Rangeland inventory and evaluation in Australia.

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1. Abstract
Rangeland inventory procedures in Australia are relatively standardized and are based on the land system concept. Rangeland evaluation is primarily concerned with the assessment of productivity for current use (extensive sedentary grazing) and with the extent to which resource condition has been altered by grazing. Considerable methodological diversity exists in this area although all procedures are capable of producing data necessary for the formulation of local or regional management policies. The major need currently is for the development of comprehensive monitoring systems which will permit the effectiveness of land management policies to be evaluated on a continuing basis. There are relatively few alternative land uses in Australian rangelands and land evaluation for alternative use has been of limited extent.

2. Introduction
The Australian continent covers an area of approximately 7.7 million sq. km encompassing 28 degrees of latitude (11°-39° S) and 40 degrees of longitude (113°-153° E). According to the definition of Meigs (1953) about 75 percent of this area is either arid or semi arid. Within these zones extensive sedentary grazing of cattle occurs also in northern Australia in areas which are humid rather than arid.

Extensive grazing is thus practised in a great diversity of environments ranging from tropical savannahs, hummock and tussock grasslands in the north to shrub steppe in the south. In total, rangeland grazing industries occupy approximately 4.7 million sq. km on which are depastured approximately 32 million sheep and 9.5 million cattle.

These rangelands are by no means adequately inventoried and while some aspects of range evaluation are widely practised (eg. carrying capacity estimation) the development of techniques for assessing and monitoring grazing impact is still at an early stage.

3. Range inventory techniques
Range inventory in Australia is based almost entirely on the land system concept of Christian and Stewart (1953). A land system is defined as ‘an area or group of areas throughout which there is a recurring pattern of topography, soils and vegetation’. Each land system is composed of a number of discrete elements, or land units. These land units are not necessarily unique to particular land systems but unique combinations and arrangements of land units do represent specific types of country which may be recognized as a distinct pattern on aerial photographs.

The land systems so defined, of course, are merely arbitrary. though logical,
divisions of the landscape and in some instances broad land systems have been subdivided into a number of smaller land systems by subsequent surveys.

While this approach to inventory is virtually universal in Australia, some local variations are apparent. Thus Dawson (1974) and Turner (1978) place major descriptive emphasis on the land units while retaining the land system as the basis for map presentation and representation of the geomorphic relationship between units. In most other inventory reports land units are described in the context of overall land system descriptions (eg. Payne et al. 1982) despite the fact that identical units may be present in more than one land system.

The land system approach is particularly suitable for the large scale regional surveys which are the norm in Australian range inventory practice. (The reports quoted above covered areas ranging from 40,000 to 150,000 sq km.) At the same time, however, land systems form an inadequate base for the mapping of vegetation types which are related primarily to land units and may be distributed throughout several land systems. Survey reports thus inevitably identify a number of distinct vegetation types which are described separately and whose distribution over the landscape may be inferred only from the land unit and land system descriptions, although broad vegetation distributions are sometimes portrayed by colour coding of similar land systems for map presentation (eg. Stewart et al. 1970). The basis for vegetation classification differs somewhat between survey groups. Thus Payne et al. (loc. cit.) identify pasture lands while Boyland (1974) and Beeston (1978) identify major floristic associations subdivided on structural form according to the classification of Specht (1970).

It is apparent that the comments made above in respect of vegetation distribution apply equally to the soils of a survey area and the same approach is adopted for their description.

The traditional mapping base for inventory surveys has been panchromatic aerial photography at scales ranging from 1:40,000 to 1:86,000. Landsat imagery has been used extensively for a rapid resource inventory of South Australia (eg. Laut et al. 1977) in which land resources were described in terms of a three level hierarchy of environmental units (essentially equivalent to land units), environmental associations (essentially equivalent to land systems) and environmental regions. For more detailed surveys, however, aerial photography is preferred although Landsat imagery may be useful in the initial stages to familiarize survey teams with the broad characteristics of the region under investigation.

