226

Construction of a 200-year annual domestic livestock distribution geographical dataset for Australia for the pre-digital era 1788 to 1980.

Irvine, SA[1,3]; Carter, JO[2,3]; Stone, GS[1,3]

[1] Grazing Land Systems; [2] Remote Sensing Centre, [3]Queensland Department of the Environment, Tourism, Science and Innovation, Brisbane, Queensland 4001, Australia.

Key words: Livestock; grazing distribution; pastoral history

Abstract

Domestic livestock statistics across all Australian jurisdictions have been collected since 1788. Cattle, sheep and horse numbers for the period were digitised from paper sources. Statistical district boundaries were also digitised from mapping sources for each year and coded to link to the digitised livestock records. Estimation of pre-European vegetation, natural waters, the development of stock water areas (bores, small dams), irrigation (fodder crops and pastures) and protected areas were used to distribute livestock within each statistical district for each year.

This work focuses on historical data as part of an undertaking to produce a comprehensive Australian high resolution time series map (1km2 grid) of livestock from 1788 to 1980. Such data is of use in grazing system models and other applications such as estimating long term methane emissions to help understand the long-term impacts of domestic livestock grazing pressures on the landscape and atmosphere.

This data collection shows a decline in data quality, due to the declining number and increased areas of statistical districts reporting livestock population. The results document the expansion of domestic livestock in area and numbers from first settlement and the probable distribution at a finer scale.

Introduction

Providing an estimate to historical grazing distribution within Australia will provide better understanding and background to the current environmental impacts. Climate variability and grazing pressure on the rangelands are well documented in McKeon et al. 2004 p 19, along with impacts on the Great Barrier Reef (Lewis et al. 2021), changes in native pasture composition (Dixon 1892; Carr and Turner 1959a; Harrington et al. 1979; Rolls 1981 pp 111,129), scrub and/or woody regrowth (Rolls 1981 p 185; Wilson 1990) and soil degradation (Carr and Turner 1959b; Rolls 1981 pp 129, 246). This dataset will facilitate exploration of issues such as land clearing, woodland thickening and methane emissions (Hempson et al. 2017). Domestic livestock within this paper refers to only horses, cattle and sheep, with feral livestock numbers not being included.

This work focuses on historical data prior to 1980 as part of an undertaking to produce a comprehensive Australian high resolution time series map of livestock from 1788 to current for use in grazing system models such as AussieGRASS (Carter et al. 2000). To this end, annual livestock population data that was available for all Statistical Districts was acquired and digitised. Mapping sources that showed the statistical districts or similar spatial entities were collected and used to estimate likely spatial boundaries at the time of collection. Later a disaggregation method was used, that proportioned the livestock population in each statistical district, in each year, to likely grazing densities that would be experienced. These are shown as an animal equivalent estimate per kilometre (AE km2).

Methods

Livestock numbers for each jurisdiction (six States and two Territories) were digitised from historical records and followed the progression of European land management throughout the 19th century (Fig. 1). Many of the livestock statistics were not continuous, and temporal gaps at the statistical district level were common. In these years, livestock totals for the jurisdiction were provided and used to estimate numbers for the statistical districts based on a percentage breakdown from the years where recorded data were present.

