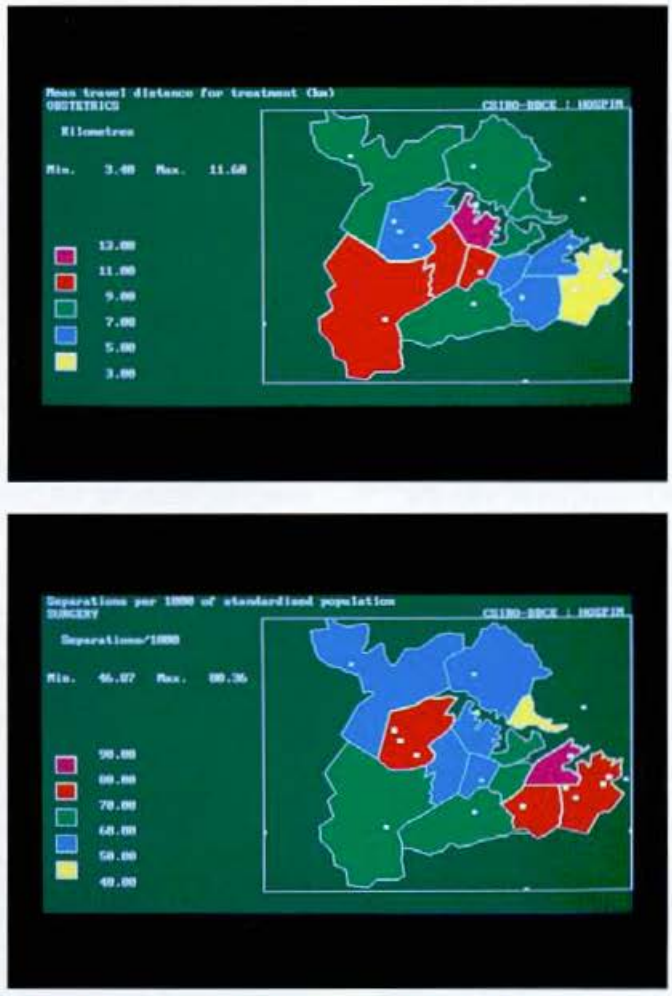
Spectrum

Planning for future needs

In comparison with other developed countries, Australia has a moderately high population growth rate — about 1·6%. But if we remove the contribution made by adult immigration, something approaching zero population growth results, as evidenced by a steady birth rate despite a net increase in population.

However, considerable variation occurs between and within States; we need to consider both the population changes inspired by immigrants from overseas and those that result from movement between States: New South Wales and Victoria, for example, receive the major share of incoming overseas immigrants, but become the greatest net losers due to migration interstate.

Australia's population is also growing older and family sizes are decreasing, both of which affect mobility patterns between city and country, and interstate. All of these factors have wide-ranging implications for the kinds of services the community needs and the distribution of those services, now and in the future.



HOSPIM illustrates the average distance travelled by obstetrics patients for hospital treatment in Sydney (top) and the number of hospital 'separations' (patients registered as they leave hospital) in Sydney per 1000 of population.

The increase in the average age of our population, for example, means greater community need for hospital services, aged-care and recreational facilities and public transportation. There is also evidence of different sectors of the population moving in different directions, with the poor and elderly tending to move to low-cost rural locations and professionals concentrating in more expensive locations that offer more diverse opportunities. This information, as well as the ability to forecast regional populations, is vital to federal and State government planners — who until now have relied mainly on census data and simple projections of trends.

Since the mid 1980s the Planning and Management Program at the CSIRO Division of Building, Construction and Engineering in Melbourne has been providing computer planning-information packages to all levels of government and to authorities such as Telecom.

In 1990, the Commonwealth Department of Industry, Technology and Commerce and the Indicative Planning Council brought together a multi-disciplinary team — co-ordinated by Division researcher Dr Joe Flood and including spatial modellers, geographers, economists and computer scientists from CSIRO, Monash University and the National Institute of Economic and Industry Research — for a major project called 'The Determinants of Internal and Interstate Migration within Australia'.

About $50 000 was allocated to the implementation of a population-forecasting package known as TEMPO (Technique for Evaluation of Mobility of POpulations), developed by CSIRO researchers Dr John Roy and Mr Miles Anderson.