The majority of the area inventoried to date has been presented at a map scale of 1:1,000,000 but some more recent surveys have been presented at 1:250,000. At the present time virtually all of the extensive grazing land in South Australia and the Northern Territory has been inventoried (at 1:1,000,000 scale). In all other states, however, there remain extensive areas of pastoral land for which no inventory information is available. It is estimated that such information, at any scale, is available for only about 70 per cent of the nations extensive grazing lands.
4. Rangeland evaluation

Rangeland evaluation may be considered either in the context of current use or in terms of potential for alternative uses. In Australia there are no significant human population pressures on extensive grazing lands although recreational use is increasing. For the most part, climatic and edaphic constraints prevent agricultural development except in parts of the humid north. The grazing industries themselves are all essentially sedentary so that no land use conflicts arise from cultural differences between various groups of rangeland users. Thus while some alternative or complementary uses are feasible, the major emphasis in land evaluation is on suitability of current use.

4.1. Range evaluation for extensive grazing

In this context range evaluation should be primarily concerned with assessing the productivity and stability of rangelands under grazing with a view to determining appropriate stocking rates or management policies. Since the vast majority of pastoral land is held under various forms of leasehold tenure from state government agencies, such information is to direct relevance both to government and land users. Unfortunately much of the range inventory data available in Australia has been compiled by organizations having no responsibility for land administration. Their aim has been primarily to map and describe land resources and while some evaluative information has been provided in the associated reports it is generally quite inadequate to meet the objectives outlined above. Some other studies have been concerned with specific problems, eg. erosion, and while they have provided detailed problem-specific information in conjunction with land inventory their scope has been too narrow to provide the basis for overall management policies (eg. Wood et al. 1979).

One of the earliest attempts to provide management guidelines from inventory information was that of Condon et al. (1969) who devised a method of determining the grazing capacity of central Australian rangelands based on the application of rating scales for soils, topography (other than unusable hills), hilliness, tree density, land (or range) condition and average annual rainfall.

These factors (other than range condition and average rainfall) were rated against a standard reference land system and were intended to reflect differences in forage production potential and accessibility relative to this standard which was assumed, on the basis of past experience, to have a grazing capacity of about 3 beasts/sq.km in good condition and in a 250 mm average annual rainfall environment. Application of these rating values or multipliers to the reference grazing capacity allowed the estimation of a 'standard grazing capacity' for each land system which was further adjusted by multipliers reflecting range condition (degree of erosion and pasture degradation) and the difference in average annual rainfall between the area in question and the 250 mm standard. Grazing capacities assessed in this way were regarded as applicable to 'normal' seasonal conditions. A similar procedure was used to establish drought grazing capacities. Since tree and shrub species are of major importance in sustaining animals under drought conditions in this environment, drought grazing capacities were estimated
by applying the multipliers for tree density, hilliness (i.e. accessibility), range condition and rainfall to the assessed drought grazing capacity of the standard land system (1.5 beasts per sq. km in country with an average annual rainfall of 250 mm and in good condition).

This approach, combined with land system maps of individual leases and details of the amount of each land system on the lease commanded by stock watering points, allowed both normal and drought carrying capacities to be estimated for each property. Furthermore, since it was considered that the normal grazing capacity could be sustained in most instances for one full year of drought (12 months without effective rain), while the drought grazing capacity should apply after three years without an effective growing season, these carrying capacity estimates could form the basis of a stock reduction policy for stations under varying drought conditions.

This approach to carrying capacity assessment has been used extensively in Central Australia. It has been adopted also in Western New South Wales and has been incorporated in land use studies in Queensland which have combined both inventory and evaluation functions (e.g. Dawson and Boyland, 1974). In the latter case the value of the assessment has been enhanced by applying the technique to land units rather than land systems in toto. These Queensland studies have also included assessments of range condition and likely trend as part of the land unit descriptions, condition being determined on the basis of the relative vigour and abundance of desirable and undesirable species and the extent of soil erosion.