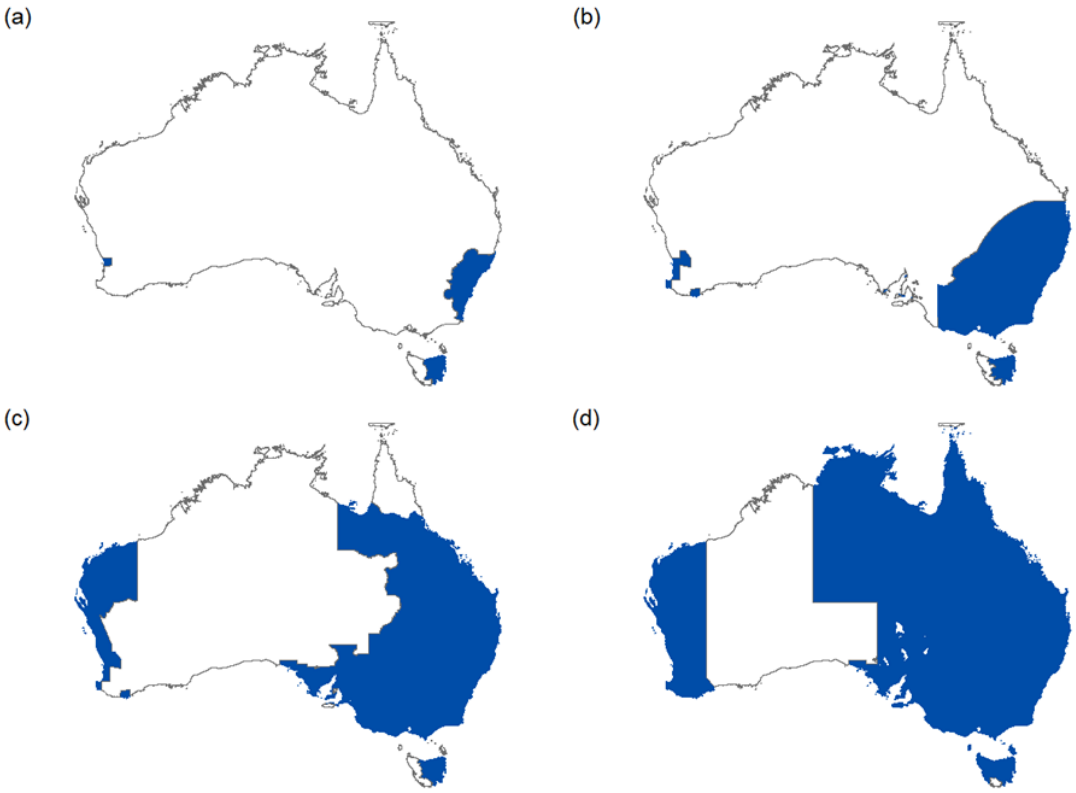

Fig. 1. The statistical districts shown in blue that were created within Australia by (a) 1830;(b) 1850; (c) 1870; and (d) 1890. The continent was fully covered by 1891, excluding major saline areas.

Mapping was based on maps used at the approximate time of the original data collection and where possible the same spatial entity as described in the textual records (i.e. local government area, police district, county etc). The spatial boundaries were subsequently captured by GIS using current digital cadastral information as a basis. The livestock numbers were converted to a common unit being dry adult equivalents (450kg cow

or horse). Sheep numbers used a conversion of 7 sheep to 1 adult equivalent, with horse and cattle numbers being assumed as the same adult equivalents (Stone 2004 p194).

A common map code was added to the livestock (tabular) and statistical district data (spatial). This allowed a spatial join to be performed within ArcGIS Pro (Environmental Systems Research Institute 2024), creating a yearly spatial dataset showing the relevant livestock data within a spatial boundary. A heuristic livestock distribution was generated via ArcGIS Pro to downscale the livestock record for each statistical district for any given year. The distribution was based on a grazing land class that estimated the grazing pressure likely to occur in the statistical district based on the grazing land class and availability of water. The full methodology including the historical background, data sources, mapping references, and the determination of land grazing classes and associated land development features is described in Irvine et al. (2024).

Results

A median livestock distribution for all years from 1788 to 1980 is shown in Fig. 2. Biannual distribution maps are shown in Irvine et al. (2024). It is also shown that from the natural state of grazing lands, approximately 992,905 km2 of Australia had been improved by 1980 via clearing, water improvements and fencing, enabling an increased livestock density across the continent.

