RANGELAND SURVEY IN WESTERN AUSTRALIA –

History, Methodology and Applications

H.J.R. Pringle

DEPARTMENT OF AGRICULTURE
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H.J.R. Pringle
Adviser, Rangeland Management Branch
Western Australian Department of Agriculture

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Department of Agriculture
3 Baron-Hay Court, South Perth
Western Australia, 6151

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The rangelands of Western Australia lie to the north–west of the agricultural areas, extending east to the Nullarbor and north to the Kimberley (Fig. 1). The major areas that are used for pastoralism are most of the Kimberley and the Pilbara, nearly all of the mulga shrublands, plus some of the Goldfields gum belt and part of the Nullarbor Plain.

The Commonwealth Scientific and Industrial Research Organization (CSIRO) began mapping Western Australia's rangelands in the 1950s as part of their Land Research Series publications (Fig. 2). These surveys were not concerned with range condition. District officers of WADA in the Kimberley are presently carrying out range condition surveys of areas originally surveyed by CSIRO.

Department of Lands and Surveys (now Department of Land Administration – DOLA) rangeland surveys conducted largely in the Pilbara and Kimberley regions of the State, commenced in the 1960s and continued until the mid 1970s. The survey teams consisted of a pastoral inspector and a draftsman from Perth. The land classification units were very broad pasture types, defined along traverse routes by the pastoral inspectors and interpreted on aerial photographs by the draftsmen. The main use for these surveys was to estimate paddock and station carrying capacities. Maps at 1:250,000 scale were produced but no reports published.

Prior to the commencement of the current regional rangeland survey program, some individual station surveys were carried out by pastoral inspectors and advisers from district Western Australian Department of Agriculture (WADA) and Department of Lands and Surveys (DOLA) offices. The station surveys produced land system descriptions, maps and frequently some form of range condition assessment. Some stations surveyed in this manner have been resurveyed in the regional survey program, with the original reports providing valuable background information.

The first regional WADA/DOLA rangeland survey was commissioned by the Pastoral Board in 1969 with a brief to investigate the causes of a succession of floods in Carnarvon in the 1960s. The current regional rangeland survey program is run by WADA and DOLA with limited support from the Department of Conservation and Land Management, the Geological Survey of Western Australia and the Agriculture Protection Board. It began as an initiative and has been driven from within the Rangeland Management Branch of the WADA. The Pastoral Board has fully endorsed the program (through its nominal commissioning of the survey reports).

