internal report **437**

Koalas and habitat management on Kangaroo Island

Seminar Seminar presented at Northern Territory University, 24 April 2003, and at Environmental Research Institute of the Supervising Scientist, 29 April 2003

P Bayliss & P Masters

June 2003

supervising scientist

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June 2003

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Supervising Scientist

Contents

Powerpoint slides

Koalas & Habitat Management

Kangaroo Island



Peter Bayliss (eriss) & Pip Masters (SA DEH)

Take Home Messages

- Wildlife management is about making value judgements
  - aesthetic & technical
- Two key knowledge needs
  - how people value wildlife & make decisions
  - an understanding of ecosystem dynamics

Supervising Scientist Division

- Two branches
  - *Environmental Research Institute of the Supervising Scientist (ERISS)*
    - Environmental protection from impacts of U-mining
    - Ecology & conservation of tropical wetlands
  - *Office of the Supervising Scientist (OSS)*
    - Supervision, audit & policy w.r.t. U-mining in ARR

Seminar Outline

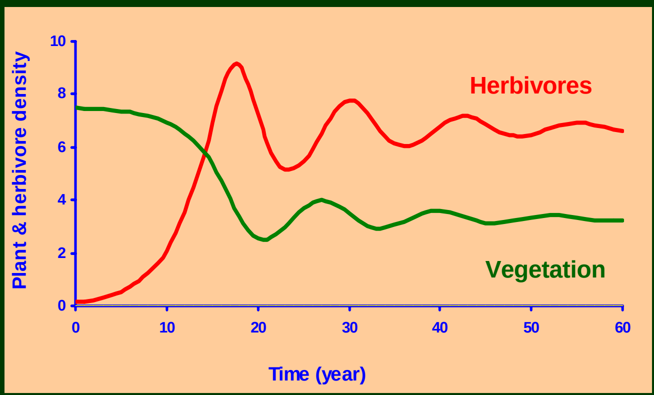
- Pest control background
  - Herbivore eruptions
  - Managing overabundance
  - Bioeconomic framework
- Koalas on KI
- Link with possums in NZ
- KI koalas – where to next?

BACKGROUND

Pest Control

Herbivores liberated on islands erupt then crash

Vegetation (food) mirrors reciprocal trend



- Moose Ilse Royal
- Possums NZ
- Several ungulate sp NZ
- Sheep Aust rangelands

Are these herbivores "overabundant" – what's the reference point?

What is "Overabundance"

- Defined as too many animals but the rigor ends here
- Generally 4 classes (Caughley 1981)

CLASS 1:	Animals threaten human life or livelihood
CLASS 2:	Animals depress abundance favoured species
CLASS 3:	Too many animals for their own good
CLASS 4:	The ecological system is off its equilibrium

- All apply to koalas on Kangaroo Island

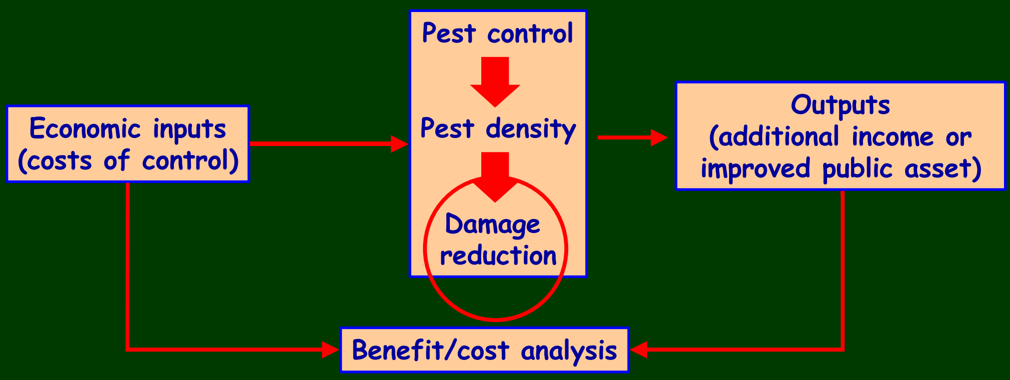
Definition of "damage" caused by Class 1 & 2 overabundance

- All animals have an impact on their consumptive resources (food & shelter)
- Damage occurs when impact causes economic or environmental harm
- How one defines "harm" depends on how one makes a living

