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Pastures for Dryland Farming Systems

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January 2024

Supported by The British Academy THE NATIONAL ACADEMY FOR THE HUMANITIES AND SOCIAL SCIENCES

Commodities of Empire Working Paper No.37

ISSN: 1756-0098

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In 1890 Arthur J. Perkins, the manager of a large wheat farm and vineyard in the French Protectorate of Tunisia, received a letter from South Australia inviting him to apply for the position of government viticulturalist.[2] South Australia (SA) was a fledgling but largely self-governing colony under the British crown with a population of 325,000 that mainly depended on an export economy of wheat and wool. Although Perkins was a British national, he had grown up in North Africa and studied agricultural science at the L'École Nationale d'Agriculture in Montpellier in the south of France. The lengthy correspondence during his recruitment clearly demonstrated an acute awareness that South Australian agriculture was based on a dry Mediterranean climate and had many parallels to North African agriculture. As Perkins himself noted "it is a pleasure to know that I shall not require acclimatizing".[3] Still there were doubts about his suitability since he was not yet 21 years old. To boost his case, he noted his experience managing a vineyard and that he spoke French and Arabic fluently—but then added "I presume these languages would not be of any use in Australia."[4] In the end, his Montpellier degree and practical, albeit limited, experience in viticulture prevailed and he was offered and accepted the job. Before departing he received another letter on behalf of the SA minister in charge of agriculture requesting that he collect seed to the value of £20 for a wide variety of cereals and forages from the region "grown on the northern and southern shores of the Mediterranean… bearing in mind that the climate [of SA] is similar to the Mediterranean area."[5]

Perkins arrived in SA in 1892 and went on to become a leading personage as professor and then Director of Agriculture until retiring in 1936. It is not known how successful his seed shipment was, but seed of some Mediterranean forages were widely distributed to the farming community soon after he arrived. Periodically, Perkins and others returned to the Mediterranean region to seek forages suited to the diverse conditions of SA agriculture and after the Second World War systematic efforts were mounted by Australian scientists to explore and collect the rich genetic diversity of Mediterranean forages. In the mid-twentieth century several pasture legumes from the *Trifolium* (the

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[1] Paper originally prepared for a workshop, Livestock as Global and Imperial Commodities: Economics, Ecologies and Knowledge Regimes, Berlin, 14-15 July 2022. This is an abridgment of that paper available at https://www.pir.sa.gov.au/aghistory/publications_and_reports/historically_important_documents. I am grateful to Jock Anderson, Karen Brooks, Scott Christiansen, Helen Ann Curry, Jonathan Curry-Machado, Greg Edmeades, Gus Gintzburger, Edith Hesse, Simon Jackson, Nadim Khouri, Tom Nordblom, and members of the South Australian Agricultural History group who provided valuable information and comments for this paper. I owe a big thankyou also to the librarians and/or archivists for providing access to obscure research reports and unpublished documents at the University of Adelaide, Australian National Library, CSIRO, National Archives of Australia, David Lubin Library of FAO, Georgetown University, ICARDA, Miami-Dade Public Library, South Australian Public Library, and the US National Agricultural Library.

[2] J. Daniels (ed.), *The Personal Letterbooks of Professor A.J. Perkins, Government Viticulturalist in South Australia*, 1890-1901, Roseworthy: Roseworthy Agricultural College, 1982. Letter 20 Oct 1890.

[3] Daniels (1982), Letter 25 March 1891.

[4] Daniels (1982), Letter 20 October 1890.

[5] Daniels (1982), Letter 11 April 1892.

clovers) and the *Medicago* genera (notably the annual medics) transformed dryland farming in SA.[6] These all originated in the Mediterranean region although most were introduced accidently from the time of settlement. By the 1950s, these pasture species had become the core element in integrating crop and livestock farming in SA that greatly increased agricultural productivity and enriched soil fertility.[7]

By 1980, SA was sufficiently confident of the success of its dryland farming systems that it hosted a major international congress with a large contingent of delegates from countries of the Mediterranean region of the Middle East and North Africa (MENA).[8] The congress showcased SA's agricultural achievements and invited the rest of the world to learn from this experience. Delegates were provided an attractive book on *South Australian Farming Systems* with detailed colour maps and climatological data to illustrate other areas of the world with a similar Mediterranean climate where these systems could be employed. They also watched a film on SA farming, *Food from the Reluctant Earth,* that, like the book, had been translated into Arabic and French to reach the delegates from MENA. Finally, and most importantly, overseas delegates were invited to purchase SA expertise, machinery, sheep breeds, and even seed of the forages originating in their region. MENA was seen as a vast new market for SA products.[9]

Motivated by a mix of commercial, scientific and humanitarian objectives the SA government and South Australian scientists, farmers and private agro-industries were already engaged in several projects to transfer the dryland farming system to countries in MENA. These were lofty ambitions for a small state still with a population of only about one million and some 6,000 'broadacre' farmers, relative to the estimated 100 million people and about 10 million farmers in similar climatic environments in MENA.[10] Still, the world food crisis of the early 1970s had put a spotlight on spiralling grain and meat imports in the MENA region, while the accompanying oil price spike had provided the resources for many countries of the region to ambitiously invest in their agriculture using SA expertise and technologies.

This paper begins by describing the main institutions and actors that developed the SA dryland system, noting how imperial links with Britain contributed to building SA into a global leader of pasture science using species from the Mediterranean region.[11] It then reviews the efforts by these same institutions and actors to systematically explore the Mediterranean region for wild forage species and strains that could be directly introduced or that could enhance the genetic diversity for forage breeding programs in SA. The final section describes the 'return of the medic' through as many

[6] Defined here as occurring in the annual rainfall range of 250-500 mm, with more than two thirds falling during the winter and spring growing season.
[7] More detail is provided in D. W. Puckridge & R. J. French, 'The annual legume pasture in cereal ley-farming systems of southern Australia: A review', *Agriculture, Ecosystems & Environment* 9 (1983), pp.229-67.
[8] *International Congress on Dryland Farming. Proceedings*, Adelaide: Dept of Agriculture, 1984. T. W. Speedie, Report on International Congress on Dryland Farming, Adelaide, SA. District Conservation Office, Swan Hill, Victoria, 1980. File No. SC/D/42.
[9] A. Tideman, *The Medic Fields*, Adelaide: SAGRIC Int., 1994.
[10] J. Dixon, A. Gulliver & D. Gibbon, *Farming systems and poverty: Improving farmers' livelihoods in a changing world*, Rome: FAO, 2002.
[11] A parallel story of the state of Western Australia interacting with is not covered in this paper. The focus there was on *Trifolium* sp. suited to its extensive areas of acid soils.

as a dozen technology transfer projects in MENA from 1970 to 1990 that in the end largely failed.[12] The conclusions reflect on the processes and limitations of agricultural technology transfer across very different social, economic and cultural contexts, despite their climatic similarities.

The analysis of the flows of the pasture legume technology in both directions highlights three major themes in this paper. First there was a sense of excitement about the SA model of ley farming that integrated Mediterranean pasture legumes. The author of a popular history of pasture improvement in southern Australia concluded that "the ley farming system of the 1950s was seen as brilliantly successful" and with its low use of agro-chemicals, notably nitrogen fertilizer, it was "a 'green' system of great natural gain."[13] This was all the more notable, given that other industrialised countries had depended on nitrogen fertiliser that had become much cheaper after WWII, to raise their yields. This was also the model for the Green Revolution that emerged in the irrigated areas of Asia from the mid-1960s. Indeed, the SA success in raising yields was especially striking as it occurred in dryland farming areas that had not yet been reached by the Green Revolution. On the livestock side, the integration of livestock through year-round grazing in SA again contrasted with the intensive livestock industry emerging in most industrialised countries that increasingly depended on feed grains. In short, SA agriculture provided an alternative model for what today would be termed 'sustainable' or 'regenerative' agriculture that due to its low use of external inputs and integration of cereals, legumes and livestock grazing, was considered especially appropriate in the developing world.

The second theme relates to the processes of agricultural technology transfer. From the late nineteenth century, the concept of 'climatic analogues' was recognised—that is areas of similar climates, that spanned regions and even continents.[14] The so-called Mediterranean climate, defined broadly as areas between 30 and 40 degrees of latitude (north and south of the equator) with a winter growing season and dry hot summers, was one such analogue that spurred a two-way flow of seeds and other technologies between SA (and southern Australia, more generally) and MENA. The idea was that the performance of a given crop and technology could be replicated in a similar agro-climatic environment. For example, historian David Moon documents how Mark Carlton, a noted US 'plant explorer' around 1900, specifically targeted his collection of wheat varieties in the Black Earths of Russia to match specific climatic analogues in the US Great Plains.[15] But even if technically replicable, differences in social, economic and institutional conditions may curtail the transfer of a given technology. As Carlton noted in his Russian explorations, the climate and landscape were remarkably like his Great Plains "except as to the people."[16]

Economists Vernon Ruttan and Yujiro Hayami agree that direct transfer of agricultural technologies across countries even of similar climates is not commonly successful so what is needed is to transfer concepts and methods along with further 'adaptive research' in the recipient country to

[12] The 'return of the medic' borrows from S. A. Breth, *Return of the Medic*, CIMMYT Today No. 3, Mexico DF: CIMMYT, 1975.
[13] D. F. Smith, *Natural Gain in the Grazing Lands of Southern Australia,* Sydney: University of South Wales Press, 2000.
[14] For example, A. Aaronsohn, *Agricultural and Botanical Explorations in Palestine,* Washington DC: USDA, 1910.
[15] David Moon, 'In the Russians' steppes: the introduction of Russian wheat on the Great Plains of the United States of America', *Journal of Global History* 3 (2008), pp.203-25.
[16] Moon (2008), p.207.

modify the innovation – so-called 'design transfer'.[17] The transfer of technology analysed in this paper took place between regions with very similar climates but that differed sharply with respect to their scientific capacity to adapt and innovate. Moreover, the transfer of an entire dryland farming system from SA involved many elements of genetics, machinery, tillage practices, rotations and grazing management – greatly adding to the complexity of adaptation and increasing the requirements for local research capacity.[18]

Third, the Mediterranean exchange relates to the burgeoning literature on the history of commodity frontiers. Historian Sven Beckert and colleagues have identified four regimes or phases in this expansion. Efforts to transfer the dryland system to MENA fits into their second and third regimes (the first regime involves violent dispossession of land and use of unfree labour). In the second regime they specifically note that expansion of the commodity frontier often involves "the conversion of a system of customary land rights… and the transformation to… concretely defined, possibly enclosed, physical spaces."[19] These changes in property rights were at the core of efforts to expand the Australian dryland system into MENA. Similarly, in their third regime, inputs are "commodified" as was the case with medic seed that was transformed from a use value in MENA to a market value in SA and then became an export commodity from SA. Indeed, this history complements the history of the phosphate frontier in North Africa to serve an emerging global market for a critical crop nutrient.[20] Here I describe the 'commodification' of nitrogen, the most important nutrient in crop agriculture, again from a North African perspective, albeit with a less extractive approach.

Cultivating the Medics

South Australia was the only Australian colony founded by free settlers (rather than transported convicts from Britain) with the explicit objective of creating a middle-class agrarian society based on family farmers.[21] It was also a highly planned settlement where land and rural townships were surveyed, and transport infrastructure designed prior to the settlement that started in 1836. Initially, land was provided on short-term leases to large sheep-grazing enterprises that developed an export-oriented wool industry. This system was exploitative not only in treading on the rights and livelihoods of indigenous peoples surviving through hunting and gathering, but in rapidly denuding the natural vegetation. Dryland areas thought to be suited to wheat were progressively opened to closer settlement through sponsored immigration financed by land sales. While there were many ups and downs in the

[17] V. W. Ruttan & Y. Hayami, 'Technology transfer and agricultural development,' *Technology and Culture* 14:2 (1973), pp.124-5. Ruttan and Hayami also include a third category, the transfer of human and institutional capacity to build comprehensive local research programs to develop their own technologies.
[18] D. Byerlee, 'Opportunities for and problems of transferring Australian farming systems research to developing countries', in J. V. Remenyi (ed.), *Agricultural Systems Research for Developing Countries*, Canberra: Australian Centre for International Agricultural Research, 1986.
[19] Sven Beckert, Ulbe Bosma, Mindi Schneider & Eric Vanhaute, 'Commodity frontiers and the transformation of the global countryside: a research agenda', *Journal of Global History* 16 (2021), pp.435-50.
[20] Simon Jackson, 'The phosphate archipelago: Imperial mining and global agriculture in French North Africa', *Jahrbuch für Wirtschaftsgeschichte/Economic History Yearbook* 57:1 (2016), pp.187-214; Rebecca Gruskin, 'The value within multiform commodities: North African phosphates and global markets in the interwar period', *Journal of Global History* 16 (2021), pp.315-35.
[21] E. Richards, *The Flinders History of South Australia*, Vol 1, Netley: Wakefield Press, 1986; Douglas Pike, *Paradise of Dissent: South Australia 1829-57,* Melbourne: University of Melbourne Press, 1967.

early years, settlement did eventually proceed in an orderly manner with farms and associated towns laid out progressively north from the planned capital city, Adelaide, into drier land with larger farms of 640 acres that were operated by family labour with the aid of pioneering innovations in labour-saving machinery for ploughing and harvesting.