Figure 1. **Principal zones of the pastoral areas in Western Australia.**

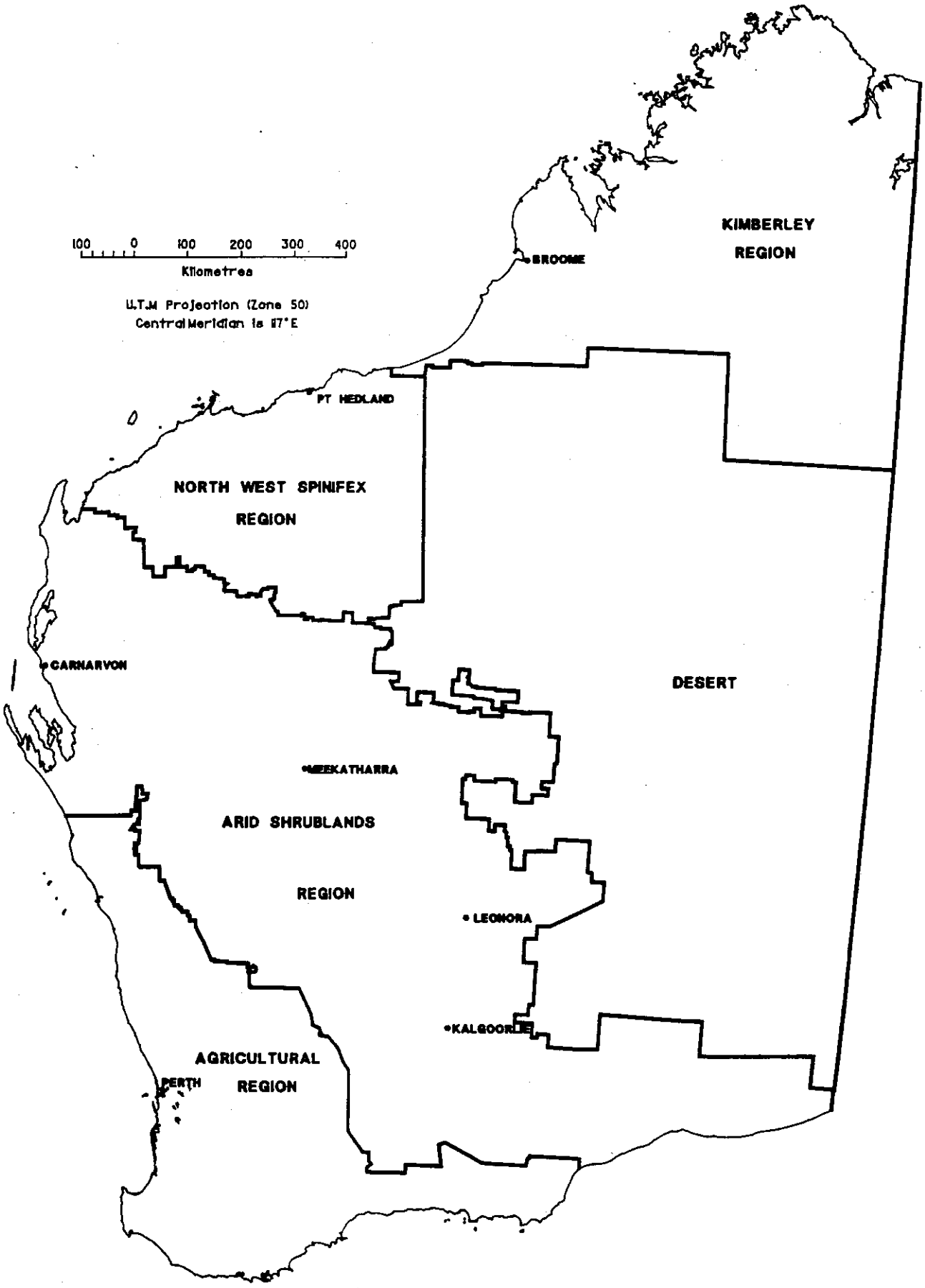
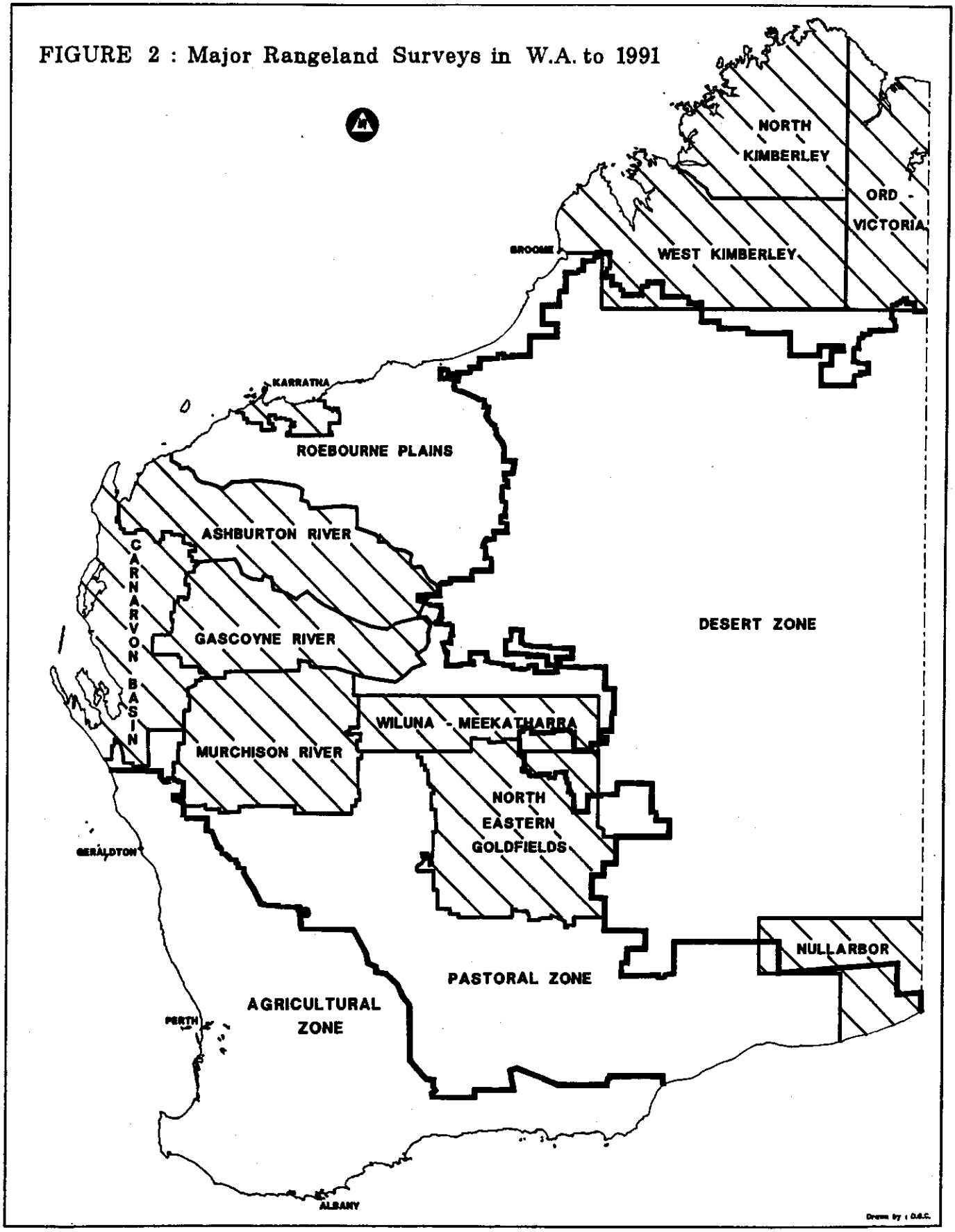


