	5	5	0	0	0	49	0	11	3	1	0	3

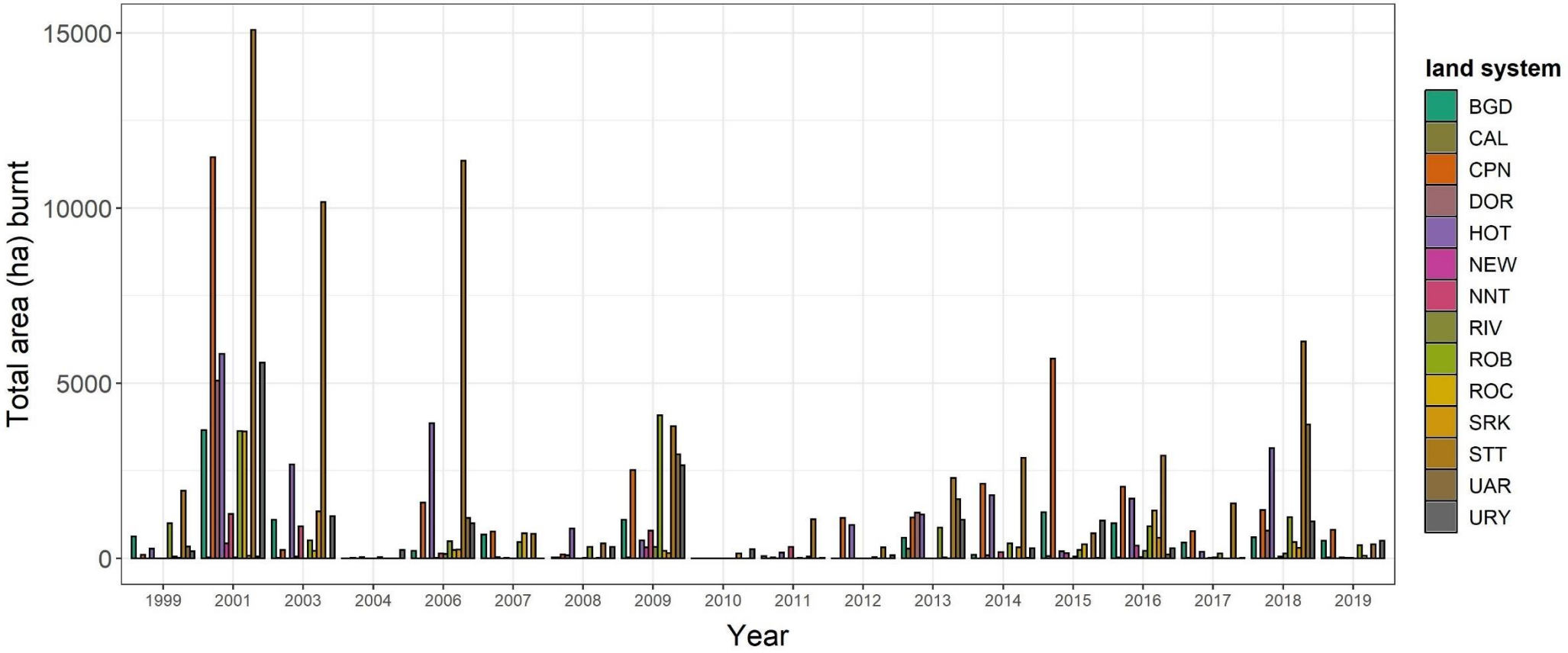

Figure 6 Total area (ha) burnt per year across Red Hill LMA land systems for each year of available fire mapping.

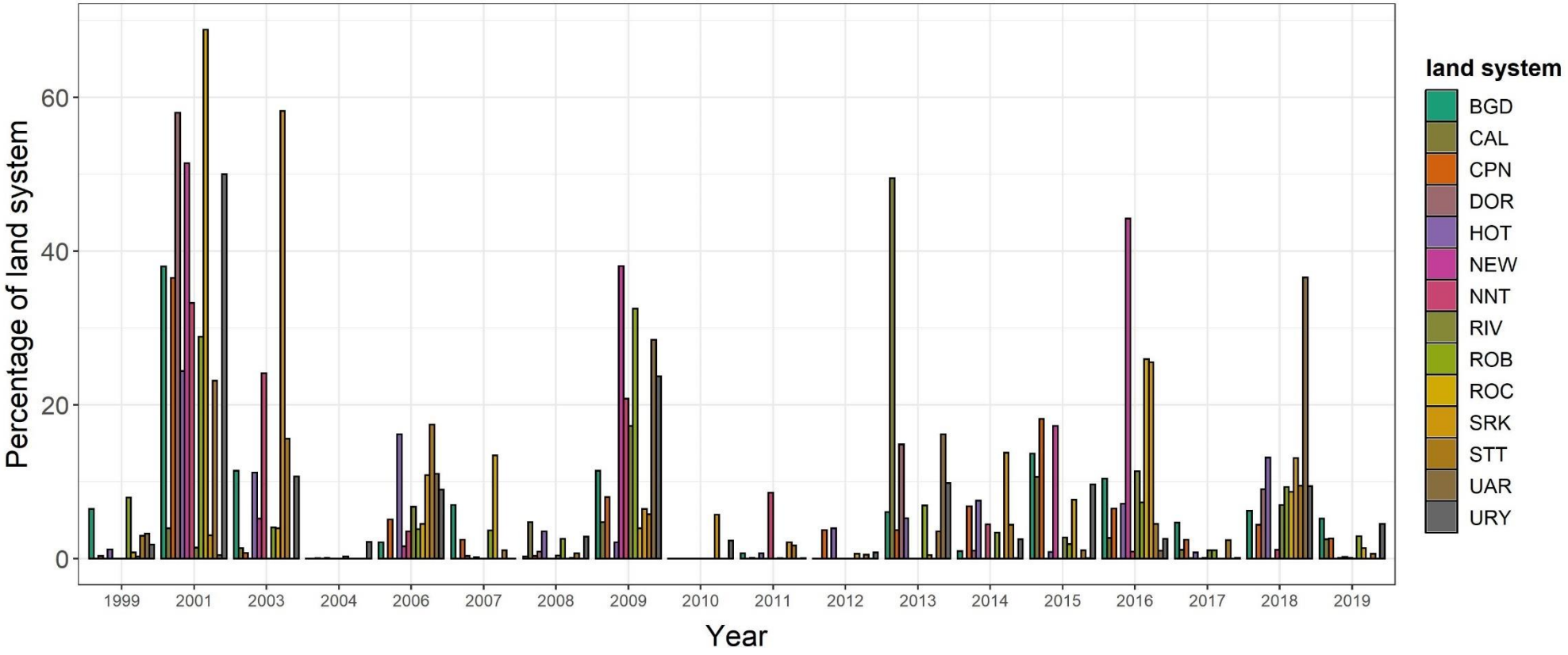

Figure 7 Total percentage burnt per year across Red Hill LMA land systems for each year of available fire mapping.

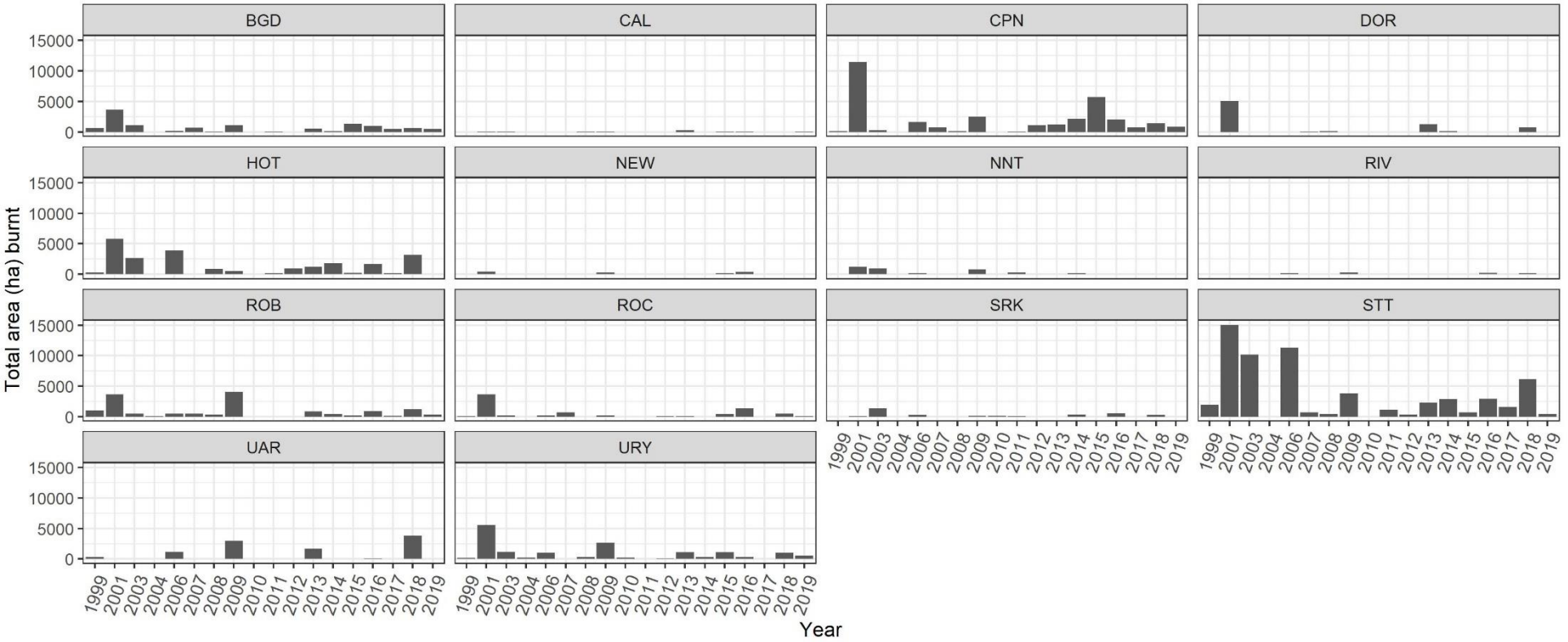

Figure 8 Alternative graph for total area (ha) burnt per year across Red Hill LMA land systems for each year of available fire mapping.