They designed TEMPO to provide predictions of future regional population distributions and their composition for developers, retailers, housing authorities, construction firms and private- and public-sector infrastructure-planners.

The package divides the population according to criteria such as age, categories of skills, household composition, income, job status (employed or unemployed) and housing status (owner-occupier or tenant). Projections can be made from alternative scenarios for economic growth, disposable income, unemployment, housing costs and overseas immigration policy. For example, possible changes in the total immigrant quota and the proportions from refugee, family-reunion and skills-based categories are fed into TEMPO, which then models a future population distribution reflecting different patterns of competition for housing and jobs between internal migrants and new distributions of overseas immigrants.

Alternatively, TEMPO can examine the effects of different housing price movements between Sydney, Melbourne and Brisbane, including identifying future supply bottlenecks. 'The results of the model will be information that is useful, comprehensive, easily manipulated and interpreted', says Dr Roy. It became available from the Division on a consulting basis from April.

A further development by Dr Roy and Mr Anderson is HOSPIM (Hospital Patient Spatial Impact Model), a hospital-planning package that allows planners to experiment interactively — on screen — with different strategies for hospital-related health care delivery. It

assesses the impact of these strategies on community standards of care, as well as the impact of changes in the composition of communities on the viability of hospitals in particular locations. Some original 'seeding' funding was provided by the federal Department of Health, with the Australian Institute of Health providing assistance in organising seminars for all States.

A joint venture between Cliff Consultants, Sydney, and CSIRO is currently applying HOSPIM in New South Wales and Tasmania, with the first applications occurring in co-operation with the New South Wales Health Department and Royal Prince Alfred Hospital, Sydney. A second joint venture for South Australia and Victoria was recently signed with Dr van Konkelenberg of Fresbout Ltd, Adelaide. Authorities in New Zealand, Boston, Brisbane and Perth have also expressed interest.

Expected uses for HOSPIM include: examining co-ordination between the public and private hospital systems; allocating high-technology tertiary treatment equipment and staff; planning for different levels of dependency in aged-care facilities, from retirement villages to nursing homes; assessing changes in the mixture of specialties in particular hospitals to cope better with the changing demographic structure of hospitals' catchment populations; and guiding the allocation of resources to hospitals within individual regions.

The software's performance indicators relate, on the demand side, to the efficiency and equity of access to appropriate levels of care within both urban and rural areas and, on the supply side, to so-called throughput efficiency (optimising factors such as average length of stay and bed occupancy rate) and levels of utilisation of hospital capacity. If the number of admissions for a particular specialty — say, thoracic surgery — decreases over time at one hospital, HOSPIM can minimise wastage of beds and staff resources by identifying other specialties with increasing demand in that hospital's catchment area.

Carson Creagh

TEMPO forecasts population shifts. *Focus* (CSIRO Division of Building, Construction and Engineering), Spring 1990.
'HOSPIM Computer User Manual.' J. R. Roy and M. Anderson. (CSIRO: Melbourne 1990.)

An elusive vitamin under the spotlight

We all know that we need an adequate supply of vitamins for good health. Indeed, a vitamin is defined as an organic substance that our bodies cannot make but that is necessary for health. But one vitamin, E — as even its name seems to suggest — frequently ranks lower in scientific and public awareness than its alphabetically senior cousins.

As recently as a decade ago some nutrition textbooks had a question-mark over its precise function in the human body, describing it as 'a vitamin without a disease'. Experiments had shown that in rats a shortfall could lead to infertility, and so for a while the vitamin was quite incorrectly connected in the public mind with sexual potency!

While scientists dismiss the aphrodisiacal claims for vitamin E, an improved understanding of its varied beneficial effects is developing. The various forms of vitamin E, or tocopherol, are now known to be antioxidants; that is, they prevent oxidation (the removal of electrons), which can damage a range of important biological compounds. We live in, and indeed depend upon, what chemists regard as a mildly reactive and corrosive gas — oxygen.

Although oxygen does contribute, being capable of removing electrons, we experience much more oxidation from the short-lived 'free radicals' formed in many of the reactions inside our cells. Proteins, fats and DNA are all susceptible to their destructive impact.