Despite being the driest of the six Australian colonies in the world's driest inhabited continent, by 1894 wheat was grown by about 12,000 farmers on 630,000 ha and SA had become the granary of the Australia colonies and the top export earner of the colony.[22] With plentiful land in the early years, an extractive system of continuous cropping of wheat developed that mined soil nutrients and led to declining yields and serious soil erosion. The first breakthrough was the discovery by one of SA's first agricultural scientists in the 1880s of a large and very profitable response of wheat to superphosphate fertiliser reflecting the very low phosphorus content of most Australian soils. The adaptive research to develop economic doses and efficient application methods was carried out by farmers themselves, resulting in almost universal adoption of superphosphate on wheat by 1910.[23] Most farmers also abandoned continuous wheat to introduce a year of bare or clean fallow, as recommended by scientists to store moisture and control weeds and diseases for the next wheat crop.

The next step in improving wheat-farming practices was to integrate sheep through the inclusion of a pasture phase, especially legumes, in the rotation to replace bare fallow. The story of pasture legumes reversed the roles of farmers and scientists in adopting superphosphate, with farmers in the lead in developing the initial system and scientists providing additional but critical refinements, after a considerable delay. Australia had only a handful of native annual legumes and these were unsuited to livestock feed – in fact, many were poisonous. Yet soon after settlement some 35 species of pasture legumes were already naturalised, including sub clover (*Trifolium subterraneum)* and several annual medics (*Medicago* species).[24] Most of these had been introduced unintentionally from the Mediterranean region through shipments of animals, animal feed, packing materials and other means.[25] They had been 'naturalised' in the sense that they were able to reproduce and spread voluntarily and, in fact, were widely regarded as weeds.[26] Indeed, the pioneering environmental historian, Alfred Crosby in his book, *Ecological Imperialism,* specifically highlighted the extensive spread of Mediterranean 'weeds' to dominate the vegetation in European settlements in many parts of the Americas and Oceania.[27] These weeds thrived because they were well adapted to the grazing animals, rotations and cultivation methods imported by the settlers.

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[22] Only 14% of area in SA is in the rainfall zone, 250-500 mm, and a mere 3.3% receives over 500 mm annually. E. D. Carter, E. C. Wolfe & C. M. Francis, 'Problems of maintaining pastures in the cereal-livestock areas of southern Australia', in *Proceedings of the 2nd Australian Agronomy Conference,* Australian Society of Agronomy, 1982, pp.68-82.

[23] Derek Byerlee, 'The super state: the political economy of phosphate fertilizer use in South Australia, 1880–1940', *Jahrbuch für Wirtschaftsgeschichte/Economic History Yearbook* 62:1 (2021), pp. 99-128.

[24] P. M. Kloot, 'Plant introduction to South Australia prior to 1840,' *Journal of the Adelaide Botanic Gardens* 7:3 (1985), pp.217-30.

[25] P. S. Cocks, M. J. Mathison & E. J. Crawford, 'From wild plants to pasture cultivars: annual medics and subterranean clover in southern Australia', in R. J. Summerfield & A. H. Bunting (eds), *Advances in Legume Science,* Kew: Royal Botanic Gardens, 1980, pp.569-96.

[26] Given that most ships stopped in Cape Town, South Africa, that also has a Mediterranean climate, many forage legumes arrived indirectly via South Africa where they were naturalised after settlement there in the seventeenth century.

[27] A. W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900,* New York: Cambridge University Press, 1986, pp.145-70.

Farmer-seedsman Amos W. Howard identified the potential of sub-clover in 1896 and actively championed its wider use in the higher rainfall areas.[28] He also developed methods to harvest the seed and recognised its excellent response to the application of superphosphate. This concept of seeding and fertilising pastures was a milestone in the development of the livestock industry in the better rainfall areas of Australia.[29] The 'sub and super revolution', as it came to be known, also spilled over into some wheat-growing areas. However, sub clover was not well suited to the extensive areas of dryland wheat with frequent drought stress and alkaline soils that made up over 75 percent of SA's wheat belt. In these areas, annual medics were very well suited and with careful management could self-regenerate annually from residual seed after the wheat harvest.

The step from naturalisation to cultivation of medics in rotation with wheat was a gradual process that took place over half a century. In practice, cultivation of medics ranged from minimally managed self-sown pastures to fertilisation and careful grazing of selected or bred strains. The adoption of superphosphate in the early 1900s favoured the growth of self-sown medics and the gradual integration of sheep into the dryland wheat-farming system in the fallow period.[30] The most common naturalised medic was *M. polymorpha*, commonly known as 'burr medic'; however, the burr became entangled with the wool leading to a significant price discount. Some farmers had also identified and were experimenting with 'burrless' medics.[31] However, no champion, such as Howard for sub-clover, had yet emerged to identify, produce and market seed of annual medics, and to popularise the dryland wheat ley-farming system.

Yet research, albeit delayed, was critical to the full development of the ley-farming system in order to identify and develop species, strains and associated *Rhizobia* bacteria that attach to legumes to fix nitrogen, fertilisation practices suited to specific rainfall and soil conditions, and appropriate rotations and grazing management regimes. Four institutions involving a handful of scientists played an outsized role within the wider Australian context in pasture research prior to the Second World War. These same institutions and many of these same actors would lead the Mediterranean exchange on medics after the war.

The establishment of Roseworthy Agricultural College (hereafter Roseworthy) was the first effort to place SA agriculture on scientific lines, and indeed was the first such institution in Australia. Founded in 1883 it emphasised teaching mainly for diploma-level courses for agricultural extension workers, but also played an important role in applied research. Identification of the strong response of wheat to superphosphate was one of its first and most enduring scientific breakthroughs. When Perkins, the viticulturalist recruited from Tunisia took over as principal in 1904, he actively championed a stronger role for Roseworthy in research.[32] His priority was to establish a wheat-breeding program that became a major source of varieties grown in the state and sometimes interstate and overseas. Roseworthy also conducted valuable work on crop rotations but was slow to recognise the role of sown pasture legumes as a replacement for bare fallowing.[33]

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[28] Smith (2000).
[29] E. F. Henzell, *Australian Agriculture: Its History and Challenges,* Melbourne: CSIRO Publishing, 2007.
[30] Indeed, about half the sheep in SA were already in the wheat belt by 1935. H. C. Trumble, 'The relation of pasture development to environmental factors in South Australia,' *J. Agric, SA* (July 1935), 38, pp.1460-87.
[31] *The Chronicle*, 8 March 1902.
[32] J. Daniels, *A Century of Service: Roseworthy Agricultural College*, Roseworthy: The College, 1983.
[33] Daniels (1983).

Roseworthy was closely linked to the SA Department of Agriculture (SADA) when it was established a few years later, since most of the staff of SADA were Roseworthy graduates and both institutions reported to the colonial and then State Minister of Agriculture. SADA's primary role was agricultural extension until after the Second World War. Reflecting the fluidity of staff between the two institutions, Perkins from Roseworthy was appointed director of SADA in 1914, a position he would hold until 1936. He became an outspoken promoter of bare fallow in a wheat-fallow system and disparaged "weedy fallows."[34] However, after the value of medics was firmly established in the 1950s, SADA would become a world leader in their collection, conservation, evaluation and breeding.

The leading agricultural research institution in the state became the Waite Agricultural Research Institute founded in 1924 by the University of Adelaide with a donation from a wealthy pastoralist. The foundation professor and first director was A. M. V. Richardson, a graduate of Roseworthy who provided outstanding leadership in the early years, including fund raising from both public and private sources.[35] He was supported by a number of junior level staff including Hugh C. Trumble, who would become the leading pasture scientist in the State until 1950.[36]

In little more than a decade, the Waite had 27 professionals with the best expertise in Australia on pastures, soils and agro-climatology, and its research was recognised internationally.[37] This success reflected its strong imperial links with Britain prior to the Second World War. Trumble in looking back on his period at the Waite, attributes much of its early success to its partnership with the Welsh Plant Breeding Station at Aberystwyth that was facilitated from 1927 by grants from the Empire Marketing Board.[38] The Welsh Plant Breeding Station under the dynamic leadership of George Stapledon had become a global centre of excellence in pasture science employing a holistic or ecological approach from selection and breeding of new pasture strains, fertilisation and integration of legumes.[39]

Stapledon made a nine-month trip to Australia and New Zealand in 1926.[40] Years ahead of the still fledgling Australian scientific establishment, he noted the role of volunteer medics in dryland wheat farms and called for the development through breeding of a "burrless medic" adapted to drier regions that would be "a goldmine" to Australian agriculture.[41] He also advocated an organised effort to cooperate across the Empire in pasture research.

Meanwhile Richardson from the Waite attended the landmark 1927 Imperial Agricultural Research Conference in London, that resolved to build central research institutes for fundamental research and to foster scientific cooperation across the Empire. In the same year, the Empire

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[34] L. Chatterton & B. Chatterton, *Sustainable Dryland Farming: Combining Farmer Innovation and Medic Pasture in a Mediterranean Climate,* Cambridge: Cambridge University Press, 1996.
[35] V. A. Edgeloe, *The Waite Agricultural Research Institute: The First Fifty Years 1924-1974,* Glen Osmond: Waite Agricultural Research Institute, 1984.
[36] For example, W. J. Hudson & W. Way, *Letters from a 'Secret Service Agent': F.L. McDougall to S.M. Bruce, 1924-1929*, Canberra: Australian Govt. Pub. Service, 1986, p.598.
[37] Edgeloe (1984).
[38] H. C. Trumble, 'Grassland agronomy in Australia,' *Agronomy Review* 4 (1950), pp.1-65.
[39] Stapledon was one of only two of his contemporaries in the agricultural sciences elected a Fellow of the Royal Society. His career is detailed in Robert Waller, *Prophet of the new age: The life and thought of Sir George Stapledon*, London: Faber & Faber, 1962.
[40] R. G. Stapledon, *A Tour in Australia and New Zealand: Grass Land and Other Studies,* London: Oxford University Press, 1928.
[41] Stapledon (1928), p.92.

Marketing Board (EMB) was established with part of its remit to provide research grants that would facilitate cooperation on research that would be "applicable sometimes for the whole Empire, but always to more than one of its countries."[42]

Frank L. McDougall, who would achieve fame after the Second World War as a founder of the United Nations Food and Agriculture Organisation (FAO), was highly influential in establishing the EMB and in managing its research grants. McDougall had emigrated to SA to take up a fruit farm in the newly opened irrigated areas on the River Murray. He was first noticed in a local conference where he and Perkins from SADA provided opposing views on markets for the growing production from the irrigation scheme. Contrary to Perkin's gloomy prognosis, McDougall highlighted the potential in British markets for South Australian dried fruit that Britain was then importing from the Mediterranean areas of Europe. Described by his biographer as having exceptional organisational, networking and writing skills, McDougall was nominated as a delegate to London for the Australian Dried Fruits Association to negotiate tariff preferences for Australian producers. He soon developed a close working relationship with Australia's prime minister, Stanley Bruce, that greatly expanded the scope of his activities.[43]

McDougall was also a strong supporter of cooperative research across the Empire, noting that "fundamental problems are better tackled jointly." He recognised the priority of pasture research, having provided an annex to Stapledon's book on Australia on 'The economic importance of Empire pastures.'[44] He also observed that Aberystwyth was the "intellectual general headquarters" for pasture research in the Empire.[45] Accordingly, one of the first EMB projects linked Aberystwyth, the Waite, and research institutes in New Zealand, Palestine and South Africa to conduct research on pastures. This project spawned three 'agrostologists' who studied under Stapledon and would lead pasture research in the UK, Australia and then internationally for decades. First, Trumble from the Waite spent a year in the UK mostly at Aberystwyth in 1928, greatly enriching his limited experience in pasture research.[46] Second, John (Jack) G. Davies, a graduate of Aberystwyth, was appointed to the Waite in 1928 for the next decade. Third, his brother, William Davies, was made Imperial Grasslands Investigator at Aberystwyth, spending three years in New Zealand and Australia in the early 1930s. Stapledon and W. Davies would author the classic textbook on ley farming as part of the British 'plough up' campaign to produce food during the Second World War.[47]

Through these links, the basic concepts of legume pastures and ley farming were incorporated in Waite research from the beginning. Under the EMB project Trumble carried out critical research to define variations in crop and pasture growth in relation to climate. It was Trumble too, who from 1939 promoted barrel medic (*M. truncatula*), a burrless medic suited to lower rainfall regions. A later

[42] Britain funded the EMB largely to reduce pressure by the Empire Dominions for special tariff preferences for trade within the Empire. Roy MacLeod, 'Passages in imperial science: from Empire to Commonwealth,' *Journal of World History* 4 (1993), pp.117-50.
[43] W. Way, *A New Idea Each Morning: How Food and Agriculture Came Together in One International Organisation,* Canberra: ANU Press, 2013; Hudson & Way (1986).
[44] Way (2013), p.82. McDougall was a colleague and friend of W. S. Kelly, a leading South Australian farmer who was promoting pasture legumes.
[45] Way (2013), p.116.
[46] H. C. Trumble, 'General account of twelve months abroad', 1928, Manuscript held at University of Adelaide Archives, Series 1268, Item 1.
[47] G. Stapledon & W. Davies, *Ley Farming,* Harmondsworth: Penguin, 1941.

