CSIRO

Division of Wildlife and Rangelands Research

Helena Valley Western Australia

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Ecological dynamics of remnants of native vegetation

PROGRAM L

Ecological Dynamics of Remnants of Native Vegetation

Conceptual Framework, Definitions and Key Questions

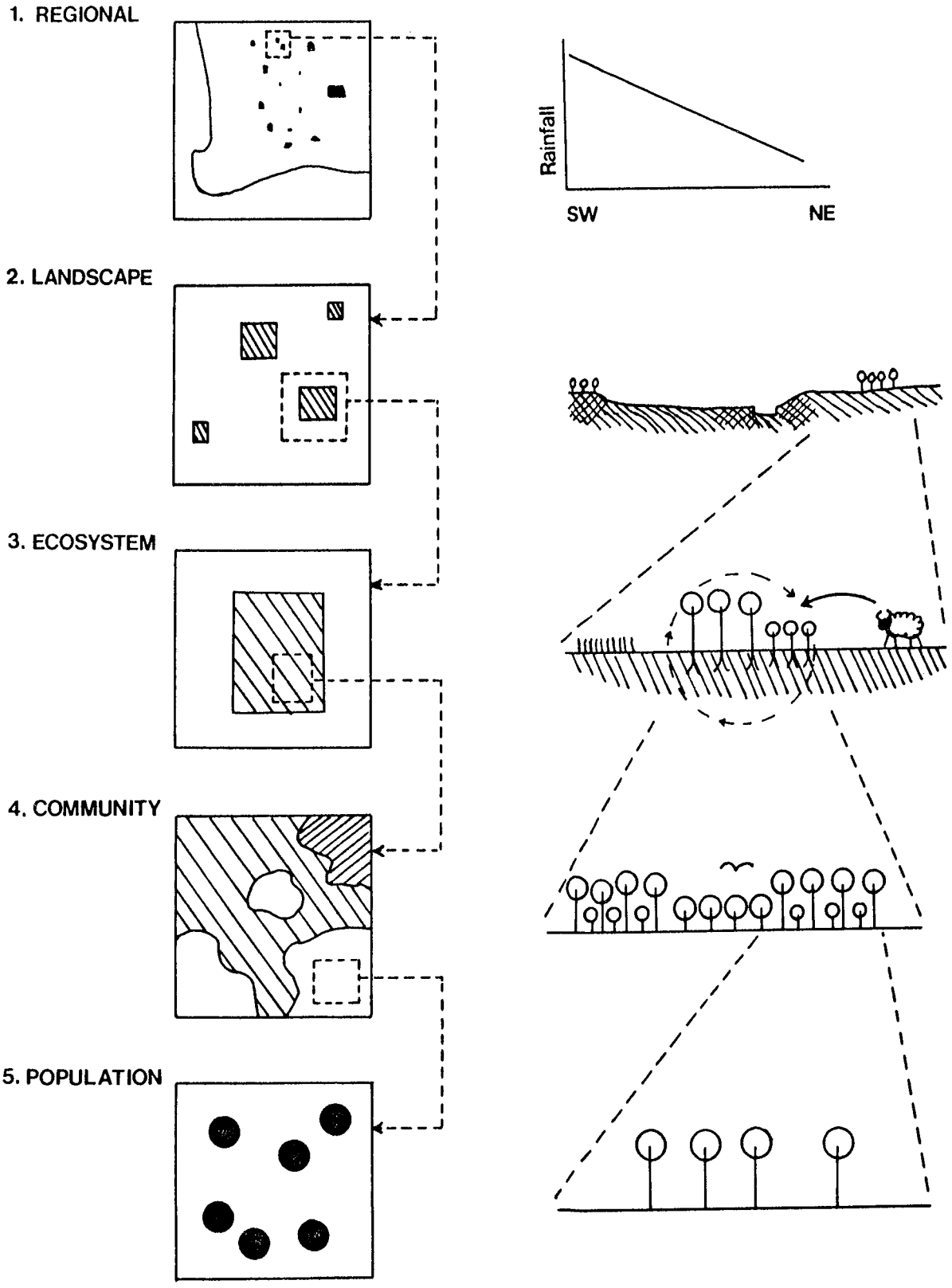
Objective: To establish the ecological principles on which management of remnants of native vegetation should be based.

Product of research: A series of scientific papers resulting from the studies and a publication "Ecological principles for the management of small nature reserves.