Of course, living things have evolved defence mechanisms to cope with oxidative damage; the longer-lived the organism is, the more elaborate its free radical defences have to be. Enzymes can repair some damaged molecules, but antioxidants constitute the first line of defence, and that's where vitamin E comes in.

Along with vitamin A, the carotenoids, vitamin C and elements such as zinc and selenium when they are incorporated into biologically active molecules, vitamin E is oxidised by free radicals, thereby acting as a shield to help protect important molecules of the cell. It follows, in theory, that the lower the concentration of antioxidants becomes, the more the free radicals will damage our cells. Over decades, the effects of the continuous free radical assault may accumulate, and contribute to the aging process. Damage to DNA by free radicals may be a factor in the onset of cancer; in cardiovascular disease (heart attack and stroke), the walls of arteries — carrying as they do oxygen-rich blood — may eventually suffer as damage to individual cells accumulates.

Antioxidants may be particularly important if you consume large quantities of polyunsaturated fatty acids. These fats, although generally regarded as being nutritionally preferable to the saturated ones of animal origin, are especially susceptible to oxidation. Studies have shown that the resulting products can disrupt cell membranes, themselves composed of fat, and disturb the normal formation of prostaglandins — hormone-like molecules that are important in regulating the aggregation of platelets, the opening and closing of small blood vessels and the immune response.

Dr Graeme McIntosh of the CSIRO Division of Human Nutrition in Adelaide has taken a particular interest in the role of vitamin E in health and disease for a number of years, and has conducted a range of studies on it.

In one experiment, he found that supplementing the diets of experimental rats and marmosets with tuna-fish oil (mainly polyunsaturated) resulted in pathological changes associated with vitamin E deficiency, despite the fact that the animals were consuming normal amounts of the

Where to find your vitamin E:

- vegetable oils, although the potency of the vitamin is lost with heating, especially frying
- cereals — particularly the germ of whole grains
- nuts and seeds
- fruits and vegetables

The most concentrated natural sources of the vitamin are almost anything oily of plant origin. However, a responsible diet involves minimising fat consumption, so fruit and vegetables (although not rich sources *per se*) will, if eaten in abundance, provide vitamin E in a 'healthy' package without the worry of high calories and fat intake.

vitamin in the rest of the diet. The high dose of polyunsaturated fats used up much of the antioxidising ability of the animals' existing vitamin E, thus giving rise to all the symptoms of a true dietary vitamin E deficiency.

In Nature, most sources of polyunsaturated fats contain vitamin E — which acts as an antioxidant to stop the fat or oil from turning rancid — but problems can arise when the oil is extracted. Frequently food manufacturers add artificial antioxidants to keep the fatty acids from oxidising during storage of the foodstuff. To what extent this remains effective inside us is not yet clear. However, Dr McIntosh points out that with excessive use such synthetic antioxidants can be toxic. It therefore seems sensible to suppose that the naturally present vitamin is safer for us.

Certain factors can influence our absorption of vitamin E. These include: a blockage of the normal flow of bile (cholestasis), a fluid necessary for the normal absorption of fats in which vitamin E is dissolved; the presence of intestinal parasites that, by damaging the inner surface of the small intestine, can reduce absorption of the vitamin as well as other dietary components; abnormal mucus formation in the gut and other organs (the disease cystic fibrosis); and excessive alcohol consumption. Absence of the normal lipoproteins (fat-carriers) in the blood can also have an effect.

So, are Australians taking in enough of this vitamin? Dr McIntosh believes the answer may not always be 'yes'. Nobody has yet carried out a comprehensive survey on the vitamin E content of foods in Australia. In the United States, a recent survey showed that as many as 20% of the population could receive inadequate supplies of vitamin E, and that certain groups — the poor, the elderly and blacks — are particularly at risk. Dr McIntosh believes that the same applies to certain groups in our society. Our own poor and elderly clearly need consideration in the light of the American findings. Chronic alcoholics, because of their generally poor standard of nutrition, are also at risk.

Some Aboriginal communities constitute another such group. In research at Yalata, S.A., Dr McIntosh measured the vitamin E status of Aboriginal children and found it to be low. He suspects that this was brought about by a combination of poor nutrition and the presence of intestinal parasites, which influence absorption via the intestine.