review of agricultural achievements in SA concluded that "Trumble did more than anyone else to identify and promote legumes appropriate to specific environmental factors."[48]

Finally, from the beginning the Waite worked closely with what was later renamed the Commonwealth Scientific and Industrial Research Organisation (CSIRO), which was being set up by the federal government at the same time as the Waite. Although CSIRO was to be headquartered in Canberra, many of its staff were located on the Waite campus and Richardson was a member of its three-man Executive Committee. CSIRO as a federal research agency aimed to carry out more "fundamental research" to complement state-level applied research activities. One of CSIRO's early appointees at the Waite was Colin M. Donald, whose early work analysed variability within Australian strains of sub clover, and with Trumble associated the suitability of medics with alkaline soils that dominated the wheat-farming areas of the state.[49] Donald took an extended overseas study leave in 1939, again spending much of it at Aberystwyth, and on his return produced a book on Australian pastures in which he argued for plant collection expeditions to support the emerging ley-farming system.[50] Donald went on to replace Trumble as Professor of Agronomy at the Waite in 1954 and to an illustrious career in Australian agricultural science, "contributing more than any other person to the understanding of pastures."[51]

After the War, changes in farmers' economic incentives, farmer innovation and an impressive research capacity at state, university and federal levels, provided the base for widespread uptake of the ley-farming system in SA and beyond. Serious droughts accompanied by huge dust storms during the War had also exposed the problems of the bare fallow system. Record wool prices due to the Korean War boom in the early 1950s stimulated investment by farmers in pasture improvement and enable the build-up of nitrogen and soil organic matter in dryland wheat systems.[52] Australia's trade protectionists policies also ensured a high price of synthetic nitrogenous fertiliser, making its use in dryland farming unprofitable or at best a high risk.[53] Finally, rainfall during the 1950s was well above average throughout the SA wheat belt and this together with high wool prices provided a tail wind to accelerate integration of crop and livestock farming.

By 2000, medics had been adopted on an estimated 25 million hectares in southern Australia.[54] Adoption was rapid and widespread but by no means complete due to the diversity of climatic and soil conditions and the narrow range of pasture legumes available. From the 1930s to 1970s wheat

[48] M. B. Spurling, 'Agricultural achievements in South Australia,' *J. Aust. Inst. Agric. Sc.* 53 (1987), pp.61-7.
[49] H. C. Trumble & C. M. Donald, 'Soil factors in relation to the distribution of subterranean clover and some alternative legumes,' *J. Aust. Inst. Agric. Sci* 4, (1938), pp.206-8.
[50] C. M. Donald, *Pastures and Pasture Research,* Sydney: Sydney University Press, 1941.
[51] Smith (2000), p.86.
[52] With the application of superphosphate, the pasture phase provided sufficient nitrogen for the following cropping cycle. An estimated 7-9 kg N is produced per kg of P applied.
[53] C. M. Donald, 'The impact of cheap nitrogen,' *J. Aust. Inst. Agric. Sc.* 26, (1960), pp.319-38; D. Byerlee & J. R. Anderson, 'Value of predictors of uncontrolled factors in response functions,' *Australian Journal of Agricultural Economics* 13:2 (1969), pp.118-27.
[54] P. G. H. Nichols et al., 'Temperate pasture legumes in Australia – their history, current use, and future prospects,' *Crop and Pasture Science* 63 (2012), pp.691-725. The estimated area under ley farming was 30 M ha including both clovers and medics: E. C. Wolfe, 'Legumes, livestock and livelihoods in the Australian mixed farming system,' 2013. Accessed online at https://uknowledge.uky.edu/igc/22/plenary/7.

yields in SA rose by 50% and wool yields tripled.[55] By 1963, Donald published his famous 'opera house' curve of cascading wheat yields that identified a new phase in wheat production beginning in 1950 brought about by adoption of the ley-farming system (Figure 1).[56]

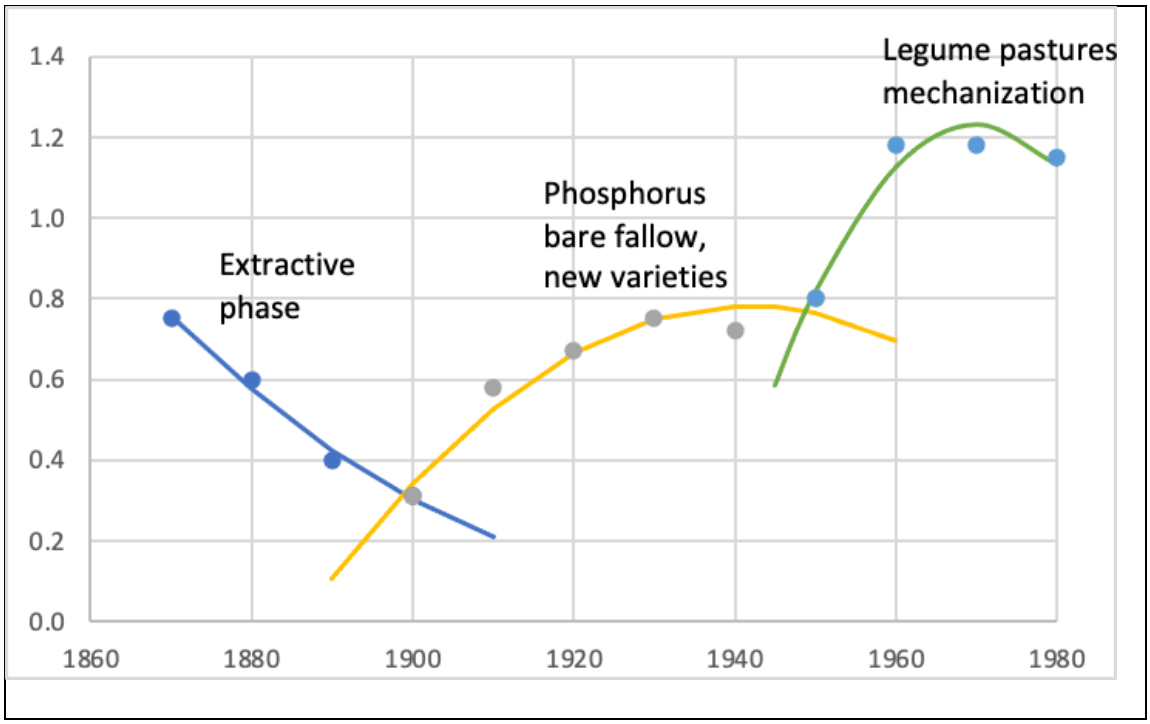

Figure 1: A version of the Donald wheat-yield curve for Australia, 1860-1980.
Each point represents the average yield in tons per hectare for the previous decade. Note the yield take-off in the 1950s due to rotation with legume pastures.
Drawn from data in Puckridge & French (1983).

In short, it seemed that SA had developed an alternative farming system that with low use of agricultural chemicals would be today labelled as 'sustainable'. The most in-depth and widely cited review at the time extolled the achievements concluding that "the dryland farming systems of southern Australia have the potential to increase productivity in most of the Mediterranean-type environments," notably the countries of MENA.[57] It was also recognised that the naturalised species and varieties available in Australia represented only a fraction of the genetic diversity available in their Mediterranean centre of origin. The search for new species and strains in the region was already well underway.

[55] G. D. Webber, 'The extension of the ley farming system in South Australia: A case study,' in A. E. Osman, M. H. Ibrahim & M. A. Jones (eds), *The role of legumes in the farming systems of the Mediterranean areas*, Springer, Dordrecht, 1990, pp.257-72.
56 C. M. Donald, 'Grass or crop in the land use of tomorrow,' Aust. J. Sci., 25 (1963), pp.386-96. See also G. D. Webber, P. G. Cocks & B. C. Jefferies, *Farming Systems of South Australia: Dryland Farming in a Semi-arid Climate*, Adelaide: Dept of Agriculture, 1976.
[57] Puckridge & French (1983).

Collecting the Medics

The first systematic plant introductions for agricultural purposes in SA were undertaken by the Adelaide Botanic Gardens under the leadership of Richard Schomburgk from 1865. Schomburgk, an immigrant from Germany, conducted an active program to introduce new crops and varieties, above all through Kew Gardens, the apex of the British Empire network of botanic gardens. Although he received and distributed seed of cultivated forages from the Mediterranean region mainly for higher rainfall areas of SA, he made little effort to target the Mediterranean region in searching for his introductions.[58] However, his counterpart at the Melbourne Botanic Gardens, Ferdinand von Mueller, who had also originally migrated from Germany to SA, maintained a very active exchange with his counterpart in Algeria, which had been colonised by the French. At the time, 'acclimatisation societies' were very much in vogue, and the climatic similarity of southern Australia and Algeria was explicitly recognised. The French were impressed with the success of British settlement in dryland areas of southern Australia and regularly requested von Mueller to send potentially useful flora and fauna ranging from *Eucalyptus* species, saltbush (*Atriplex* species) and even kangaroos.[59] There were also flows in the other direction, and in 1887 von Mueller distributed seed of two burrless medics, noting that he had "introduced these into Australia, where in the dry hot inland regions, they have surpassed most other fodder herbs."[60]

The efforts by the botanic gardens depended on contacts to access existing collections elsewhere. Perkins in Tunisia in 1892 may have been the first to personally assemble a collection of seeds in the Mediterranean region specifically for SA. While Perkins was recruited as a viticulturalist and naturally collected vines, the letter from the colonial government of SA specifically requested shipment of forages. The final shipment included 23 pasture legumes selected from seed available in the market – that is, they were already being cultivated to some extent in the region. One annual medic, black medic (*M. lupulina*), was included in his shipment, and the seed was widely distributed to farmers in SA in 1892 with some success in higher rainfall areas.[61]

A few years later in 1897, Perkin's colleague at Roseworthy, William C. Grassby, travelled extensively in the eastern Mediterranean in search of seed of horticultural crops such as olives, figs and vines, and quite likely gathered seed of cultivated forages as well. Grassby also sought knowledge to improve management of these crops. Notably he was very impressed with the skill of the Arab farmers he met. He concluded that "when carefully examined, methods of cultivation of ignorant *fellaheen* are based on absolutely correct scientific principles."[62]

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[58] P. Payne, 'Dr. Richard Schomburgk and Adelaide Botanic Garden, 1865-1891', PhD thesis, University of Adelaide, 1992.

[59] R. W. Home, & Sara Maroske, 'Ferdinand von Mueller and the French Consuls,' *Exp1orations: A Bulletin Devoted to the Study of Franco-Australian Links* 18 (1995), pp.3-50. For a discussion of this exchange from the French side, see Helene Blais, *L'empire de la nature: Une histoire des jardins botaniques coloniaux*, Paris: Champ Vallon, 2023.

[60] The medics were *M. orbicularis* and *M. scutellata*. F. von Mueller, *Select Extra Tropical Plants Readily Eligible for Industrial Culture or Naturalization,* Melbourne: Government of Victoria, 1891, pp. 273. Also see *Sydney Morning Herald*, 12 January 1887, p. 9. There is no concrete evidence that von Mueller's samples were from Algeria but both species are natives there and he was in frequent contact with Algeria.

[61] See P. M. Kloot, 'The naturalised flora of South Australia: Its manner of introduction,' *Journal of the Adelaide Botanic Garden* 10:2 (1987), pp.223-40.

[62] *South Australian Register*, 4 February 1897, pp.10.