Managing Pest Impacts

- Involves making choices
  - how much management intervention at what cost ($) ?
  - what benefit is delivered?
- Challenge is to make choices that are
  - sensible
  - pragmatic
  - defensible
- Requires benefits & costs to be balanced at least
  - past focus on "activity-based" management
  - new focus on "damage-based" management within a budget
  - involves complex decision making - use modelling tools

Bioeconomic Modelling

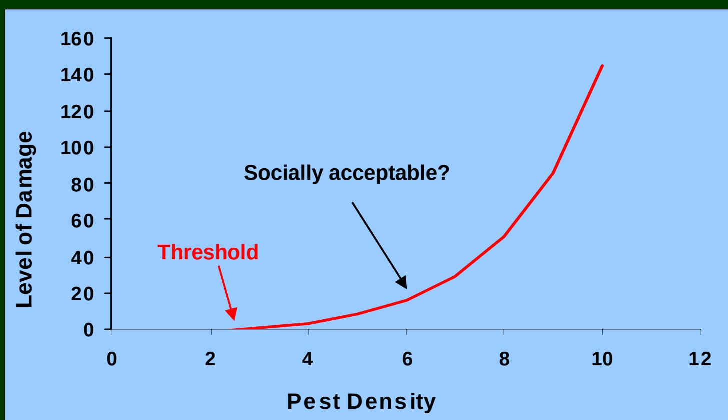


Monetary benefit/cost analysis
Benefit maximisation
Cost minimisation

There are 3 key sub - models

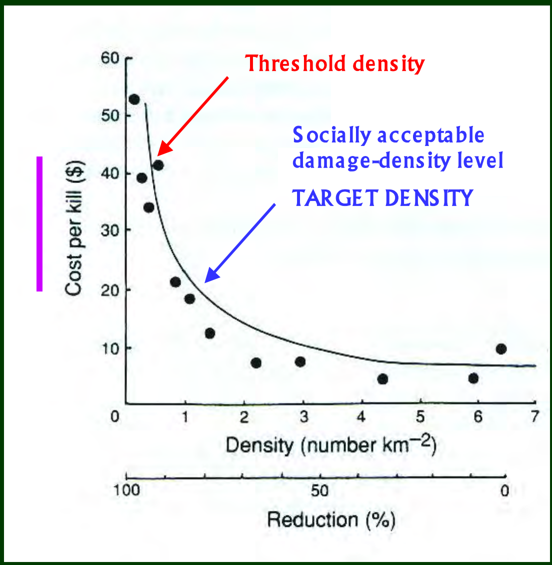
1. Damage – pest density relationship
2. Exponential cost-of-control curve
3. Population growth response

1. Damage – density relationship



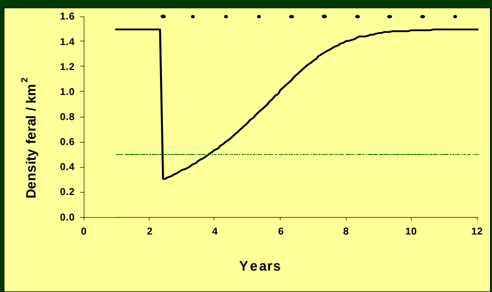
2. Cost - of - control curve

Choosing the right "Target Density"

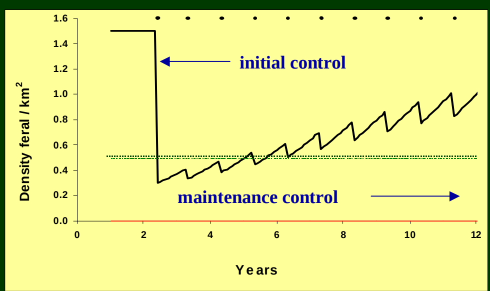


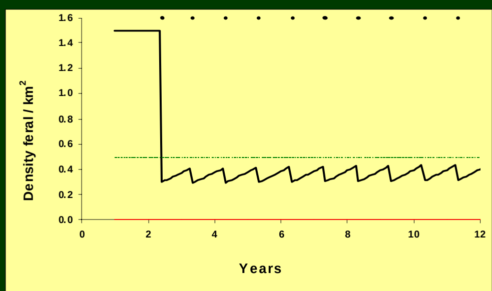
Buffalo – Arnhem Land
Bayliss (1985)