While this approach to evaluation does provide a basis for assessing carrying capacity and drought sales policy the various reports in which it has been used have nevertheless been of somewhat limited scope. In particular they lack detail concerning the spatial variation in range condition, and thus carrying capacity, within land units or management units, providing only ranges or overall assessments. Nor is information provided on the location of areas of severe erosion or pasture degradation which may require the implementation of specific management policies.

These deficiencies have been largely overcome in the approach to range inventory and condition surveys adopted in Western Australia, of which Payne et al. (loc. cit.) is an example. In these surveys the land system remains the mapping unit within which the vegetation and soil characteristics of each land unit are defined by detailed sampling at a number of field sites. The main data base for land evaluation, however, is compiled from ratings made at 1 km. intervals during traverses throughout the survey area.

Ratings are applied to wind erosion, water erosion and pasture condition (as reflected in the abundance and relative proportions of desirable and undesirable species) while land system and land unit are simultaneously recorded. From these basic data, ratings for total erosion (the combination of wind and water erosion) and range condition (the combination of pasture condition and total erosion) are subsequently derived. Traverse records for
any index may then be sorted to produce statements for each land system and its component land units on each station, each station as a whole, each land system and its component land units within the entire survey area, and for the survey area as a whole. Furthermore since traverse ratings are depicted on the final maps, together with property boundaries and areas of severe erosion or pasture degradation (at 1:250,000), a comprehensive spatial representation of resource condition is provided. When this information is presented at 1:100,000 scale in the form of individual property maps it can serve as the basis for property development and management. The only limitation here is the extent to which uniform coverage can be achieved by vehicular traverses, which, since positional accuracy is required, are mostly confined to tracks.

The procedure for estimating carrying capacity in these surveys differs from that of Condon et al. described previously. Safe carrying capacities are estimated for each of the pasture lands identified in the survey region at three levels of range condition. These estimates are based on information drawn from a number of sources but, as far as possible, are objectively based. Information used in these assessments includes botanical composition of pasture lands in various condition states, palatability and dry matter production of component species and assumed safe utilization rates.

Since the proportion of each pasture land in each land system is known (pasture lands being closely associated with individual land units) and since land systems can be quantitatively described in terms of their range condition from the traverse data, safe carrying capacity estimates can be readily calculated for individual leases and the entire survey area. Capability estimates, representing the potential carrying capacity if all land were in good condition, can also be produced.

Surveys of this type provide, on a regional basis, the most detailed land resource information available in the extensive grazing areas of Australia. Their major deficiency is that carrying capacity estimates are calculated as year-in-year-out values. No estimates of drought carrying capacity are provided which could serve as a basis for stock reduction policies although this defect is offset to some extent by the fact that adherence to recommended stocking levels should minimize the need for stock reductions except in extreme circumstances.

Such surveys, however, represent only the first stage of land evaluation. They provide an inventory of resources and an assessment of their current condition sufficient for the development of management policies. The second and perhaps most demanding stage involves the implementation of monitoring systems by which the effect of management policies on resource condition can be evaluated and the policies modified accordingly.

No such comprehensive monitoring system currently exists in Australia although considerable effort has been devoted to technique development in recent years and a sizeable number of fixed range monitoring sites has been established in some areas (approximately 1000 in Western Australia alone). Techniques have included conventional ground assessment procedures (eg. Lendon and Lammacraft, 1976), various forms of ground-based
photographic procedures, large scale vertical aerial photography (eg. Carnegie et al., 1971) and analysis of digital Landsat data (eg. Graetz et al., 1981).

