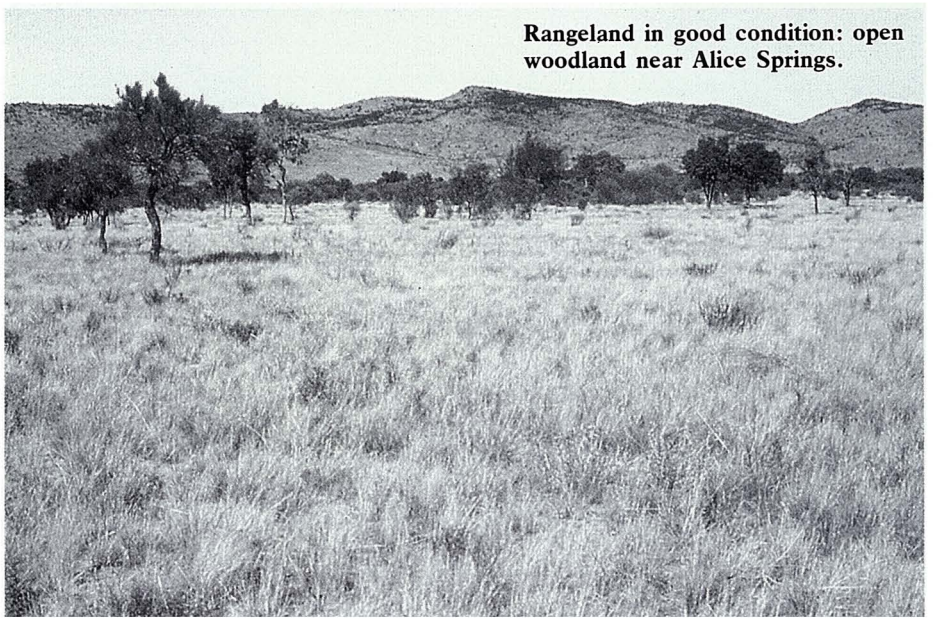
Monitoring the health of the arid inland

What is happening to Australia's arid and semi-arid land? Does it grow as much pasture as it used to? Is it eroding — and, if so, how badly? And are the native plant communities adequately conserved?



Rangeland in good condition: open woodland near Alice Springs.

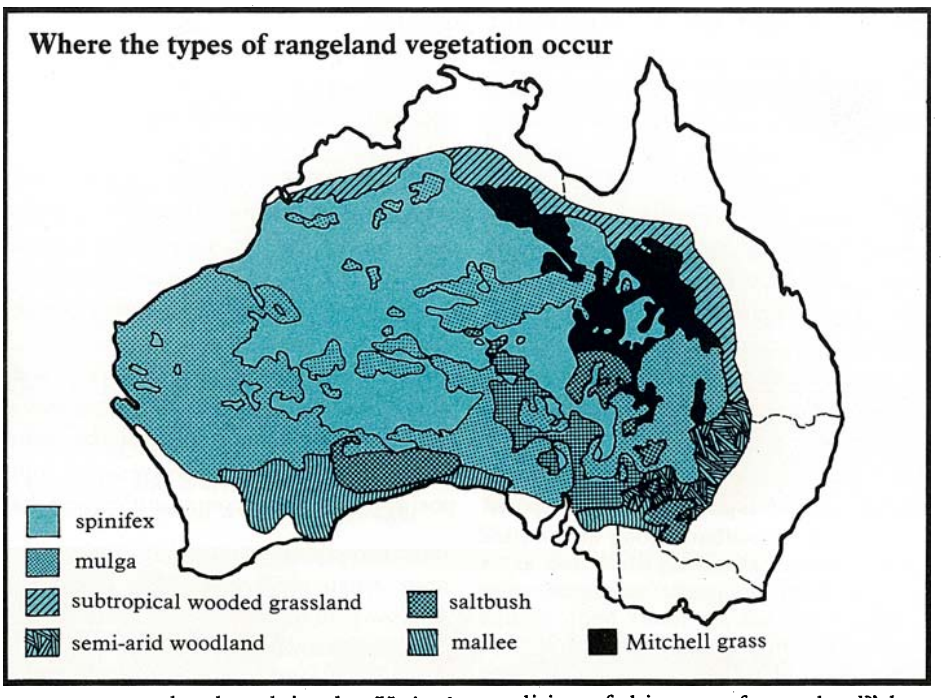
Although rangelands make up more than 70% of the nation's area, and although stock first ran over parts of them 130 years ago, we cannot yet fully answer these questions — a state of affairs that researchers at the CSIRO Division of Land Resources Management are determined to change.

Dryland pastoral country presents its own particular challenges to both graziers and scientists. Nobody ploughs, fertilizes, or sows seed. Native plants (augumented by some accidental aliens) make up the only crop, grazing and fire the only major tools of management.