3. Population growth response

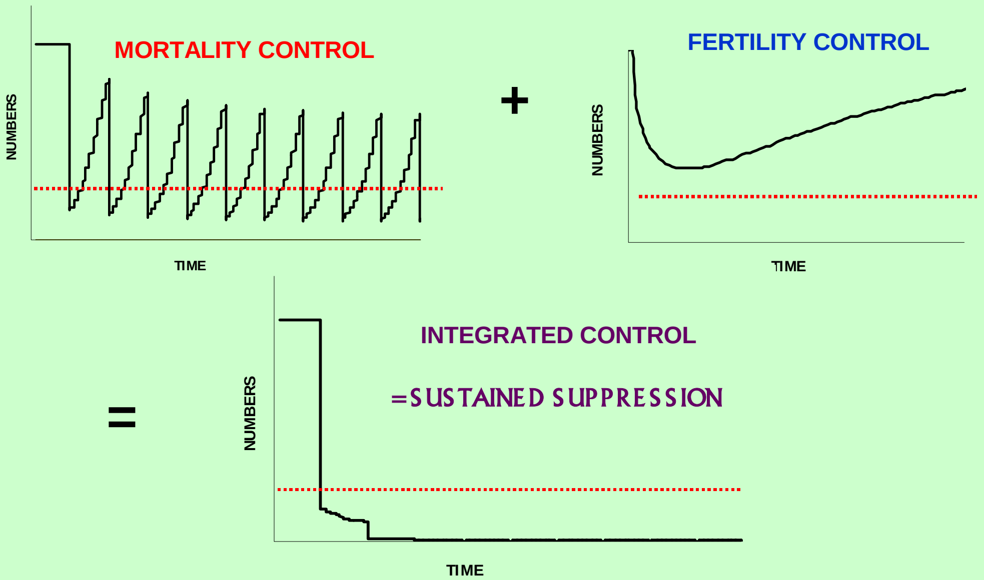


- Logistic population growth model as 1st approx
- Rapid recovery rate for pest species
- Manage control interval (yrs) & initial & maintenance kill rate





Target density & control technology



Summary
How to manage damage

- Clearly define damage caused by overabundance
- Identify the damage - density "threshold"
- Identify a socially acceptable level of damage & corresponding animal density
- Use bioeconomic & ecological frameworks (models) to guide control program cost - effectively

KOALAS

KANGAROO ISLAND

KANGAROO ISLAND SOUTH AUSTRALIA

- Jewel in the crown of conservation lands in SA
- Koala is only introduced major animal pest species

THE STORY

- Koalas introduced KI 1925 in attempt save species thought to be diminishing on mainland (85 released: 1923 – 1964)

THE STORY

- Populations flourished – by 1965 severe over-browsing damage to prefered food trees (e.g. Manna gum – *Eucalyptus viminalis*)

THE MAIN ISSUES

- Koalas quickly defoliate trees – now a "threatening process" to large areas of Eucalypt forests
- High risk of local extinction of preferred species
- Closest rival in reputation is introduced possum in NZ

- 1996 – SA Koala Task Force & National Koala Conservation Strategy established

SA Koala task Force Recommendations

(Possingham *et al.* 1996)

- Do nothing
- Protect & restore degraded habitat
- Suppress fertility via introduction of *Chlamydia* virus (suggested by Koala Foundation)
- Suppress fertility by surgical or hormonal methods
- Translocate surplus animals to other sites
- Culling

BUT .... different perceptions of value of koalas

- Koalas - high & favourable profile in the Australia physch
- Obvious tourist benefits to KI ($$$$)
- But cause tree damage – so big conflict in values
- Determines how they are managed




Response to SA Koala task Force Recommendations

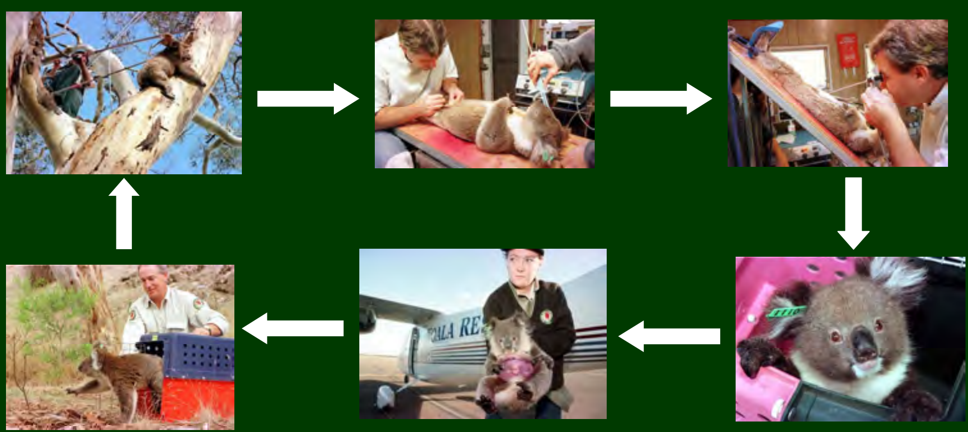
- Do nothing – not an option
- *Chlamydia* rejected on animal welfare grounds
- Adverse national & international reaction to culling – forget totally
- No room for translocations on KI, shift some to SA mainland
- Maintain low koala densities on KI via fertility control
- Implement habitat protection & restoration program on KI
- Yes - develop community education program
- Yes - expand research & management effort (1996-2000)