This program aims to study the structure, dynamics and management of plant and animal communities in remnants of native vegetation, both within individual remnants and at a broader landscape level. Most of the designated reserves and other remnants in Western Australia are, as in other parts of the world, relatively small and require management for the maintenance of their diversity and resilience.

Problems relating to conservation and management of biota in isolated remnants of native vegetation cover a broad range of levels of organisation and deal with spatial patterns at many scales and processes operating on many timescales. Fig. 1 illustrates the hierarchical nature of these various levels. We first define these levels and specific terms used. For each level we then identify the major patterns and processes and suggest a number of key questions which need to be investigated. Questions for which at least some information will be obtained by the programme are indicated by * in the right-hand column. At this stage most of the research effort of the programme is aimed

Figure 1. Dynamics of vegetation remnants: levels of organisation and scales of pattern.



at the landscape, community and population levels. We consider the ecosystem level to be of great importance also, but at present the programme lacks suitable expertise at that level.

Definitions

Region: the geographic setting for the study; i.e. SW Australia, in particular the W.A. wheatbelt.

Landscape: the local study area comprising a number of vegetation remnants, their connecting corridors and the surrounding farmland, in the context of geomorphological patterns. An area 40 x 40 km centred between Kellerberrin and Trayning, 200 km east of Perth, has been selected for study.

Ecosystem: an individual vegetation remnant and its immediate surrounds. Patterns and processes are defined by trophic levels (and their interactions) rather than by individual species.

Community: level used to describe within-remnant patterning and processes related to groups of interacting species. Both within- and between-community patterns are treated at this level.

Population: spatially or genetically distinct groups of individuals of a single species.

Remnant: any area of uncleared natural vegetation, usually surrounded by agricultural land.

Patch: area within a remnant bounded by one community, developmental stage or habitat type.

Biotic diversity: numbers and relative abundance of species present which are native to the original communities (i.e. excludes alien species and species which have invaded from other communities).

Resilience: the ability of a community or ecosystem to recover from a disturbance and remain in the same domain as the original.

1.

Regional level

Patterns:

Large-scale variations in geology and climate, especially rainfall.

Regional patterns of species abundance.

Variations in clearing history, remnant sizes, road verge characteristics and maintenance.

Variations in present land use.

Variations in attitudes to remnant vegetation and management of these (especially using fire) by local government and individuals.

Processes:

Long-term climatic variations, including drought cycles.

Long-distance dispersal and migration within and outside region, nomadism.

Geographical isolation, leading to population differentiation.

Key questions:

1. Is the study site at Kellerberrin sufficiently representative to allow findings of the studies to be applied more generally? *

2. If regional differences exist to what area will the results from Kellerberrin be applicable? *

3. Are there any long-term biological or sociological trends taking place which will interact with or override management objectives?

2. Landscape level

Patterns:

Geology, soils, geomorphology and climate.

Spatial distribution of vegetation remnants.

Presence/absence of connecting corridors.

Vegetation catenary sequences.

Distribution and abundance of animal species.

Processes:

Erosion, deposition, nutrient movement.

Changes in soil salinity due to land clearance.

Fragmentation of natural habitat.

Movement of biota between vegetation remnants, and movement of non-native species.

Key questions:

1. How does landform and soil type affect vegetation patterning and biotic diversity? *

2. Do vegetation remnants occur on all landscape and soil types, or are certain types under-represented due to preferential clearing? *

3. Does fragmentation have an effect on the distribution and movements of the faunal community, and if so on which species? *

4. Are corridors between patches necessary to allow movement of fauna, and if so what characteristics must a corridor possess for particular species? *

5. What are the ecological/economic/sociological effects of the presence of remnant vegetation on neighbouring properties?

3. Ecosystem level:

Patterns:

Site and community differences in production, decomposition and nutrient levels.

Spatial differences in organic matter and nutrient levels due to past disturbances (fire, clearing etc.).

Landform and drainage patterns within remnants.

Habitat heterogeneity within remnants.

Distribution of detritivores.

Processes:

Organic matter production and storage, decomposition and energy flow.

Nutrient cycling within patches and nutrient flow between a patch and its surroundings.

Water movement within patches and in relation to surroundings.

Trophic level relationships (predator/prey, herbivory).