If too many sheep or cattle feed on the pasture, the plant community may go into a decline resembling an ecological succession in reverse: the community's composition and productivity change, some species become extinct, and the soil may become unstable. In severe cases the changes may prove irreversible, particularly if erosion sets in and only a handful of unpalatable plants remain.

In essence, these points are only too well

Old pictures and diaries give some insight into the land's former condition. This 1903 snap of a New South Wales property shows tall corkscrew grass, young and old poplar box, and burnt mulga and native pine.



known to those who try to wrest a living from the arid and semi-arid zone; but, for research purposes, broad qualitative generalizations do not suffice. If scientists are to detect changes in the 'health' of the rangelands before serious 'sickness' sets in, they must identify and measure the factors involved.

They must find ways to record the accumulated knowledge of experienced graziers and agricultural advisers, in a form that can usefully be passed on to newcomers. (It is all very well to read in an old diary that 'the country was a sea of wire-grass', but how much was 'a sea'? And which species of 'wire-grass' did the writer have in mind?)

Scientists must teach pastoralists how to recognize the early symptoms of ailing rangeland: to identify the key species and learn their responses to different grazing pressures and to different seasons. In short, they must encourage the pastoralist to 'read the land'.

A recent South Australian interdepartmental working group inquiring into the State's *Pastoral Act* commented on the 'dearth of knowledge' about the arid lands. 'To a large extent', the group said in its report, 'we do not know what resources these lands support and how they are affected by various land uses.' Apart from pasture, dryland areas serve forestry, water supply, mining, conservation, tourism, and other purposes. 'There is an urgent need', the report added, 'to create an inventory of arid zone resources and determine the extent, cause, and nature of degradation.' These remarks apply with equal validity to the rest of Australia's rangelands.

The state of the country

From considerations such as these has arisen the idea of 'range condition'. This concept was developed in the United States of America, and different people have defined range condition in different ways.

Dr Allan Wilson, the officer-in-charge of the Division of Land Resources Management's laboratory at Deniliquin, N.S.W., likes to define the condition of the land in terms of its potential value. If people's use or management of an area has reduced that land's potential, then its condition has deteriorated.

Dr Wilson stresses that this definition has nothing to do with the normal fluctuations in productivity that come with favourable and poor seasons. All land, whatever its condition, has both good years and bad. 'Range condition does not refer to the amount of forage growing on the land, or to the fatness of the livestock', he explains. It is a statement of how closely a particular area approaches the best performance of which that land type is capable.

It is all very well to read in an old diary that 'the country was a sea of wire-grass', but how much was 'a sea'?

Just what performance may be expected of the land depends, of course, on the purpose to which it is being put, and for this reason Dr Wilson insists that different scales for measuring land condition must be devised to assess a site's suitability for different types of land use. By this philosophy, the question 'What is the condition of this area of rangeland?' has no single answer. Overseas, range condition has been variously defined: in the United States field workers assess it by estimating the extent to which the original vegetation has undergone ecological change, while South Africans prefer to assess it in terms of the land's capacity to carry stock.

Dr Wilson argues that these approaches may serve pastoralists well, but that one must always remember that the land's suitability for some other purpose, such as recreation, tourism, or conservation, may be quite different.

Even when the land use has been specified, a number of difficulties face the scientist setting out to devise a scale for measuring range condition. For example, different land types or areas with different climates respond in different ways to man's interference, and separate scales may be needed for each. Furthermore, the 'background signal' of, say, a decline in the land's condition must be distinguished from the 'noise' caused by fluctuating seasons. To make the task yet harder, grazing continues all the time, and cannot be halted so that scientists can see what happens. And researchers always face the problem of grappling with the huge size of Australia's rangelands.

Plants come and go

The system of pastoral land assessment used in America dates back to the second decade of this century. Mr A. W. Sampson suggested that when a land-owner noticed some plants replacing others he knew he was grazing the land too intensively. The Soil Conservation Service of the United States Department of Agriculture fol-

