

# Vegetation dynamics on coastal sandstone plateaus of the Sydney Basin



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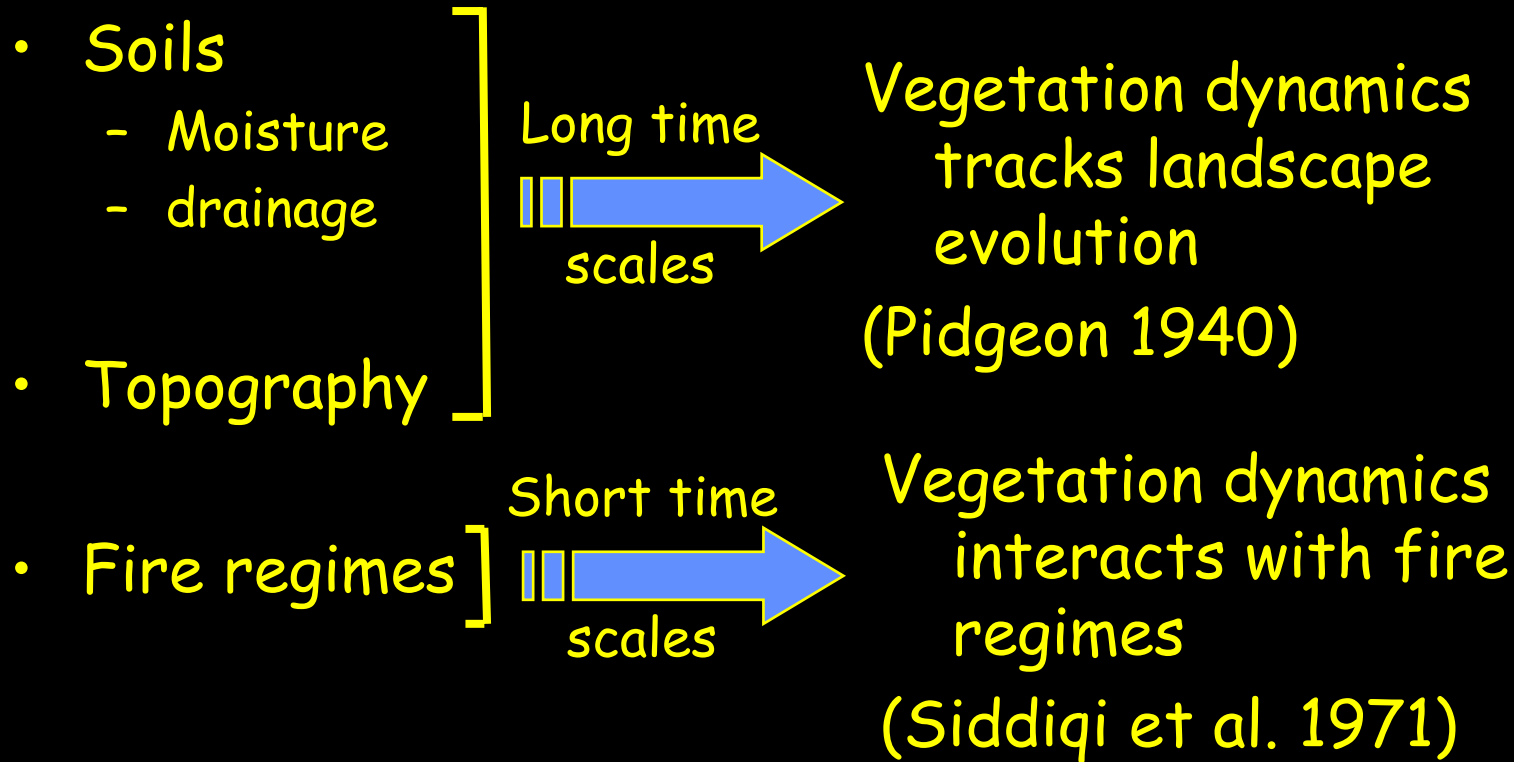
# Sandstone plateau vegetation

## Diversity & heterogeneity

- Several hundred vascular plant taxa
- Woodland, scrubland, heathland, sedgeland
- Spatial mosaics
- Temporal variability



# What controls vegetation patterns on sandstone plateaus?



## Implications for biodiversity conservation

- fire management can influence distribution of habitats over short (decadal) time scales