What happened next ?

- Politics took over – urgent action required
- Management was activity-orientated, not strategic
- e.g. in absence reliable information, arbitrary sterilisation (e.g. 70% pop) & translocation targets were set

Koala Rescue Program

- Funds available to research tree damage & manage koala populations on KI by surgical sterilisation & translocation
- Called **"Koala Rescue"** Program not **"Habitat Rescue"**



Cost to Public ?

- In 1 year alone – 1997/98 FY
- 3,396 sterilised
- 1,105 relocated off Kangaroo Island
- Total cost = $300,00 or $131 / koala

Is the program working?

- Action plan based on initial pop estimates for Cygnet River catchment (most browsing damage) = 3,000 – 5,000 koalas
- Other catchments not surveyed – when included = 26,000 (i.e. 5 – 9 times extent of perceived problem)
- Rapidly running out of sites on mainland to dump sterilised koalas from KI
- Answer up front: locally yes, globally no – unsustainable

Then what happened ?

- Program reviewed 2000 - request to Marsupial CRC to:
  - analyse all available information on browse damage (1996 - 2000)
  - help estimate koala densities island-wide
  - develop quantitative decisions support tools (bioeconomic models, ecological risk assessment) to guide strategic management
- Until this request no previous analysis of information made because of pressures of operational actvities
- Results follow

Management Data

- Recent (1996 – 2000)
- Historical (1925 – 1995)

Funding allocated to koala management on Kangaroo Island (1996 - 2001)

Management Activity	1996/97	1997/98	1998/99	1999/00	2000/01	TOTAL
Fertility control	$190,000	$150,000	$155,000	$170,000	-	$665,000
Coordination & Monitoring	$75,000	$70,000	$20,000	$30,000	$15,000	$210,000
Translocation	$25,000	$50,000	$15,000	-	-	$90,000
Community education	$45,000	$30,000	$10,000	-	-	$85,000
Island wide pop estimate & program review	-	-	-	-	$185,000	$185,000
TOTAL	$335,000	$300,000	$200,000	$200,000	$200,000	$1.235M

Koala population estimate (& SE%) per catchment (# sample sites) on Kangaroo Island (2000)

Catchment (number of sites)	Population estimate	Standard Error (%)
North Coast (25)	5,636	31
South West (22)	5,884	30
Eleanor-Timber Ck (24)	5,196	21
Finders Chase NP (21)	2,993	31
Cygnet River (27)	5,442	31
TOTAL (119)	25,871	12
Pre-1996 estimate	3,000 – 5,000	None

Predicted extinction rates of Manna gum trees in management units if no intervention (from 2000)

Management Unit	Koala density Nos / ha	% Manna gum with <%50 canopy cover	Years to all trees severely damaged
Flinders Chase	5.01	94	2
Timber-Creek	1.46	75	9
North Coast	1.64	79	7.5
Cygnet River	1.85	60	15
South west	-	90	3.5

Browse damage classes & associated koala population estimates (1996-1999)

- 119 sites – mark-recapture "double count" method used in sites (varying 1-10 ha) to estimate koala density
- Koalas tagged, sexed, aged, weighed, sterilised & released or sterilised & translocated
- All species of trees counted & classified according to damage

Class 1: Crown normal (no visible signs)

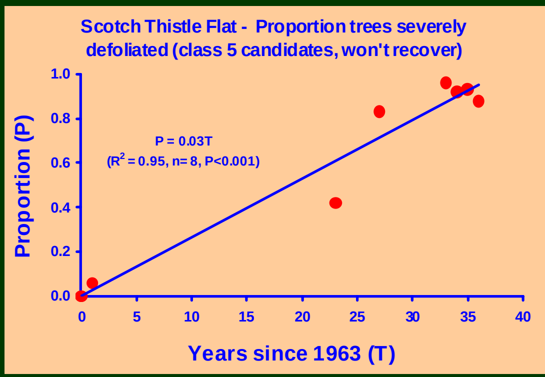
Class 2: Thinning of crown (up to 50% defoliation)