It is likely that the future development of monitoring systems will involve the integration of a number of approaches. In particular satellite data analysis from large areas is likely to be interpreted in conjunction with detailed botanical and soil data from a manageable number of ground sites. Simultaneously, the use of satellite data analysis as a change detection procedure may allow areas requiring more detailed ground monitoring to be identified. Analytical procedures for determining indices of cover and greenness from Landsat data have been developed for some southern Australian shrub lands (Graetz and Gentle, 1982) but little research along these lines has been conducted in northern grasslands and savannahs. Ground based monitoring methods for both of these environments, however, have been developed at least in terms of field data collection procedures. In Western Australia shrubland monitoring is based primarily on species density and size class data while grassland monitoring is based on total basal cover and species frequency. Apart from the establishment and maintenance of a comprehensive site network two major challenges remain in respect of ground based monitoring systems. One is to develop a suitable procedure for determining soil condition. The other is to develop the procedures by which data will be analysed, summarized and reported, taking cognizance of the need to separate, as far as possible, the seasonal and management influences on vegetation change.

4.2. Evaluation for alternative uses

As noted previously there are relatively few land use conflicts or alternative land uses in the Australian pastoral areas. Tourism, while increasing, is largely restricted to a few major national parks and areas adjacent to major roads. The total area involved is small as is the case with mining operations despite their economic importance. In some areas small scale forestry industries do exist eg. extraction of sandalwood (Santalum spp.), but these are conducted in conjunction with the pastoral industry rather than in competition with it.

In the arid grazing areas a major alternative use could be flora and fauna conservation. This subject has been completely ignored in the reports of many inventory surveys but has received more attention in recent times. The Queensland land use studies referred to earlier do comment on the adequacy of existing reserves in terms of the conservation of the vegetation types identified within the survey areas while South Australian studies (eg. Laut et al. loc. cit.) include conservation status as an integral part of environmental association descriptions.

Only on the humid fringes of the extensive grazing lands can consideration be given to alternative uses in terms of the development of cropping or improved pasture systems. Few studies have therefore dealt in detail with this aspect of land evaluation. One example is that of Day et al. (1979) who described the land resources of a pastoral lease in a wet tropical environment of the Northern Territory. In addition to conventional land unit descriptions,
these authors assessed the land use limitations applicable to each unit in terms of such factors as slope, susceptibility to erosion, soil depth and fertility, drainage and degree of waterlogging, weed invasion, assessibility and timber density. Potential land use could then be assessed on the basis of current agronomic knowledge of the area. Kubicki and Beer (1975) used a similar procedure, together with average annual rainfall data, to determine areas highly suitable, moderately suitable and unsuitable for pasture improvement with Townsville Stylo (*Stylosanthes humilis*) in the North Kimberley area of Western Australia.

5. Conclusions

Rangeland inventory in Australia is based on the land system concept. While local variations are evident this basic principle underlies virtually all large scale inventory surveys. Its widespread adoption is attributable to the relative ease with which land systems may be mapped from aerial photographs and the compatibility between the mapping units so defined, the scale of inventory operations and the scale of map presentation. Nevertheless, resource inventory has been completed for only an estimated 70 percent of extensive grazing lands.

Resource evaluation is concerned primarily with assessment of productivity for current use (ie. extensive sedentary grazing) and with the assessment of grazing impact on the resource base. Procedures employed here are far more diverse than those used for basic inventory. There are marked differences between survey groups in the approach taken to the assessment of carrying capacity and, in particular, in respect of the amount of spatial information provided concerning resource condition. Despite these differences the methodologies do exist by which data required for the formulation of management policies at either local or regional levels can be produced. The major need currently is the development of (integrated) range monitoring systems by which the effect of land use on resource condition may be evaluated on a continuing basis.

Relatively few alternative land uses exist for most of the extensive grazing lands and land use conflicts are thus comparatively rare. Nature conservation is one such use to which increasing attention is being paid in land inventory surveys. Only around the humid fringes, however, or in those relatively small areas in which irrigation development is feasible, does evaluation for other agricultural pursuits assume importance. To date such evaluations have generally been of relatively small scale and specific in nature.