# Understanding ecosystem dynamics with models

## Models

- Representations of reality
- Set of beliefs about how the world works
- Verbal, pictorial, graphical, mathematical
- Explanatory models
  - Explaining causes & effects of observed behaviour
- Predictive models
  - Predicting future outcomes given particular scenarios/circumstances (If... then...)
- Decision support for management of biodiversity and wild landscapes

# Classical succession - Clements (1916)

- A temporal sequence of plant communities (stages) following disturbance
- Each stage facilitates the development of its successor
- The temporal sequence ends in the development of a stable climax community

Stage 1



Stage 2



Stage 3



Climax



Disturbance



# A new model of vegetation dynamics

- Understanding how fire regimes influence vegetation dynamics
- Predicting vegetation responses to alternative fire scenarios
- Informing management of fire regimes

# Model structure

Species grouped into functional types

- groups of species sharing *traits* that govern mechanisms of response to environmental perturbations (e.g. recurring fires)

Patch types (states) defined by characteristic functional types

Patch dynamics determined by

- Seedbank accumulation
- Recruitment
- Competitive elimination
- Senescence
- Dispersal

Mediated by fire

State and transition framework

# Functional traits & classification

Sandstone flora exhibits great diversity of life histories

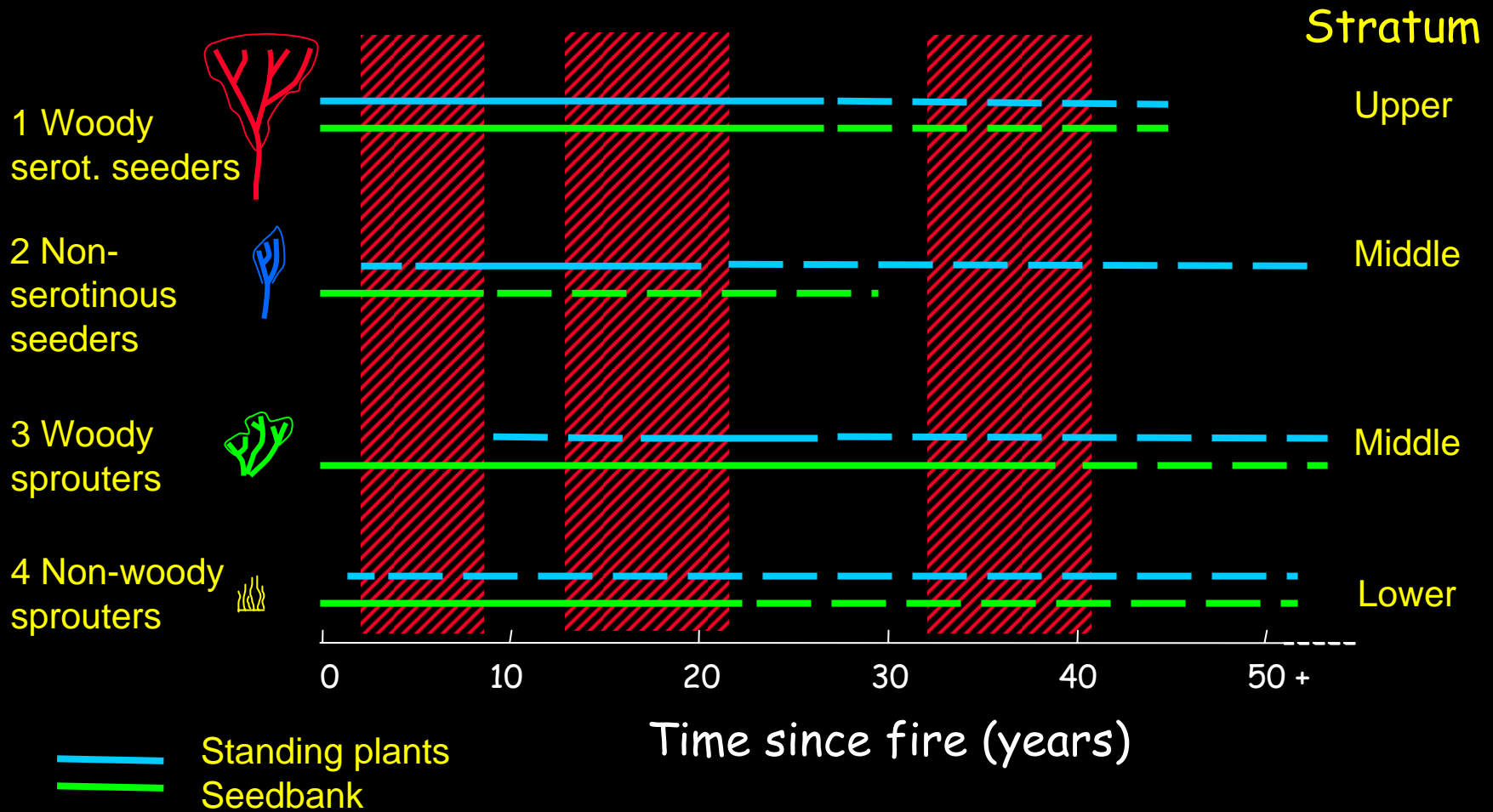
- only 3 traits defining 4 functional types are necessary to represent salient processes in model