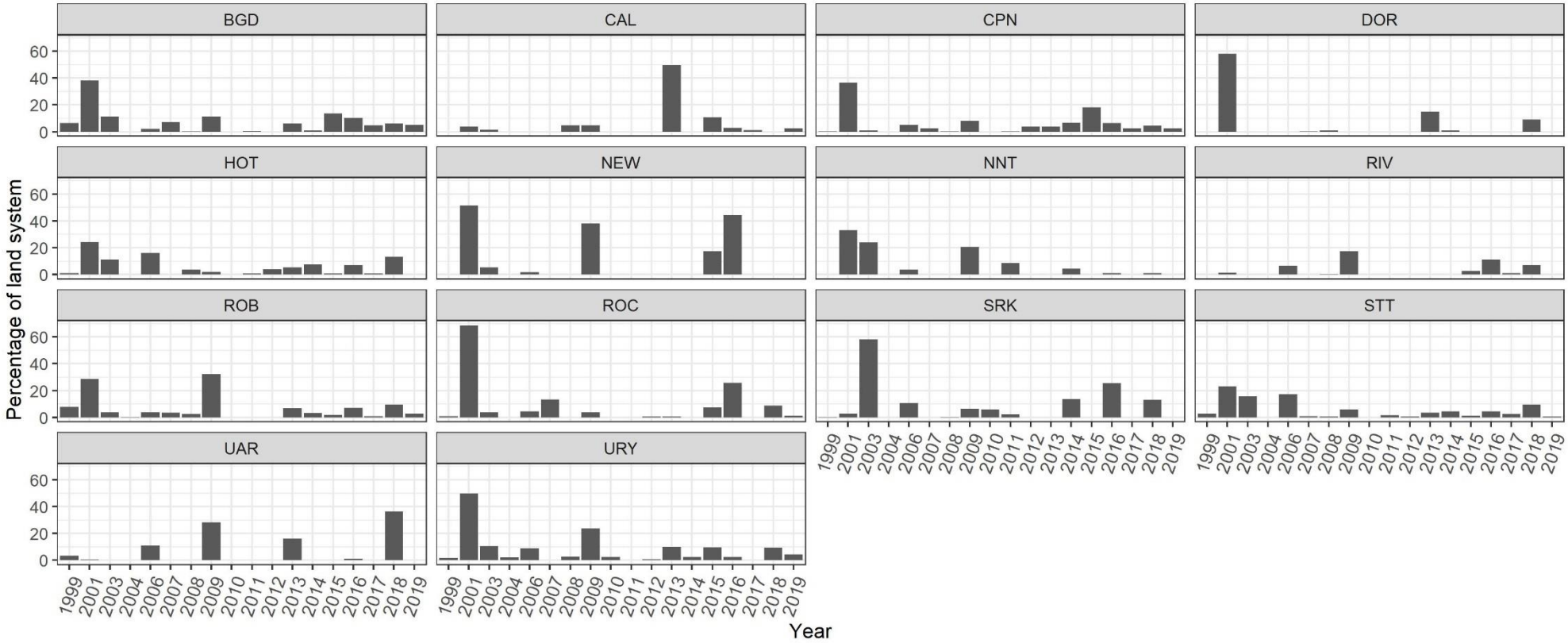

Figure 9 Alternative graph for total percentage burnt per year across Red Hill LMA land systems for each year of available fire mapping.

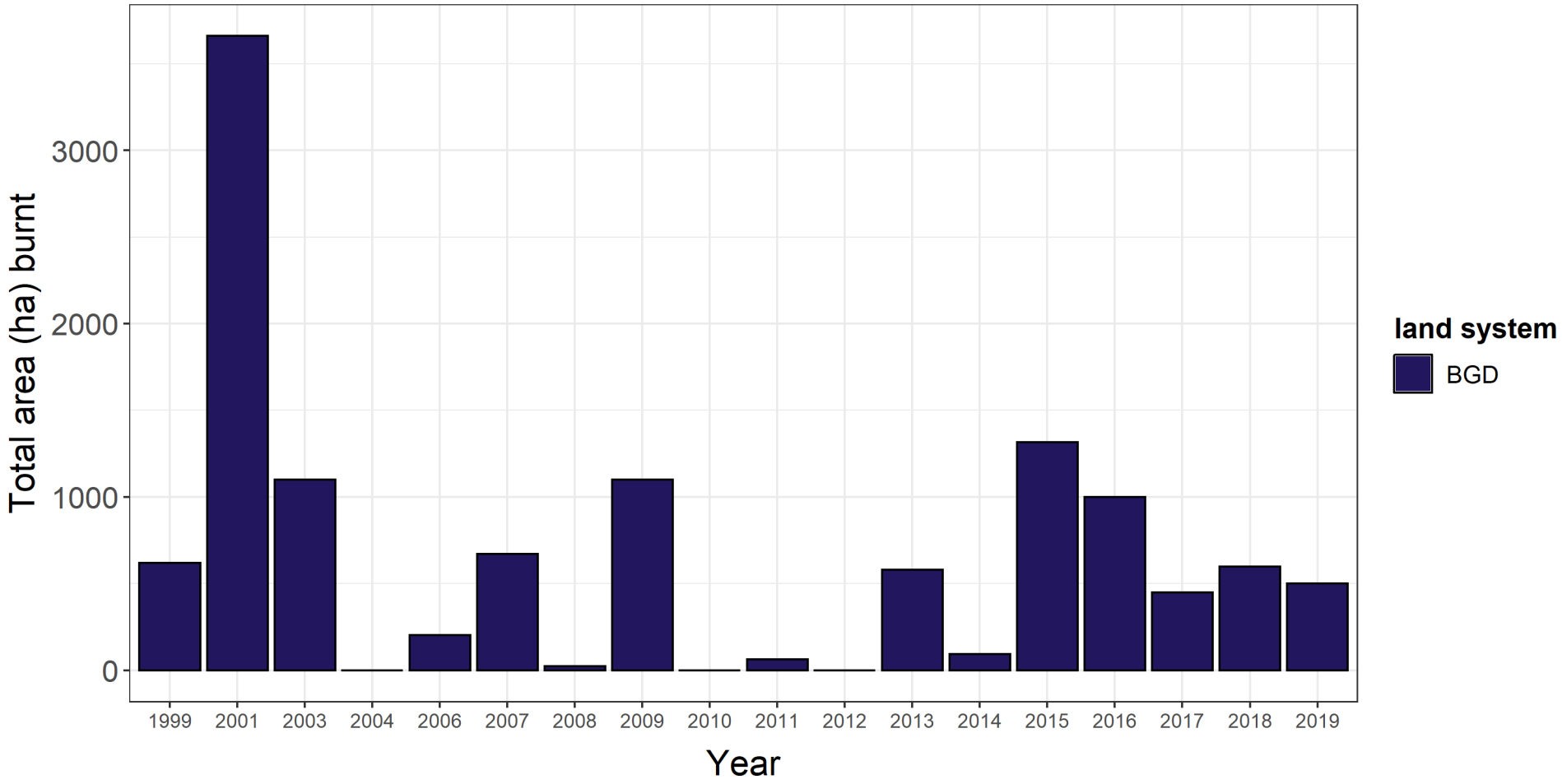

Figure 10 Total area (ha) burnt per year across the Boolgeeda land system for each year of available fire mapping.