Key questions:

1. What types of disturbance have the greatest effect on ecosystem processes in vegetation remnants?

2. What are the patterns of organic matter accumulation and nutrient levels following disturbances such as fire? *

3. To what extent does nutrient input from surrounding farmland change normal nutrient flows?

4. Which nutrients, if any, are limiting to production at each trophic level, and what factors influence availability?

5. What effects do termites, ants and phytophagous insects have on nutrient cycling?

6. Which are the most important herbivores, and what effect do they have on vegetation productivity and diversity? *

7. To what extent is the hydrology and salt balance within a vegetation remnant influenced by activities on surrounding lands?

8. What effect does remnant size have on susceptibility to changes in ecosystem processes?

9. What is the effect of remnant size and shape (= amount of edge) on animal abundance?

10. What are the minimum requirements which will give a remnant sociological importance?

4. Community level

Patterns:

Distribution of plant communities along environmental gradients, mosaics due to soil differences, and ecotones.

Differences in plant community composition due to disturbance.

Vertical structure and spatial pattern of plant communities.

Spatial variation in flowering and seed set.

Distribution patterns of fauna in relation to plant community composition and structure and in relation to food supply.

Processes:

Long-term successional processes, and community responses to climatic regime (e.g. drought cycles).

Changes in boundaries between communities.

Vegetation development in response to disturbances, with associated changes in fauna.

Annual cycles in plant and animal development, and flowering phenology.

Movement of fauna between and within communities.

Invasion of natural communities by non-native species, including weeds, rabbits and introduced predators.

Reinvasion of cleared areas by native species.

Key questions:

1. What factors influence the diversity of plant and animal communities within vegetation remnants? *

2. What are the major patterns of vegetation dynamics? *

3. What are the sequences of vegetation development following fire in different community types? *

4. What are the effects on vegetation and fauna of variations in frequency, season and intensity of fires? *

5. What determines how susceptible different plant communities are to invasion by weeds? *

6. What effects do weed invasions have on natural community processes, and which kinds of weeds have the greatest effects? *

7. What effects do herbivores and seed pedators have on plant community composition and structure? *

8. To what extent are interactions between processes such as disturbance, herbivory and weed invasion important? *

9. Is vegetation heterogeneity within remnants an important habitat variable for the fauna? *

10. To what extent does spatial and temporal variation in phenology affect movement and population dynamics of nectivorous, frugivorous and insectivorous animals? *

11. What factors determine the ability of native species to reinvade cleared or disturbed areas and how can such areas be best restored? *

12. Can guilds of species with similar life histories and responses to disturbances be recognised?

5. Population level:

Patterns:

Species distributions and abundances with respect to environmental gradients and mosaics.

Discontinuous population distributions.

Age structures within populations.

Gentic variation across populations.

Processes:

Population dynamics; fecundity, survival, dispersal, predation, parasitism and disease.

Growth rates of individuals (ecophysiology).

Fauna movement between and within patches.

Gene flow between populations.

Competition for resources.

Key questions:

1. What are the age-related patterns of development of the dominant plant species? *

2. Are there critical events or combinations of events which govern the episodic establishment and mortality of plant species? *

3. What factors are important in the population dynamics of animal species from different guilds or trophic levels? *

4. Are there threshold effects such as a minimum patch size which will maintain populations of particular species? *

5. What are the important habitat variables determining levels of animal populations. *

6. What effects does fragmentation have on inbreeding, heterozygosity and genetic drift, and are bottleneck or founder effects important? *

7. What effect does fragmentation have on the genetic composition of sedentary cf vagile species? *

8. What effects does fire have on the long-term survival of animal populations? *

9. What effects does grazing by domestic and feral herbivores have on the long-term survival of native animal populations?

6. Management

Key questions:

1. What problems and opportunities do remnants present to farmers, shire councils and others?

2. What are and what should be the management objectives for remnants?

3. What are the major management problems and what options are available and economically feasible to management authorities? *

4. What effects will present management practices have at each of the levels described above? *

5. Can long-term monitoring programmes be built in to management procedures to assess these effects?

6. Should management be directed at only designated nature reserves or are other vegetation remnants important for conservation? *

7. To what extent can the local population be motivated to manage natural areas for conservation?

8. Can management strategies be evolved to prevent degradation and to accelerate processes leading to habitat improvement? *

9. Can techniques be developed for the restoration of degraded areas such as abandoned farmland and gravel pits? *

10. Is an expert systems approach applicable to the management of remnant vegetation? *

PROJECT DESCRIPTIONS

Project LA: Effects of fire on animal populations.