Functional Type	Fire persistence	Reproduction	Vertical stratum
Serotinous seeder	killed	serotinous seed	upper
Non-serotinous seeder	killed	soil seed	middle
Woody sprouter	survives	soil seed	middle
Non woody sprouter	survives	soil seed/ vegetative	lower



# Process model & functional types

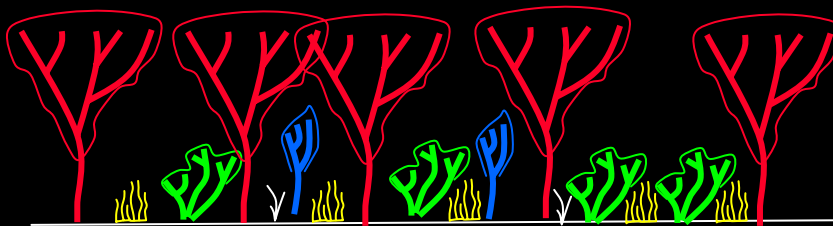


# Ecosystem states

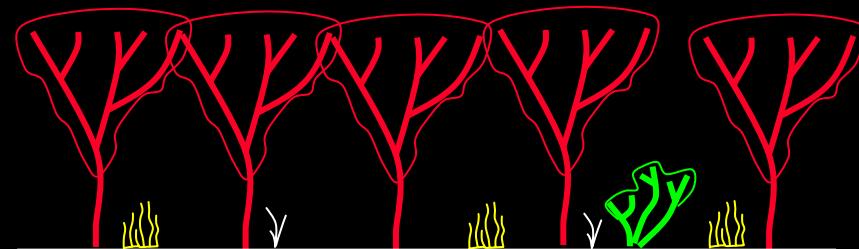
Diverse open heath



Depauperate open heath