Meanwhile Perkins recognised the need to collect additional forages from the dry areas of the Mediterranean region, noting in 1902:

> For situations in which rainfall is deficient and summer heat intense no suitable plants have yet been forthcoming [in SA]…After numerous trials they [Algerian agriculturalists] abandoned attempts at acclimatisation of foreign plants and set about cultivating indigenous plants that were known to be tasteful to stock, particularly leguminous plants ….At all events [forage] plants that succeed in Algeria will succeed here and I shall endeavour to secure some.[63]

Perkins, by now Professor at Roseworthy with wide responsibilities for crops and livestock, returned to the Mediterranean region in 1910-1911 and travelled for one year to six countries or colonies as well as to the UK. Despite or perhaps because he grew up in the region, he especially disparaged Arab farm management practices but also those of the French colonists in the region. After nearly two decades in SA, his report exhibits a superior attitude on the merits of SA agricultural practices over those he visited in the region.[64] He did collect some seed, and was especially enthusiastic about one forage legume, Sulla (*Hedysarum coronarium*), and promoted it on his return.[65] After his extensive trip, Perkins became Director of Agriculture in SADA, but paid little attention to pastures and livestock as he increasingly became a 'wheat man'. In this capacity he may have continued to interact with French officials in the region as wheat varieties from Roseworthy were reported to be widely grown in Morocco in 1924.[66]

The scientific community in Australia was slowly recognising the potential value of organised plant collection expeditions. In 1917, the first Australian conference on agricultural research chaired by none other than SA's Perkins, made a strong call for systematic plant collection, introduction and distribution, recognising that federal leadership would "lead to economy of effort and money." The well-funded efforts of the United States Department of Agriculture (USDA) on plant exploration were cited with specific reference to the payoffs from the introduction of durum wheat from Central Asia but with no mention of forages.[67]

Trumble from the Waite was the first Australian sent to MENA to "obtain preliminary information as to the value of these regions for plant exploration… for the discovery of pasture species suitable for the semi-arid regions of the Empire" as well as to identify the best sites for collection and make appropriate contacts for such an expedition.[68] The trip was again arranged by McDougall of the EMB using his wide imperial connections, as a detour on Trumble's return to SA from his stay at Aberystwyth in 1928.[69] His visits to Palestine, Southern Rhodesia and South Africa, all part of the

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[63] *J. of Agric and Ind.*, 1 October 1902, pp.183.
[64] A. J. Perkins, *Agriculture in Other Lands: Notes Collected During the Course of a Visit in 1910 to Europe, Northern Africa, and Asia Minor,* Adelaide: Government Printer, 1912.
[65] *Advertiser* (Adelaide), 14 March 1912.
[66] *Southern Argus*, 10 April 1924, pp. 4.
[67] G. L. Sutton, 'The acclimatisation of plants,' *Agricultural research in Australia,* Melbourne: Advisory Council of Science and Industry, 1918, pp.86-95.
[68] H. C. Trumble, 'Report of a visit of agricultural enquiry to Palestine, Algeria, and Morocco with particular reference to the natural pastures of the regions visited. Report to the EMB, 1928', Manuscript held at University of Adelaide Archives, Series 1268, Item 1, p.2.
[69] H. C. Trumble, *General Account of Twelve Months Spent Abroad*. Report to the EMB, 1928. Manuscript held at University of Adelaide Archives, Series 1268, Item 2.

Empire, were logically arranged and escorted through participants in the EMB pasture project. Even the visits to Morocco and Algeria, both within the French Empire, were organised through British imperial contacts. In both cases he was able to link with British 'Orientalists' resident in those countries with deep knowledge of the local Arab and Berber cultures and languages.[70]

Frequently, noting the "close similarity" of rainfall and temperature data to those of Adelaide, Trumble observed that many of pasture plants in the areas he visited were identical to those naturalised in SA, including several of the annual medics. He also discovered a "new Australia" of Eucalyptus trees and other Australian flora introduced earlier via von Mueller's exchanges that were "very reminiscent of SA." Trumble did not have enough time or resources to systematically collect seeds nor was the season appropriate for seed collection. The only record of success was for seed of a Palestine strain of strawberry clover suited for high rainfall areas that he collected in Rhodesia.[71] However, based on his travels, Trumble became a strong advocate for systematic plant collection in the region, noting in his trip report that the advantages of such expeditions to the Empire would be "enormous". A decade later, after no follow up action, he concluded:

> It is unbelievable that Australia has not thought it worthwhile to send a well-qualified expedition to these parts for scientific study… it would result in the collection of… likely practical value in southern Australia.[72]

Anticipating later efforts by SA to export pasture technology to the region, Trumble was also asked by McDougall and the EMB to investigate the status of French efforts to establish sheep farms in North Africa that were importing the Australian Merino breed and had hired Australian farm managers, with the aim of developing a wool industry. Although McDougall and the EMB were clearly alarmed by this competitive threat to British Empire interests, Trumble concluded, prophetically as it turned out, that "it was very easy to predict that Australian [sheep] stock and methods would be destined to failure in this environment." He specifically noted the very different social and economic environment, musing that the proposed fencing of the sheep farms "would soon lead to troubles of many kinds." [73]

In 1929, a year after Trumble's trip, the Australian federal government established a Plant Introduction Section in the recently created CSIRO. The focus of this section from the beginning was on introduction of new pasture species and 'ecotypes'. Although the section was modelled on the USDA's Plant Introduction Section, it depended for its first two decades on introduction by correspondence only. Since neither sub clover nor annual medics were cultivated in their centre of origin in the Mediterranean basin, introductions were necessarily limited to wild ecotypes and species that had already been collected by others – that is, very few.[74]

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[70] They were Sir Andrew Ryan, British Consul General, Rabat, and Major R.V.C. Bodley, who was living in Algeria to study Arab culture while investing in sheep production in partnership with local herdowners.
[71] It had been introduced to Rhodesia by a soldier returning from the Middle East in World War I. *Herald*, 1 December 1928.
[72] Trumble (1949), p.127.
[73] Trumble (1949), p.116; H. C. Trumble, 'Report of a visit of agricultural enquiry to Palestine, Algeria, and Morocco with particular reference to the natural pastures of the regions visited. Report to the EMB, 1928', Manuscript held at University of Adelaide Archives, Series 1268, Item 1, p.12.
[74] An important exception was USDA's collections of clovers and medics in North Africa and Spain from the early 1900s. David Fairchild, *Exploring for plants,* New York: MacMillan,1931, pp. 137.

The need for collection expeditions for pastures continued to be echoed by scientific leaders but the onset of the Great Depression 1930 curtailed expensive exploration trips. In 1937, Otto Frankel, then a wheat geneticist in New Zealand, delivered a lecture in Adelaide calling for international collaboration in plant collection, evaluation and storage. Frankel, who had left Austria along with many Jewish families, had developed an abiding interest in genetic diversity and collection of land races and wild relatives of crops after he visited Vavilov in the Soviet Union in 1935. In the 1960s he would lead global efforts to collect and conserve plants relevant to agriculture.

Yet field expeditions would again be delayed by the Second World War and then by limited funds and contacts after the War. Mounting a full-scale plant collection expedition over many months required not only scientific expertise but considerable resources and local logistics. In the end, Aberystwyth connections, especially the two Davies brothers, facilitated the first collection expedition for pastures in the Mediterranean in 1951 through the Organisation for European Economic Cooperation (OEEC). The OEEC had been set up to foster European integration and reconstruction after the War with funding from the US in what became known as the Marshall Plan. The OEEC Grasslands Working Party was chaired by W. Davies, formerly Imperial Grasslands Investigator at Aberystwyth with extensive experience in Australia. Meanwhile his brother, J. Davies, had moved from the Waite to become principal agrostologist in CSIRO, Canberra. OEEC organised a survey mission on fodders and forages in the Mediterranean region that set the stage for the Australian collection expedition.[75]

Not surprisingly, the survey team had strong Aberystwyth and antipodean links. In the field, the team was led by Robert Orr Whyte, who was raised in New Zealand and from 1929 had (with Stapledon) headed the Imperial Bureau of Pastures and Forages, naturally also located at Aberystwyth. Whyte had already conducted extensive surveys of Mediterranean forages in the British colonies of Cyprus and Palestine, organised a review of pasture research in Australia, and interacted with Trumble on the potential value of collection expeditions.[76] Invoking Vavilov's concepts of the Mediterranean region as a "primary centre of origination" for forages Whyte noted the potential value to Australian pastures of "gene hunting" expeditions.[77] Donald, who had also moved from the Waite to Canberra to work under J. Davies, was a logical addition to the team – he was already recognised as an expert on Mediterranean pasture species and as a proponent of the value of field collection in the Mediterranean region. Other members of the team included a South African who had participated in the pre-War EMB-Aberystwyth pasture project and two US pasture specialist no doubt in a nod to US financing of most OEEC activities.[78]

The OEEC team visited some eight countries and colonial territories and presented their report in 1951 in Rome. Not only did the trip expose Donald to a wide range of issues in pasture management in the region, but it enabled him to establish links and logistics for an immediate follow-on trip of six months to most of the same countries timed to maximise seed availability in the early summer. The

[75] OEEC, *Pasture and Fodder Development in Mediterranean Countries,* Paris: OEEC, 1951.
[76] Imperial Bureau of Pastures and Forage Crops, *Grassland investigations in Australia,* Aberystwyth: Imperial Bureau of Pastures and Forage Crops, 1940.
[77] R. O. Whyte, 'The phytogeographic zones of Palestine,' 40 (1950), pp.600-14. At the time of the OEEC survey, Whyte was in transition to a posting in the newly established FAO headquarters in Rome.
[78] Despite strong support from OEEC the costs to CSIRO, both in terms of budget and Donald's extended absence, were initially vetoed by his supervisor. See National Archives of Australia A9778, B1/5/35, barcode 3146104.

OEEC report also provided legitimacy to the collection expedition by recommending that collection, evaluation and exchange of pasture germplasm be made a priority in the region. Together with John Miles from the Plant Introduction Section of CSIRO, they visited thirteen countries and collected 1,300 field samples with the primary focus on sub clovers and medics.[79] The collection, once evaluated under field conditions in southern Australia, immediately established the value of such expeditions in terms of greatly increasing the diversity of species and strains then available. Two decades later, Donald counted nine released cultivars based on selections or breeding from the collections he made during his 1951 trip.[80]

This initial success, combined with a rapid increase in budgets for agricultural research in the booming 1950s and the initiation of pasture breeding programs, all provided the impetus and resources for further collection expeditions in the region. High-level support was ensured when Frankel, a leading advocate for such collections, took the position of Chief of the Plant Industry Division of CSIRO in 1951. In addition, Richard G. Casey was Minister in Charge of CSIRO – he had previously been British Prime Minister Winston Churchill's Minister-Resident in the Middle East during the War and was well versed in the potential value of Mediterranean pastures to Australia.[81] Indeed, it was Casey who had facilitated Trumble's travels in Morocco in 1928.[82]

Meanwhile, both Whyte from Aberystwyth (and a member of the OEEC team) and Trumble from the Waite moved to FAO in 1949 and 1951, respectively, and established a solid scientific base for Mediterranean pastures. Whyte immediately set up an FAO Working Party on Mediterranean Pasture and Fodder Development and over the next fifteen years became a very influential force for collection expeditions, naturally focused on his specialty in pastures. FAO, largely through the efforts of Whyte, logically became the main partner for an extensive expedition by CSIRO in 1954 as well as many later expeditions.[83] FAO could draw on a wide network of recently established country offices to provide contacts and trip logistics. The 1954 expedition was led by Cedric A. Neal-Smith, who had carried out research with Donald on diversity in Australian strains of sub clover before moving from the Waite to CSIRO's Plant Introduction Office.[84] He travelled some 25,000 km in nine countries over eight months, making it a much more comprehensive and systematic effort than the 1951 expedition. He also initiated efforts to sample strains of *Rhizobia* in the region.[85]

Together the 1951 and 1954 trips added immensely to the diversity then available in Australia and provided the foundation for several research programs on pasture improvement through selection and breeding. By 1959, an early strain of barrel medic collected in Cyprus had been widely distributed. Meanwhile, FAO under the leadership of Whyte was assisting countries to undertake their own collections and organising distribution of nurseries of diverse pasture species for testing across

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[79] 'Search for new plants,' *Queensland Country Life* 26 April 1951, pp.10.
[80] C. M. Donald, 'Temperate pasture species,' in R. M. Moore (ed.), *Australian Grasslands,* Canberra: Australian University Press, 1970, pp.303-20.
[81] *Farmer and Settler (Sydney)*, 9 September 1955, pp.3.
[82] At that time, Casey was Commonwealth of Australia Liaison Officer in London. Andrew Ryan, British Consul General, in Rabat, Morocco, was Casey's uncle. See Trumble (1949).
[83] On the CSIRO side, both Frankel and Donald were the main contacts. The lead up negotiations to this expedition are described in detail in the National Archives of Australia A9778, B1/5/36, barcode 3146105.
[84] C. M. Donald & C. A. Neal-Smith, 'Strain variation in subterranean clover,' *J. Council for Scientific and Industrial Research* 10 (1937), pp.277-90.
[85] C. A. Neal-Smith, *Report on Herbage Plant Exploration in the Mediterranean Region, March 1-Oct 15, 1954*, Report No 415, Rome: FAO, 1955.

the region. Whyte published three landmark books in the 1950s: *Legumes in agriculture* (with Trumble), *Grasses in agriculture,* and *Plant exploration, collection, and introduction*, all focused on forages. He also visited CSIRO in 1956 and held discussions with Frankel on international coordination of plant collection and introduction activities. As a result of these efforts, FAO was charged by its member countries with the responsibility of coordinating and facilitating plant collection and conservation of genetic resources for the benefit of the global community.[86]

From 1965, CSIRO's Frankel engaged with FAO to strenuously promote international efforts to conserve genetic diversity of crop species. The concept of genetic erosion – the permanent loss of land races and wild relatives of crops due to replacement by 'modern varieties' and degradation of natural ecosystems by humans – added further urgency to efforts at plant collection and conservation. Led by Frankel, the FAO 1967 conference resulted in the landmark *Genetic resources in plants: their exploration and conservation*, regarded as a turning point in the global conversation about genetic resources. Arguably, the Australian interest in Mediterranean forages from the early 1950s had stimulated FAO interest and global leadership in the emerging area of genetic resources.[87]

Eight further Australian expeditions were mounted for Mediterranean forages from 1955 to 1971 together covering nearly all countries of the Mediterranean region as well as Chile. Scientists from the Waite Institute and SADA led half of these often with logistical support provided by FAO. By 1960, Eric Crawford of SADA had set up a gene bank emphasising annual medics, and in 1967 he mounted a collection expedition focusing on medics.[88] SADA even placed an advertisement in an FAO newsletter announcing that "South Australian Pasture Breeders Seek Medicagos."[89] By the 1980s the small gene bank in Adelaide had evolved into the Australian Medicago Genetic Resources Center, with 16,000 accessions of annual medics alone, the largest and most comprehensive collection in the world.[90] It is now recognised as the world's 'base collection' for annual medics.[91]

Meanwhile, as discussed below, the International Center for Agricultural Research in the Dry Areas (ICARDA) was founded in 1977 to serve the farming systems of MENA and built its own collection of forage legumes from the region. From its beginnings, ICARDA collaborated closely with scientists from Australia in organising several collection expeditions on forages – indeed its forage program was ably led for much of the 1980s by a senior scientist recruited from SADA, Philip S. Cocks.