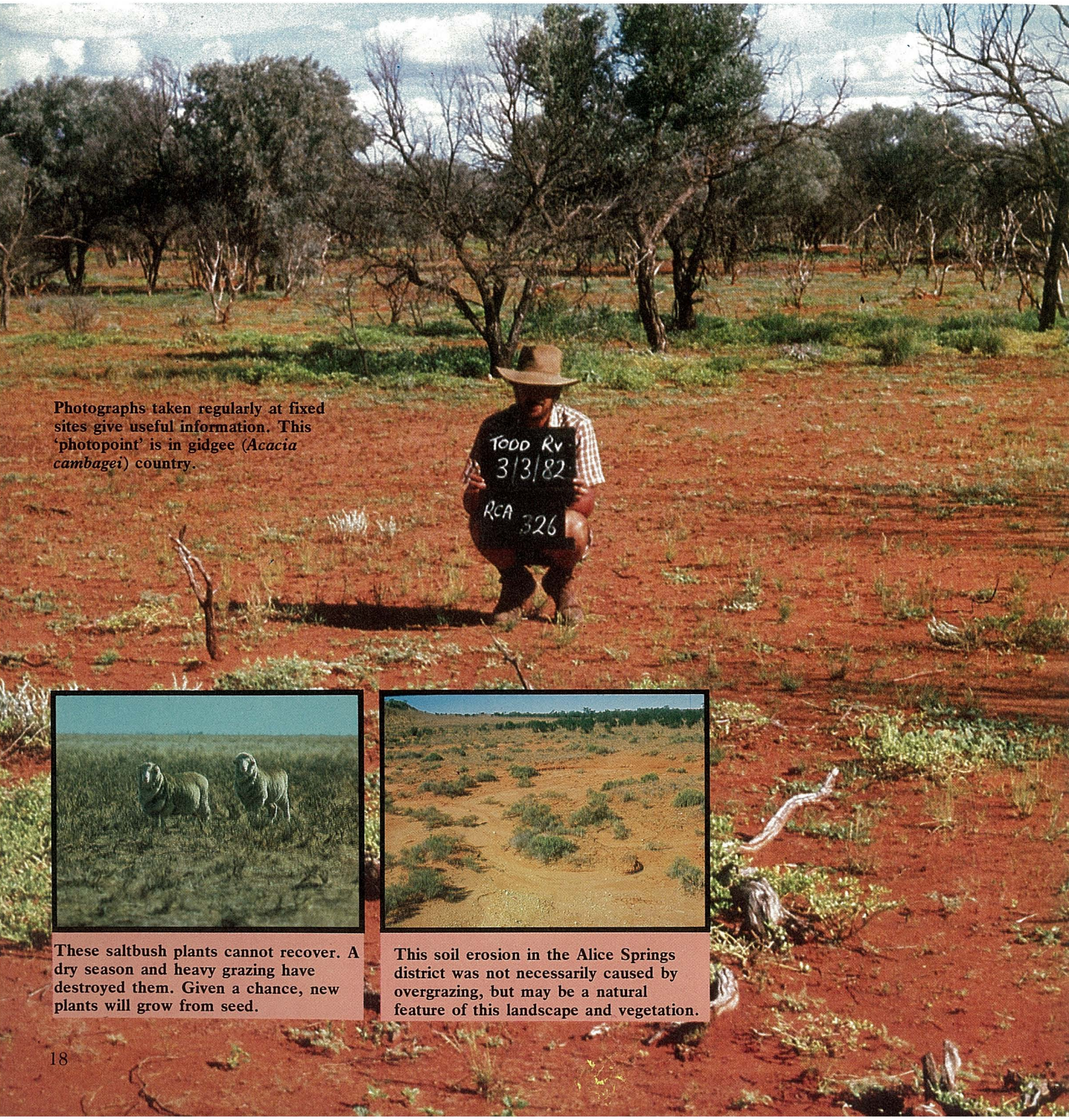
lowed up this idea, and soon after World War II Mr E. J. Dyksterhuis, who laid the basis for current assessment methods, defined range condition as 'the percentage of the present vegetation which is original vegetation for that site'.

Dr Wilson explains that the Dyksterhuis system does not satisfy Australian needs. In the first place, the United States approach begs the question whether the original vegetation was necessarily 'best' — a question whose answer must depend on the land use. In any case, in an area that has been settled and used for a long time, scientists may have difficulty establishing just which plants did make up the original community, and in what proportions.

Introduced plant species create another obstacle. There seems little point in comparing the vegetation of a piece of Australian rangeland with its supposed presettlement state if the introduction of vigorous exotic species, some of them valuable pasture plants, has guaranteed that the 'virgin' community can never be restored under natural conditions.

The American system can work well — it grew, after all, out of field experience. But the system assumes that the main change to rangeland involves the composition of its plant communities, and that other important changes go hand in hand with these shifts in vegetation. In Australia these assumptions do not always hold. Moreover, the American system ignores soil erosion and — a vital consideration in open woodland — does not take trees into account.

All in all, Dr Wilson maintains that the condition of the land must not be thought of as a precise quantity, simply waiting for a researcher to come along and measure it with scientific precision. 'Range condition is a concept, like succession', he says. 'You cannot tie it down mathematically; it occurs in so many different forms.'



Photographs taken regularly at fixed sites give useful information. This 'photopoint' is in gidgee (*Acacia cambagei*) country.

These saltbush plants cannot recover. A dry season and heavy grazing have destroyed them. Given a chance, new plants will grow from seed.

This soil erosion in the Alice Springs district was not necessarily caused by overgrazing, but may be a natural feature of this landscape and vegetation.