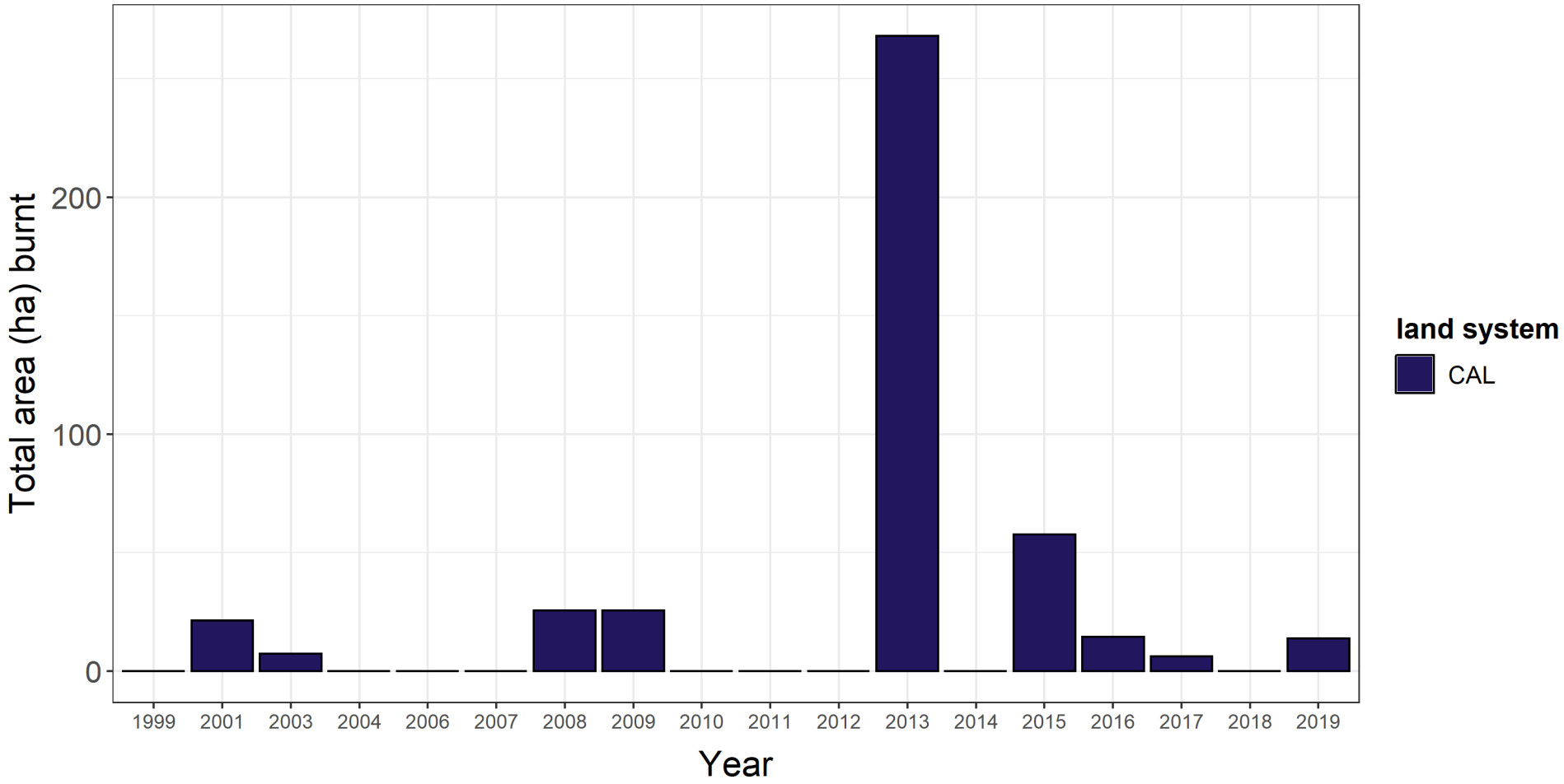

Figure 11 Total area (ha) burnt per year across the Calcrete land system for each year of available fire mapping.

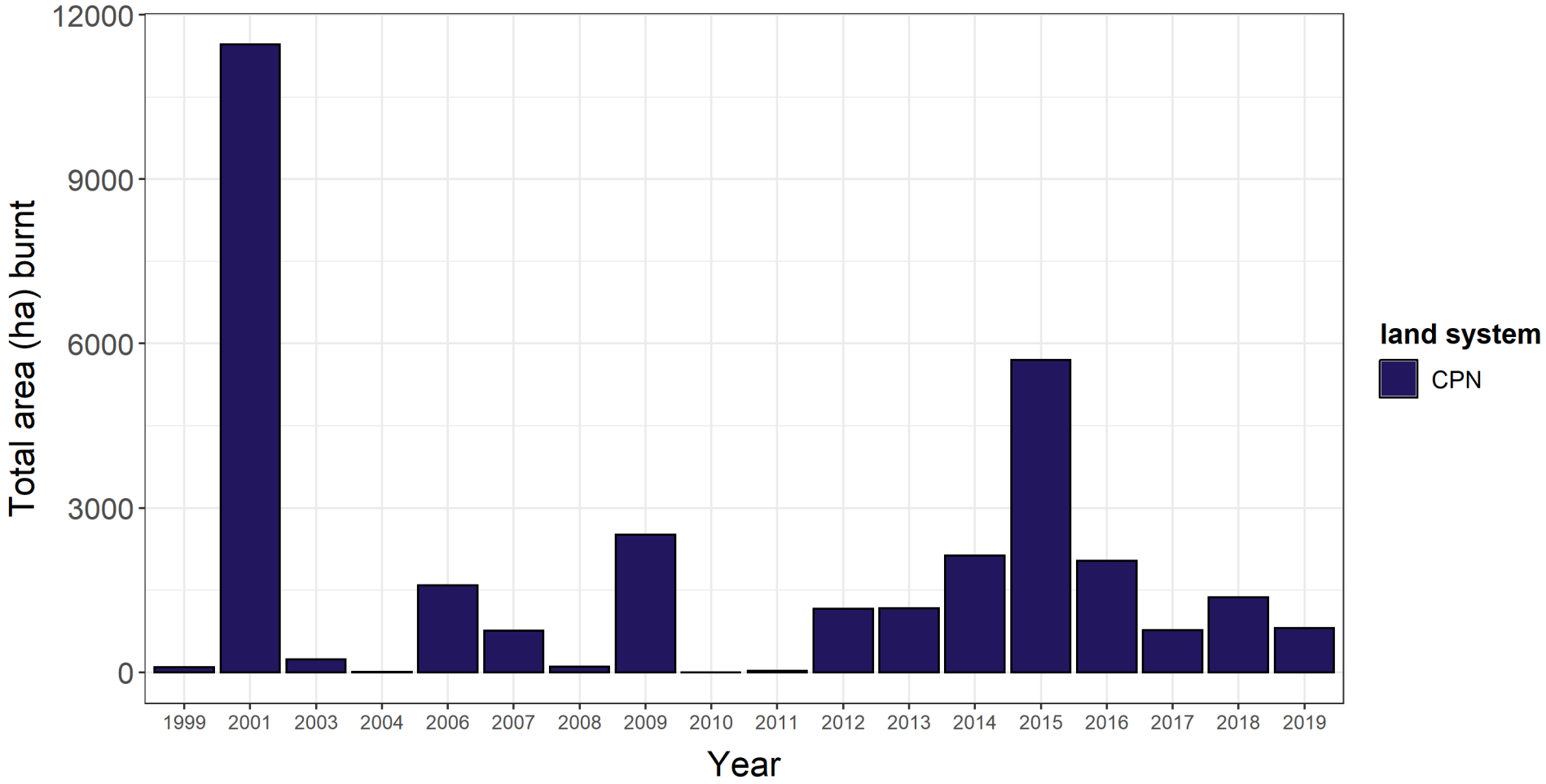

Figure 12 Total area (ha) burnt per year across the Capricorn land system for each year of available fire mapping.

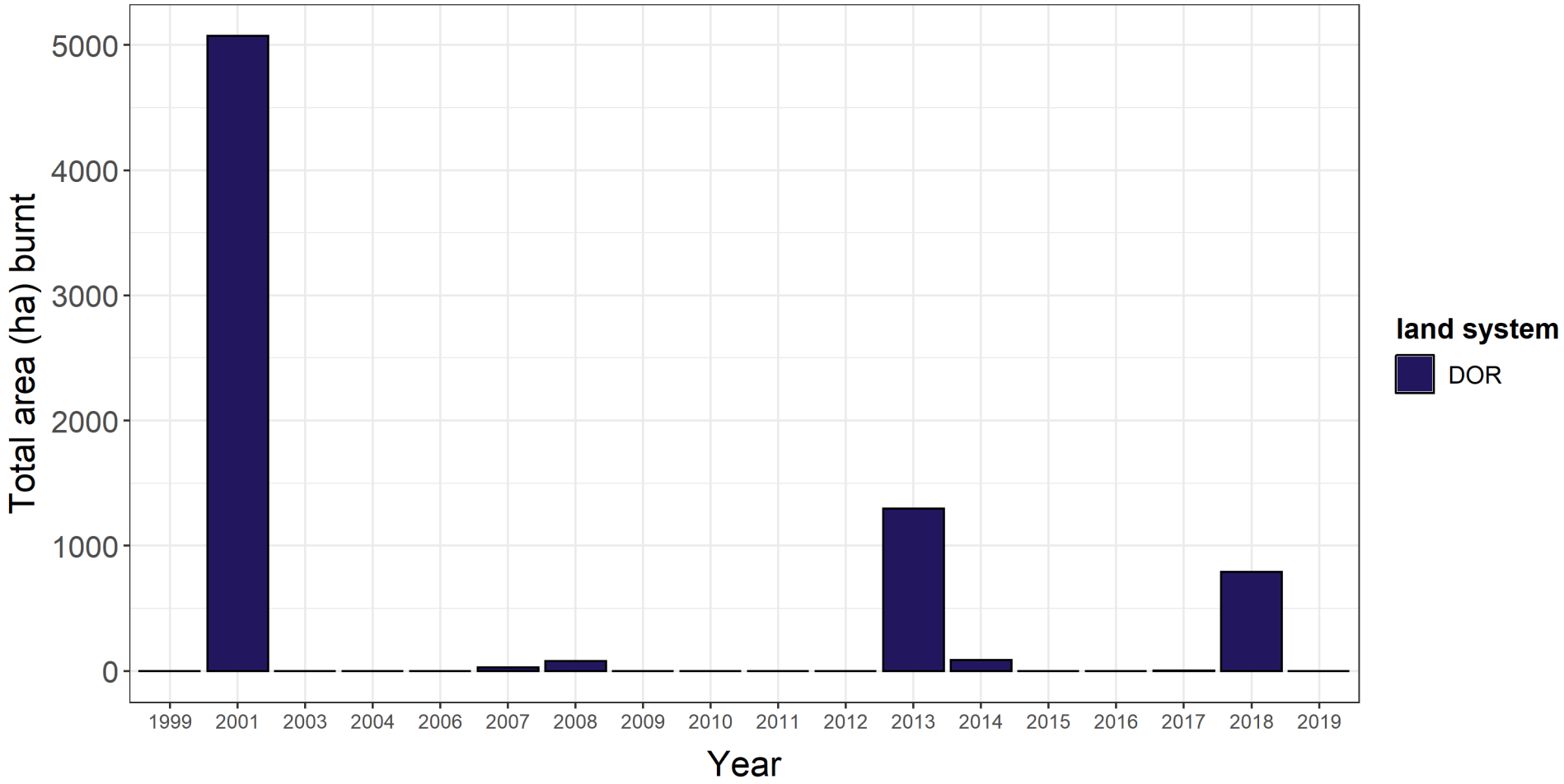

Figure 13 Total area (ha) burnt per year across the Dollar land system for each year of available fire mapping.

