ECOGEOGRAPHIC ASSESSMENT OF MEDITERRANEAN ENVIRONMENTS FOR TARGETING LEGUME COLLECTIONS

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ABSTRACT

The mediterranean area is the centre of diversity for many of the legume species of agricultural importance and their wild relatives. Ecogeographical assessments are a method of determining the areas within the mediterranean that are homologous with a particular area within southern Australia. Using Geographical Information Systems the distribution of legume species are mapped and related to other climatic and edaphic factors. Using this data it is possible to show which areas of the mediterranean have been well collected and where the edaphic requirements of a species can be found and therefore where to collect it. The detail of an ecogeographic assessment allows factors such as site habitat, water drainage, altitude, aspect and pH to be included, as well as soil type and climate, and in particular, rainfall. Two examples are given; a herbarium based study on perennial medics (*Medicago*) and a seed collection in Crete for pasture, forage and grain legumes.

KEYWORDS

Ecogeography, mediterranean, Geographical Information Systems (GIS), legumes, *Medicago*, *Trifolium*, diversity

INTRODUCTION

Legumes are an important part of the southern Australian agricultural system because of their ability to fix nitrogen and thus increase the fertility of the soil. However their productivity is limited due to the narrow genetic base within each species in the southern hemisphere and the few legume species in cultivation.

Southern Australia has a similar climate to that found in the Mediterranean with warm to hot, dry summers and cool wet winters, but there are major differences in the soil and rock types. The mediterranean is composed of a high proportion of limestone and high pH soils. These highly fertile soils support a large number of plant species, including legumes. In southern Australia the soils are older and weathered, and subsequently more acidic and nutrient poor, resulting in a much lower natural diversity.

The objectives of this study were to show;

1. The importance of the mediterranean for legume collections for southern Australian agriculture,
2. The value of ecogeographic assessments in targeting collections, and the relevance of Geographical Information Systems in ecogeography.

MATERIALS AND METHODS

Ecogeography is the collection and synthesis of ecological, geographical and taxonomic data. The results are predictive and can be used to determine collection and conservation priorities (Maxted *et al*., 1995). Ecogeographical surveys can be conducted using either herbarium specimens or seed collections. However for a true estimation of a taxa's distribution, detailed data is required with each specimen.

Two detailed ecogeographical analyses were conducted, one on perennial *Medicago* species from herbarium specimens and one from a collecting trip to Crete.

The perennial *Medicago* specimens were collected from four herbaria; Kew Gardens, Edinburgh Botanic Gardens and the British Museum, U.K, and le Jardin de Botanique in Montpellier, France (unpublished, summary in Bennett, 1996). Co-ordinates for latitude and longitude were acquired for each specimen for the GIS analysis which is an integral part of the ecogeographical assessment.

The seed collection took place in Crete in May 1995, for potential grain and forage legumes, and associated pasture legumes (Francis *et al*., 1995) The target was to collect species from heavy soils of high pH.

The passport data associated with each study was entered into a database management system. Each specimen was plotted onto a map of the mediterranean area using GIS. This data was then queried to determine the distribution of each species and their occurrence at particular climatic and edaphic conditions.

A conspectus was also generated to give a general overview of the ecogeography of each taxa within each study. For more detail on designing conspectus' see Maxted *et al*. (1995), Maxted (1995) and Edmonds (1990).

RESULTS AND DISCUSSION

Herbarium specimen collection. *Medicago sativa* (lucerne or alfalfa), is the only perennial species of *Medicago* cultivated in Australia. However there are 21 other perennial species in the genus, occurring in the mediterranean areas of Europe, north Africa and west Asia. There is potential that some species may be suitable for agricultural use in southern Australia, either in their own right or as part of a breeding programme.

The 1575 *Medicago* specimens recorded for the study were identified from a range of 25 taxa, and from 51 countries around the mediterranean. The most widespread species were *M. falcata*, *M. lupulina*, *M. marina*, *M. sativa* and *M.* x *varia* and the countries containing the most diversity were France, Italy, Turkey and the former Soviet Union. No herbarium specimens of *M. platycarpa*, *M. rupestris* and *M. saxatilis* were identified, and *M. cancellata*, *M. dagestanica* and *M. glutinosa* were found to be very rare.

The habitat and soil type preferences of each taxa were established using the passport data, along with their altitudinal range and natural distribution (Table 1). There was a wide range in altitude, but less difference in habitat and soils as most taxa showed a preference for grasslands and for alkaline soils, often calcareous. Two species, *M. lupulina* and *M. marina* are described to show the variation found in edaphic adaptation.