The land's attributes fall in three categories: vegetation, soil, and productivity.

Deciding what to measure

If range condition is such a slippery entity, how then can you measure it? According to Dr Wilson, you draw up a list of the site's characteristics, usually referred to as attributes, and rank them in an order of importance that will depend on the land type and the use to which it is to be put.

The land's attributes fall into three categories: vegetation, soil, and productivity. Typical vegetation attributes include the composition of the plant community, the density of trees and shrubs, and the extent of cover afforded by smaller plants. The vegetation begins to show the impact of grazing or other use before either soil or productivity, and is the easiest to measure.

A soil's attributes include its structure and fertility, whether it is eroding (and, if so, how fast), and whether the surface has developed a crust.

Productivity may be assessed in terms of the number of animals that the land supports, the quality of the forage it produces, its ability to withstand drought, its value as wildlife habitat or for tourism or the conservation of rare plant and animal species, or even (if it forms part of a catchment area for water supply) the amount of water it yields.

Soil erosion, Dr Wilson emphasizes, must always be given the top priority (the extent and rate of soil erosion in Australia were described in *Ecos* 25). Land use will determine which attribute to put next on the list.

How in practice, then, do you set about assessing the condition of a particular rangeland property? To answer this question, let us look in more detail at one widespread type of pasture land, the bladder saltbush (*Atriplex vesicaria*) community, and let us start by considering how to arrive at a measurement (often called an index) of the vegetation.

Assessing saltbush country

In general, you can make two measurements of the plants: qualitative and quantitative. A qualitative approach involves recording which species occur in the study site; you can make it semi-quantitative by recording each one's frequency of occurrence.

What teeth and hooves can do: severe degradation around a drinking trough.

For a fully quantitative index, you must measure some feature of the plants, such as their biomass (how much they weigh), or — more simply — how much they contribute to the total cover. The quantitative measures seem more precise, but unfortunately they are also more sensitive to grazing, and so researchers have recommended that in bladder saltbush country you should measure each species' contribution to the cover, but only during periods of light grazing.

Although changes in the vegetation make up one of the most striking and rapid results of heavy grazing, the condition of the land may well hinge far more on the stability of the soil. A paddock may look grazed to exhaustion, but, provided the soil has not begun to erode, it may not have suffered any irreversible damage and, given good rains and wise management, the land may well recover.

Once erosion sets in, however, the soil loses both those vital nutrients that were held in the top layers and its capacity to hold a good proportion of the water received in a downpour. Light-textured soils wash away, and 'duplex' soils (those in which one type of earth overlies another contrasting one) become scalded — that is, they lose their fertile, porous upper layer, exposing an infertile, hard new surface that takes in little water and supports sparse, poor vegetation.

In order to judge whether a particular paddock has begun to erode, you must devise an index appropriate to that soil type. Sometimes the ratio of plant cover to bare, eroded ground provides a satisfactory measure; sometimes you will need to assess such symptoms of erosion as rills, gullies, and 'pedestals' of higher soil on which tussocks of grass grow, surrounded by lower, more eroded, soil.

In New South Wales, researchers are testing two measures: the proportion of the surface area that has suffered sheet

Saltbush in good condition (left) and eaten out. Both paddocks can carry the same density of sheep and produce equally good wool, but the one on the right is more likely to erode and lose productivity.

erosion (loss of the upper layer) or scalding, and the extent of those symptoms like rills and gullies. Scalding affects saltbush country; sheet erosion, rills, and gullies occur in savannah woodlands.

The procedure for assessing saltbush and bluebush country (collectively known as chenopod shrublands) is being devised and tested by collaborating teams of researchers from the South Australian Pastoral Board, the New South Wales Soil Conservation Service, and the CSIRO Division of Land Resources Management. Although the details remain to be worked out, we can picture fairly clearly how a land-owner or an adviser will set about quantifying the condition of a particular property.

For a really thorough examination of the property, the assessors would measure the vegetation and other attributes at five sites in every paddock. In practice, there will probably not be enough time or people to permit this, and so each paddock (or as many as possible) will receive a general survey, complemented by measurements at just one or two carefully chosen sites.

From the survey, an experienced assessor will ascertain the present condition of the land; then repeated measurements in subsequent years will pinpoint changes — in particular, giving early warning of any deterioration.

If maps of the land systems making up the property are available, the assessors will consult these before selecting which paddocks to survey. Failing maps, a preliminary study of the distribution of the land types will do; the paddocks studied should include at least one in each main land type.

In making their general survey of a pad-

The 'background signal' of a decline in land's condition must be distinguished from the 'noise' caused by good and bad seasons.