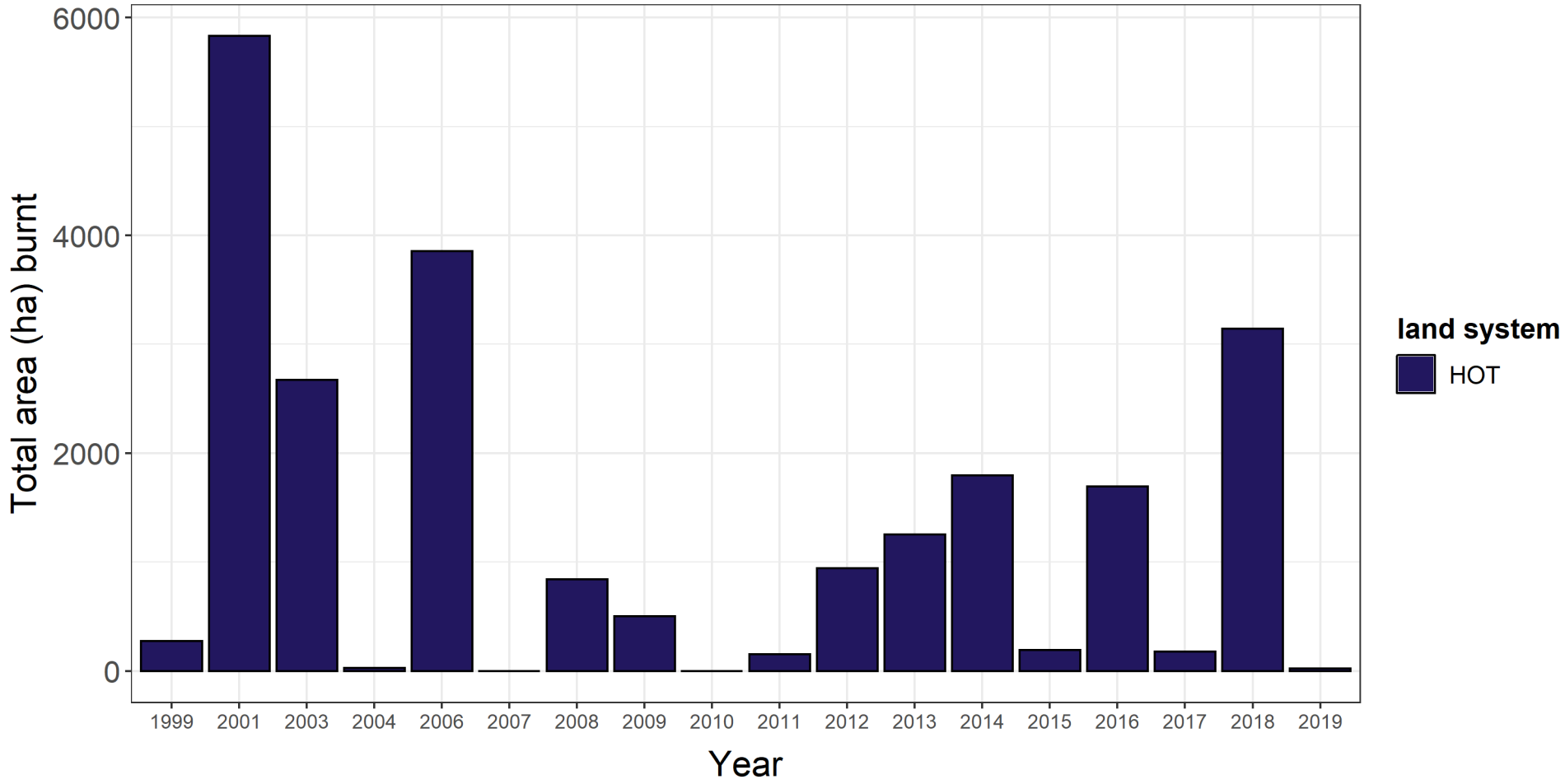

Figure 14 Total area (ha) burnt per year across the Houndstooth land system for each year of available fire mapping.

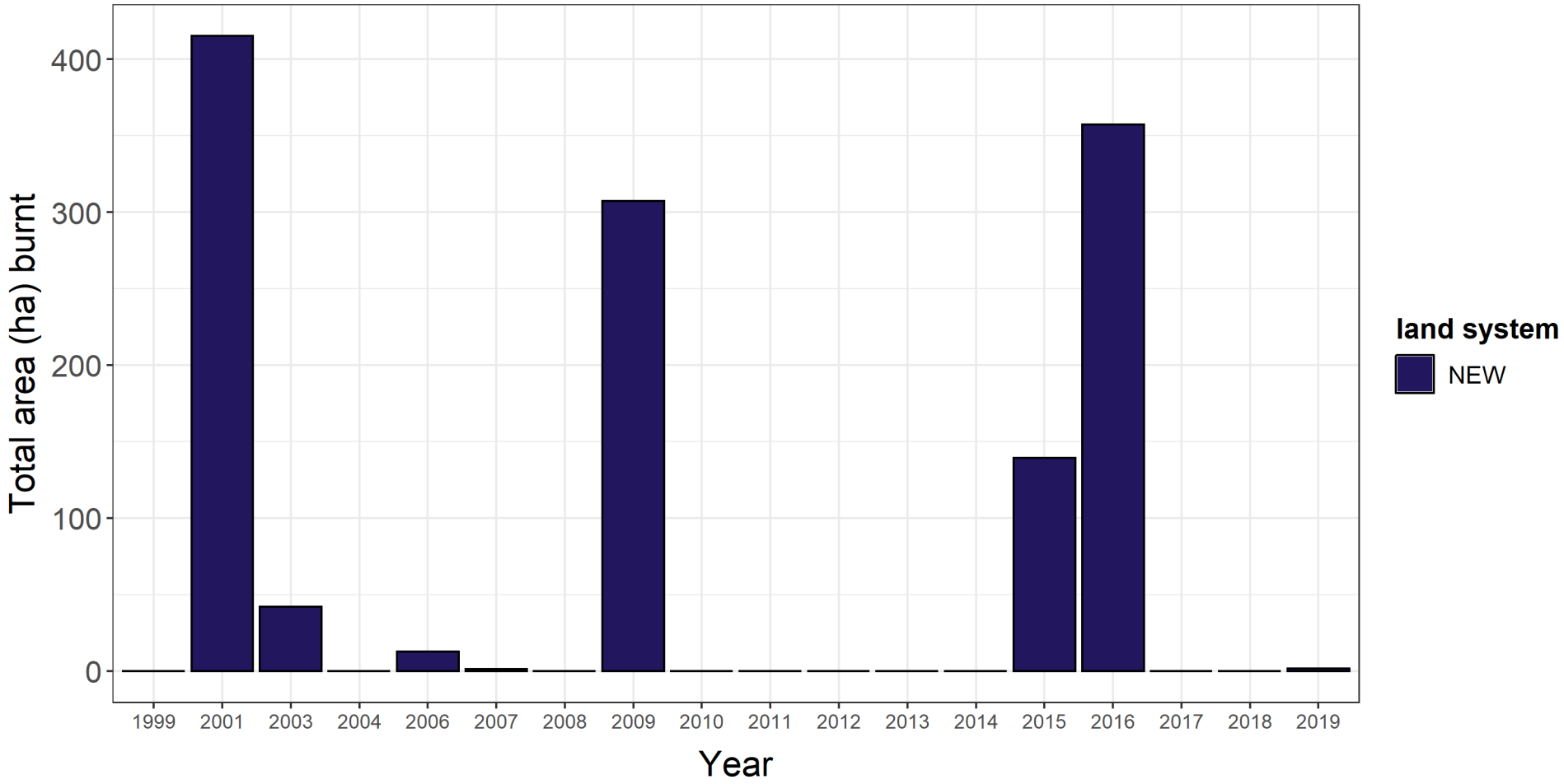

Figure 15 Total area (ha) burnt per year across the Newman land system for each year of available fire mapping.