Diverse thicket



Depauperate thicket

# Vegetation dynamics

Diverse thicket

Diverse open heath

Burnt

<5 years since fire

<5 years since fire

Juvenile

5 - 10 years since fire

5-10 years since fire

Mature

10 - 20 years since fire

10-30 years since fire

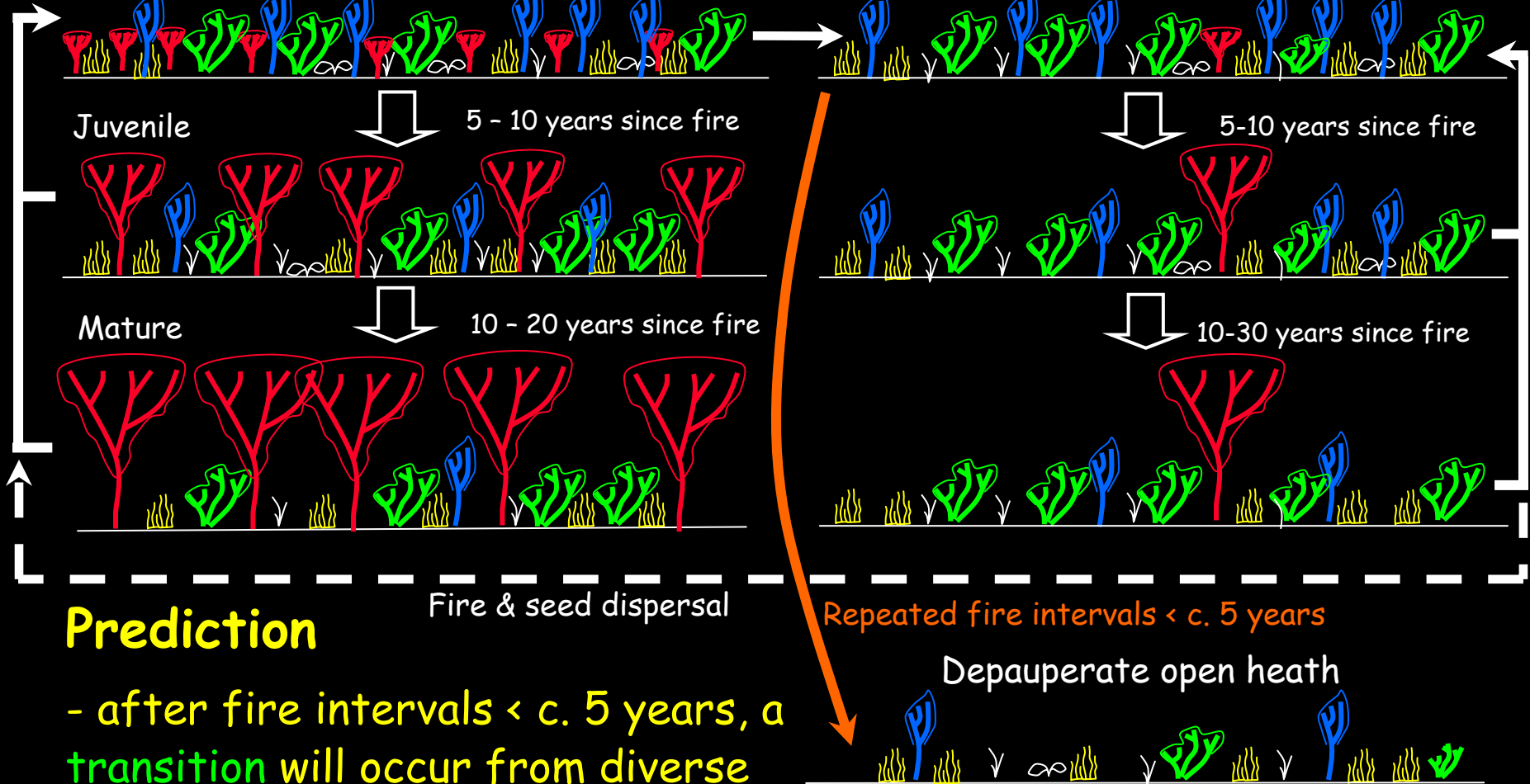
## Prediction

- after fire intervals < c. 5 years, a transition will occur from diverse thicket to diverse open heath (elimination of serotinous seeders)