The factors affecting range condition

vegetation	soil	productivity
species composition	structure	number of animals
density of trees and shrubs	crusting	forage quality
herbage quantity and cover	fertility	ability to withstand drought
litter cover	erosion rate	water yield
lichen crust		wildlife habitat
		amenity value
		species conservation

Dr Wilson suggests that anybody wishing to assess land's condition must choose from among these attributes. Which ones are emphasized will depend on the use to which the land is put: grazing, wildlife conservation, or water catchment, for example.

dock, the assessors will 'score' the land on three counts: the chenopod shrubs, perennial forage plants, and quality of the soil surface. Each of these attributes could be given a rating on, say, a five-point scale: excellent, good, fair, poor, or very poor. If they are to mean anything to people in the future, these categories must be precisely defined. In the past, such survey estimates, using ill-defined categories, have proved of little value.

Lines and transects

The assessors will give careful thought to choosing their measurement sites. These sites will contribute enormously, not only to the ratings that this paddock receives when the land is first examined, but also to the impression that assessors obtain over the years of any changes in the land's condition. The sites should not suffer heavy stock movements, and should therefore be at least 1·5 km from any watering point, and away from fence-lines.

The assessors will probably make measurements of plant canopy cover along a 500-m transect, pushing along the line a wheel bearing several spikes. As a spike touches the ground, the assessors record what species is growing at that point. The spike may land on bare soil, in which case the assessors will note its state — for example, whether it is scalded.

Measuring the density of bushes will require a transect about 100 m long and 1 m or more wide.

To complete their record of the special study sites, the assessors will take several photographs, following a standard procedure. Already State government officers in South Australia have established some 700 'photopoints', marked by posts, at which pictures are regularly taken, partly to complement other information on changes in the landscape brought about by seasonal or management influences, and partly for the impact they can bring to an extension officer's recommendations.

After a paddock has been examined in this way, it will be awarded separate ratings for shrubs, forage, and soil. Just how these three ratings are combined into one final score remains to be decided. Researchers say it would be meaningless simply to average the three figures, as the importance of each attribute will vary from place to place. The stability of the soil should always receive the heaviest weighting.

Rangeland properties

Australia's rangelands contain about 4000 properties, with an average size of some 500 sq km. Most fall on the small side of the average; typically, a sheep station occupies 200 sq km, and a cattle station 12 000 sq km. Almost all the land is leased from State governments for 40–50 years. There are virtually no federally owned or common lands. Each State retains ownership of the arid lands within its borders, and the responsibility for management rests with one or more State agencies.

In order to eliminate the relatively short-lived effects of varying seasons, the researchers suggest that the study sites should always be compared with a 'reference area'. In the United States of America, where this idea originated, a reference area consists of a piece of land of the same type as the study site, fenced off against stock.

Australian paddocks generally lack fenced-off sections, and in any case scientists have some reservations about the value of eliminating stock entirely from a reference area, as the vegetation may become senescent or overgrown with shrubs.

Where chenopods grow, the reference area could be a lightly grazed site, say 5 km from a water hole. In saltbush country, particularly, where their food contains quite large amounts of salt, the animals generally graze only lightly land that is far from water.

In Western Australia, the State Department of Agriculture has been developing methods for assessing range condition for some 12 years. During the course of large-scale surveys of the State's pastoral resources, field workers compare the soil and vegetation with agreed standards for the land systems being examined, and come up with scores for both erosion and pasture condition. From these scores the assessors can assign each land system to a range condition category.

These assessments have been used in drawing up recommendations on such management matters as stock-carrying capacities, fencing, and even the withdrawal of badly affected land from use to allow it to recover.

Here, too, reference areas or 'benchmark sites' will provide a measure of the effects of climate over the years. By reference to these sites, the Western Australian field workers will be able to distinguish between seasonal variation on the one hand, and, on the other, changes in range condition due to management

Landsat picks up light of a wide range of wavelengths. As infra-red is invisible, scientists represent it by a visible colour, and shift other colours accordingly.

How a 'false image' is made

original subject	blue	green	red	infra-red
↓	↓	↓	↓	↓
colour on false image	none (filtered out)	blue	green	red

practices. Assessors will monitor trends in condition at fixed sites, where they will record the plant community's species composition, and measure plant density and vegetation cover.

Similar principles will govern the assessment of other types of rangeland, but the detailed procedure must be worked out separately in each case. Researchers from the New South Wales Soil Conservation Service and CSIRO are drawing up suggestions for semi-arid woodlands. Here, heavy grazing leads to an invasion of inedible shrubs, and the land's condition will perhaps be expressed mainly in terms of tree and shrub cover and the degree of soil erosion.

Cattle country

For cattle country in central Australia, an assessment tool called STARC (Standards for Testing and Assessing Range Condition) has been developed by members of two Northern Territory agencies (the Department of Primary Production and the Land Conservation Unit of the Conservation Commission) and the CSIRO Division of Land Resources Management at Alice Springs.