FIGURE 2 : Major Rangeland Surveys in W.A. to 1991



The major rangeland surveys conducted to 1991 are listed in Table 1.

Table 1. Major rangeland surveys of Western Australia (to 1991)

a)	**CSIRO land research series**		
	North Kimberley area	Speck *et al.*	1960
	Wiluna Meekatharra area	Mabbutt *et al.*	1963
	West Kimberley area	Speck *et al.*	1964
	Ord–Victoria area	Stewart *et al.*	1970
b)	**WADA/DOLA Range Condition Surveys**		
	West Kimberley	Payne *et al.*	1979
c)	**WADA/DOLA Range Inventory and Condition Surveys**		
	Gascoyne River Catchment	Wilcox and McKinnon	1972
	Nullabor Plain (part)	Mitchell *et al.*	1979
	Ashburton River Catchment	Payne *et al.*	1982
	Carnarvon Basin	Payne *et al.*	1987
	Murchison catchment	Curry *et al.*	in prep.
	North Eastern Goldfields	Pringle *et al.*	in prep.
d)	**Other WADA surveys**		
	Roebourne Plains	Payne and Tillé	in prep.
	South Broome Shire (parts)	Cotching	in prep.

The program aims to provide biophysical resource inventory and condition data for all of the State's rangelands by the turn of the Century. The completed surveys have consistently used the land system approach to description and mapping of range resources.

The (1987) Roebourne Plains survey (Payne, A. and Tille, P., in prep.) was one recent survey commissioned by the Commissioner of Soil Conservation in response to concerns over dust pollution around Karratha.

The Wilcox and McKinnon report (1972) represented the first extensive range condition survey in Western Australian rangelands. Based on the inventory of mapped land systems and range condition data, the authors reviewed the capability of the land. This re–assessment was based on the most comprehensive collection of extensive biophysical resource data from which pastoral land capability – in terms of recommended stocking rates – had been assessed. The report recommended, amongst other things, a reduction of stock numbers in the survey area from 416,833 to 237,290 "in order to prevent further erosion and to assist in rangeland rehabilitation".

The pastoral industry reacted strongly against this recommendation. The outcome was essentially a conciliatory bureaucratic response. The Pastoral Board (then the Pastoral Appraisement Board), in consultation with the Department of Agriculture, convened review committees to re–assess the extent of degradation on each lease and the recommended stock numbers for those individual leases. The committees operated on a station basis and included

the current lessee. The sum of the agreed stock numbers for all of the stations within the survey area from this exercise was 351,900. This represents 84% of the stock numbers at the time and 148% of Wilcox and McKinnons' recommendation.