M. lupulina (black medic) showed the widest genetic adaptation in both habitat type and soil type, but occurred more frequently in grasslands, along waterways and in woodlands, with a strong preference for calcareous soils. This species is currently cultivated in America although to date its yield capacity is low (Lesins and Lesins, 1979; Townsend, 1974). However it persists readily even under a severe grazing regime and is known to reseed readily in a pasture (Small and Jomphe, 1989). *M. marina* is a specialist species that occurred almost exclusively by the sea and in loose sand. It was the only *Medicago* species of such habitat requirements. It is a stabiliser of loose sand and is thought to contain a degree of salt tolerance. However its range of pH tolerance is not known, and for use in southern Australia it would need some adaptation to acid sands.

To date a conspectus has been constructed for each taxa and the associated herbarium passport data has been mapped and relationships determined between taxa, distribution and ecology. The predictive ability of this ecogeographical assessment can be improved

by including rainfall and temperature data for the mediterranean area rather than relying on the minimal climatic data associated with the herbarium specimens. This is the next stage of the project and will result in an ecogeographical assessment that will greatly assist in the planning of future collection missions for the perennial medics.

Seed collection. Crete was chosen for the seed collecting mission as limestone is a predominate feature of its geology and it has the relatively high rainfalls that are associated with heavy, high pH soils (Francis *et al.*, 1995). The distribution of each of the species was mapped in relation to altitude, rainfall and soil pH. *T. angustifolium* and *T. lappaceum* are thought to show the most promise for colonising areas of high pH as *T. lappaceum* was only collected from one site with a pH of less than 7.5 and *T. angustifolium* was collected from a total of 10 sites of which 6 were above pH 7 and all were above pH 6. *T. resupinatum*, *T. pallidum* and *T. nigrescens* also showed some tolerance to high pH (figure 1).

Grazing pressure is also important when collecting for possible pasture or forage species. *T. nigrescens* and *T. resupinatum* were the only species collected in the heavily grazed areas but most other collected species were adapted to moderate grazing (Francis et al., 1995).

The results of this collecting mission have been used as part of an ecogeographical assessment of potential legume species for heavy alkaline soils. Thus if further collections of promising species are required, following trials in southern Australia, the information can be used to target the climate, soil type, and habitat types of the species in question.

Both of the ecogeographic assessments described above show the value of using this method to target collections in the mediterranean. With increasing costs and restrictions in quarantine, it is important to ensure that the collected taxa are those required in terms of genetic adaptation and agricultural potential. By using GIS in ecogeographical assessments then the chances of meeting those aims are greatly increased compared to the previous non-selective methods.

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Table 1
Perennial *Medicago* species and their geographic requirements

Perennial *Medicago* species	Altitude range	Habitat preference	Soil requirement
M. arborea	1 - 780m	seashore & gardens	calcareous
M. cancellata	?	?	?
M. carstiensis	47 - 650m	mountains and woodland	calcareous
M. cretacea	?	mountains	rocky, calcareous
M. daghestanica	?	?	?
M. falcata	3 - 1800m	variety, especially grassland	sand and calcareous
M. glomerata	350 - 650m	variety	calcareous
M. glutinosa	?	?	?
M. hybrida	?	?	?
M. lupulina	1 - 3571m	variety, especially grassland	calcareous and gravel
M. marina	1 - 149m	seashore	sand
M. papillosa	200 - 2530m	grassland	rocky
M. papillosa ssp. *macrocarpa*	1786 - 2530m	mountain grassland	?
M. papillosa ssp. *papillosa*	200 - 2530m	mountain grassland	rocky
M. pironae	250 - 600m	woodland	calcareous
M. platycarpa	?	?	?
M. prostrata	230 - 1350m	grassland	rocky
M. rhodopea	?	grassland hills	?
M. rupestris	?	?	?
M. ruthenica	?	?	rocky
M. sativa	1 - 3869m	variety, much cultivated	calcareous
M. sativa ssp. *caerulea*	1000 - 1520m	grassland	calcareous
M. sativa ssp. *sativa*	417 - 2150m	cultivated	?
M. saxatilis	?	?	?
M. suffruticosa	175 - 2750m	mountains	rocky, calcareous
M. suffruticosa ssp. *leiocarpa*	225 - 4500m	mountain grassland	calcareous
M. suffruticosa ssp. *suffruticosa*	208 - 1800m	mountain grassland	rocky, calcareous
M. x *varia*	18 - 2083m	grassland	rocky, sand, calcareous