About one-third of all the properties in the Alice Springs district have now been assessed using STARC, which involves analysing the composition of the plant community found at each study site. Extension officers of the Department of Primary Production, who have used STARC when examining properties, see it as a tool that helps assessment, and therefore ultimately management, but have found that it needs both modifying and complementing.

Each paddock will receive a general survey, with measurements at just one or two carefully chosen sites.

Modifications are required because, as it happened, STARC was developed during a run of good seasons. Since then the district has experienced drier weather; pioneer and colonizing species make up a larger proportion of the vegetation, and perennial grasses have declined.

The present STARC scales therefore give a misleading impression of the range's condition after a dry spell. The Department of Primary Production, in a joint project with the Division of Land Resources Management, intends to carry out the necessary research to adapt the system for the conditions that prevail during and soon after drought.

A spiked wheel helps sample the vegetation along a transect.

In the revised STARC, as in the scales being developed for chenopod shrublands and semi-arid woodlands, assessments of both shrubs and soil will complement forage indices. Assessors in the Alice Springs district have found that simply measuring the biomass percentages of fodder plants does not give a full enough picture of the state of the land.

How Landsat can help

Every set of measurements takes up a great deal of time — and still leaves the problem that the site chosen may not typify the paddock under study. In arid country, one paddock may occupy more than 100 sq km.

Arid zone researchers are therefore keen to develop satisfactory ways of estimating vegetation cover and the extent of soil erosion.

Aerial photography has proved a useful tool, giving impressions of entire properties and helping with mapping — for example, of land systems; but the regular orbits of the Landsat satellite provide a steady stream of information that, if it can be suitably interpreted, may prove of considerable value for the management of Australia's inland properties.

The earth's surface acts as a partial mirror, reflecting some wavelengths of sunlight up into the sky. As Landsat passes overhead, its own mirror scans to and fro, receiving the light reflected from a strip of the planet's surface that lies adjacent to the strip surveyed during the satellite's previous orbit. In this way Landsat 'looks at' every point on the planet once every 18 days.

Range condition is a concept; you cannot tie it down mathematically.

The satellite's mirror reflects the light it receives onto equipment that responds to four bands of wavelengths, converting the energy of these wavelengths into radio signals picked up by tracking stations on the ground. The Australian station is at Alice Springs.

From these signals, scientists reconstitute the image 'seen' by Landsat. Because two of the bands of wavelengths measured by the satellite lie in the infra-red, and therefore cannot be seen by the human eye, scientists compile their Landsat images in 'false colours': they may represent infra-red as red, and objects that to the satellite appeared red may come out on a Landsat picture in green, and so on.

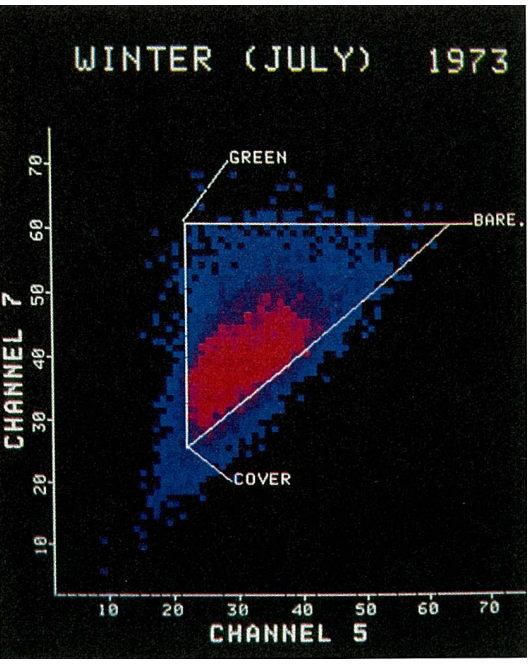
The resulting glossy, colourful prints make striking wall displays — but how can they help management?

To be of use, the images must convey valuable information about the land's condition. In other words, if Landsat's images can tell us the extent of vegetation cover and any other attributes that assessors study on the ground, then the satellite could prove a major tool in rangeland assessment.

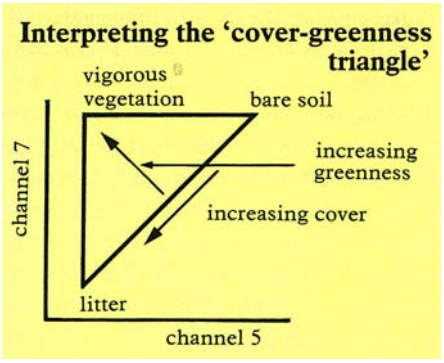
Before they could translate a Landsat image into shrubs and soil, researchers had to find out how much light, in each of the four wavelength bands Landsat uses, bounced back off the different kinds of surface found on a pastoral property. To do this they used a hand-held radiometer, an instrument that recorded the amounts of light it received in those bands.