Fire & seed dispersal

Repeated fire intervals < c. 5 years

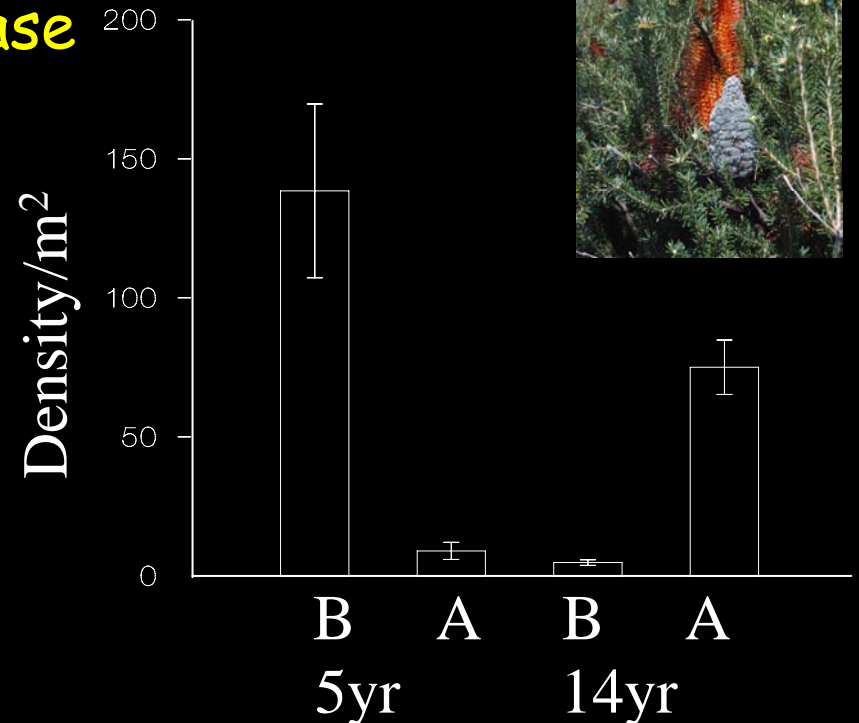
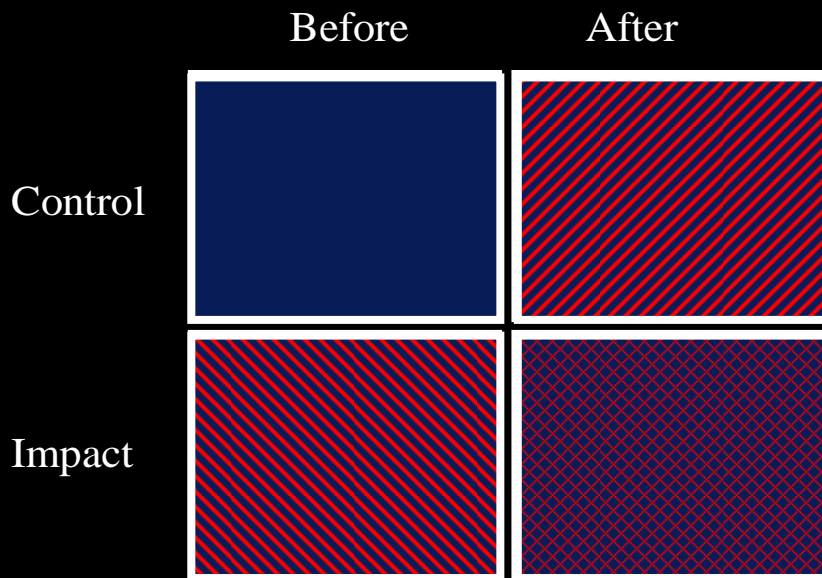
Depauperate open heath