Dr McIntosh, in collaboration with Dr Robert Gibson of the Flinders Medical Centre, has conducted research that suggests diabetics too could benefit from an increased intake of vitamin E.

One of the most serious long-term complications of diabetes is the slow blockage of small blood vessels, which can lead to a range of major problems. If it occurs in the retina of the eye, blindness can result; if in the brain, a stroke. The occlusion of the vessels comes about because the clotting agents in the blood — the platelets — start sticking together when they shouldn't. Although we know how the aggregation of platelets occurs normally (when a blood clot is necessary), scientists have little idea why they sometimes clump together at the wrong time.

The incorrect functioning of platelets is a well-known phenomenon in people with diabetes. Scientists believe that it could be connected with the level of vitamin E because the behaviour of platelets becomes disturbed when the vitamin is deficient. (This comes about through the deficiency-induced change in prostaglandin levels mentioned earlier.)

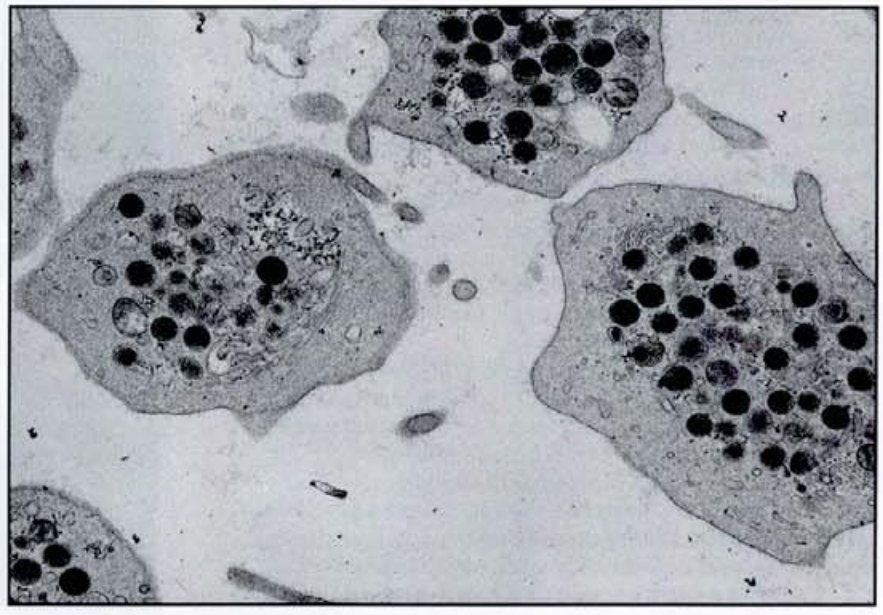
But Dr McIntosh's study did not find any shortage of vitamin E in the malfunctioning platelets, although he and his colleagues did observe various biochemical changes in them. The plasma (the blood fluid rather than the cells) contains an actual surplus of vitamin E, suggesting that abnormal transport could be occurring.

However, preliminary results from a small study of mature-onset diabetes — which is primarily a disease of middle age connected with obesity and the consumption of too many calories — gave quite different findings. Sufferers from this condition generally have too much insulin, and their body's cells don't respond properly to it. They also have too much of the wrong sorts of fats in the blood.

The research showed that such people had normal or high quantities of vitamin E in their plasma, but not enough in their platelets. The vitamin seemed to be pooling in the blood, perhaps 'blocked' in some way from entering the cells and platelets as a result of the abnormal pattern of fats. Dr McIntosh believes that supplementary vitamin E in the diet could help these patients, but would only be effective if combined with simultaneous changes in their diets aimed at normalising their blood fats, which could overcome blockage to the normal transport of the vitamin.

Despite his finding of high concentrations in the platelets of juvenile-onset diabetics, Dr McIntosh points to other studies that suggest that supplementing with vitamin E will nevertheless decrease the aggregation of platelets in these patients. How it works, scientists don't yet know; the nature of the biological response to high doses of vitamin E is still poorly understood. Clearly, much more remains to be discovered about this rather 'low-profile' vitamin, but already the evidence suggests it is far more 'influential' than was at first thought.