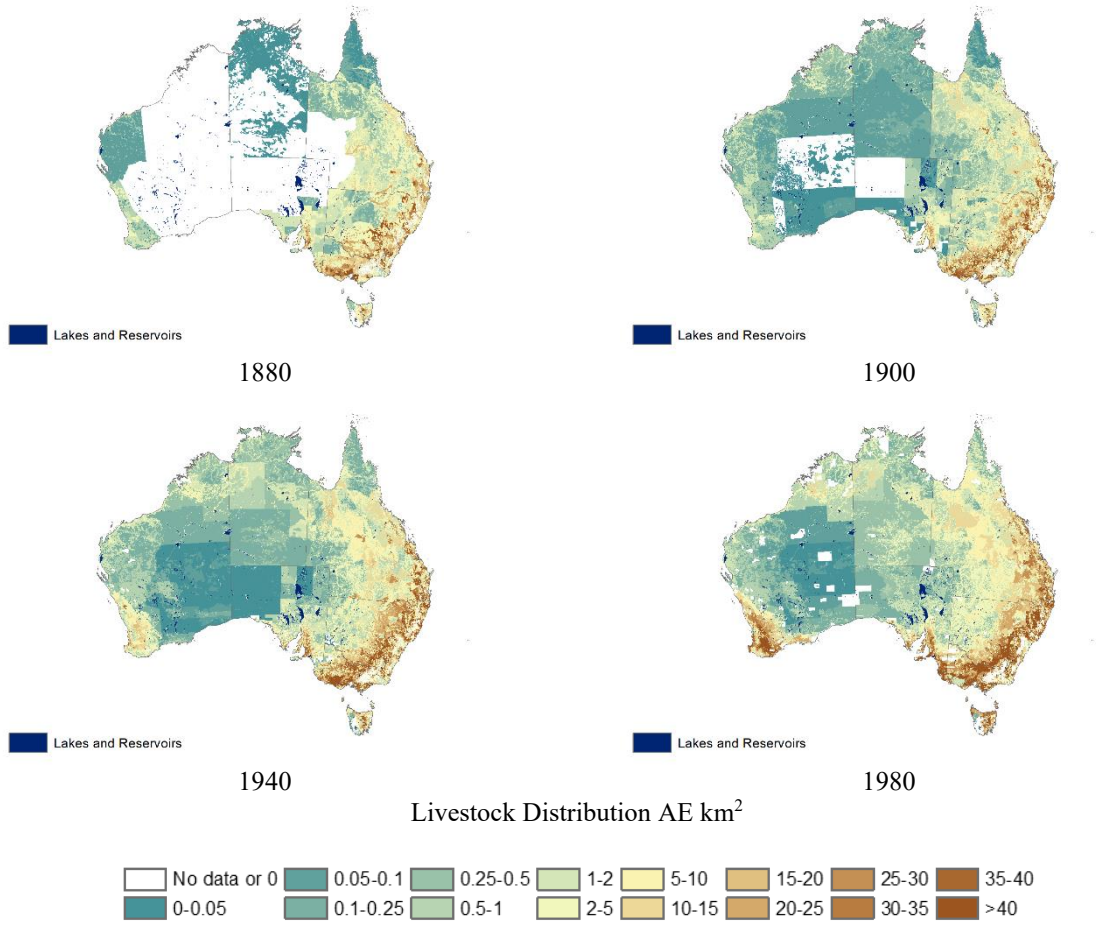

Fig. 2. Livestock distribution calculated for selected years.

In contrast to the continuous land improvement and increased livestock population, the statistical districts being used have decreased in number (Fig. 3) and are larger in area due to recent local government area amalgamations.

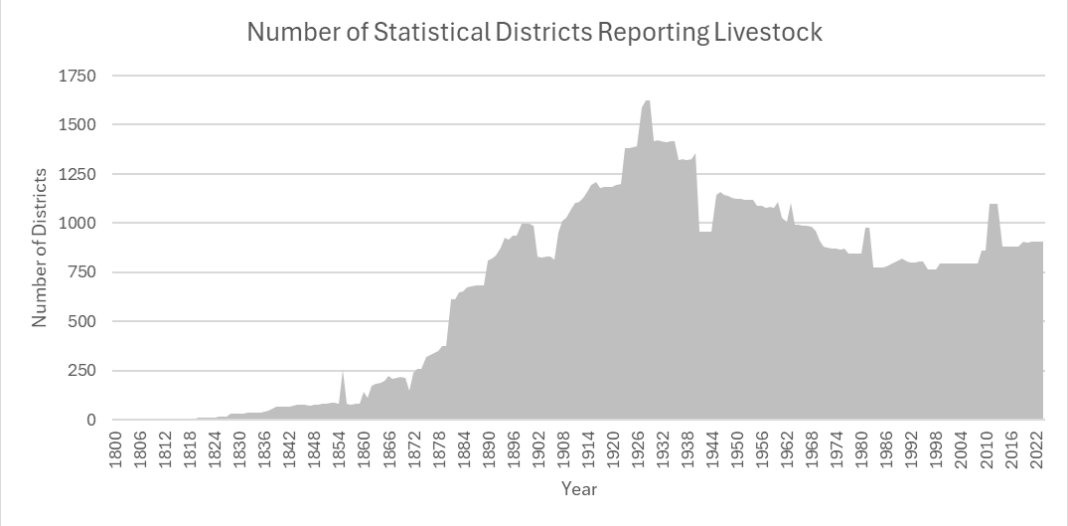

Fig. 3. The number of statistical districts reporting livestock have generally been declining since the 1920's.

Discussion

This study has accumulated all readily available Australian livestock population numbers collected at a statistical district scale, in a standardised format, proportioned to likely grazed areas and presented at a 1km resolution. However, significant gaps and limitations still exist due to the absence of records and/or inability to find all records.