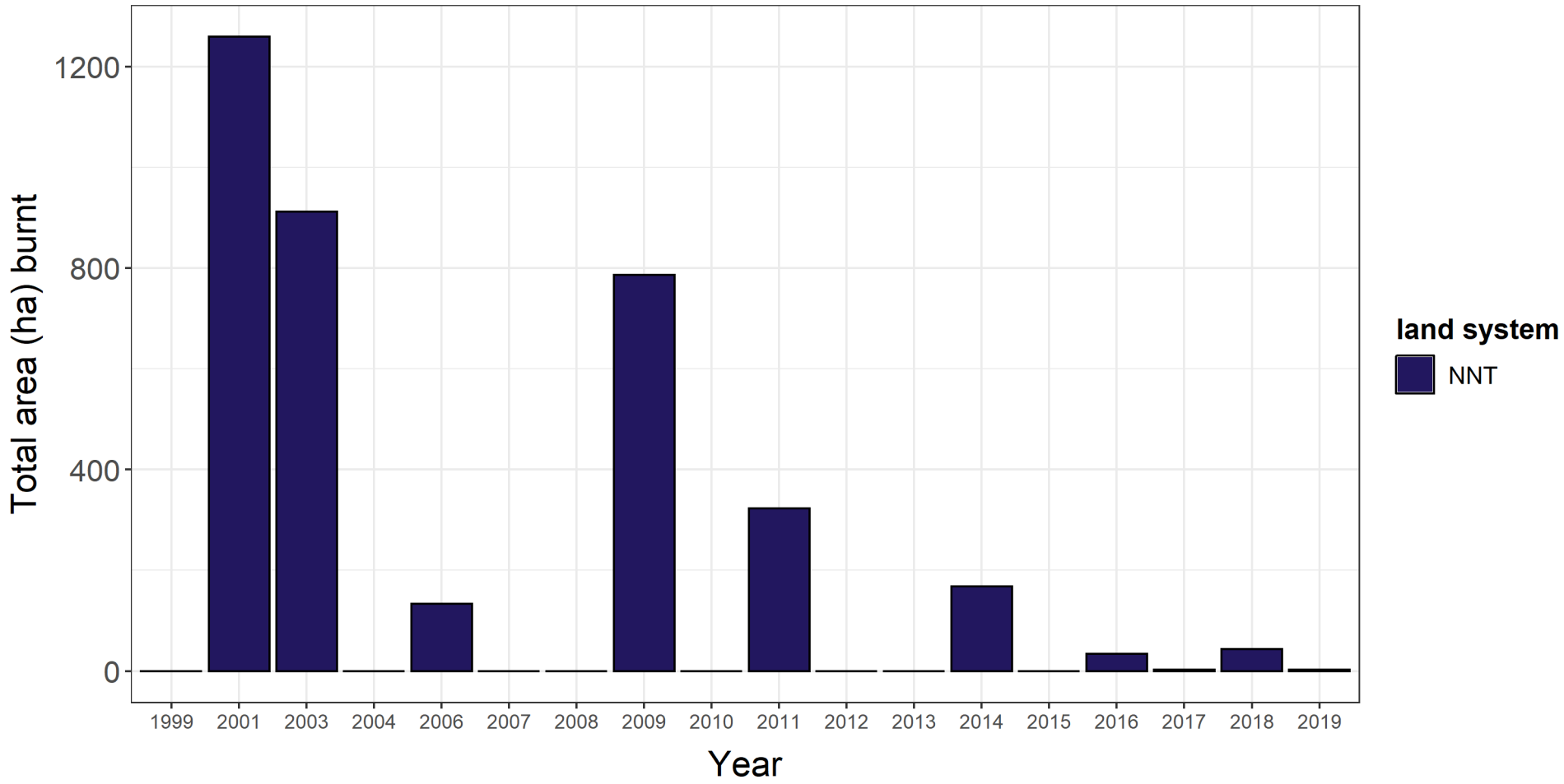

Figure 16 Total area (ha) burnt per year across the Nanutarra land system for each year of available fire mapping.

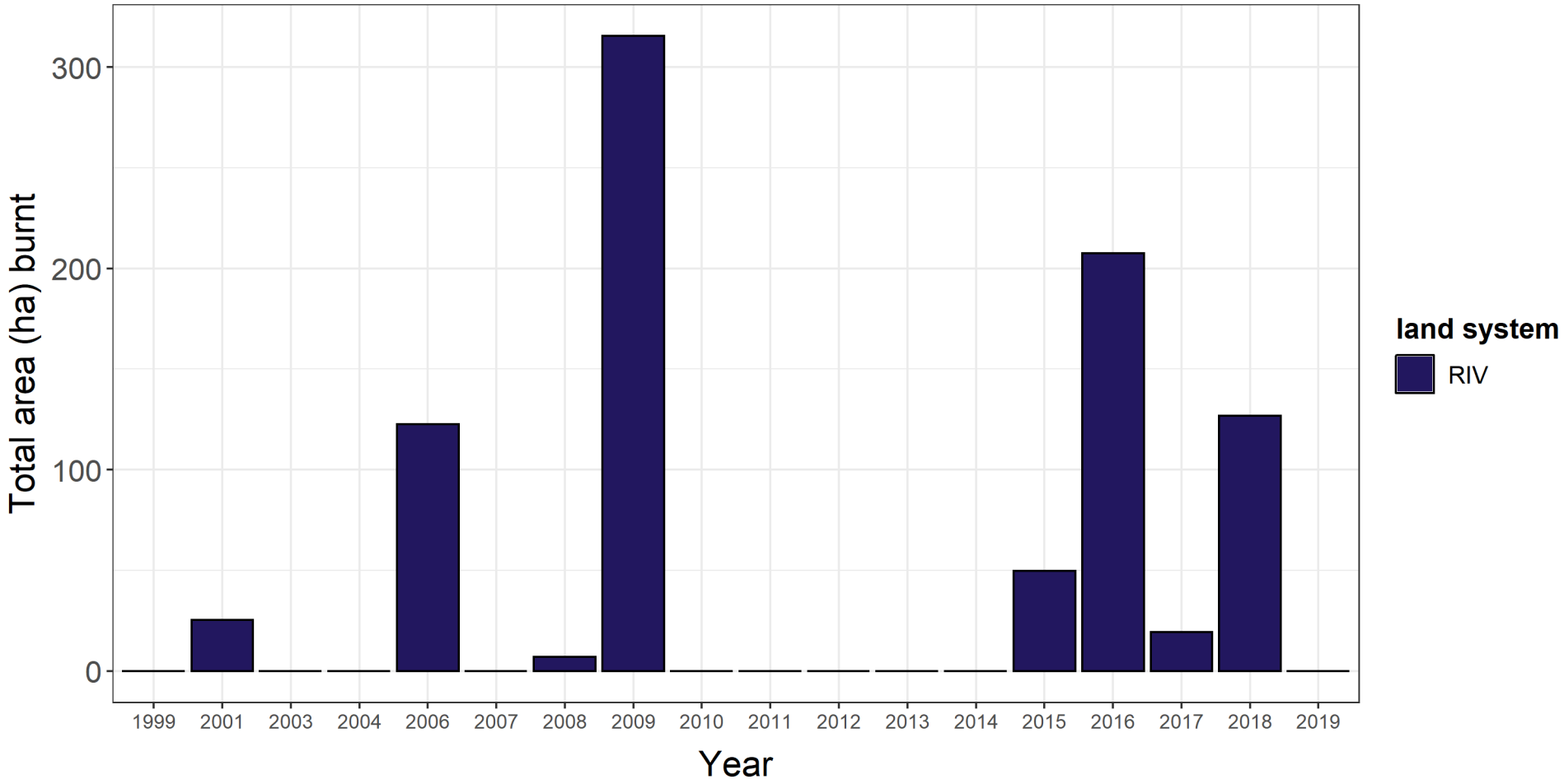

Figure 17 Total area (ha) burnt per year across the River land system for each year of available fire mapping.

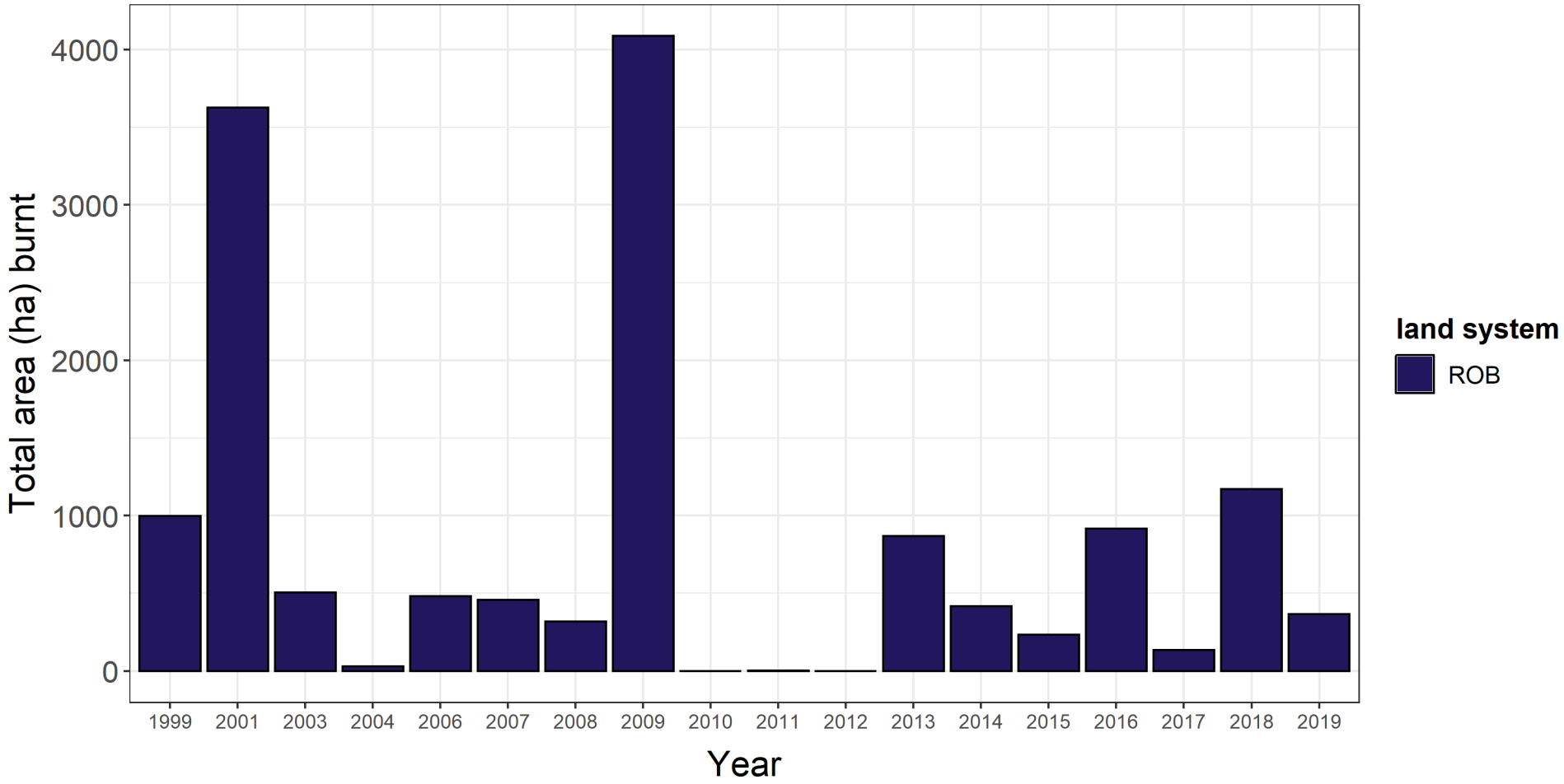

Figure 18 Total area (ha) burnt per year across the Robe land system for each year of available fire mapping.