A very similar sequence of events followed the release of Payne *et al.* rangeland survey report on the West Kimberley.

In both cases mentioned above re-assessments of land capability based on newly acquired, detailed resource information were set aside in favour of conciliatory re-assessments. Current stocking levels in the West Kimberley and Gascoyne regions are similar to those recommended in the survey reports. Factors such as drought in the Gascoyne, and the Brucellosis and Tuberculosis Eradication Campaign in West Kimberley, rather than compliance with bureaucratic recommendations or conditions, have been important causes of the reduction in these stock numbers.

Changing attitudes within the pastoral industry (in particular the widespread adoption of conservative management philosophies) and improved extension efforts, have overcome many of the problems described above. The Pastoral industry now responds more positively to the rangeland survey program, due partly to increasing local participation in survey projects.

Currently, about two-thirds of the State's area under pastoral lease have been covered by the survey program, with the Murchison catchment (Curry *et al.* in prep.) and North-Eastern Goldfields surveys (Pringle *et al.* in prep.) completed but not yet published. Areas remaining to be surveyed are the Pilbara, the southern Goldfields, the western Nullarbor Plain, the Yalgoo-Paynes Find-Sandstone area, the pastoral country of the Wiluna-north Meekatharra survey and not necessarily in that order.

The Western Australian Museum (WAM) and CALM have a biological survey program in which they map the rangelands into very broad landform classes for which they describe the flora and fauna (e.g. Dell, J. *et al.* 1988). The major differences between the CALM/WAM biological surveys and the WADA/DOLA rangeland surveys are that the rangeland surveys involve considerably greater sampling intensity of perennial vegetation and detailed mapping and reporting of management induced changes whilst the biological surveys pay considerable attention to fauna and ephemeral flora at a small number of study sites which are visited several times. The rangeland surveys do not formally address fauna. However, listing of vascular plants has been extensive on recent surveys. Their soils information gathered during fieldwork and disseminated in the reports is considerably more thorough than that in the biological surveys. In a geographical sense, rangeland surveys are conducted intensively, involving considerably more reconnaissance supported by hundreds of inventory sites to sample every element of the landscape.

Closer cooperation and better exchange of data from each other's surveys can only improve our knowledge of the State's rangelands.

2. Range condition and inventory survey procedures

The major phases in each survey are:

(i) survey area selection;
(ii) research of available information;
(iii) reconnaissance field-work;
(iv) preliminary analysis and survey technique refinement;
(v) main field-work phase and interim station reporting;
(vi) re-interpretation of aerial photographs;
(vii) data analysis;
(viii) mapping; and
(ix) report writing.

Survey areas are generally confined, as far as is practical, to a number of 1:250,000 geological map sheets within a natural region of the State. The CSIRO surveys tended to have neat 1:250,000 map sheet edge boundaries, more recent surveys try to include only whole stations in each survey. A lesson learnt in the North–Eastern Goldfields survey area was that the inclusion of a small area of markedly different biogeographical characteristics to the majority of the survey area generated a disproportionately high number of land systems which were less intensively sampled than other, more common land systems.

Research of all available information is an exceptionally important phase. It lays the foundations for the survey, and can highlight problems such as that dealt with immediately above. The most well used sources of information are Beard's vegetation maps and explanatory notes, the 1:250,000 geological maps and explanatory notes produced by Geological Survey, and the Atlas of Australian Soils Series (e.g. Northcote *et al.* 1968). Other sources include the WAM/CALM series and research reports from organizations such as CSIRO and the Mulga Research Centre (Curtin University). Reports on adjacent rangeland survey areas are paid particular attention in an effort to maintain continuity in land system nomenclature.

Reconnaissance field–trips are planned so as to include sampling of as many of the major land surface types identified from background research as possible. The land surfaces are marked onto 1:50,000 black and white aerial photographs as broad land system types. Reconnaissance field–work usually entails five or six weeks of field–work, usually split into two trips. On these field–trips, extensive traverse notes on vegetation and landforms are recorded and roughly 100 inventory sites selected and details of soil, landform and vegetation collected.

During the reconnaissance trips, land system descriptions are gradually developed as the team becomes more familiar with the survey area. This process is thoroughly revised after the reconnaissance trips so that the main field–work can commence with as complete a selection of land system descriptions as possible.