1. Monitoring the Noisy Scrub-bird *Atrichornis clamosus* population.

Objective: To monitor the annual changes in the distribution, population and habitat use of the Noisy Scrub-bird. The aim of the study is to provide managers with the data that will enable them to decide if, when and where on the reserve, management needs to be implemented.

Location: Two Peoples Bay Nature Reserve

Staff: G.T. Smith

Duration: Project started in 1970 and will continue indefinitely.

2. Effect of fire on scorpion populations.

Objectives: To assess the effect of fire on 1. the population structure and density of a population of burrowing scorpions and in particular, its effect on fecundity and annual recruitment. 2. The populations of two vagrant species of scorpions. The long life span, low metabolic requirements and high resilience of scorpions makes them excellent "basement" species for modelling the effect of fire on the fauna.

Location: Kellerberrin

Staff: G.T. Smith and J.S. Ross

Duration: 1985 to 1990

3. Effect of fire on lizard communities

Objectives: To understand the effect of fire on the population dynamics of a lizard community in the Western Australian wheatbelt. In particular, the effect of post-fire vegetation

dynamics, patch size and shape on the post-fire populations and their interactions.

Location: Kellerberrin

Staff: G.T. Smith and J.S. Ross

Duration: 1986 to 1990

Project LB: Avian populations on remnants of native vegetation.

Objectives: To examine the species composition, dynamics and movements of avian populations on remnants of native vegetation so as to evaluate the long-term conservation potential of such remnants.

Key questions: (i) Are patches of native vegetation isolated by land clearing a group of independent isolates with the avifauna of each isolate being independent of that existing on neighbouring isolates?

(ii) What effect does the vegetation heterogeneity have on the distribution and movements of avian species?

(iii) What effects do the elements of the avian community have on the ecosystem?

(iv) Will the value of the habitat isolates to the avian community be enhanced if they have connecting corridors of native vegetation to allow movement between them?

(v) What effect does habitat fragmentation have on a population of hole nesting, long-lived birds?

Location: Kellerberrin, Coomallo Creek, Rottnest Island

Staff: D.A. Saunders, J.A. Ingram, C.P. de Rebeira

Duration of Project: Minimum of 5 years commencing 1985

Project LD - Dynamics of plant communities

1. Vegetation response to fire

Objective: To determine the effects of fire on shrub and woodland communities.

Vegetation recovery following fires at different times of year. Comparison of recovery in different community types. Derivation of longer-term vegetation dynamics by examining sequences of stands of known fire history.

Location: Durokoppin, E. Yorkrakine, Gingin, Gooseberry Hill.

Staff: R.J. Hobbs, L. Darlington.

Duration: September 1984 to June 1989 (sub-projects completed prior to 1989).

2. Invasion of native vegetation by non-native species.

Objective: To determine the factors allowing non-native species to invade remnants of native vegetation.

Differences in invasability of natural communities. Effects of soil disturbance and nutrient input. Weed invasion following fire. Population dynamics of native and non-native annuals.

Location: Durokoppin, Gooseberry Hill.

Staff: R.J. Hobbs, L. Darlington.

Duration: September 1984 to September 1986.

3. Reinvasion of abandoned farmland and disturbed areas by native vegetation.

Objective: To examine the extent to which native species are capable of reinvading disturbed areas.

Factors affecting the ability of native species to reinvade disturbed areas: seed dispersal, nutrient levels, competition with non-native annuals. Population dynamics of recolonising shrub species. Methods of rehabilitation of disturbed areas such as sand and gravel pits.

Location: Durokoppin and surrounding area.

Staff: V.J. Hobbs (voluntary), R.J. Hobbs, L.Darlington.

Duration: August 1985 to June 1989.

4. Effects of kangaroo grazing on plant community structure and composition.

Objective: To determine the effects of varying grazing pressure on native vegetation.

Reciprocal experiments on the removal and addition of kangaroo grazing to native vegetation. Effects of grazing intensity on biomass, structure and composition of vegetation (in co-operation with Project LE). Interaction between fire and grazing.

Location: Yalanbee, Durokoppin

Staff: R.J. Hobbs, G.W. Arnold, L. Darlington.

Duration: September 1984 to June 1989.

5. Ant - plant interactions in shrub communities.

Objective: To determine the timing and importance of ant activity with respect to seed dynamics in native vegetation.