Given the continuing interest by Australia and FAO, many countries in the region began to appreciate the potential value of the large number and diversity of wild legume species growing throughout the region. In 1976, the Libyan government financed a very comprehensive country

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[86] R. Pistorius, *Scientists, Plants and Politics: A History of the Plant Genetic Resources Movement,* Rome: IPGRI, 1997; R. O. Whyte, *Plant Exploration, Collection, and Introduction,* Rome: FAO, 1958.
[87] Pistorius (1997).
[88] E. J. Crawford, 'General report on overseas pasture seed collection mission-April-August, 1967,' *Plant Introduction Review* 4:2 (1967), pp.25-31; E. J. Crawford, A. W. H. Lake & K. G. Boyce, 'Breeding annual Medicago species for semiarid conditions in southern Australia,' *Advances in Agronomy* 42 (1989), pp.399-437.
[89] FAO, *Plant Genetic Resources Newsletter* No 25, Jan 1971, Rome.
[90] Since 2015 merged into the Australian Pastures Genebank, also headquartered in Adelaide.
[91] Western Australia also became very active in collection expeditions. Its scientists emphasized *Trifolium* species since they were more relevant to that state, and established the Australian Trifolium Genetic Resources Center, again a world base collection. These efforts were led by Clive M. Francis who conducted 12 collection expeditions to 10 countries, a feat that was recognized by the Russians when he received the Vavilov Institute Memorial Medal in 1999.

collection of medics that was coordinated by FAO with technical support from SA and WA.[92] The Moroccans led a pioneering effort to define species and "ecotypes" of indigenous medics in terms of climate and soils. Countries on the north side of the Mediterranean stored collected forages in gene banks to serve the region.[93] By the 1970s, collection expeditions for Mediterranean pastures had become routine, with a total of 44 by 1990 and as many as 90 by the most recent count.[94]

By 1990 over 80 percent of medic varieties released in Australia were from introductions made since 1950, originating from 17 different countries, and involving the 'domestication' of several additional species of medics.[95] Improved cultivars developed by breeding programs drawing on the increased diversity of genetic resources available from the collections have also become common. They were widely adopted since it was a simple task for farmers to substitute newer varieties for those they already used in their farming system.

Australian farmers and consumers have been the main beneficiaries of these efforts. At first glance this might appear to be a prime example of the Global North freely using the genetic resources of the Global South, in this case somewhat incongruously represented by South Australia and North Africa, respectively. By 1990, these North-South tensions had become centre stage in the ownership of genetic resources.[96] However, as early as the CSIRO/FAO 1954 collection expedition, a long series of correspondence between FAO with CSIRO was needed to ensure agreement that a duplicate of the collection would be quickly shared with the countries of the region in anticipation that they would be of value for developing more productive farming systems in the region.[97] Another factor muting controversy may have been the many efforts to 'return' the cultivated medics in the form of improved dryland systems – the subject of the next section.

Returning the Medics

During the colonial era in North Africa there had been a long debate on agricultural intensification through the reduction of fallow land and the extent of land degradation in both the cereal areas and rangelands. Much of this debate related to French needs to justify privatisation of land, control the movement of pastoralists, promote reforestation, and most importantly to provide a rationale for European settlement.[98] The 1951 OEEC survey of eight Mediterranean countries by W. Davies, Donald, Whyte and others was carried out against this colonial backdrop, and indeed, the French territories in North Africa had yet to achieve independence. Not surprisingly the OEEC report echoed

[92] The FAO agronomist was Gustave Gintzburger from France who later moved to Western Australia to manage a novel accelerated evaluation of the collection in Libya in the northern winter and Australia in the southern winter.
[93] R. Sackville Hamilton, S. Hughes & N. Maxted, '*Ex situ* conservation of forage legumes,' in N. Maxted & S. J. Bennett (eds), *Plant genetic resources of legumes in the Mediterranean,* Springer Science & Business Media, 2001, pp.263-91.
[94] R. W. Smith et al., 'A history of Australian pasture genetic resource collections,' *Crop and Pasture Science* 72 (2021), pp.591-612.
[95] Crawford et al. (1989); E. J. Crawford & G. C. Auricht, 'Australian contributions to the conservation of medic germplasm,' in S. Christiansen et al. (eds), *Introducing Ley Farming to the Mediterranean Basin: Proceedings of an International Workshop*, Aleppo, Syria: ICARDA 1993.
[96] See for example, C. Fowler, *Unnatural Selection: Technology, Politics and Plant Evolution*, Reading: Gordon & Breach, 1994.
[97] National Archives of Australia A9778, B1/5/36, barcode 3146105.
[98] Susan Davis, *Resurrecting the Granary of Rome,* Athens: Ohio University Press, 2007.

many of the same ideas. In particular, the team stressed the importance of replacing fallow with pastures to reduce grazing pressure in the rangelands. They concluded that the "the most adverse feature of the farming system is the almost complete lack of integration of crop and livestock husbandry."[99] Noting the very similar climatic conditions to SA, Donald drew attention to the emerging success in southern Australia in incorporating pasture legumes into the rotation and its potential use in MENA. However, he "appreciated technical and sociological differences of adopting these practices in areas in which farm units are very small."[100]

The economic and institutional environments were indeed quite different. In SA, reflecting its history of highly organised settlement, these conditions were quite uniform across the state. Most farmers owned both land and livestock and managed them jointly as part of a system that relied on fencing to control grazing and protect crops. Farms were large with an average size of 900 ha and 1200 sheep in 1970, wages were high, and farm operations were highly mechanised.[101] By contrast, in MENA farm size was relatively small (most commonly from 10 to 50 ha[102]), farms were often fragmented, labour was cheap, and mechanisation was limited. Land tenure varied widely from private ownership, customary, individual and collective tenure, and after independence, cooperatives and state farms that took over farms of European settlers. As a result of this diversity of tenures there were also many large farms in MENA. Most importantly, although crop farmers often owned a small household flock, management of most livestock was in the hands of specialised herders, often nomadic, who by traditional law enjoyed open grazing rights on any land that was not under crop, including cropland in the fallow phase. Recognising and addressing this diversity of farm size and tenure situations would be central to the challenge of introducing Australian dryland systems over the next four decades.

During the 1950s with the movement to independence, FAO became an important player in the region. Whyte, in addition to coordinating FAO efforts to collect pasture species, organised 'Working Parties' on pastures and fodders for the region that distributed forage nurseries, including medics collected locally as well as medics introduced from Australia. Another FAO agronomist, Peter Oram, who had collected forages with the FAO/CSIRO expedition in 1954 in Libya, was commissioned to design options for experimentation on crop rotations with forages.[103] He advocated testing alternatives that included grain legumes, green manures, and forages for cut fodder and forages for grazing, especially sub clover and medic. He also noted the complication of "shepherds with no land and cultivators with no animals" and that "management may well prove the nemesis of sown pastures in the Mediterranean."[104] Other FAO 'experts', including some from Australia, also continued with more in-depth country studies of forages all within the overarching aim of substituting productive pastures for fallow.[105]

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[99] OEEC (1951), p.12.
[100] OEEC (1951), p. 132
[101] E. D. Carter, *The Potential for Increasing Cereal and Livestock Production in Algeria,* Mexico, D F: CIMMYT, 1975.
[102] P. J. M. Cooper et al., 'Improving water use efficiency of annual crops in the rainfed farming systems of West Asia and North Africa,' *Experimental Agriculture* 23:2 (1987), pp.113-58.
[103] P. A. Oram, *Pastures and Fodder Crops in Rotations in Mediterranean Agriculture,* Rome: FAO, 1956.
[104] Oram (1956), p.30
[105] For example, G. Perrin de Brichambaut in Rome, and M. Thault in Tunis. For an FAO consultancy from CSIRO see E. T. Bailey, *Report to the Government of Jordan on Pasture and Fodder Plant Introductions and Establishment Problems,* Rome: FAO, 1967.

In 1960, FAO endorsed what became known as the UN Mediterranean Project being promoted by Gunnar Myrdal, a noted Swedish social scientist and later winner of the Nobel Prize in Economic Sciences. The central idea of the project was "the integration of agriculture and animal husbandry", again through replacement of fallow by forages.[106] The Mediterranean Project had ambitious plans to attract donor investment, but lacking funding, the main output was a series of detailed studies on climate and land use. The climatic similarity of the countries of the Mediterranean region to other regions of the world, including southern Australia, was highlighted through detailed maps of climate and vegetation.[107]

The international agricultural research centres of what became known as CGIAR were the first to actively promote the Australian ley-farming system in the region motivated by their mission to use science to feed the world. In 1960, Norman E. Borlaug, the head of wheat research in the Rockefeller Foundation in the Americas, was asked to review an FAO regional program on wheat and barley breeding in MENA that had operated for a decade. Borlaug travelled extensively in the region to observe wheat research, noting that not only Gabo, a variety from Australia, was extensively grown, but his own wheat varieties from Mexico (many of which had Gabo parentage) were also performing well.[108] This experience stimulated his interest in the potential of broadly adaptable wheat varieties as opposed to the prevailing view that breeders should aim at specific adaptation.

Shortly after, Keith W. Finlay, a plant breeder at the Waite, co-authored a seminal paper on adaptability of a global collection of barley varieties in SA.[109] Not only did this show the superiority of North African varieties in SA, but it demonstrated a simple statistical method for measuring adaptability. The paper caught the attention of Borlaug for its practical applications in his international wheat-breeding program.[110] Finlay interacted extensively with Borlaug over the next few years and invited Borlaug to deliver the keynote address to the International Wheat Genetics Symposium in Canberra in 1968. There Borlaug expressed his admiration for the Australian dryland ley-farming system, "hoping to see the day when the knowledge and skills you have developed… are transplanted back to North Africa and the Middle East where they are so badly needed."[111] Borlaug recommend that CIMMYT hire Finlay, which it did as its Director for Basic Research in 1969.[112] As its first Australian scientist Finlay's appointment ensured a lead role for South Australian scientists in CGIAR work in MENA for the next two decades.

Meanwhile, the Ford Foundation had begun supporting research in MENA and asked CIMMYT to strengthen research capacity on dryland wheat in North Africa. With his background in breeding for drylands in SA, Finlay became actively engaged in this program and asked John B. Doolette, a senior agronomist in SADA, to review the potential for SA dryland farming system in

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[106] Egon Glesinger, 'The Mediterranean Project,' *Scientific American* 203 (1960), pp.85-105.
[107] UNESCO-FAO, *Bioclimatic map of the Mediterranean Zone,* Paris: UNESCO, 1963.
[108] N. E. Borlaug. Observations made by Norman E. Borlaug on the FAO Near East Wheat and Barley Project, March 6th through May 9th, 1960. Borlaug papers, CIMMYT, Mexico, 1960.
[109] K. W. Finlay and G. N. Wilkinson, 'The analysis of adaptation in a plant-breeding programme,' *Australian Journal of Agricultural Research* 14 (1963), pp.742-54.
[110] M. Baranski, *The Globalization of Wheat: A Critical History of the Green Revolution,* Pittsburgh: University of Pittsburgh Press, 2022.
[111] N. E. Borlaug, 'Wheat breeding and its impacts on world food supply,' in *Proceedings of the Third International Wheat Genetics Symposium*, Canberra: Australian Academy Science, 1968.
[112] Memo by Norman E. Borlaug to Robert Osler, 1 August 1968. University Minnesota Archives, Norman E. Borlaug Papers, Correspondence, 1954-2006. Chronological Correspondence. (Box 3, Folder 7).

North Africa. In a narrowly technical report that largely ignored the complexity of introducing a new farming system, Doolette enthusiastically supported a research program to evaluate medics in place of fallow. Shortly after, in 1971, he moved to Tunisia with CIMMYT to implement the program. Finlay also contracted a SA colleague from the Waite, Edward (Ted) Carter, a pasture agronomist, to review the potential for medics in Algeria. In his report, Carter noted that "it was soon obvious to me that there were striking ecological similarities between Algeria and southern Australia and that Australia had a great deal to offer in… the science and technology related to cereal and livestock production and integration.[113] CIMMYT then recruited a second agronomist, again from SADA, to introduce the SA farming system to Algeria.

