# Estimating Nitrogen Fixation by Pastures on a Regional or Continental Scale

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**Introduction** With fertiliser N inputs dramatically increasing in Australia in recent years (Angus, 2001), regional and continental scale estimates of biological nitrogen fixation (BNF) are now required for assessing the risks of terrestrial and surface water eutrophication, groundwater contamination, and gaseous N emissions.

**Methods** A simple model was developed for assessing annual BNF inputs into different pasture types in areas equivalent to local government districts, for the years 1983 – 1997. An existing dataset (Pearson *et al.,* 1997 (ATPD)) provided data on pasture types, legume species and content, and groundcover for some 562 local government areas of the Australian crop and pasture zone. Pastures were aggregated into 15 different types, representing ecological responses to the principal environments. The pasture types were allocated proportionally to the total pasture area (largest source of error) for each region based on the ATPD. Data from the literature and unpublished studies on pasture dry matter (DM) production and seasonal rainfall (annual for perennial based pastures and April-October for annual pastures) was used to construct linear regressions of rainfall *vs* dry matter production. When coupled with annual rainfall datasets, this was used to estimate annual DM production for each pasture type in each of 409 areas. Annual legume DM was calculated from the percentage legume for each pasture type given in the ATPD. A literature survey was similarly used to estimate $N_2$ fixation/tonne legume dry matter, including an estimate for "below-ground N" (Unkovich & Pate, 2000).

**Results** Nitrogen fixed/t legume DM ranged from 22.7 kg/t for annual Medicago and most perennial legume based pastures, to 26.2 kg/t for annual Trifolium pastures, both include estimated fixed N in below-ground root and nodule fractions. Total N fixation in all pastures was estimated as 3.9 Mt in 1994, a low rainfall year, to 5.0 Mt in a wetter year (1992). 'Pasture types' in Table 1 reflect the pasture base, not necessarily principal legume components. Annual *Trifolium* pastures were estimated to contribute *ca* 1,339 kt N (23 million ha), and all pastures 4.6 Mt N (92 million ha). In the same year, N fertiliser use in Australia was *ca* 800 kt, rising to 1100 kt in 2000.

**Table 1** Total pasture areas, total N fixed, and averaged N fixation/ha for 1996

| Pasture type | ha x $10^3$ | kt N fixed | kg N fixed/ha |
|---|---|---|---|
| Tagasaste | 49 | 3.8 | 77.4 |
| **Lpuinus cosentinii** | 428 | 58.3 | 136.4 |
| Fertilised native annual | 593 | 3.9 | 6.6 |
| Native annual | 2646 | 1.5 | 0.6 |
| Native perennial | 10508 | 154 | 14.7 |
| Fertilised native perennial | 1193 | 10.1 | 8.5 |
| Oversown perennial | 5228 | 49.7 | 9.5 |
| Tropical grass | 3161 | 542.9 | 171.7 |
| Naturalised medic | 3601 | 40.2 | 11.2 |
| Annual grass | 1114 | 7.6 | 6.8 |
| Madicago sativa | 5739 | 673.8 | 117.4 |
| Perennial grass | 10364 | 961.4 | 92.8 |
| Perennial legume | 1224 | 199.4 | 162.9 |
| Annual *Medicago* | 22462 | 453.5 | 20.2 |
| Annual *Trifolium* | 23438 | 1338.9 | 57.1 |
| TOTAL | 91748 | 4499 | |

**Conclusion** Pasture legumes are estimated to have contributed 80% of the N input into Australian agriculture in 1996. McLaughlin *et al.* (1992) estimated N fixation in pastures to be 1.5 Mt (1987-88), and Jenkinson (1990) gives global biological fixation to be 140 Mt. On the basis of the present data, continental scale estimates for biological N fixation may need to be revised upwards.

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