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Review of rangeland inventory and evaluation techniques in South America

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1. Environment and resources

The physical and biotic environment differs considerably in a continent which ranges from 10° N to 55° S of latitude and possesses extensive high mountains and plateaus. Spacial occupation is uneven, sometimes due to historical circumstances; social and economic conditions are different as well, even in the same country. In all cases a high degree of human impact – present and past – exists, affecting the present pattern of vegetation units. Small scale maps of the continent are available showing soils vegetation, savanna areas, land use and cattle/sheep distribution. (For technical and financial reasons the original colour maps could not be reproduced in this paper, ed.)

2. Studies

Evaluation works have been carried out in an irregular way, as a consequence of scarce financial resources, usually appointed to specific institutions. These commonly represent the efforts of reduced groups of specialists. Frequently, they happen to constitute isolated actions, not corresponding to coordinated plans; there are – however – good examples of the opposite. The performed pedological, agrological, botanical, etc. researches lack uniformity – even in the same country – and have not been solved on the basis of a ground systematization. Published maps are comparatively scarce, mainly due to their cost. Aerialphotography, aerialphotogrammetry, aerialphotointerpretation and interpretation of satellite images have allowed to perform studies in shortening stages. Credible previous information is often scarce and scattered. In most cases reliable base maps are available; but the aerial photocoverage is frequently incomplete, having different dates and scales. Qualified human resources are limited, as are – almost always – financial resources.

2.1. Soils

Soil classification generally follows American ideas, described in the Soil Survey Manual (1951) and the VIIth Approximation (1960) and later complements; and in publications by Aubert (1967), Duchaufour (1964) and Northcote (1964). Research scales are different ('reconnaissance', detailed'). Many works have the support of photointerpretation.

Argentina

The study of soils has progressed much in the last 20 years. The following
works deserve to be mentioned:
- Soil map of the Pampean region (covers 600,000 sq.km; published at 1:50,000 scale – semidetailed – with geomorphology at 1:100,000 INTA).
- Studies on soils and plants of Patagonic steppes (with FAO's support).
- Chubut (1:250,000 scale): from Sierra de San Bernardo to Sarmiento plain.
- Santiago's Chaco (1:20,000 scale) and arid Chaco (reconnaissance, semidetail, use capacity) (INTA – Provincial Government).
- Depressional area of the Buenos Aires Province (INTA).
- Reconnaissance soil map of the Tucuman Province (National Univ. of Tucuman).
- Santa Fe and Cordoba soil regions (INTA).
- Salta Province: San Martin and Rivadavia Department (1:400,000 scale); Calchaqui valleys; agro-ecological study of the NE (1:1,000,000).
- Mendoza Province: Basins of the Grande and Colorado Rivers (1:200,000) (Provincial Government); Piedras de Afilar area (1:200,000).
- Soils of the lower basin of the Bermejo River (INCYTH/OAS).
- Erosion maps cover more than 40 million hectares in the Mesopotamia, the Pampean region and Tucuman (INTA).
- Malvinas' soils (INTA).
- Soil map of the Province of Corrientes (1:30,000 scale) (Provincial Government/INTA/Nat. Univ. of the NE).

**Bolivia**

- Soil studies of tropical and subtropical untilled areas: 250,000 sq.km (reconnaissance) and 50,000 sq.km (semidetailed).
- Very few studies have been conducted in the savannas of eastern Bolivia (Santa Cruz area, 'llanos de Mojos', 'Llanos del Beni and del Momore'), in spite of their relative importance for the agricultural economy of the country. A recent and in depth study on the soils of the Santa Cruz de la Sierra region and a FAO publication exists.
- Soil map of the Altiplano (1:50,000) (ERTS-Bolivia).

**Brazil**

- There are abundant maps on the pedology, geology and geomorphology of the savannas of central Brazil ('campos') and of the Amazonic Hylaea.
- Several reconnaissance maps: Soils of the Sao Paulo State, Sao Francisco River Basin (with FAO's support).
- Soil resources in western and central Brazil (FAO).
- Soils of the Amazonic Brazilian region (Centre for Agr. Pub., Wageningen).
- Erosion maps for the States of Minas Gerais, Paraiba, Rio Grande, Sao Paulo.