These programs soon demonstrated the technical potential of ley farming using a rotation of medic varieties directly imported from SA to substitute for use of nitrogen fertiliser in wheat, although no livestock component was included.[114] By 1975, with the oil shock and a nearly ten-fold increase in the price of nitrogen fertilizers, CIMMYT was ready to show case its efforts. A glossy CIMMYT report, *Return of the Medic,* concluded that "the cereal legume rotation is a bold stroke… that could improve the lives of millions." Indeed, the main constraint was lack of sheep to graze the newly established pastures with Doolette, noting that income from sheep would be "the cream on the jam."[115]

A conference sponsored by CIMMYT and FAO in 1975 in Tunisia gave special attention to the unfolding promise of the new rotation and system. The keynote address for this session was delivered by Borlaug (now a Nobel Peace Prize Laureate) against the backdrop of escalating prices of nitrogen fertiliser. He made a passionate call for investment in fertiliser manufacturing capacity. Characteristically, he also delivered a broadside against organic farming, although he noted parenthetically that "this is not meant to ignore the important use of legumes."[116] The follow-up presentations led by Doolette unanimously endorsed the potential of the ley-farming system.[117] A Ford Foundation delegate, not coincidentally another Australian agronomist, estimated the huge potential of sowing medics in the region, concluding that "the rotation could be introduced with a minimum of adaptive work and with maximum results."[118] Only R. Glenn Anderson, Borlaug's deputy in CIMMYT, sounded a note of realism on the complexity of introducing the system, given separation of management of crops and livestock.

As CGIAR expanded rapidly in the 1970s it explored the potential of a regional centre for dryland agriculture in MENA to address a gap in its research portfolio and to attract funding from countries in the region growing wealthy from the oil boom. In 1973, the Technical Advisory

[113] Indeed, he estimated that Australian methods could be adopted on five million ha provisioning an additional 10 million sheep. Carter (1975), p.v.
[114] Higher altitude areas of Algeria with a colder climate required a search for local cold-tolerant medics.
[115] Breth (1975).
[116] N. E. Borlaug, 'The role of fertilizers – especially nitrogenous – in increasing world food supply,' in *Proceedings of the Third Regional Wheat Workshop, April 28-May 2, 1975*, Mexico, DF: CIMMYT, 1976, p.224.
[117] Doolette concluded that the system was technically possible and "assumed it would be economically sound". J. B. Doolette, 'The strategy of establishing a crop rotation programme using annual forage legumes,' in *Proceedings of the Third Regional Wheat Workshop*, 1976.
[118] D. W. Leeuwrik, 'The relevance of the cereal-pasture legume rotation in the Middle East and the North African Region,' in *Proceedings of the Third Regional Wheat Workshop*, 1976. Ironically, the Foundation had launched its program in MENA five years earlier by commissioning a major report that emphasised the "social, cultural and institutional requisites" for improving grazing management. See M. Clawson, H. H. Landsberg & L. T. Alexander, *The Agricultural Potential of the Middle East,* New York: American Elsevier Pub, 1971.

Committee (TAC) of the CGIAR, chaired by Australian economist, J. (Jack) C. Crawford, commissioned a team to explore the feasibility of such a centre. Crawford was well aware of the Mediterranean 'agro-climatic analogue' and employed Carter from the Waite as a member of the team.[119] Oram from FAO, who had moved to become the Secretary of TAC, also joined the team, bringing his two decades of experience with forages in MENA. Their extensive report recommended the establishment of what became the International Center for Agricultural Research on the Dry Areas (ICARDA), with one of its priorities to conduct research on forage legumes including the application of the 'Australian model'.

As ICARDA was being set up in 1977, it brought Carter back again for an extensive survey across the region on research priorities on legumes. Visiting some ten countries over a three-month period his report largely ignored food legumes, and drawing on the experience of the Australian and FAO programs that had been initiated in several countries, strongly promoted research on ley farming with medics.[120] He carefully quantified the potential in terms of 23 million hectares of farmland suited to the cereal-pasture legume system that could produce 86 million *additional* sheep and 1.4 million tons of nitrogen for the following cereal crop. As in his previous visits, his report heavily emphasised the technical side, although vaguely noting that it would require a "delicate blend of political, social, economic and technical expertise."[121] ICARDA was impressed by the numbers and ley farming became the core of ICARDA's research on forages and farming systems in its first decade. Doolette transferred from CIMMYT to ICARDA to initiate the work. ICARDA did recognise from the outset that it should seek to transfer the ley-farming concept rather than the system *per se*, and over time, with a much larger team, initiated long-term research on rotations that integrated livestock. As already noted, collection of forage legumes from the region was also a core activity of ICARDA that fed into forage breeding activities. Even so, the research still lacked a broader systems perspective and socio-economic input.[122]

By 1973 SADA and allied private industries began promoting the SA dryland farming model in MENA. In contrast with the science-driven motivation of the CGIAR initiatives, the SA initiative was 'demand driven', oriented by commercial interests on the SA side and agricultural development and food security objectives on the part of countries in MENA. In total, SADA signed contracts in four countries to demonstrate and extend ley farming, but through FAO projects and study tours its influence extended widely throughout the region.[123]

The first contacts were made by Bashir Jodeh, the dynamic young director of the Jebel El Akhdar Authority (JAA) in north-eastern Libya. Jodeh had studied in Western Australia and travelled extensively in the farming areas of southern Australia. Flush with oil revenues in the 1970s, the JAA had been set up by Libya's leader Colonel Muammar Gaddafi as part of his 'Agricultural Revolution'

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[119] Crawford and Donald had worked closely in the Department of War and Industry during the War and Crawford likely asked Donald to join the team or suggest a colleague.

[120] Carter observed results of some of the medic research started years earlier with FAO and now led by national scientists, especially the strong program at the University of Mosul, Iraq. E. D. Carter, *A Review of the Existing and Potential Role of Legumes in Farming Systems in the Near East and North Africa* (Mimeo), Aleppo, Syria: ICARDA, 1978.

[121] Carter (1978), p.76.

[122] Much of this section is based on the External Management and Program Reviews conducted by the CGIAR of ICARDA in 1984, 1988, 1993 and 2000, available at https://cgspace.cgiar.org.

[123] Arthur Tideman, one of the main protagonists from SADA, has described these projects in some detail in his book, *The Medic Fields* (1994), including some assessment of their payoffs—at least to SA.

program. With an annual budget of US $300 million (equivalent to the *total* budget of the government of SA), JAA aimed to develop agriculture in a marginal dryland environment through the settlement of some 2,000 medium-size farmers of about 80 ha each. Farmers were expected to follow the ley-farming methods aided by fencing to control entry of livestock from outside. In 1973 JAA contracted with the South Australian Seedgrowers Cooperative Ltd (SeedCo) to supply pasture seed and to send an average of eight SA farmers per year to provide short-term training to Libyan farmers. SeedCo was very entrepreneurial in moving into a risky and unknown market in MENA and established ambitious targets for selling seed throughout MENA of medic varieties, many originating from Australian collections in the region.[124]

In addition, JAA requested SADA to set up a 1,000 ha demonstration and adaptive research farm. The SA Premier Don Dunstan (the State's highest political position) enthusiastically agreed, seeing opportunities for new markets for SA products beyond seed, such as farm machinery, fencing materials and sheep. Although representing the left-of-centre Labor Party, he was keen to "involve ourselves in business."[125] That SADA would agree to a project in a 'socialist state' half a world away reflected a recent radical change in SA political leadership from a staid conservative government in office for over three decades to a liberal-minded and socially oriented government headed by Dunstan. Growing up in Fiji, Dunstan was interested in international affairs having already gained experience in MENA through a fact-finding mission on the Cyprus conflict.[126]

The JAA demonstration farm was essentially a 'turnkey project' to replicate a large Australian farm. Wheat and medic varieties, machinery, and fences as well as sheep, a shearing shed and even shearing instructors were all imported from SA. With paddocks (fields) named kangaroo, kookaburra, and koala, one agronomist recalled that "we were trying to treat it as an Australian farm."[127] Generous funding allowed JAA to hire the needed expertise from SADA to implement the project under the competent leadership of Jodeh.[128]

Dunstan himself made an extended trip to Libya and the region in 1978 and endorsed a search for further such projects. In doing so, he was strongly supported by his agricultural minister, Brian Chatterton. Self-described as a member of the SA "landed gentry", Chatterton had studied agricultural science in the UK and managed the family's farm and vineyard before entering politics.[129] He invariably worked as a team with his wife, Lynne Chatterton, a political scientist described as having a "forthright style", who was a close adviser to Premier Dunstan.[130] The Chattertons became outspoken champions of ley-farming methods after they made an extended visit to the region in 1979 – indeed it became their passion. They recognised the challenge posed by separate ownership and management of crops and livestock, but advocated fencing (as in Libya) and cooperatives to manage

[124] R. H. Badman & P. A. Farnan, *SeedCo, Seeds of Success: A 25 Year History*, Adelaide: Lutheran Publishing House, 1988.
[125] D. Armstrong, 'Libyan deal takes the heat off Dunstan,' *The Bulletin* 9 August 1977, p.78.
[126] A. Woollacott, *Don Dunstan: The Visionary Politician who Changed Australia*, Sydney: Allen & Unwin, 2019.
[127] T. Dillon & K. Bicknell, Australian demonstration farm, El Marj: Report on operations for 1975/76. Agronomy Branch, SADA, Adelaide, 1976. Interview with Peter Barrow on 30 March 2004 in regard to the history of SADA. Accessed online at https://history.pir.sa.gov.au/__data/assets/pdf_file/0006/48597/Barrow_peter_int.pdf
[128] Tideman (1994).
[129] B. Chatterton, *Roosters and Feather Dusters*, Renwick: Pulcini Press, 2003.
[130] *Canberra Times,* 1 May 1983, p.2.

grazing of pastures.[131] Rather than changing the system to fit the institutions, they argued for the much more difficult task of changing the institutions to fit the system, a position they would hold for the next two decades.

Dunstan, the Chattertons, and SADA more generally, saw the Libyan project with extensive areas of medics imported from SA growing on both the demonstration farm as well as by many individual farmers as "highly successful" and a shining example for the whole region.[132] SADA released a glossy booklet, *The Libya story: Food from an empty bowl*, complete with colour photographs showcasing its achievements in Libya. Not to be outdone Jodeh (as well as Ghadaffi) saw Libya as a leader in dryland farming in the region and produced an impressive coffee-table book, *Harvest for all seasons in Jebel El Akhdar,* illustrating its progress. Both books were published in three languages – Arabic, English, and French – to present to the growing number of international visitors to JAA to learn from its ley-farming experience.

Still there were clouds on the horizon. The future of the SADA demonstration farm in Libya was never clarified, but judging by a parallel Western Australian project in the western side of the country, it was to be broken up into private farms, a process that was managed disastrously in the 1980s.[133] Sales of seed and machinery were significant in the early years but with declining oil prices Libyan revenues to fund the project and purchase farm inputs dried up. The farmer-to-farmer extension seems to have had some success in improving crop management and maintaining machinery, but by SeedCo's own assessment it was much less successful in explaining the more complex management decisions on grazing and self-seeding of the medics – especially given the Australian farmers' lack of skills in even basic Arabic. As Lynne Chatterton reflected, "when the Australian farmers left around 1980, the Arab farmer had to manage without the helpful friendly Australian farmer who could be called in to remind and repair, and they often gave up in despair."[134] Jodeh's promotion to Minister of Agriculture followed by his untimely death in 1983 largely ended the effort on dryland farming systems in Libya based on the Australian model.

The Chattertons and others who extolled the success of the Libyan project during its heyday, failed to recognise its unique historical legacy that negated its wider relevance in the region. The project was built on the push in the 1930s by Benito Mussolini, Italy's Fascist leader, to settle Italian farmers in the area by brutally expelling the Bedouin herders.[135] After the War, the departure of the Italian colonists left a legacy of individual farms enclosed by fences. The abandoned farms were then transformed into a settlement project for Libyans, many of them descendants of the original displaced Bedouins who were familiar with livestock. The size and number of farms was further expanded by the Ghaddafi government's policies to enclose remaining uncultivated grazing land suitable for farming. These settlers were provided extremely generous financing, machinery, and inputs, drawing

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[131] B. Chatterton & L. Chatterton, *Report on rainfed cereal and livestock production in West Asia and North Africa: Following a mission by the South Australian Minister of agriculture,* Adelaide, Mortlock Library, 1979.
[132] B. Chatterton & L. Chatterton, 'The Jackson report and agricultural aid,' in P. Eldridge, D. Forbes & D. Porter (eds), *Australian Overseas Aid*, Surrey Hills: Croom Helm, 1986, pp.171-90.
[133] N. Halse, 'Lessons from attempts to transfer farming technologies from Mediterranean Australia in West Asia and North Africa', in J. R. Anderson (ed.), *Agricultural Technology: Policy Issues for the International Community,* Wallingford: CAB International, 1994, pp.304-20.
[134] Lynne Chatterton, *Red Herrings,* Renwick: Pulcini Press, 2001.
[135] For an analysis by a distinguished anthropologist, see E. E. Pritchard, 'Italy and the Bedouin in Cyrenaica,' *African Affairs* 45:178 (1946), pp.12-21.

on the ample resources of the JAA.[136] In short, land tenure, farm size, experience with livestock and access to JAA services were very atypical of the region as a whole.