# Evidence of transition

Changes in abundance of thicket dominant

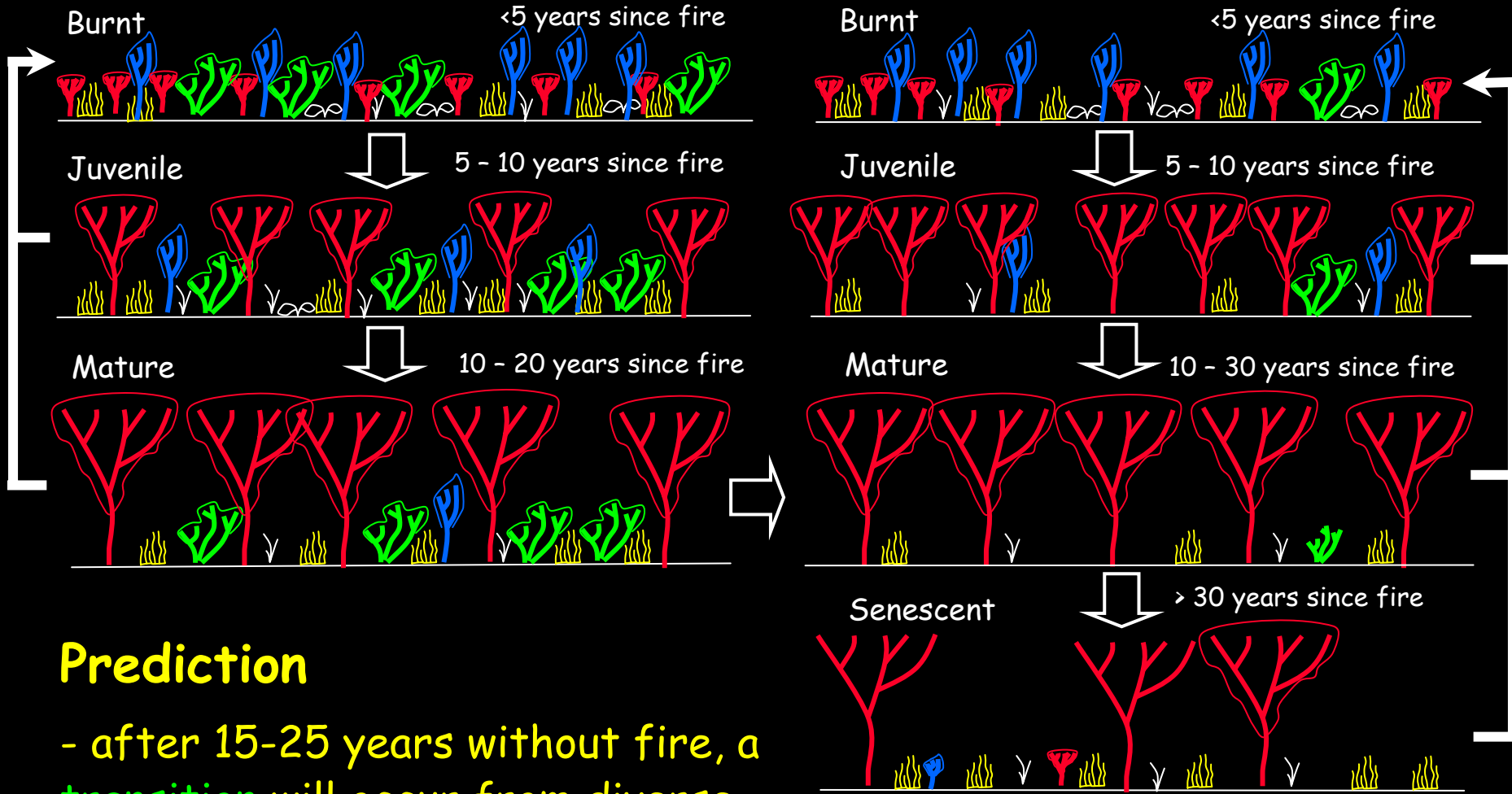
- BACI design
- 5 yr interval - major decline
- 14 yr interval - major increase