**Chile**

- Soils of arid lands of Chile.
- Coastal drylands of the IVth Region (Coquimbo-Los Vilos); (1: 200,000 scale) (PRIZAS).
- Volcanic Ash Soils of Chile.
- Soil study of 300,000 hectares having livestock potential.
- Aerialphotogrammetric project on natural resources: land use; soil and
limiting factors; use capacity of lands – 120,000 sq.km; based on aerialphotography (1:10,000 to 1:50,000 scale) (OAS/IDB).

**Colombia**
- Soil reconnaissance of the eastern ‘Llanos’ (FAO).

**Ecuador**
- National Soil Map: Sierra (1:50,000 and 1:200,000); Coast (1:200,000); East (1:50,000).
- IFAC Report (Puyo, Toaschi River).

**Guyanas**
- Surinam: Reconnaissance studies in the north and in the ancient coastal plains, with aerialphotography.
- French Guyana: ORSTOM studies.

**Paraguay**
- Several FAO studies, the Plan Triangulo and those of the Institute of Interamerican Affairs should be mentioned.
- The OAS is carrying out a study: Inventory of renewable natural resources of the Paraguayan Chaco.

**Peru**
- Soil study in the Yurimaguas area (FAO/ONERN).
- Las Lomas soils (Llachay) (CIZA).

**Uruguay**
- Many studies have been performed, but publications do not abound.
- Soils, in 1:100,000 scale (Dept. of Soils, MAP).
- Great Groups (whole country) (Dept. of Soils, MAP).
- Inventory of soils (whole country) (1:200,000 and 1:40,000) (Dept. of Soils, MAP).

**Venezuela**
Numerous studies have been published; among which:
- Apure savannas (with aerialphotography).
- Pedology, geology and geomorphology of the ‘Llanos’ (several scales).
- Land use (1:250,000; 1:100,000; 1:50,000 and 1:25,000 scales); with air photointerpretation.
- Soil map (1:2,000,000 scale); in black and white (MAC).
- Report to the Government of Venezuela on the major soils of Venezuela (FAO).

2.2. Vegetation
Most of the studies are of the physiognomic-floristic type (Zurich-Montpellier; CEPE); some, according to Holdridge’s ideas.
Argentina
- Patagonia: not totally covered; local studies by Soriano and Boelke; several works by INTA, Univ. of Buenos Aires and the Centro Nacional Patagonico.
- Chubut: physiognomic-floristic maps (1:250,000).
- Monte: several works in western Argentina (IADIZA, Univ. of the La Rioja Province and the Nat. Univ. of Cordoba).
- Studies in the central-eastern part of Santiago del Estero (INTA-Provincial Government).
- Semi-arid Pampean region (1:100,000) (INTA).
- Numerous works on the Chacoan region (INTA and others).

Bolivia
- Vegetation studies are relatively scarce. The work by M. Cardenas (1958) on phytogeographic formations should be mentioned; as well as the current works from the Ecology Institute, concerning the vegetation of the Huaraco and Wariscata areas and the Beni Savannas, and also on ecological air photointerpretation.

Brazil
- Classification of the types of ‘campos’ (Eiten).
- Vegetation of the German colonies in southern Brazil.
- Numerous phytogeographic and descriptive works concerning central Brazil and bordering areas.
- More than 100 phytogeographic and ecological publications concerning the savannas of the Amazonic Hylaea.

Chile
- Floristic and phytosociologic study of the Quebrada de la Plata and Cauquenes (1:12,500) (Univ. of Chile).
- Coastal drylands of the IVth Region (Coquimbo-Los Vilos) (1:200,000) (PRIZAS).
- Flora and vegetation of the experimental stations of Los Vilos, El Boldo and Las Cardas (1:2,000) (IREN).
- Vegetation zones and distribution of plant species and some typical associations of Chile.
- Vegetation of Atacama.