Back in SA there was also grumbling by its farmers about the extended absence of SADA technical staff given SADA's very small cadre of less than fifty agronomists and extensionists.[137] The Libyan and other projects in MENA employed over a hundred person years of SADA expertise over the decade, a significant share of SADA's human resources. Further, the federal government was unhappy about a state government running what seemed its own foreign assistance and diplomacy efforts in a politically sensitive region and with what was increasingly seen in the West as a 'rogue state'. Indeed, B. Chatterton was seen by some as a 'stooge' of Gaddafi.[138]

FAO also mounted its own regional and country projects to promote ley farming, often in close cooperation with SA.[139] In 1974, the FAO coordinator for the regional cereals project visited Australia and became an enthusiastic convert to the Australian farming system.[140] This was followed by many 'study tours' for regional scientists to Australia. The most ambitious FAO program (funded by Saudi Arabia) sent some fifty agronomists from the region to Roseworthy from 1976 to 1980 to complete a one-year post-graduate diploma in dryland farming systems.[141] Aided by these exchanges, national leaders emerged who led research on ley farming and medics in countries where SADA was not directly engaged.[142] There is some indication that they were more attuned to the challenges of introducing the system in a very different social and economic context.[143]

After their 1979 trip, the Chattertons planned the 1980 international dryland farming congress in Adelaide described at the beginning of this paper. This was probably the largest international agricultural congress held to date in Adelaide, but ironically the Labor Party was voted out of office before the congress so neither Dunstan (who had already resigned) nor Brian Chatterton presided as expected – although Chatterton sniped from the side-lines about its "failure".[144] Nor did the keynote speakers endorse the efforts to directly transfer the SA system to MENA. FAO Assistant Director General, D. Bommer argued that an "understanding of social structures and economic and cultural motivation" was needed to affect such a transfer. Another FAO agronomist with over three decades of experience in the region chastised the commercial orientation of SA projects given the substantial benefits SA had reaped from Mediterranean legumes.[145] He called for fruitful North-South exchanges through technical and financial assistance to benefit the poorest. Oram, the former FAO agronomist, was quite critical of efforts to directly transfer the system and recommended much more attention to

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[136] FAO, *Report to the Government of Libya on Development of Tribal Areas and Settlement Project,* FAO/LIB/TF20, Rome: FAO, 1969.
[137] Interview with Jim McColl on 9 October 2003 in regard to the history of SADA. Accessed online at https://history.pir.sa.gov.au/__data/assets/pdf_file/0005/16439/mccollint.pdf
[138] Chatterton (2003).
[139] FAO country projects in Algeria and Syria, were managed by an Australian agronomist, R. Gallacher, formerly of the Victorian Department of Agriculture.
[140] FAO, *Report of the national task force leaders study group to Australia and New Zealand*, Cairo: FAO Near East Regional Office, 1975.
[141] Daniels (1983).
[142] Notably M. Bounejmate in Morocco, M. N. Bakhtri in Algeria, and A.K. Al Fakhry in Iraq.
[143] See, for example, M. N. Bakhtri, *Cereal Annual Lucerne Rotation in North Africa and the Near East*, Rome: FAO, 1983.
[144] B. A. Chatterton, 'Dryland Congress a failure,' *Stock Journal*, 11 September 1980.
[145] G. Perrin de Brichambaut, 'Dryland agriculture in the Mediterranean regions of the world,' in *International Congress on Dryland farming. Proceedings*, Adelaide: Dept of Agriculture, 1984.

socio-economic issues. Australian scientists were also more cautious. Doolette, who had done so much over a decade to demonstrate the technical feasibility of the system, noted the diversity of farms and tenure regimes and recognised a "need for knowledge of farm size, ownership, resources, cropping patterns and attitudes."[146]

Despite these cautionary messages, SADA continued to pursue projects in the region. In 1980 SADA (through its state-owned company, SAGRIC Int) signed a US$10 million deal with Iraq to develop a 5,000 ha demonstration farm in the Kurdish area in northern Iraq. This was modelled on the Libyan project and "fencing materials, silos, sheds, the whole box and dice came from Australia."[147] As one SA agronomist recalled "we ran the project as much as we could just as our farmers run it here [in SA]."[148] Beyond design flaws, notably the lack of any outreach or extension component on the Iraqi side, the timing was unlucky. The Iran-Iraq war broke out in 1980 and conflicts between the Iraq government under President Saddam Hussein and Kurdish insurgents meant that a military guard accompanied the Australian advisers at all times – even in the field. Despite this security measure, the fences and sheep were frequently stolen, and the livestock component was abandoned. Even more tragically, the Iraqi project director was assassinated – a serious blow to the project. Further, as Saddam Hussain's infamy grew on the international stage, SADA was gaining a reputation for associating with Arab despots, following its 1970s project in Libya. The Iraq project ended in 1985 as did a parallel and equally unsuccessful project run by Western Australia in northern Iraq that assessed its impact as "virtually nil."[149]

SADA mounted another adventure in Algeria beginning in 1979 with World Bank funding that also failed, as well as a development project in Jordan funded by Australian aid that had modest success with introducing legumes into the cereal rotation but not with ley farming with medics. When the Labor Party resumed power in 1982 and Brian Chatterton resumed his ministerial post, the Chattertons moved aggressively to restructure the projects. However, this resulted in protracted bureaucratic and political infighting, notably a "colossal row" between the Minister and SADA's Director General.[150] Dunstan, an ardent supporter of the overseas ventures in the 1970s, was no longer premier and Brian Chatterton claiming lack of political support resigned as minister in 1983, although he and Lynne would continue to be intimately engaged as private citizens in the medic saga for another decade.

By the late 1980s, after nearly two decades of efforts by CIMMYT, ICARDA, FAO, SADA, JAA and others to transfer the Australian model and against the early estimate of its potential in the tens of millions of hectares, there were at most 50,000 ha of sown pasture legumes, mainly medics, in North Africa.[151] However, the constraints were much better understood, largely through research

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[146] J. B. Doolette, 'The Australian ley farming system in North Africa and the Middle East,' in *International Congress on Dryland Farming,* 1984, p.647.
[147] Interview with Peter Barrow on 30 March 2004, in regard to the history of SADA. Accessed online at https://history.pir.sa.gov.au/__data/assets/pdf_file/0006/48597/Barrow_peter_int.pdf.
[148] Interview with Arthur Tideman on 28 Oct. 2003 in regard to the history of SADA. Accessed online at https://history.pir.sa.gov.au/__data/assets/pdf_file/0018/16443/tidemanfin.pdf.
[149] Halse (1994), p.317.
[150] Interview with Peter Barrow, 30 March 2004. Full details are in Interview with Jim McColl, 9 October 2003. Also see 'A political conflict hits agriculture in SA.' *Stock Journal*, 1983
[151] K. G. Boyce, P. G. Tow, & A. Koocheki, 'Comparisons of agriculture in countries with Mediterranean-type climates,' in V. Squires & P. Tow (eds), *Dryland farming: A systems approach,* Sydney: Sydney University Press, 1991, pp.250-60; M. Bounejmate, 'Role of legumes in the farming systems of Morocco,' in Osman et al. (1990).

by ICARDA, which had increasingly integrated socio-economic and farming-systems research. ICARDA's forage program also diversified under the leadership of SA's Phil Cocks during the 1980s and initiated a concerted effort to work with local farmers using participatory approaches to understand the diversity of farming systems, quantify the relative importance of cereals and livestock, understand grazing management and seasonal fodder calendars, and even assess the forage value of 'weedy' fallows.

The end of the 1980s was another period of stocktaking through a series of conferences, the most important being ICARDA's conference, *Introducing ley farming in the Mediterranean Basin*, held in Perugia, Italy, with participants from fifteen countries. Building on the much-expanded research base and the experience in many countries, the previous consensus was now more nuanced in recognising the difficulties of introducing the system. Economists questioned the profitability of ley farming with medics over alternative systems and the high cost of fencing irregular fields, even if fencing would be socially acceptable.[152] Participants recommended more focus on transferring concepts rather than the system, better socio-economic and geographic targeting, and efforts to improve existing systems based on 'weedy fallows.'[153]

This was a turning point for ICARDA as it began to phase out its work on ley farming, seeking more flexible options that considered food as well as forage legumes and harvesting for grain and green and dry fodder, as well as grazing.[154] These options recognised that herders needed flexibility to move the feed to the animals as well as to move their animals to the feed. ICARDA scientists, especially its social scientists, were increasingly vocal in their criticism of ley farming, concluding that medics were less profitable to small farmers than traditional systems.[155] In Syria, Tah village, the focus of ICARDA's on-farm research efforts over a decade, was described in a paper entitled 'Another unsuccessful attempt to introduce ley farming in the Mediterranean Basin'.[156] France's leading specialist for Mediterranean pastures also chimed in by noting that "hundreds of millions of dollars have been spent… since the 1960s, with a net result of less than 10,000 hectares of actually ley farming in the Mediterranean basin today!"[157]

Several post-mortems provide excellent reviews of the effort to transfer the ley-farming system, many by actors who participated in them.[158] In short there were technical problems, such as choice of medic cultivars and depth of ploughing, that were largely solved through adaptive research in many of the projects. Others related to weeds and pests not found in Australia, some quite

[152] T. L. Nordblom, 'Ley farming in the Mediterranean from an economic point of view,' in Christiansen et al. (1993).
[153] 'Discussion and recommendations,' in Christiansen et al. (1993), pp.289-93.
[154] A. El Moneim & J. Ryan, 'Forage legumes for dryland agriculture in Central and West Asia and North Africa,' in S. C. Rao & J. Ryan (eds), *Challenges and Strategies for Dryland Agriculture,* Madison: American Society of Agronomy, 2004.
[155] T. L. Nordblom et al, 'From weed to wealth? Prospects for medic pastures in the Mediterranean farming system of north-west Syria,' *Agricultural Economics* 11:1 (1994): pp.29-42; J. Tiedeman et al., 'Sheep production on medic and weedy pasture in semi-arid Morocco,' *Journal of Range Management* 51:3 (1998), pp.288-92.
[156] S. Christiansen et al., 'Tah village project in Syria: another unsuccessful attempt to introduce ley-farming in the Mediterranean basin,' *Experimental Agriculture* 36:2 (2000), pp.181-93.
[157] H. N. Le Houérou, 'Unconventional forage legumes for rehabilitation of arid and semiarid lands in world isoclimatic Mediterranean zones,' *Arid Land Research and Management* 15 (2001), p.198.
[158] For succinct reviews see, S. Risopoulos, 'The perils of technology transfer: The Australian wheat/medic system in the Near East/North Africa,' *Tropicultura* 8:4 (1990), pp.196-98; Boyce et al. (1991). For views of a political scientist, see R. Springborg, 'Impediments to the transfer of Australian dryland agricultural technology to the Middle East,' *Agriculture, Ecosystems & Environment* 17:3-4 (1986), pp.229-25.

unexpected such as the severe damage to medic pastures by the invasion of tens of thousands of sky larks in Iraq.[159] These pest issues might have been overcome with further research or other measures. More intractable was the effect of economic policies such as subsidies on nitrogen fertiliser and on livestock feeds that biased incentives against ley farming. However, the overwhelming problem was lack of control by farmers over grazing rights of medic pastures due to traditional land tenures. As a long-time ICARDA agronomist noted, "with open grazing rights, management of grazing of the pasture phase is impossible." Even on individual fenced farms, grazing management to supply adequate feed and at the same time leave sufficient seed for medic self-regeneration was found to be a "delicate and tricky system" requiring considerable skill.[160] Doolette, who had pioneered the effort in 1970, recalled years later:

> There would have been better acceptance had we listened to the traditional farming ways and the reasons for these traditions and taken into account the social and political implications.[161]

By the early 1990s, with SADA and ICARDA phasing out their work on ley farming, all, including national scientists and extension agencies, were moving on – all except the Chattertons. After their political demise, the Chattertons continued to soldier on through a series of consulting contracts with FAO and others, eventually moving to an olive grove in Italy to facilitate travel within the region. In 1996 they published a book, *Sustainable Dryland Farming*, to explain and promote the huge potential of ley farming based on medics in the region.[162] Rich in historical perspective from SA, the book provides a critical review of Australian projects in the region that laments the lack of farmer involvement, both local and SA farmers. They are especially harsh on Australian professionals, deploring their "absence of intellectual rigour that is reflected in the way in which data and experiences are simply ignored or rejected."[163] Yet the Chattertons themselves failed to cite the increasing evidence from the 1980s questioning the relevance of ley farming in the region, notably ICARDA's 1989 conference on ley-farming experiences across MENA. As in their earlier writings they did not seriously address the problem of grazing management beyond vague talk of "incentives to maintain pasture" and their faith in transferring the SA farming system model to MENA never wavered.