The analysis of reconnaissance data is used to generate land vegetation types (LVTs – previously termed 'pasture types'). This is achieved by running classification and ordination programs of floristic, soil and landform data – together and separately – on the data. The result is a classification of the inventory sites, accompanied by a description of distinctive characteristics to help in field classification of subsequent sites during the main survey. The classified groups are ordinated in such a way as to represent their interrelationships in two dimensional diagrams.

After the first reconnaissance field–trip condition site assessment techniques are devised based on perceived range condition indicators in the various broad vegetation formations encountered such as wanderrie grasslands and chenopod shrubland alluvial plains. These techniques are tried during the second field–trip and further refined prior to the start of the main field–work phase. The technique should be sensitive to range condition, and represents a trade–off between thoroughness and time restrictions.

During the main field–work program, roughly half a 1:250,000 map sheet (about 8000 km^2) will be covered per three–week field–trip. Prior to each field–trip, the relevant aerial photographs are interpreted for land system boundaries.

Daily traverses are then planned with reference to the aerial photographs, the geological map and station plans. Traverses are planned to cover all parts of a station, the main land systems on it, the most productive areas and any areas of uncertainty or particular interest. At every kilometre interval, a subjective assessment of the condition of perennial vegetation and the presence, type and extent of soil degradation is recorded. Inventory and condition sites are located along each traverse. At inventory sites, detailed information regarding vegetation, soil, landform, general geology and surface mantling is recorded, whilst at condition sites the data

collected are specifically related to parameters reflecting the long–term condition of the soil and vegetation. Traverses average about 80 km in length with about nine sites. Generally speaking, the balance in sites shifts from inventory to condition sites as the survey progresses and the land system descriptions become more familiar – and adequately sampled.

After each field–trip the land systems and LVTs are reviewed. Plant specimens collected in the field are identified at the Western Australian Herbarium (CALM) and the species list is up–dated.

At the end of each year's field–work – the survey team remains in Perth from mid–December to April – informal interim reports of the findings of the survey team on individual station properties are compiled and sent to each pastoralist. The reports contain a brief description of the 'country types' (broad groups of similar land systems) on a lease and their pastoral value and limitations. This is followed by a brief range condition summary of the areas of the paddocks traversed and a final summary including any areas of concern such as severe pasture degradation and soil erosion.

The re–interpretation of aerial photographs involves finalizing land system boundaries based on traverse notes and site information. Re–interpretation of the field–work generally takes about ten working days per 1:250,000 map sheet.

Data analysis involves the finalizing of land system descriptions, LVTs and soil classifications, and the description of patterns of range condition in the various LVTs. Descriptions are generally prepared by running sorts and perhaps basic classification programs on the inventory site data, whilst the analysis of condition site data is more complex.

Patterns of range condition within the pre–determined LVTs are searched for by running statistical packages to derive indices such as desirable density, desirable:undesirable ratio, and Shannon–Wiener Diversity Index for each site. The indicator value of each species is generally determined by literature reviews and canvassing of opinions from experienced range managers and scientists. It is possible to objectively derive indicator values using parametric ordination and classification programs such as those in CSIROs PATN package. PATN may also be used to elucidate and display patterns in range condition as reflected in phytosociological groupings or trends. A recent development has been the investigation of natural variation in parameters used to investigate range condition. It involves analysing data from sites that have not been stocked and presents a useful quantitative evaluation of selected key range condition parameters.

Another recently acquired technological advance that is being increasingly used is thematic mapped LANDSAT imagery. It is hoped that the production of 1:100,000 landsat scenes with land system overlays will help extension officers communicate with pastoralists about the distribution of their improvements and grazing patterns in relation to the characteristics of the rangelands on their leases.

Not all recently adopted techniques and technologies are new. Cyclic patterns may be observed in some instances such as the Bitterlich gauge, which fell out of use but has been recommended as a tool for rangeland monitoring in tropical grasslands of Western Australia and is likely to be used in the next rangeland surveys.

The mapping of finalized land system boundaries is done by DOLA. During the field–work, station plans are checked for accuracy and new developments are recorded on the photographs. DOLA produces digitized multi–layered geographic information system (GIS) data bases from which colour–coded 1:250,000 land system maps and 1:100,000 station plans with land system boundaries are produced. Condition and inventory site locations and traverse condition ratings, taken at kilometre intervals on all traverses can be shown on both 1:250,000 and 1:100,000 maps.