Roger Beckmann



Blood platelets under the electron microscope. The dark circles in them are molecules that, if released, bring about reactions that can lead to blood clotting. Proper levels of vitamin E in platelets appear to be essential for their correct functioning.

Vitamin E and human health — is our diet adequate? G.H. McIntosh. *Medical Journal of Australia*, 1989, **150**, 607–8.
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Unwanted nitrates — the termite connection

Ever tried to lather soap in the outback? The problem is the 'hardness' of the water, due to the dissolved minerals and salts in the bore water on which most arid settlements rely.

Water from many bores in central Australia contains nitrate ions, NO_3^- (generally balanced by positively charged sodium ions). Usually, nitrates in rivers, lakes, groundwater and the sea are a sign of pollution. They can come from agricultural fertilisers or sewage, and their presence, along with that of other nutrients such as phosphorus, often causes excessive algal growth or eutrophication.

But central Australia has a very sparse human population, and no widespread application of fertiliser occurs. Yet, in some aquifers in the Ti-Tree basin of the Northern Territory, hydrologists have found nitrate concentrations as high as 360 mg per litre in water of otherwise low salinity.

Above a certain concentration, nitrates can be toxic — and their derivative nitrites (NO_2^-), which can form by the action of bacteria, are even worse. Those most at risk are babies under the age of 3 months. Bacteria in contaminated feeding bottles or in the stomach convert the nitrate to nitrite. And, when absorbed into the bloodstream, this nitrite attaches easily and irreversibly to the infant's haemoglobin, forming a compound called methaemoglobin, which is inefficient at carrying oxygen.

The babies therefore become anaemic and (because of the low oxygen concentration in their blood) often appear blue, giving the condition the name 'blue baby syndrome'. Adult haemoglobin is more resistant to the binding of nitrite and so adults can tolerate higher water nitrate levels than infants.

A further worry is the suggestion by some medical researchers that lengthy exposure to high levels of nitrate in food and water could be one of the factors predisposing towards cancers of the stomach and throat.

So nitrates pose a problem, and they may preclude the use of underground water as the drinking-supply for a small settlement. Where do nitrates in such abundance come from, and how do they get into the groundwater?

This was a question that Dr Chris Barnes of the CSIRO Division of water Resources, and his colleagues Mr Gerry Jacobson of the Bureau of Mineral Resources and Dr Geoff Smith of the Australian National University, decided to investigate. Soil microbes associated with the roots of acacias 'fix' nitrogen gas from the atmosphere into organic compounds, and other scientists had suggested that such biological 'fixation' could produce nitrates in the soil, which perhaps were leached down into the groundwater.

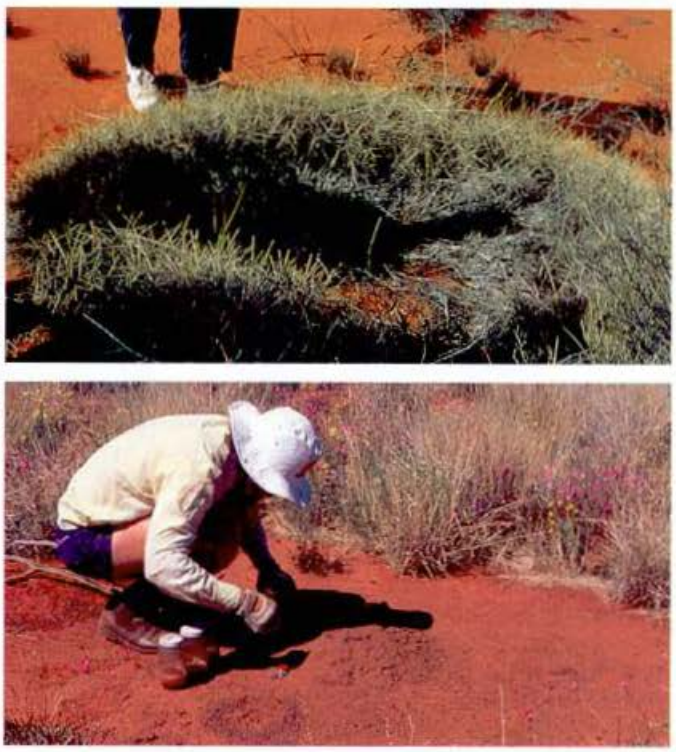
To test this idea, Dr Barnes and Mr Jacobson chose a study site near the Yulara tourist resort at Ayers Rock, where they analysed the nitrate in water from a number of bores. They found its concentration to be greater than 42 mg per litre. (Prospective visitors to the resort can be reassured that the water there undergoes complete desalination — which includes nitrate removal — by reverse osmosis.)