Down to earth

By holding the radiometer in turn over bare soil, sparse vegetation, dense cover, and so on, Dr Dean Graetz of the Division of Land Resources Management found that the sort of information needed for land assessment could be extracted from just two of the wavelength bands (numbered 5 and 7); the other two bands virtually duplicated this information.



When the information from two Landsat channels is plotted, points fall more or less within a 'cover-greenness triangle'.



Bare red soil reflects light brightly; the darkest images come from shadows, from dark rocks, and from places completely covered in vegetation.

The scientists examined some 400 sites. Each type of land reflected light in a particular way, characteristic of that type of land in that condition. When the researchers placed each site on a graph, plotting the strength of light reflected in band 5 against that reflected in band 7, they found that all the sites fell more or less into a triangular pattern.

Just where in that triangle one site ended up depended essentially on two factors: the proportion of bare soil and the greenness of the vegetation (see the diagram).

The Division organized an even more comprehensive calibration of Landsat's imagery last summer, when researchers visited 43 sites in South Australia, west of Broken Hill. At each site they took radiometer readings and measured the ratio of vegetation cover to bare soil, the amount of plant litter, and the extent to which lichen encrusted the soil — lichen's reflectance is much like that of saltbush. In addition, every plot was photographed from an altitude of 300–500 m.

There is an urgent need for an inventory of arid zone resources.

The researchers made these measurements on or about 17 December, when Landsat passed over the area. Unfortunately the satellite's view of the ground that day was obscured by cloud, but no such problem marred the following orbit, on 4 January. As the intervening period had been free of rain, the state of the land had remained virtually the same, and the researchers are now analysing the mass of information collected in the field and matching it against the Landsat pictures of 4 January.

Among other things, the scientists want to sort out exactly what influence the atmosphere exerts on the Landsat image: it seems that the air absorbs some of the wavelengths registered by the satellite, but not others.

The more clues a detective examines, the more complete his reconstruction of the scene of the crime will be. Likewise, scientists augment satellite pictures with other information: for example, Landsat tells you how much vegetation is growing, but by taking into account the time of year and recent rainfall figures you can deduce how much of that foliage is perennial and how much must be ephemeral.

Nonetheless, Landsat can tell you only so much about the land. Study sites on the ground will always be needed, both for fuller information and for continuous calibration of the satellite's images.

Above all, land condition depends on management, and for a full interpretation of satellite images researchers therefore need to know how each property is managed (see the box) and where the property boundaries lie.

Getting straightened out

Much of this additional information is stored on conventional maps, and researchers have therefore needed to 'stretch' or 'squash' the satellite pictures in order to bring them into line with these maps. Landsat images have a shape of their own, determined by various things — including the varying speed at which the mirror performs its sweep, any yawing or pitching by the satellite, perspective, and the earth's curvature.

A radiometer, by picking up the same reflected wavelengths as Landsat, helps scientists to calibrate the satellite's images.

To align satellite pictures with the Australian Map Grid, the researchers identify landmarks such as creek junctions or road intersections and re-scale the satellite image accordingly.

Once the image has been 'rectified' in this way, scientists can readily superimpose on it such information as property boundaries, rainfall statistics, stock records, contours, and soil types. The collected information then constitutes the heart of LIBRIS, a Land Image-Based Resource Information System, developed by Dr Dean Graetz of the Division of Land Resources Management, Dr John O'Callaghan of the Division of Computing Research, and the South Australian Pastoral Board.

LIBRIS, which the scientists developed from a similar system devised in California to examine land use in and near cities, constitutes a store of information that may be analysed and drawn upon to assist our understanding of the land and how it can be used.

To put LIBRIS through its paces, the researchers chose an area of more than 8000 square km of South Australian sheep country west of Broken Hill, containing about 50 properties and ranging from saltbush shrubland in the south to sandplain mulga in the north. (Last December's calibration exercise took place in this area.) They analysed two sets of pictures taken 5 years apart, in July 1973 and July 1978, taking a grid of points about 200 m apart, and determining from the satellite image the extent of vegetation cover at each point.

A sociologist examines the human element

Analysis of Landsat images of the rangelands west of Broken Hill reveals man-made patterns in a number of places. Some of these patterns can be explained by property boundaries: perhaps the land may have less cover on one side of a fence because that pastoralist has stocked more sheep to the hectare than his neighbour.

Other lines on the images correspond not to modern boundaries but to fences that were pulled out at least 40 years ago. This is one of the unexpected discoveries made by Ms Melissa Gibbs, a sociologist with the Division of Land Resources Management, who is investigating the social factors that influence pastoralists' management decisions.

Miss Gibbs has visited 30 properties in the LIBRIS study area of north-eastern South Australia.