The dataset generated from this analysis is a step in the process of estimating historical total grazing pressure, extending knowledge to previously unknown areas. It provides a standard baseline for any investigation to any aspect of Australian historical livestock populations, providing a grazing distribution to any spatial area.

The statistical record is being seen as degrading in quality mainly due to the amalgamation of pastoral statistical districts in recent years (Fig 3.), leading to a current discussion on the suitability of livestock data for analysis (Fordyce et al. 2023). This has likely led to changes and the development of new methodologies for the collection of livestock statistics, as noted by the Australian Bureau of Statistics (2024).

Acknowledgement

The authors are grateful for the assistance of Terry Beutel and Paul Novelly for their initial reviews.

References

Australian Bureau of Statistics (2024) Australian Agriculture: Livestock, Statistics on value of principal livestock disposals and products and the cattle herd for 2022-23 financial year. Available at https://www.abs.gov.au/statistics/industry/agriculture/australian-agriculture-livestock/2022-23 [Accessed 15 06 2024.

Carr SG and Turner JS (1959a) The ecology of the Bogong High Plains. I. The environmental factors and the grassland communities. Australian Journal of Botany 7(1): 12-33. https://doi.org/10.1071/BT9590012

Carr SGM and Turner JS (1959b) The ecology of the Bogong High Plains. II. Fencing experiments in grassland communities. Australian Journal of Botany 7(1): 34-63. https://doi.org/10.1071/BT9590034

Carter JC, Hall WB, Brook KD, McKeon GM, Day KA, Paull CJ (2000) Aussie Grass: Australian Grassland and Rangeland Assessment by Spatial Simulation. In 'Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems. Atmospheric and Oceanographic Sciences'. (Eds Hammer GL, Nichollis N, Mitchell C). 21, pp. 329-349. Springer, Dordrecht. Available at https://doi.org/10.1007/978-94-015-9351-9_20.

Dixon S (1892) The effects of settlement and pastoral occupation in Australia upon the indigenous vegetation. Transactions of the Royal Society of South Australia 15: 195-206.

Environmental Systems Research Institute (2024) ArcGIS Pro 3.1.2. Redlands, CA.

Fordyce G, Shephard R, Moravek T, McGown MR (2003) Australian cattle herd: a new perspective on structure, performance and production. *Animal Production Science* 63, 410-421. Available at https://doi.org/10.1071/AN20342

Harrington GN, Oxley RE, Tongway DJ (1979) The effects of European settlement and grazing on the biological system in poplar box woodlands. Proceedings of the Poplar Box Symposium, Cobar, N.S.W. *Australian Rangeland Journal* 1 (27): 1-9. https://doi.org/10.1071/RJ9790271

Hempson GP, Archibald S, Bond WJ (2017) The consequences of replacing wildlife with livestock in Africa. *Sci Rep* 7: 17196. Available at https://doi.org/10.1038/s41598-017-17348-4.

Irvine S, Carter J, Stone G (in prep) Estimating Historical Domestic Grazing Density for Australia, 1788-1980 Technical Paper. Queensland Government, the Department of Environment, Science and Innovation, Brisbane

Lewis SE, Bartley R, Wilkinson SN, Bainbridge ZT, Henderson AE, James CS, Irvine SA, Brodie JE (2021) Land use change in the river basins of the Great Barrier Reef, 1860 to 2019: A foundation for understanding environmental history across the catchment to reef continuum. Marine Pollution Bulletin 166: 112193. https://doi.org/10.1016/j.marpolbul.2021.112193

McKeon GM, Watson IW, Hall WB, Henry BK, Power SB, Stone GS (2004) Summary In 'Pasture Degradation and Recovery in Australia's Rangelands: Learning from History'. (Eds McKeon G, Hall W, Henry B, Stone G, Watson I). pp. 17-26. Department of Natural Resources Mines and Industry, Queensland Government, Brisbane.

Rolls EC (1981) A Million Wild Acres: 200 years of man and an Australian forest. Penguin Ringwood, Victoria.

Stone GS (2004) Analysis of grazing pressure from the long-term livestock records of two western Queensland pastoral properties. In 'Pasture Degradation and Recovery in Australia's Rangelands: Learning from History'. (Eds McKeon G, Hall W, Henry B, Stone G, Watson I). pp. 191-207. Department of Natural Resources Mines and Industry, Queensland Government, Brisbane.

Wilson AD (1990) The effect of grazing on Australian ecosystems. Proceedings of the Ecological Society of Australia 16: 235–244.