To be fair, the SA adventures in MENA took place against the backdrop of a highly influential article in *Science* in 1968 by G. Hardin, *The tragedy of the commons.*[164] Hardin had argued that open access to natural resources such as pastures leads to overexploitation and degradation to the detriment of society as a whole. He further proposed that these "market failures" were best remedied through privatisation of those resources by granting exclusive property rights to individuals and households, or sometimes by central (i.e. state) control of the resource. Yet over the next two decades, the political scientist and future winner of the Nobel Prize in Economic Sciences, Elinor Ostrom, was assembling case studies to show how many communities voluntarily organise to collectively regulate the use of

[159] N. Halse & H. J. Trevenen, 'Damage to medic pastures by skylarks in northwestern Iraq,' *J. Applied Ecology* 22 (1985), pp.337-46.
[160] M. H. Halila, A. B. K. Dahmane & H. Seklani, 'The role of legumes in the farming systems of Tunisia,' in Osman et al. (1990), pp.113-30.
[161] Tideman (1994), p.42.
[162] L. Chatterton & B. Chatterton (1996).
[163] L. Chatterton & B. Chatterton (1996), p. xx.
[164] G. Hardin, 'The tragedy of the commons,' *Science* 62 (1968), pp. 1243-8.

their common pool resources to the benefit of the community.[165] There is little evidence of successful cooperation among farmers and herders for improved pastures in MENA in part due to state appropriation of traditional common property rights in many countries as well as the fact that herders were often nomadic and from different tribal or ethnic groups to farmers.

Meanwhile back in SA, ley farming was also in trouble. In 1981, only one year after the International Dryland Farming Congress in Adelaide, SADA organised a symposium at Roseworthy on *The medic crisis in cereal-livestock farming systems of South Australia.* Ted Carter, who had done so much to promote the system in MENA, listed ten reasons why the system was in decline in SA. These included the lack of investment by farmers in pastures, poor grazing management, increased frequency of cropping, growing damage from insects, increased use of herbicides, and rising acidity in some soils. These problems in turn reflected the system's "reliance on a very narrow suite of legumes and the tendency to manage these as monocultures."[166] They also related to changing economic conditions – declining wool prices relative to wheat had reduced the length of the pasture phase, and introduction of non-legume crops such as canola had led to increased use of nitrogen fertiliser.[167] It also seems that the famous Donald 'opera house' curve of wheat yields had overestimated the gain in yields from ley farming due to the unique weather and price conditions of the 1950s.[168] Indeed, between 1960 and 1990, when SA was promoting its technology in MENA, wheat yields in SA rose more slowly than in any country in MENA except Algeria.[169]

Although change in MENA has been much more diverse across countries and rainfall regimes, there has also been important evolution in farming systems there as well. Land left fallow has declined almost everywhere as cropping has become more intensive. Both grain legumes and forage legumes (but not medics) are on the rise, but so is the unsustainable trend toward continuous cereals.[170] Livestock numbers have dramatically increased but supplying adequate feed resources and arresting land degradation and desertification continue to be major challenges.

Conclusions

This tour of a century of Mediterranean exchanges built around pastures provides a number of insights relating to technology transfer and evolution of farming systems more generally. At first glance, Australian farmers and scientists did develop a dryland farming system integrating crops and livestock that was an alternative system to the prevailing trend toward systems dependent on external inputs.

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[165] E. Ostrom, *Governing the commons: The evolution of institutions for collective action,* New York: Cambridge University Press, 1990.
[166] J. G. Howieson, G. W. O'Hara & S. J. Carr, 'Changing roles for legumes in Mediterranean agriculture: developments from an Australian perspective,' *Field Crops Research* 65:2-3 (2000), pp.111.
[167] J. F. Angus, 'Nitrogen supply and demand in Australian agriculture,' *Australian Journal of Experimental Agriculture* 41:3 (2001), pp.277-88.
[168] As noted, rainfall was well above average in the 1950s. The high wool prices in this period also extended the pasture phase of the rotation and shifted marginal land from wheat to wool. See also J. F. Warren, 'Wheat yield trends in Australia,' *J. Aust. Inst. Agric. Sc.* 35 (1969), pp.240-52.
[169] Computed through linear trend analysis of yields available online at https://www.fao.org/faostat/en/#home. However, absolute yields in SA remained above those of most countries in MENA. For similar conclusions see, A. Hamblin & G. Kyneur, *Trends in Wheat Yields and Soil Fertility in Australia,* Canberra: Aust Gov Publishing Service, 1993.
[170] S. Ates et al., 'Annual forage legumes in dryland agricultural systems of the West Asia and North Africa Regions: Research achievements and future perspective,' *Grass and Forage Science* 69 (2014), pp.17-31.

Notably, the adoption of the dryland system was facilitated by short-run economic benefits especially from the 1950s combined with long-run benefits in the form of soil conservation. The lack of adoption of this system in other dryland areas, notably MENA, reflected in part different economic incentives and endowments of land, labour and capital. Over time, however, incentives have converged with market liberalisation so that use of nitrogen fertiliser on cereals has become standard practice in both SA and MENA in all but the driest margins of farming. Further, there has been a global convergence of thinking about the importance of legumes in sustainable farming. The worldwide movement to 'conservation agriculture', as defined by FAO, emphasises the maintenance of year-round soil cover and increased diversity of crops in a rotation, both commonly achieved by adding legumes to the farming system.[171]

Second, the scientific community overemphasised the role of 'climatic analogues' in the Mediterranean exchange. To be sure there was a strong rationale for Australian scientists to seek forage legumes from the Mediterranean region since as a biological innovation they were quite sensitive to climatic factors – forages that were earlier introduced from the UK were unsuited to the dryland wheat areas. As observed by a leading legume scientist, "Australia is umbilically connected to the Mediterranean region for germplasm."[172] In contrast, the transfer of an entire farming system based on climate analogues was surely naïve, even at the time. After all, Australian pasture science was initially built on the application of concepts and methods from the UK, above all at Aberystwyth, in a very different climate. These strong links built the capacity of Australian scientists to effectively apply these concepts and methods in their own environment. In returning the medics to MENA, scientists initially saw the task as a biological innovation to simply replace fallow with a suitable pasture species, rather than working out how to intensify crop-livestock systems in a very different social and economic context. Indeed, these socio-economic differences far outweighed the climatic similarities.

Third, the historical analysis of transfer processes across a century, reveals how the rise of international organisations such as the FAO and CGIAR greatly facilitated interaction and technology transfer in the post-colonial period across distant countries with different imperial ancestries and cultures. Prior to the Second World War, interaction within colonial Empires was, of course, common, and indeed encouraged, but much more limited across Empires due to imperial trade rivalries and language barriers. Australian scientists operated largely within the confines of the British imperial scientific establishment and even interaction with US scientists was limited even though they been collecting annual medics in the Mediterranean and undertaking research that led to their wide adoption from around 1900.[173] Nonetheless, as Jonathan Curry-Machado notes, despite efforts to maintain imperial autarky in markets, technologies and scientific knowledge, such geopolitical boundaries are often quite porous, and limited ad hoc exchanges between MENA and Australia dated from the nineteenth century.[174] Even after the high potential value to Australia of forage collection expeditions in MENA had been verified in a field visit in 1928 it took more than two decades for Australia to

[171] https://www.fao.org/conservation-agriculture/en/.
[172] W. Erskine, 'Benefits to Australia from involvement in agricultural research for development, using Western Australia as an example'. Accessed online at https://www.crawfordfund.org.
[173] For US experience with medic pastures and collection expeditions in MENA, see the unbridged version of this paper at https://www.pir.sa.gov.au/aghistory/publications_and_reports/historically_important_documents.
[174] Jonathan Curry-Machado, 'Global histories, imperial commodities, local interactions: An introduction.' *Global histories, imperial commodities, local interactions*, London: Palgrave Macmillan, 2013, p.5.

mount its first organised expedition. Part of this reflected scarcity of resources in the depression and the outbreak of war, but language barriers and lack of local contacts to arrange logistics were also significant factors. From the 1950s, FAO, and later the CGIAR centres, assumed a mandate to provide or facilitate access to agricultural technology and scientific knowledge, including the collection and conservation of genetic resources. Although these international bodies were seen as assisting poorer countries, they greatly benefited Australian research on pastures and its agriculture more generally.[175] Similarly, after 1970 FAO and CGIAR centres played central roles in research and capacity building for 'returning the medics' by promoting the Australian ley-farming system in MENA.

Fourth, it required many years of transfer efforts to recognise the limitations of the ley-farming system in MENA. This applied not only to the Australian scientists and project managers, but also national leaders, and the international organisations. Initially the narrow disciplinary orientation of research teams resulted in an overly technical approach to the problem. Over time, however, scientists active in the field, both Australian and national, came to appreciate the challenges. Still, they were slow to understand the variation and complexity of existing farming systems and to introduce more flexible options to meet this underlying diversity. Moreover, champions, with high-level political connections, effective communication skills and a great deal of energy, remained enthusiastic promotors of the Australian system, delaying a change in strategy. This misguided enthusiasm in the face of growing evidence of the limitations of the system seemed to reflect a combination of humanitarian motives and a quest for international fame in an era of 'brand heroes' such as Norman Borlaug in international agriculture.[176]

Finally, the Mediterranean exchange illustrates how commodity frontiers play out in very different contexts. As suggested by Beckert and colleagues' phases of commodity frontier expansion, the 'commodification' of pasture varieties initially originating from the Mediterranean region was key to intensifying SA's dryland farming systems.[177] However, and in contrast to the agribusiness domination of seed markets more broadly, the pasture seed industry was developed by farmers themselves through a cooperative enterprise, SeedCo. In efforts to intensify systems in MENA using medics SeedCo did play an important role along with many other actors but economic incentives and/or autocratic powers of political leaders were rarely sufficient to achieve even the second phase of the commodity frontier expansion requiring changes to customary land rights and enclosure of the commons to manage grazing.

A century of Mediterranean exchange has undoubtedly produced enormous benefits to Australia. This is especially so in acquiring genetic resources, but its scientists and farmers also gained from overseas experience and interaction in returning the medics to MENA.[178] SA agribusiness achieved significant sales although far less than initial expectations. It is more difficult to ascribe benefits to the countries of MENA since the experiences were highly diverse, but they have undoubtedly been much smaller. Oil-rich countries that invested heavily in the projects did not see a

[175] J. P Brennan, A. Aw-Hassan, K. J. Quade, & T. L. Nordblom, *Impact of ICARDA research on Australian agriculture*, Economic Research Report No. 11, Wagga Wagga: NSW Agriculture. 2002.
[176] J. Sumberg, D. Keeney, and B. Dempsey, 'Public agronomy: Norman Borlaug as 'brand hero' for the Green Revolution,' *Journal of Development Studies* 48, 11 (2012), pp. 1587-1600. However, a major difference to the case discussed here is that Borlaug's semi-dwarf wheat varieties became the most widely grown varieties in the world.
[177] Becket et al., 2021. Commodification of inputs markets represents their third phase of commodity frontier expansion.
[178] Erskine, 'Benefits to Australia', at https://www.crawfordfund.org.

return, partly due to difficulties of adapting the system, but also to political and economic instability. However, there were also benefits to countries in appreciating and conserving the richness of their genetic heritage, in building their capacity for research on forages, and in establishing broader scientific linkages outside of their historic ties to Europe. Sustainable intensification of dryland agriculture through the integration of crops and livestock remains a challenge today in MENA, and continued interaction with Australia, among others, has the potential to yield mutual benefits.

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Commodities of Empire is a British Academy Research Project based at the **Centre for Modern and Contemporary History, University of Birmingham**. It consists of a growing international network of researchers and research centres. Its websites and publications are hosted by the **School of Advanced Study, University of London**

The mutually reinforcing relationship between 'commodities' and 'empires' has long been recognised. Over the last six centuries the quest for profits has driven imperial expansion, with the global trade in commodities fuelling the ongoing industrial revolution. These 'commodities of empire', which became transnationally mobilised in ever larger quantities, included foodstuffs (wheat, rice, bananas); industrial crops (cotton, rubber, linseed and palm oils); stimulants (sugar, tea, coffee, cocoa, tobacco and opium); and ores (tin, copper, gold, diamonds). Their expanded production and global movements brought vast spatial, social, economic and cultural changes to both metropoles and colonies.

In the Commodities of Empire project we explore the networks through which such commodities circulated within, and in the spaces between, empires. We are particularly attentive to local processes – originating in Africa, Asia, the Caribbean and Latin America – which significantly influenced the outcome of the encounter between the world economy and regional societies, doing so through a comparative approach that explores the experiences of peoples subjected to different imperial hegemonies.

The following key research questions inform the work of project:

1) The networks through which commodities were produced and circulated within, between and beyond empires;
2) The interlinking 'systems' (political-military, agricultural labour, commercial, maritime, industrial production, social communication, technological knowledge) that were themselves evolving during the colonial period, and through which these commodity networks functioned;
3) The impact of agents in the periphery on the establishment and development of commodity networks: as instigators and promoters; through their social, cultural and technological resistance; or through the production of anti-commodities;
4) The impact of commodity circulation both on the periphery, and on the economic, social and cultural life of the metropoles;
5) The interrogation of the concept of 'globalisation' through the study of the historical movement and impact of commodities.

http://commoditiesofempire.org.uk/

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