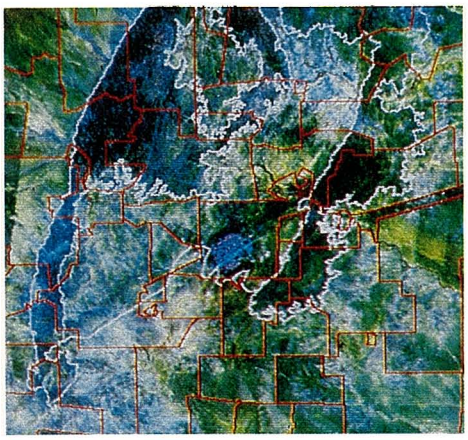
She is asking how people manage their land (how many stock they run and so on), and asking for details of their families, of their financial circumstances (where people are prepared to divulge these), and of the history of the property. When she has finished gathering and analysing all this information, she hopes to be able to pinpoint which social and other factors exert the greatest effect on the condition of the land.

As she points out, you can learn quite a lot from Landsat images, but you cannot always explain what you see. It is all very well to record that 'this land is in poor condition', but does the cause lie in today's management or in that practised half a century ago?

And how far are pastoralists' options restricted by social factors? With no local schools, many graziers feel they have to send their children to boarding school in Adelaide — an expensive commitment that, like debt, may rule out those management options that put less pressure on the land but yield lower immediate returns.

Miss Gibbs would also like to know more precisely what the word 'drought' conveys to pastoralists; she is asking them how they define a drought and what signs they look for in deciding whether a drought has begun and stock should be moved. In the same vein, she is investigating the pastoralists' perceptions of the quality of their land and the extent — and seriousness — of erosion.

But when all is said and statistically done, questionnaires are, Ms Gibbs stresses, of limited value. 'You also have to watch people in a drought and see what they actually do.'



Landsat's view of Broken Hill, with property boundaries superimposed by computer.

By adding information on property boundaries, the scientists were able to calculate whether the amount of cover on each property had improved or deteriorated over the 5-year period. And, since bare soil soon erodes, this information referred to both the quantity of fodder and the stability of the soil on these properties.

The researchers have stored all this information (property boundaries, Landsat signals, and so on) on computer, and can 'call up' on a screen a map of the study area with, say, the property boundaries or rainfall figures superimposed.

To help analyse the results, the scientists often assign colours to the different types of information that interest them. For example, in their analysis of the two Landsat images taken 5 years apart, they instructed the computer to work out which areas had experienced an improvement in cover and to mark them in one colour, giving another colour to areas that had deteriorated, and a third to areas showing no appreciable change.

But can this technique provide accurate, useful information on the condition of the land? Yes, say the researchers; the LIBRIS assessment of vegetation cover generally agreed with measurements made on the ground, and, as a result of exercises like the one conducted last December, the interpretation of Landsat images will go on improving.

If all goes well, the Pastoral Board of South Australia, which carries responsibility for the land under survey, will eventually use LIBRIS as a tool to assist in giving management advice. The Board has agreed to evaluate the project.

Landsat, then, could play an important role in the assessment of range condition and in monitoring the effects of management programs. Ideally, this should assist pastoralists and government departments to develop management practices that extract the best productivity from rangelands that can be achieved without prejudice to the long-term stability and fertility of the land.

John Seymour

More about the topic

Concepts and factors applicable to the measurement of range condition. A. D. Wilson and G. J. Tupper. *Journal of Range Management*, 1982, 35 (in press).

Range condition assessment in *Atriplex vesicaria* communities: a report on the Pine Creek workshop, 1981. G. J. Tupper and A. D. Wilson. *CSIRO Division of Land Resources Management Technical Memorandum* No. 81/9, 1981.

Standards for testing and assessing range condition in central Australia. C. Lendon and R. R. Lamacraft. *Australian Rangelands Journal*, 1976, 1, 40–8.

A report on erosion and range condition in the West Kimberley area of Western Australia. A. L. Payne, A. Kubicki, D. G. Wilcox, and L. C. Short. *Western Australian Department of Agriculture Technical Bulletin* No. 42, 1979.

The application of Landsat image data to land resource management in the arid lands of Australia. R. D. Graetz, M. R. Gentle, J. F. O'Callaghan, and B. D. Foran. *CSIRO Division of Land Resources Management Technical Memorandum* No.80/6, 1980.

The development of a land image-based resource information system (LIBRIS) and its application to the assessment and monitoring of Australian arid rangelands. R. D. Graetz, M. R. Gentle, R. D. Pech, and J. F. O'Callaghan. *Proceedings, International Symposium on Remote Sensing of Environment, 1st Thematic Conference: 'Remote Sensing of Arid and Semi-arid Lands', Cairo, Egypt, 1981* (in press).