Flowering phenology in two adjacent shrub communities and ant activity in relation to this. Effects of ant predation or dispersal on seed abundance and availability.

Location: Durokoppin

Staff: R.J. Hobbs, L. Darlington, J. Majer + student (WAIT).

Duration: November 1985 to January 1987, with possible extension.

6. Classification and mapping of vegetation and landforms.

Objective: To place areas of remnant vegetation within a geomorphological framework and to provide baseline vegetation data for animal studies.

Mapping of landforms and vegetation of study areas at a broad scale. Classification and mapping of vegetation within study reserves. Development of herbarium reference collection for study reserves.

Location: Kellerberrin area, including Durokoppin, Kodj Kodjin and E. Yorkrakine Reserves.

Staff: B. McArthur (contract), R.J. Hobbs, L. Darlington.

Duration: timing dependent on provision of aerial photography and reserve survey through Heritage Commission.

Project LE: Large marsupials in reserves and the surrounding countryside.

1. Biogeographic survey of remnants of native vegetation

Objective: To analyse the relationship between biogeographic characteristics of remnants of native vegetation and their conservation value.

Landsat imagery of the SW of Western Australia has been used to map all the remnants of native vegetation. Within selected areas the size, landscape position, vegetation and conservation status

of each remnant is being assessed. It is proposed to assess relationships between physical attributes of remnants and their conservation status. A selected number will be used for monitoring the dynamics of some animal species.

Location: Kellerberrin, Trayning, Tammin

Staff: G W Arnold, J Weeldenberg, D Steven

Duration: 1985 to 1987

2. Fluctuations in population sizes and in movements of Macropus fuliginosus ocydromus and Macropus robustus erubescens between remnants of native vegetation.

Objective: To determine the key factors influencing the distribution and abundance of the two major large herbivores in the agricultural areas of Western Australia.

Population densities of these two species are being monitored in a number of remnants differing in size and in vegetation characteristics. Variation in use of different plant communities is being examined including the effects of fire. Movements of individuals within and between remnants will be studied in relation to food and water supplies.

Location: Kellerberrin, Pingelly, Baker's Hill

Staff: G W Arnold, J Weeldenberg, D. Steven

Duration: 1985 to ?

3. Effects of herbivory by kangaroos on the ground vegetation in remnants of native vegetation.

Objective: To assess the impact of herbivory by kangaroos on the growth and structure of ground vegetation.

Kangaroos are the only large herbivores in natural ecosystems in the south-west of Western Australia. Their foraging behaviour may well have an important effect on the productivity and structure of these ecosystems. The basic patterns of foraging behaviour are being studied in the Western Grey Kangaroo and its effect on ground vegetation measured at different animal densities, in co-operation with Project LD.

Location: Baker's Hill

Staff: G W Arnold, R J Hobbs, J Weeldenberg, D Steven

Duration: 1986 to 1988

Project LF: Social dynamics of animal populations.

1. The effect of intense fire on birds.

Objective: To study the recovery of the vegetation, the fluctuations in insect numbers, and the changes in social organisation and population dynamics of a range of bird species following a very intense fire (30.1.85)

Location: Gooseberry Hill, Helena Valley

Staff: M.G. Brooker, J. Leone, I. Rowley

Duration: Indefinite

2. The genetics of small populations

Objective: To study the genetic structure of a population of small passerines (Malurus splendens) that has been pedigreed since 1973.

Location: Gooseberry Hill

Staff: M.G. Brooker, J. Leone, I. Rowley

Duration: 1985-1990

3. Why did the Grass wren go extinct?

Objective: Only one species of passerine has become extinct since the wheatbelt has been established - the thick-billed grass wren Amytornis textilis. Populations of this species do exist in the state and a study of their ecology should show why they failed to cope with the clearing necessary for wheat farming and, in particular, why they have not survived in any of the wheatbelt reserves. This study will also provide ecological data on other ground feeding birds.

Location: Monkey Mia, Shark Bay

Staff: M.G. Brooker, J. Leone

Duration: 1985 to 1990

4. The effect of fire on forest birds.

Objective: To build up a body of ecological data, comparable to the Gooseberry hill material, based on a congeneric Malurus elegans, and to measure the response of this population to a prescribed "fuel reduction" fire.

Location: Smith's Brook Reserve, Manjimup

Staff: I. Rowley in collaboration with R & M Brown (private citizens).

Duration: 1980-1990