As part of the survey team's responsibilities, stocking rates are recommended according to the potential and range condition of each land system. Traditionally this exercise has been conducted by the advisers involved with each survey, perhaps in consultation with other experienced officers from the Departmental of Agriculture familiar with the area being surveyed.

In the current North Eastern Goldfields survey, field workshops have been held with pastoralists to discuss stocking rates with respect to vegetation types and varying range condition. The pastoralists were asked their opinion on stocking rates applicable to the above, which will be analysed along with experienced advisers' recommended figures and research trial data on biomass production to derive final recommended stocking rates in the report.

This initiative is an example of how land managers are being encouraged to participate in the survey process, partly in the hope that this will facilitate the widespread use of survey reports when they are released.

The final reports that accompany the published 1:250,000 land system maps include chapters on survey methods, climate, hydrogeology, geology and geomorphic districts (where applicable), vegetation, vertebrate pests and weeds, land system descriptions, soil descriptions, LVTs and patterns of range condition and regeneration requirements, station reports and a plant species list. The Agricultural Protection Board contribute the vertebrate pests and weeds section whilst the Mines Department provide a section on hydrogeology.

Whilst the survey reports were originally styled almost solely for the use of pastoral managers and advisers, they now include a wider range of resource features which are of interest to a wide audience. Users of rangeland survey reports include the pastoral industry, conservation bodies, planning authorities, mining companies and their environmental consultants and those members of the public with an interest in rangeland environments.

3. Applications for rangeland survey information

Wise land use planning requires extensive resource survey information of the land in question. The survey information should include information regarding topics such as economic, social and biophysical attributes. Planning without this foundation is likely to lead to inappropriate land use in many cases, which in turn may require further, reactive planning. An unfortunate reality is that many areas have not been adequately surveyed despite quite long histories of land use. A further reality is that some land use planning pays scant regard to existing survey information.

Rangeland survey information has been used by Government planners in some instances. The Carnarvon Basin report (Payne *et al.* 1987) provided the biophysical resource inventory mapping as the basis for the Shark Bay Regional Plan overseen by the State Planning Commission and Department of Conservation and Land Management (1987). The resource data was further used in consideration of proposals for World Heritage listing of the area.

Post graduate university students and researchers use rangeland survey reports for background biogeographical information for their research.

A good example of the price we pay for not planning thoroughly at an early stage in the history of an area's land use is in the conservation arena. The conservation reserve system is grossly inadequate in terms of the proportion of major land surface types under reservation in large areas of the rangelands. Correcting this situation presents problems because it will require the reservation of land being used for pastoralism. Having leased the land, resumption of the leases would generally be too costly in terms of the payment of compensation to the lessee. The Government now has to acquire areas for reservation as it can afford the pastoral leases or as stations are vacated.

The rangeland surveys produce two very useful types of information with regard to the identification of areas suitable for reservation for conservation purposes. The inventory component describes the variety and extent of the various land surfaces whilst the condition ratings can be examined to find areas of reasonable or better range condition suitable for reservation. There is little point in reserving an irrepairably degraded area unless it is the only known example of its type.

Having accepted that land use has generally preceded survey work in the large majority of the State's rangelands, survey work now aims to provide resource information to enhance and improve land use in some cases; highlight problems regarding inappropriate land use in others, and perhaps recommend alternative land uses. Survey information can also provide the base information required to regenerate those areas with a history of mis-use.

The pastoral industry remains the major user of rangeland survey information. Armed with a land system map and accompanying detailed land system descriptions in the survey report pastoralists have the opportunity to make decisions based on a greatly increased understanding of the precise distribution of country types on their leases. Gradual redevelopment of fencing according to country types will ensure that management strategies can be increasingly specific to the pastures within effective grazing areas, thus improving the (conservative) use of each pasture type or group of similar types on the lease.

The re-positioning of waters and fences with respect to land systems or groups of similar land systems can also halt or even reverse degradation processes caused by concentrated grazing. The placement of waters near preferred pastures generally leads to their degradation and the relative under utilization of poorer pastured areas. Placing the water away from the preferred pasture will generally make stock use more of the paddock and reduce the pressure on the preferred pasture. Better still, as previously mentioned, combining the re-positioning of water points and fencing of the different country types will allow optimal use (stock numbers) of both pastures.