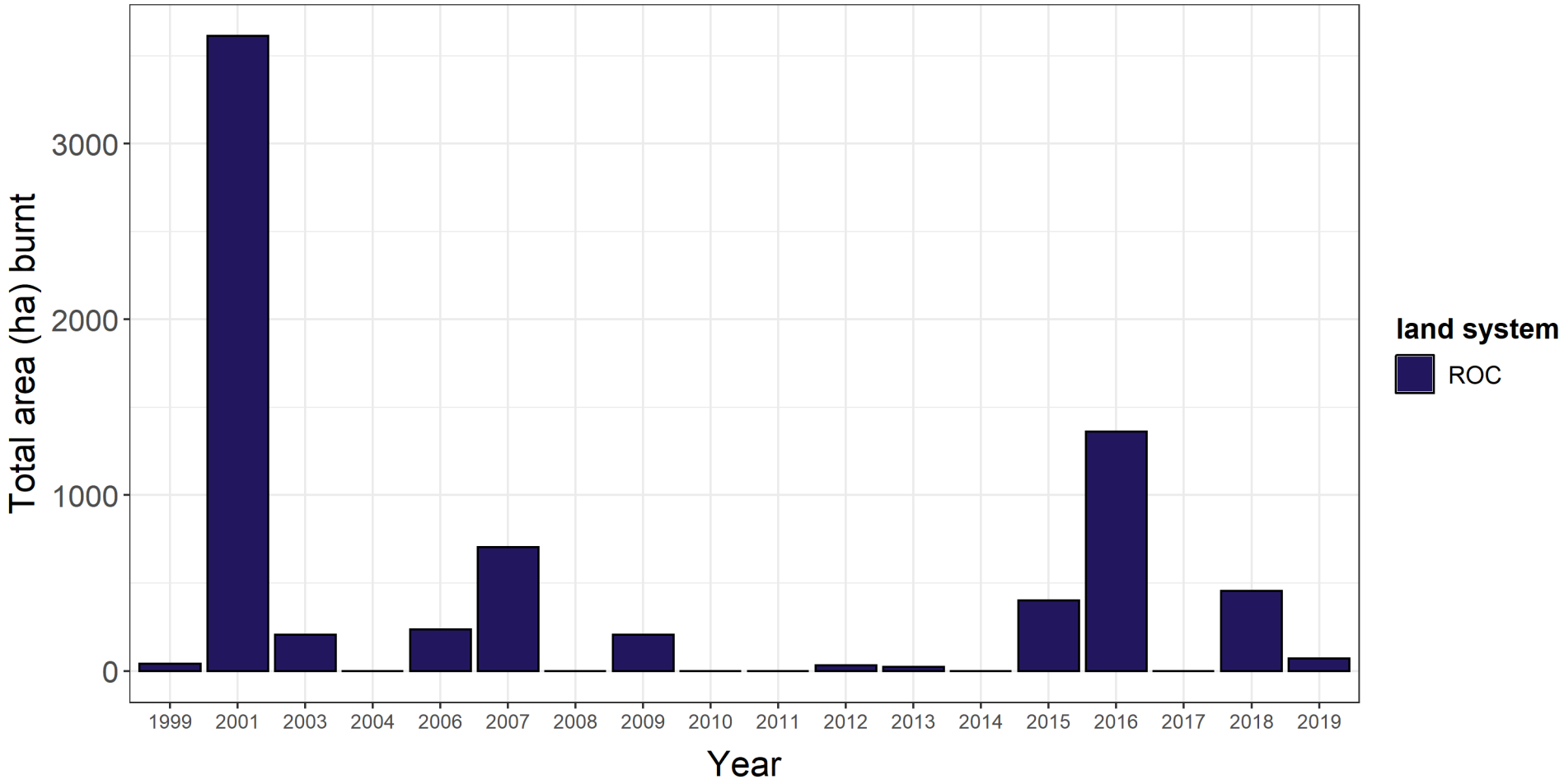

Figure 19 Total area (ha) burnt per year across the Rocklea land system for each year of available fire mapping.

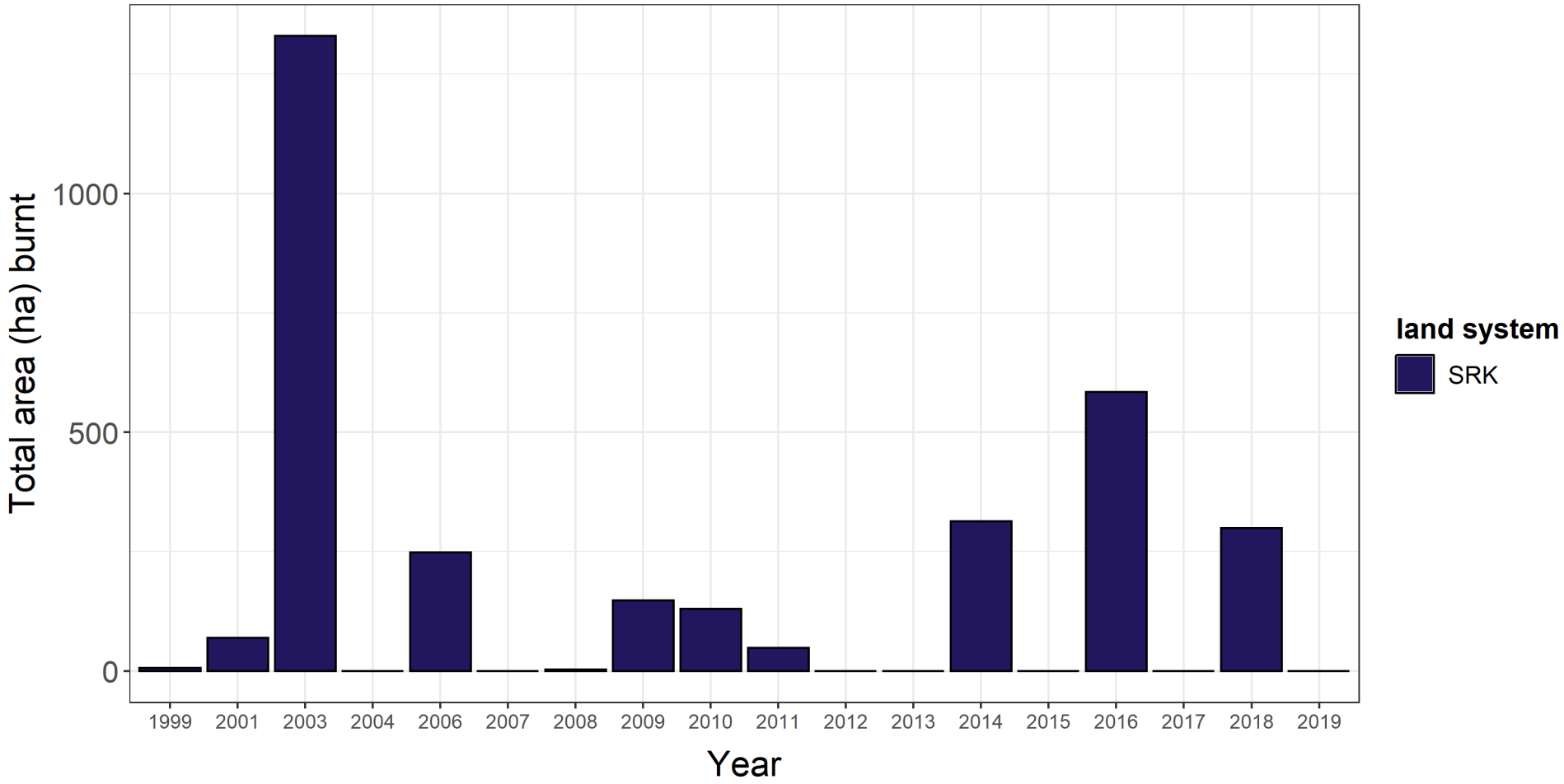

Figure 20 Total area (ha) burnt per year across the Sherlock land system for each year of available fire mapping.