Colombia
Detailed works concerning the savannas of the Northern Andes are scarce.

Ecuador
The works by M. Acosta Solis on coastal savannas are important.

Guyanas
- Important studies on plant ecology of the savannas have been performed during the last 20 years in Surinam, published in the series ‘The Vegetation of Surinam’.
- The most detailed information on the savanna bioma of Guyana corresponds to the ‘Savanna Research Project’.
The ORSTOM of Cayena has recently published important works on plant ecology of the French Guyana.

**Paraguay**

There exist few studies on the vegetation of the subtropical savannas of the Paraguayan Chaco.

**Peru**

- Reconnaissance studies on the Gran Pajonal savannas (Eastern Peru) (ONERN).
- Inventory of the Tambo River area, in the Gran Pajonal (ONERN).
- Life Zones of the Gran Pajonal (ONERN).
- Abundant studies on the vegetation of the coastal desert, Arequipa, Lomas.
- Plant formations – Holdridge – at 1:200.000 scale (reconnaissance), in the Chancay-Huaral Project (ONERN).

**Venezuela**

- Vegetation map (1:200,000) in colours (IPLA, Univ. of Los Andes).
- 12 cartographic descriptions and studies on the Venezuelan savannas ('Llanos')
- A few detailed works on the savannas of the Coastal Cordillera.
- Sketch of phytogeographic zones of the Zulia.
- Plant communities of the subtropic, Cordilleras and the Caracas Valley.
- Study on the vegetation of the Maracaibo lowlands.
- Studies at 1:250,000 scale, according to Holdridge’s scheme.

2.3. Integrated Studies

Integrated studies according to modern concepts are relatively recent, and generally based on the interpretation of satellite images and aerialphotographs. There are different methodologies: land system (Christian, 1958); overlapping (Zaffanella, 1968); Mabbutt (1963); etc.

**Argentina**

- Patagonia (700,000 sq.km) from the Andes Cordillera to the Atlantic Ocean, between 45°30’ and 46°S. Maps at 1:25,000 scale. (INTA and others).
- Vegetation and environment units in the Argentinian Chaco (1:100,000) (INTA and others).
- Macro-ecological study of Los Llanos in La Rioja.
- Agro-ecologic study of the Mendoza and Tunuyan Rivers (INTA).
- Cubanea dryland area – San Javier, Rio Negro Province (1:200,000).
- Ecologic Map of the Province of Mendoza (1:200,000) (IADIZA).
- Badlands of central Mendoza Project (1:100,000) (IADIZA, with U.N.U. support).
- Uplands of Mendoza between 1,000 and 2,500 m.a.s.l. (1:100,000) (IADIZA with IDB support).
- Survey on tabacco areas of Salta (INTA).
- Integrated Inventory of Natural Resources of La Pampa Province (1:500,000) (INTA/Nat. Univ. of La Pampa).
- Agro-ecological study of Salta.

Bolivia

- It comprises almost the whole country (scale 1:1,000,000), with about 50% corresponding to arid and semi-arid lands.
- Regional study (with MAB's support).
- Map on current land use (1:100,000) (ERTS/Bolivia).
- Land use map (1:50,000) for the Santa Cruz area (ERTS/Bolivia).

Chile

- Regional study (with MAB's support).
- Desertification study in the Coquimbo area (145 sq.km) (supported by UNDP/FAO/WMO/IDB).

Colombia

- Conservation of renewable natural resources of the Meta Department (OAS).

Ecuador

- Patate River Valley (CLIRNR).
- Chambo area (near Riobamba) (CLIRNR).
- Studies on geomorphology, use, aptitude, erosion, ecology, climatology, livestock (in progress) (PRONAREG).

Paraguay

- Studies on natural resources of the Paraguayan Chaco (with OAS support).