They then sampled the soil surface in a number of places, also measuring the level of nitrate. As expected, the tops of sand dunes gave low readings. Relatively high nitrate levels occurred beneath open ground and spinifex, with slightly lower levels underneath groves of young mulga trees (a type of acacia). The scientists found significantly lower concentrations beneath stands of mature mulgas.

A clue about the source of the nitrate came from laboratory analysis of soil samples, which showed the presence of blue-green algae, or cyanobacteria, in crusts. These primitive microbes were producing nitrate, which the mulgas, and other vegetation, then used. Cyanobacterial crusts occurred everywhere except on top of sand dunes.

But the biggest surprise concerned termite mounds: some of them contained a staggering concentration of nitrate — up to a hundred times the level found anywhere else. Just to be sure of this unexpected finding, the team carried out further sampling in July 1989, which confirmed their first results.

Not all mounds were nitrate-rich — differences between termite species existed, but the scientists could not investigate this fully. Those mounds that did harbour large quantities of nitrate carried most of it in the hard outside wall. Dr Barnes suspects that results from evaporation.



Photos: Gerry Jacobson

Relatively high concentrations of nitrates occurred beneath spinifex (top), but not nearly as high as those found in the soil surface of certain termite mounds. Dr Barnes (lower photo) samples a small pavement mound.

A windmill operating a bore — the source of water in many outback settlements.

Scientists Dr Geoff Smith (left) and Dr Chris Barnes taking samples to find the origin of nitrate-rich groundwater in central Australia.

When the mound is soaked, the soluble nitrates from the termites disperse. Then, as the mound dries, the water is drawn up, travelling to the outside where it evaporates, leaving the nitrates concentrated in the outer skin.

The next heavy rain — and rains in this part of the world are rare but generally heavy when they do arrive — will rinse the nitrates off the outside of the mound and down, eventually, into the water table. Indeed, when the scientists carried out core sampling beneath spinifex, bare soil and cyanobacterial crusts, they found pulses of nitrates at various depths, corresponding to nitrate 'flushes' from the surface after a big 'rain event'. Bacteria able to break down the nitrate appeared to be scarce in the arid zone soils, possibly as a result of a shortage of carbon for them.

The only remaining piece of the puzzle is the question of why and how termite mounds become such a rich nitrate source. Perhaps bacteria in the gut of certain termite species fix nitrogen; other possibilities are that nitrifying bacteria at the mound surface convert the termites' ammonia excretion to nitrate, or that a termite secretion, perhaps used as a 'cement' in the mound, is rich in nitrate-containing salts. Whatever the details of the biochemistry, the fact remains that the particular termite species in the region have surely been in operation for tens of thousands of years, acting as nitrate-generators filling up the water in great basins beneath the desert with a chemical that we could do without.

All this is more than merely academic. The Northern Territory Power and Water Authority wants to know the origin of the nitrates in the hope that the knowledge could help predict which bores will be low-nitrate and which areas it should avoid for bore-drilling because of the likelihood of strong nitrate contamination.

Further work may help provide a measure of prediction, but several factors complicate the picture. Until we know all the relevant termite species and their distribution, any useful correlations will be hard to derive because mounds are ubiquitous and fairly evenly spread throughout the region. Furthermore, the hydrology of each area affects the recharge of water, leading to concentration in certain places; also, slow chemical reactions — probably brought about by bacteria — take place in groundwater, and old water very slowly loses some of its nitrate, even if it is in a high-nitrate zone.

Roger Beckmann

Cyanobacterial nitrogen fixation in arid soils of central Australia. G.D. Smith. R.M. Lynch, J. Jacobson and C.J. Barnes. *FEMS Microbiology Ecology* 1990, **74**, 79–90.

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