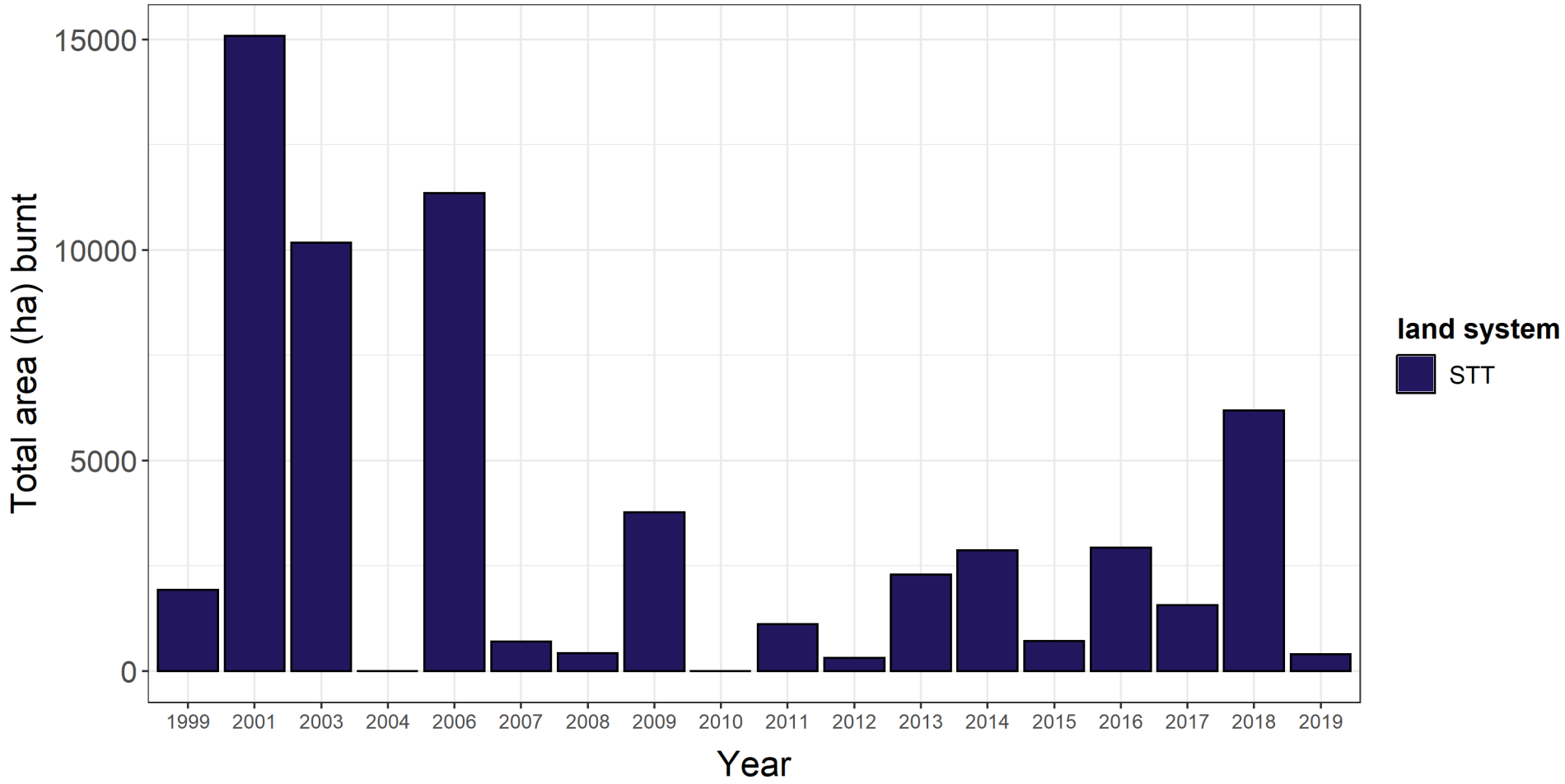

Figure 21 Total area (ha) burnt per year across the Stuart land system for each year of available fire mapping.

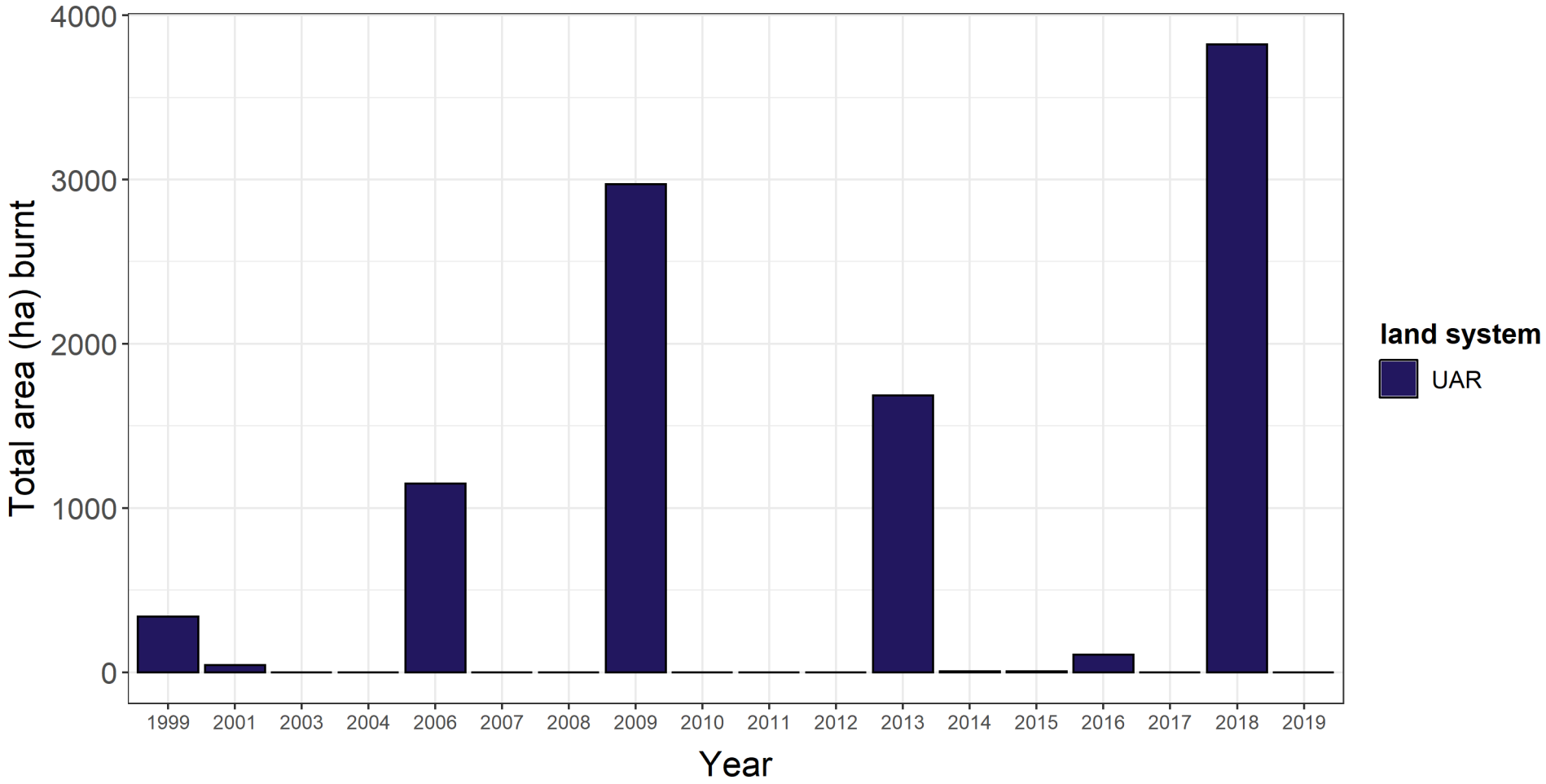

Figure 22 Total area (ha) burnt per year across the Uaroo land system for each year of available fire mapping.