Thus, the inventory component of the rangeland survey can both enhance the use of the range resource and aid in the rehabilitation of degraded preferred pastures.

A further use for inventory information is in the locating of rangeland monitoring sites. Sites need to be placed in areas likely to be sensitive to change in range condition. Land system maps and descriptions will tell the pastoralist which land systems are likely to receive most grazing pressure and which land units within them are likely to be most sensitive to grazing pressure. Thus, the placement of monitoring sites, a very important part of the monitoring program, will be done on a more informed basis.

The mapping of traverse range condition assessment records will aid the pastoralist in identifying problem areas requiring a management response to allow rehabilitation. The traverse record will also give the pastoralist a better idea of the health of each pasture type (LVT) on his lease. When setting stocking rates, it is vitally important to take into consideration the type of rangeland involved and its current range condition. A degraded area will have fewer palatable perennial shrubs for stock to graze than a similar area in good condition. If the area is stocked at a level applicable to an area in good range condition the degradation processes will accelerate as will the loss of pastoral value.

The analysis of condition site data according to major LVTs is used to derive patterns of range condition. The final reports detail the indicators of range condition for major LVTs. Pastoralists can use this information and a monitoring system to assess the range condition of their leases on an on-going basis and alter management strategies accordingly. Land system maps, descriptions and detailed information on range condition patterns within major LVTs will also enhance the basis upon which WADA staff assess range condition when inspecting leases.

Another important outcome of rangeland surveys is that knowledge of the distributions of the flora is increased. During the Murchison survey, Murchison mint (*Eichlerago tysoniana*) was collected for the first time since the 1890s. During the North–Eastern Goldfields survey the first recording for the genus *Apatophyllum* in Western Australia was collected. Numerous known range extensions have resulted, several taxa, presumed extinct, have been rediscovered and new taxa have been found.

The mining industry can also benefit from the use of rangeland surveys in planning their facilities. Within each land unit of each land system are notes on factors such as pastoral value and susceptibility to erosion. Ideally off–site mining facilities would be placed on areas of poor pastoral value with inherent soil stability. Exploration techniques should be compatible with the inherent stability of specific range types. For instance grading grid–lines through fragile breakaway footslopes is likely to cause considerable water erosion.

On a less pragmatic level, rangeland surveys are useful in that they improve our knowledge of the less densely inhabited areas of the State. It is nice to know what is out there; and to understand a little better how landforms, soils and vegetation reflect spatially and temporally varied natural processes in the more remote areas of the State. Rangeland survey reports add to our understanding and knowledge of the biogeography of our State. However, they are not readily recognized by other State and Federal Government agencies or conservation groups – possibly in part due to their pastoral connotations. This is unfortunate as they represent the most detailed data on perennial plant distributions in the arid zone of Western Australia, and perhaps Australia. Rangeland survey information has been used as the background biographical resource information for the limited scientific research carried out in these often remote and somewhat neglected areas of Western Australia.

Many of the rangeland degradation problems faced by land users and administrators today reflect historical mismanagement borne of poor understanding of the characteristics and capabilities of the land. It follows therefore, that resource surveys should be conducted over the entire State. The adoption of this philosophy could result in land planning, based on (unusually) adequate biophysical resource data, prior to land use. In such circumstances the risk of adopting inappropriate land uses would be reduced and new land uses would reap the benefits of having mapped resource information as a firm foundation from which to build.

Conclusions

Biophysical resource information is collected by two groups of Government agencies in Western Australia, closer cooperation and better exchange of information from each other's surveys can only improve our knowledge of the State's rangelands.

Rangeland surveys improve the basis upon which land use decisions for the future can be made by making available information for the evaluation of alternative land uses. That information can also be used to enhance current land use practices or future practices under alternative land uses. The contribution to our knowledge of the environment in these generally remote areas is also important in terms of conservation – we can only plan conservation reserve systems once we appreciate the distribution pattern of what we wish to conserve. It is important that resource inventory surveys are carried out throughout the State. The fact that areas of Vacant Crown Land are not being used now does not mean that land use decisions will not have to be made for them in future.

If rangeland surveys can provide information that leads to a better understanding of rangeland environments, and if this improved understanding is translated into better, conservative land use practices – then they will have been worthwhile.

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