Class 3: Crown sparse (50-80% defoliation)

Class 4: >80% defoliation, predominant epicormic growth

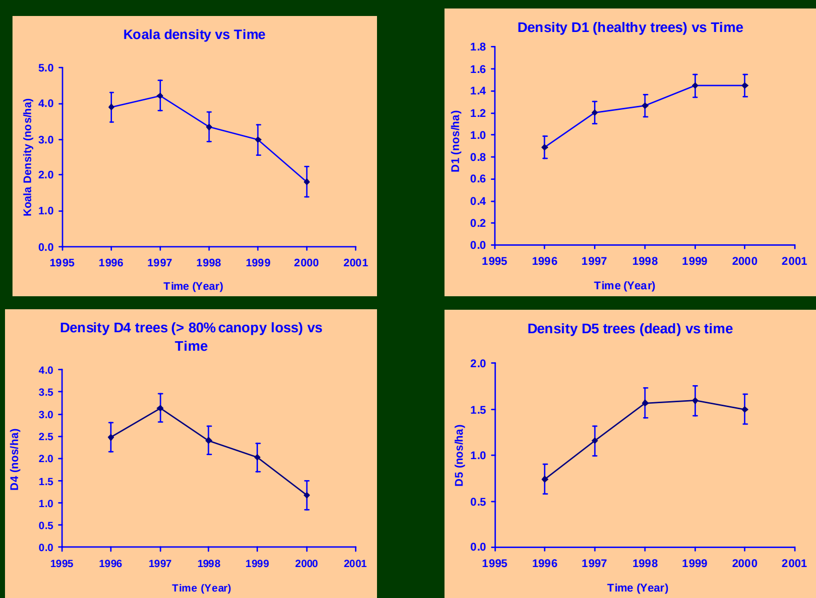
Class 5: Crown absent, tree dead

Scotch Thistle Flat – Flinders Chase National Park, Kangaroo Island (1964 – 2000)

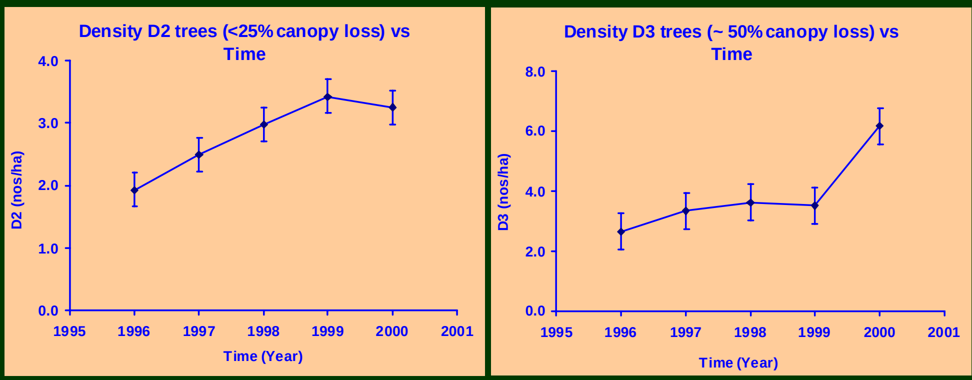


- 47 koalas released in 1964
- 35 years to extinction of Manna gum habitat at 3% p.a. tree loss rate

Time trends koala density & severe Damage Classes of Manna gum trees, Cygnet River catchment (1996 – 2000)



