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Foreword

Nitrous oxide (N_2O) is a potent greenhouse gas with a Global Warming Potential of nearly 300 times that of carbon dioxide. Agricultural soils emit more nitrous oxide to the atmosphere than any other anthropogenic source. Nitrous oxide is produced in soils through the microbial processes of nitrification and denitrification, which are directly influenced by the amount of nitrogen applied to soils, whether that be in the form of mineral fertilisers, urine from livestock, organic manures, or compost. In addition to these direct emission sources, mineral nitrogen losses from volatilisation and leaching indirectly contribute to N_2O emissions. Unlike carbon dioxide, N_2O has no significant terrestrial sink, and mitigation is only achieved by manipulating nitrogen inputs and the soil biophysical environment.

Australia's diverse agricultural systems and soils provided a rich environment for developing a comprehensive understanding of the abiotic and biotic processes underpinning N_2O and associated gaseous emissions of di-nitrogen and ammonia. This special edition of *Soil Research* represents a snapshot of the results obtained by the Nitrous Oxide Research Program (NORP) (2009–2012) and the National Agricultural Nitrous Oxide Research Program (NANORP) (2013–2016). The NORP and the NANORP field research studies were underpinned by fully automated greenhouse gas sampling chambers with *in situ* analysis of carbon dioxide, N_2O, and methane. Similar systems have subsequently been deployed through institutional collaborations in Chile, Brazil, India, and the United States.

Both the NORP and the NANORP were funded by the Department of Agriculture and Water Resources managed by the Grains Research and Development Corporation and coordinated by Queensland University of Technology. Other major investors included Dairy Australia, the Cotton Research and Development Corporation, Sugar Research Australia, and Incitec Pivot Ltd.

The NANORP was a nationally distributed network of 23 field, laboratory, and simulation research projects including universities, State Government departments, and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). NANORP was specifically designed to identify N_2O mitigation strategies, which embrace the synergies of the soil carbon and nitrogen cycles, and increase nitrogen use efficiency, the long-term productivity, and profitability of Australia's rural industries.

Projects within NANORP were allocated to one of four overarching themes:

- The role of efficiency fertilisers in reducing N_2O emissions.
- The role of soil carbon in N_2O emissions.
- Reducing nitrous oxide emissions through improved nitrogen use efficiency.
- Improved process understanding of the N cycle and new technologies to reduce gaseous N losses.

The specific outputs of the NANORP included:

- Standardised data collection to ensure provision of high-quality data for full greenhouse gas accounting of agroecosystems.
- High-quality sub-daily temporal resolution data on N_2O emissions as a function of soil chemical and physical properties and agronomic management in a usable format for a wide variety of end users.
- A collective, advanced understanding of the soil biogeochemical processes underpinning N_2O emissions from Australian soils and how these are influenced by soil management and climate.
- The accurate translation of laboratory and field research to mechanistic models to significantly enhance their ability to predict N_2O emissions as a function of soil type, climate and management.
- A coordinated systems approach for end-to-end delivery of robust, practical management strategies to reduce N_2O emissions from soils.

The NANORP studies included the innovative use of stable isotopes (^{15}N) in combination with automated chambers and laboratory studies to deliver the high temporal resolution emissions data required for an advanced understanding of the nitrogen cycle and N_2O emissions. In total, over 250 individual datasets were collected. Annual N_2O emissions ranged from a near zero background from unfertilised coarse textured cropping soils of Western Australia to $18.2\,kg\,N\,ha^{-1}$ from sugarcane receiving $140\,kg\,N\,ha^{-1}$ in northern Queensland. This information now underpins the Australian National Greenhouse Accounts and decision support systems, which provide growers with the best management practices for sustainable management of their soil resources while reducing greenhouse gas emissions and maximising productivity.

This special issue is a culmination of a significant time commitment by researchers, project managers, government administrators, and growers over 7 years. The success of the

NORP and the NANORP programs was only possible through the enthusiastic, collegiate, and constructive attitude of all involved. The invaluable assistance of Klaus Butterbach-Bahl and his team at Karlsruhe Institute of Technology in the early days of our N_2O endeavours is also gratefully acknowledged.

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