Peru

- Study on desertification and rational use of the national territory (ONERN).
- Regional study (with MAB's support).
- Chancay-Huaral Project: inventory and reconnaissance of natural resources (1:200,000) (ONERN).
- Ecologic map of Peru (ONERN).

Uruguay

(See Soils).

Venezuela

- Los Llanos area.
- Ecologic map (1:2,000,000, in colour) (MAC).
- Regional analysis of the vegetation and environment of the Falcon State (1:250,000).
- Agrologic study - ample view - of the Tocuyo River Valley.
3. Evaluation Methods

3.1. 'Agro-ecological inventory' by Zaffanella

**Essentials**

Purpose: To set up the main combinations of the environmental factors and circumstances defining different agro-ecological conditions in the area under study.

Procedure: To establish which aspects of climate, vegetation, soils, water, properties (tenancy, size, type) reveal different manifestations, through bibliographic information, aerialphotographs, maps and personal consultation. If maps at scales smaller than 1:50,000 are available, the variation of those factors and circumstances should be traced using lines of different type and colour (or in several overlapping transparent sheets).

Used: Provinces of Cordoba, Corrientes, Mensoza, Salta, San Juan (Argentina).

3.2. Inventory of vegetation/reconnaissance by Guva

**Essentials**

Purpose: a) to make an inventory of the great ecologic systems of a region, using the phyto-ecologic methodology; b) to work out an efficient chart of general relations between each vegetation unit and the environmental factors which determine it.

Procedure: In this method, the characterization of (macro)ecosystems is based on the simultaneous and integrated use of phyto-sociological criteria and on the physical environment – sampling and analysis – which allows to analyze the vegetation/environment complex. The whole area covered by the same repetitive pattern of photophysiognomies, is the greatest stratification unit for sampling, and the largest synthetic cartography unit. These major units, of about 600 sq.km, are called Great Vegetation and Environment Units. Each Great Unit is discernible and capable of being mapped in the standard aerial photograph (1:35,000 to 1:50,000) through the repetitive pattern of its elements. There are three perception levels: 1:250,000, 1:50,000 to 1:35,000 and 1:1,000.

Used: Argentine Chaco, province of La Rioja (regions almost not occupied by man, with relatively little alteration of the natural environment, with deficient information).

3.3. Land System developed in CSIRO in Australia

**Essentials**

Purpose: To perform an ecological study revealing the problems and resources of a wide area, in a short period of time and at a low cost.

Procedure: The method integrates four fundamental disciplines: geology, geomorphology, edaphology and vegetation physiognomy. Interpretation of aerial photographs is performed (scale 1:40,000) as first reconnaissance of vast areas. The mapping unit is the ‘pattern’. The starting point is that different morphological and vegetation formations allow to distinguish different patterns, which repeat themselves, forming a complex of related units. The ‘land systems’ group smaller units, the ‘land units’ – management units – which are more easily definable in quantitative terms; they are surfaces
with a peculiar combination of ‘forms’ (land form), soils and vegetation. The intensity of sampling depends on the chosen scale. Used: In a 700,000 sq.km area, SW of the province of Rio Negro (Patagonia).

Vegetation

Studies are basically of the physiognomic-structural kind. Vegetation dynamic analyses are just beginning.

Teledetection

The need to carry out inventories of renewable natural resources and to carry out periodic controls has caused the use of the remote sensing technique also in the countries of the region. There are vast areas – arid or semi-arid in great part – where objects and surfaces must be identified, and the physical, biological, vegetation, etc. parameters may be measured as well.

4. Most important consulted literature


Huber, Otto, 1974. Le Savane Neotropicali (853 pp.); IILA/Istituto Botanico dell’Università die Roma; Rome.

IILA, 1980. Simposio Internazionale Sulla Integrazione della Ricerca per la Valorizzazione delle Zone Aride e Semiaride dell’America Latina; IILA/FAO, Roma, 1-5 October 1979; Rome.