# Vegetation dynamics - infrequent fire

Diverse thicket

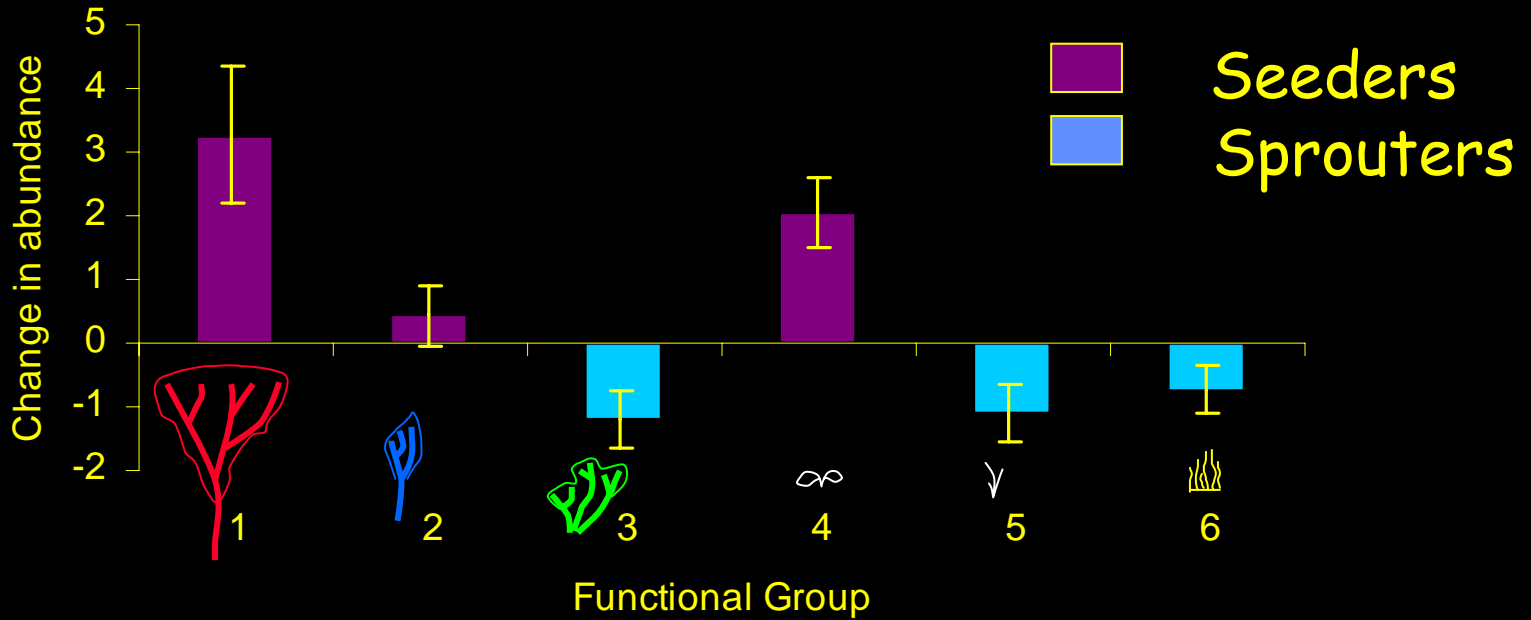
Depauperate thicket



## Prediction

- after 15-25 years without fire, a transition will occur from diverse thicket to depauperate thicket (decline & loss of woody sprouters)

# Evidence of transition



## Temporal comparison before & after 17-year fire interval

- Increase in woody serotinous seeders & other seeders
- Decline in woody sprouters
- Decline in non-woody sprouters

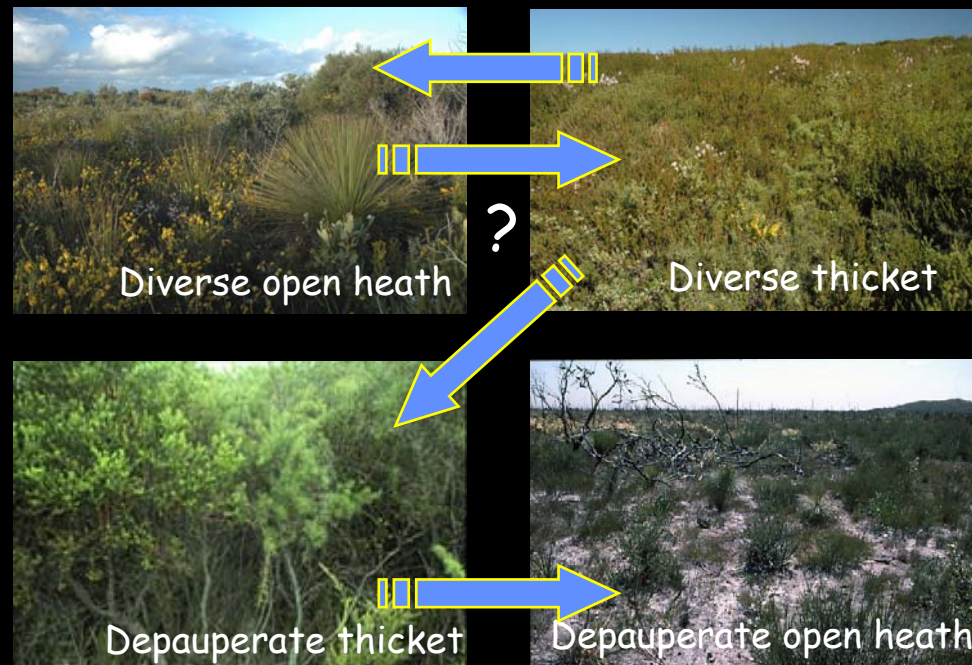
# Decision support for fire management

Developing a predictive model from an explanatory one

- ecosystem states
- transitions between states
- environmental drivers (fire, climate, soils)
- conditional probabilities of transitions
- time scales

How are alternative states connected?

How can management influence turnover & persistence?