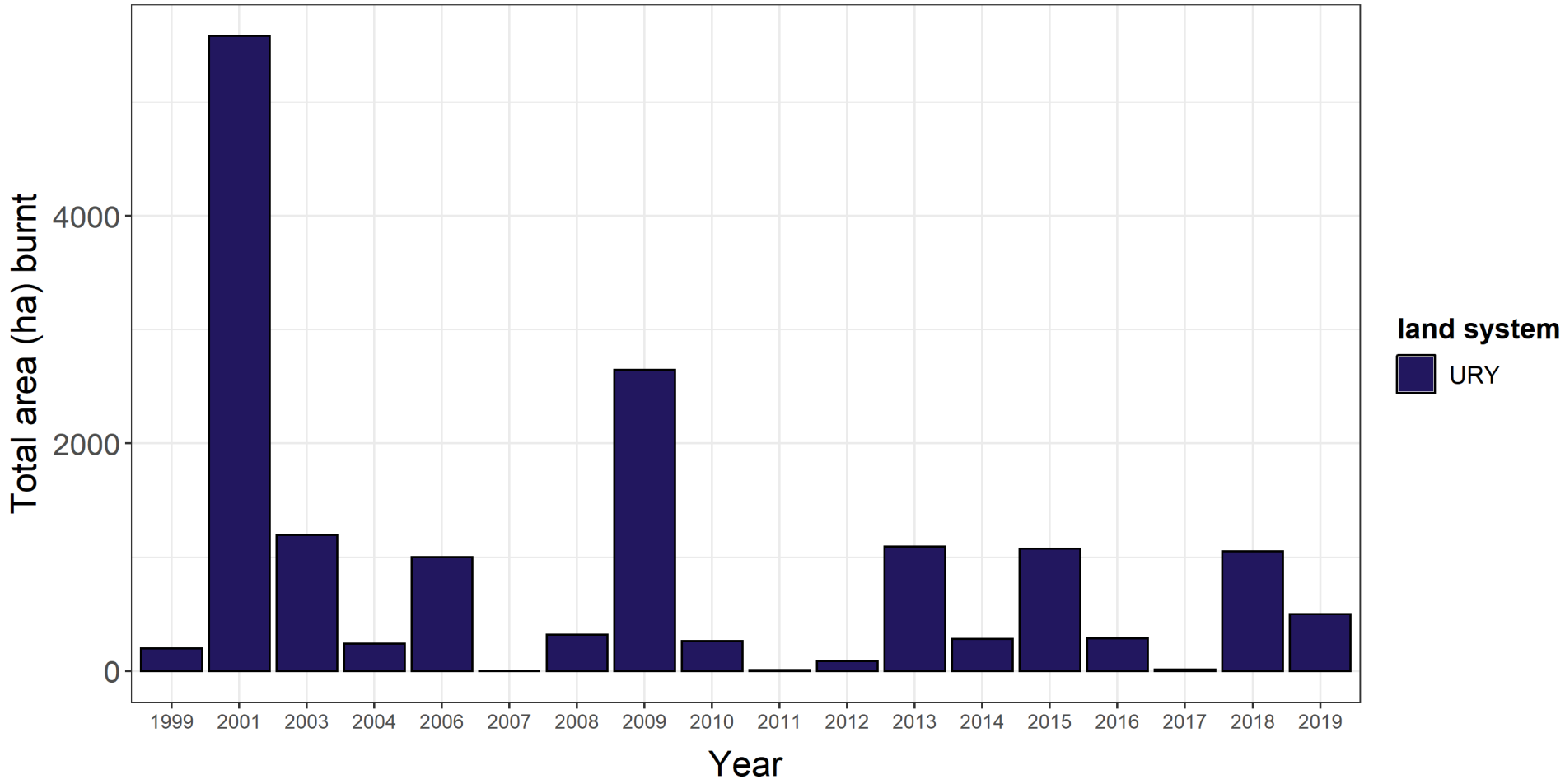

Figure 23 Total area (ha) burnt per year across the Urandy land system for each year of available fire mapping.

4 Data limitations

4.1 Spatial resolution

Landsat satellite imagery has a 30m pixel resolution for the reflectance bands which are used for extracting fire scars. Small fires less than 30m X 30m and detailed edging around larger fires are not able to be extracted at this resolution. Due to the uncertainty around the smaller fires any isolated area of mapped ‘fire’ less than 1 hectare is deleted from the final dataset.

4.2 Fire data attribution

At this current time, it is not possible to attribute the fire scar data with monthly date attribution for every month of the year. Fire scars are currently mapped using a difference image between two dates which are generally one year apart; occasionally they are mapped more frequently. Using this method, we are only capable of showing the change in the vegetation between those two dates and as such can only determine that the fire occurred at some point in that year interval.

4.3 Size class distribution of fire scars

In order to calculate metrics based on the size class distribution of fire scars it must first be possible to attribute the fire scars with a more accurate date. The fire scars represent an annual change in vegetation cover over an area. For example; if a fire starts in March and burns 50 ha before extinguishing then another fire starts in June and burns another 50 hectares right up to the boundary of the March fire an annual snapshot of that area would show one larger fire of 100 ha rather than two smaller 50 ha fires a few months apart in age. Calculating metrics based on size class distribution using the current fire scar data could overestimate the percentage of larger fires.

4.4 Missing annual fire scar data

Historical fire scar data for years 2000, 2002 and 2005 is not available; therefore, comparisons of annual changes in fire scar area cannot be made for the period 1999 – 2006. Where there are greater than annual gaps, the fire scars identified could have occurred at any time within the two year period between image dates. This impacts the fire metric analysis in that statistics such as average burnt area per year cannot be calculated across the entire time period.

The table below indicates the imagery dates for previous years fire mapping.

Table 9 Historical fire mapping image sources and dates over Red Hill pastoral lease

Source data	Image date	Mapping Year
NCAS	23/11/1999	1999
NCAS	16/02/2002	2001
NCAS	21/06/2004	2003
NCAS	16/02/2005	2004
NCAS	06/02/2007	2006
NCAS	04/10/2007	2007
NCAS	10/01/2009	2008
NCAS	14/02/2010	2009
USGS	23/12/2010	2010
USGS	12/02/2012	2011
USGS	02/03/2013	2012
USGS	25/02/2014	2013
USGS	16/03/2015	2014
USGS	29/12/2015	2015
USGS	31/12/2016	2016
USGS	18/12/2017	2017
USGS	06/01/2019	2018
USGS	24/12/2019	2019

4.5 Landsat 7 SLC-Off missing data stripes

During the period November 2011 to April 2013 the only available Landsat imagery was from Landsat 7 ETM+ and this imagery had missing data lines (‘stripes’) which affects the detection and attribution of fires scars. This results in some fires having ‘stripes’ of missing mapping which then affects the calculation of areas, fuel age and fire frequency.

Landsat images affected by the Scan Line Corrector (SLC) failure are missing approximately 22% of data. Generally, the most area lost is towards the edges of the scene with the middle of a scene unaffected. Figure 10 shows an example of the area of the Red Hill LMA affected by the SLC failure in 2012. The white stripes in the image represent missing data.

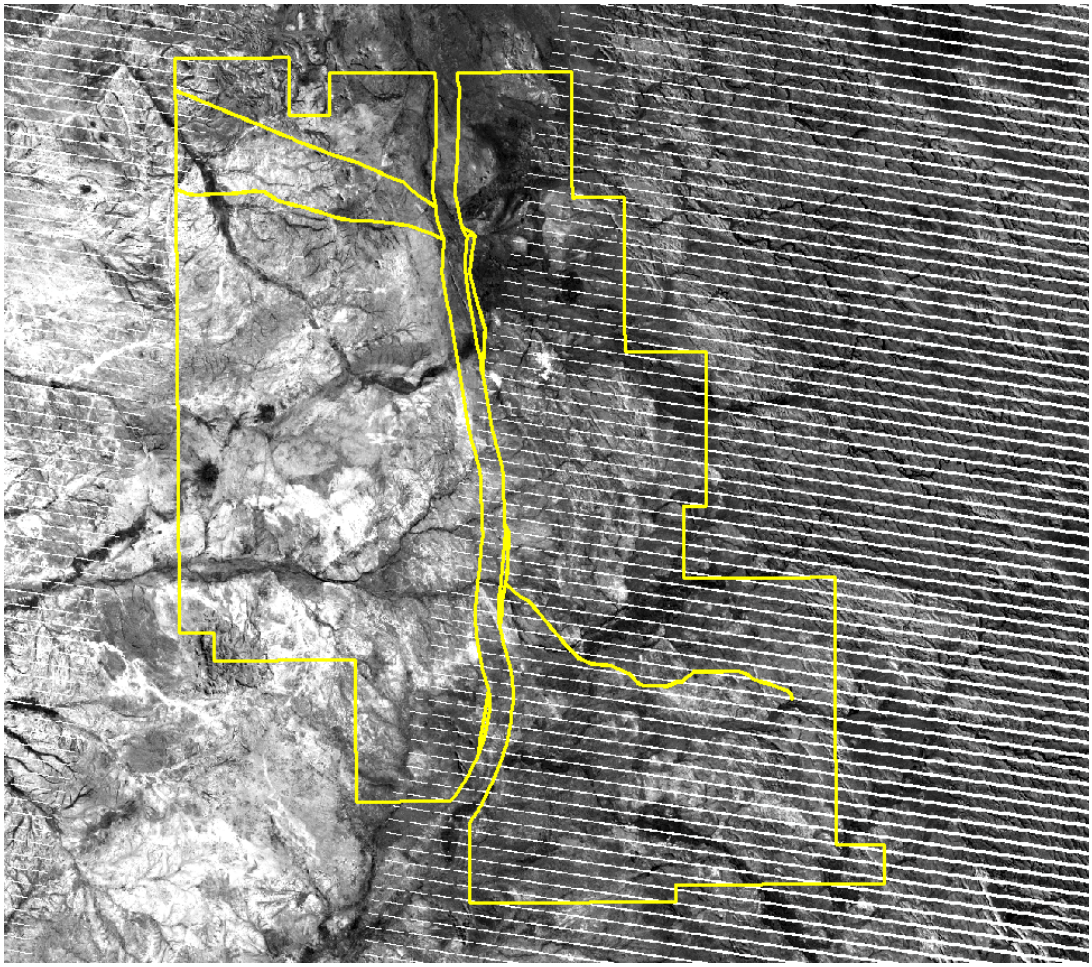

Figure 24 Location of missing data across the Red Hill LMA for Landsat image date 02/03/2012.

Landsat 7 images affected by the SLC failure were used for the fire mapping in years 2012 and 2013. Within the Red Hill LMA approximately 5.6% of data is missing for these years.

References

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van Vreeswyk, A. M., Leighton, K. A., Payne, A. L., and Hennig, P., (2004). An inventory and condition survey of the Pilbara region, Western Australia, Department of Agriculture and Food, Western Australia. Technical Bulletin 92, 424p.

Data delivery

Datum and projection: GDA 94 MGA50

Date delivered: 25/8/2020

Contact: Katherine Zdunic/Jane Chapman, Remote Sensing Science, Department of Biodiversity, Conservation and Attractions

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Dataset Delivered	**Format**	**Description**
RedHill_Fire_1998_2019_10km_buff	ESRI shapefile	Fire scar mapping for Yarraloola LMA and surrounding area within a 10 km buffer for the time period 1999 – 2019 for all available years
RedHill_2019_Fire_stats_report	PDF	This report document
RedHill_graphs	JPEG	The graphs contained in the report as JPEGs derived from the raw data
redhill_total_area_burnt_years_stats_2019	Excel csv	Raw data