# Model development - Transition matrix



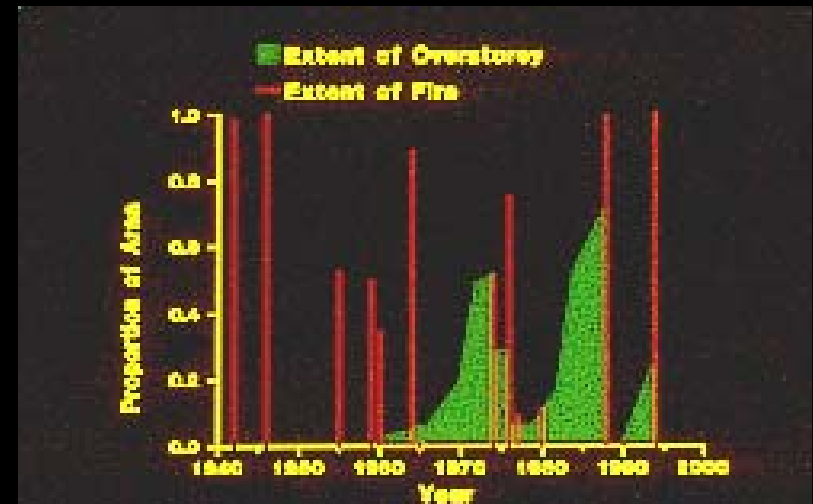
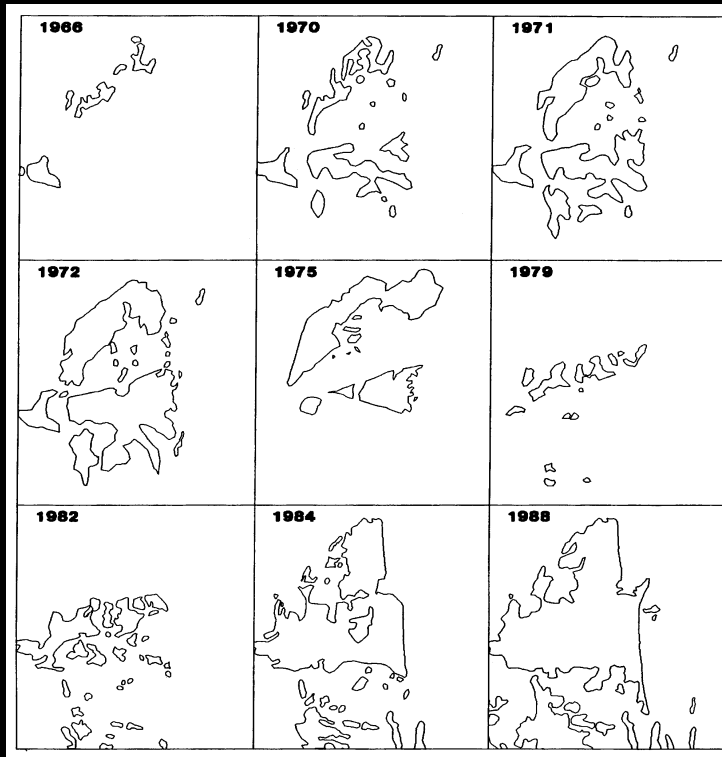
oody	HHb	HHj	HHm	HLb	HLj	HLm	HLo	HLu	LHb	LHj	LHm	LHo	LHu	LLb	LLj	LLm	Llo	Llu
HHb	FD	F	F					FD		FD	FD	FD			FD	FD		
HHj	NF																	
HHm		NF																
HLb				FD	F	F	F								FD	FD	FD	FD
HLj				NF														
HLm					NF													
HLo			NF			NF												
HLu							NF											
LHb	FN	FN						FD	F	F	F	F	F		FD	FD		
LHj									NF									
LHm										NF								
LHo											NF							
LHu												NF	NF					
LLb				FN	FN		FN	FN	FN					F	F	F	F	F
LLj														NF				
LLm															NF			
Llo																NF		
Llu								NF									NF	NF

NF No fire  
 FN Fire & no dispersal  
 FD Fire & dispersal  
 F Fire & dispersal or not



# Landscape dynamics

- Shifting mosaic of thicket & open heath 1940-2001



# Conclusions

## 1. Heathlands are dynamic ecosystems

- Transitions between alternative states
- Shifting mosaics
- Causes & effects involve fire regimes (& climate)

## 2. Conserving biodiversity requires maintenance of multiple states within the landscape

- heath-dependent spp
- thicket-dependent spp
- renewal & turnover (cf static approach to mgt)

## 3. Long term ecological studies coupled with models of ecosystem dynamics

- central to learning by doing
- essential to inform management of complex systems