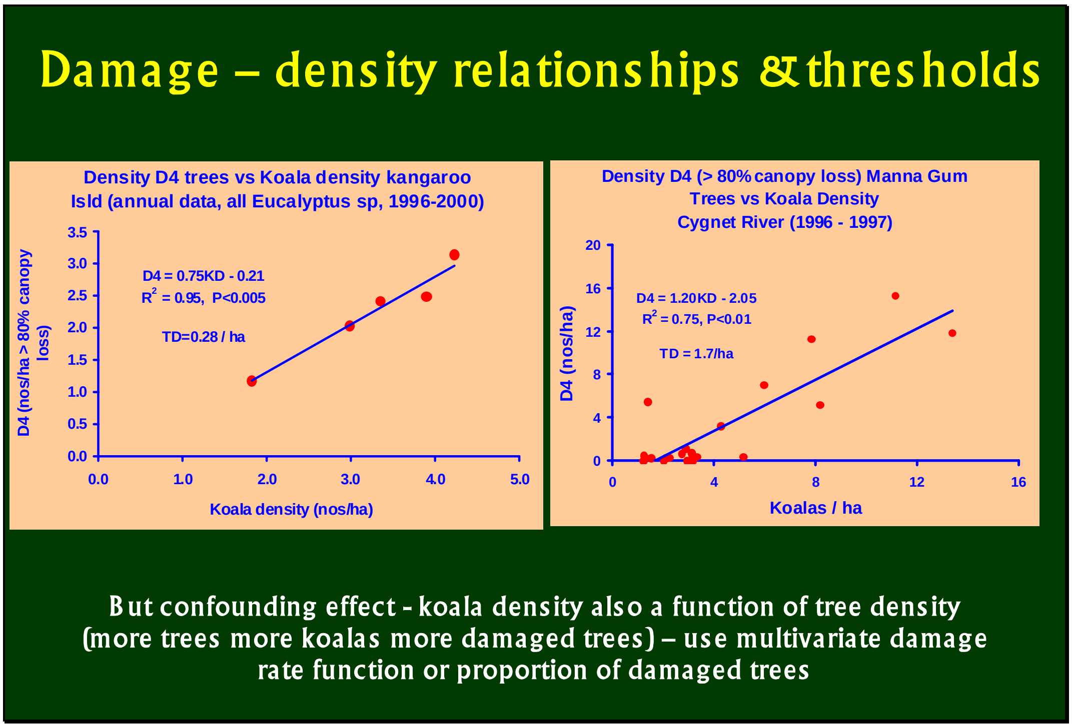
Time trends of intermediate Damage Classes of Manna gum trees, Cygnet River catchment (1996 – 2000)

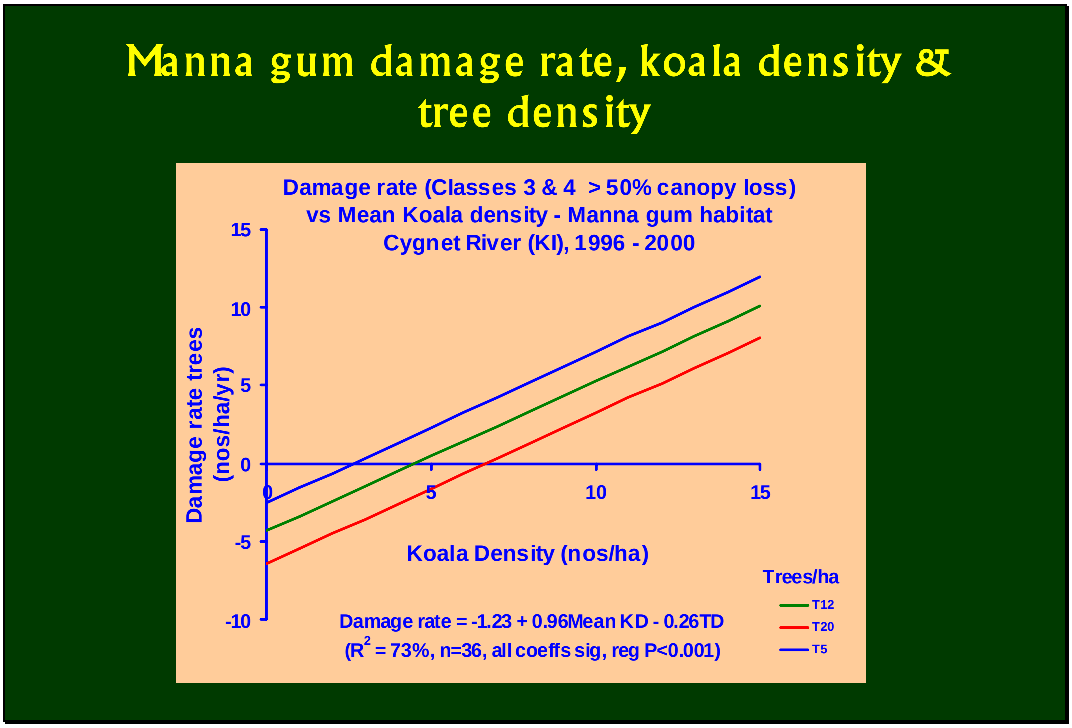


As Class 4 trees (80% canopy loss) recovered they enter Class 3 & then 2, which explains their increasing trends

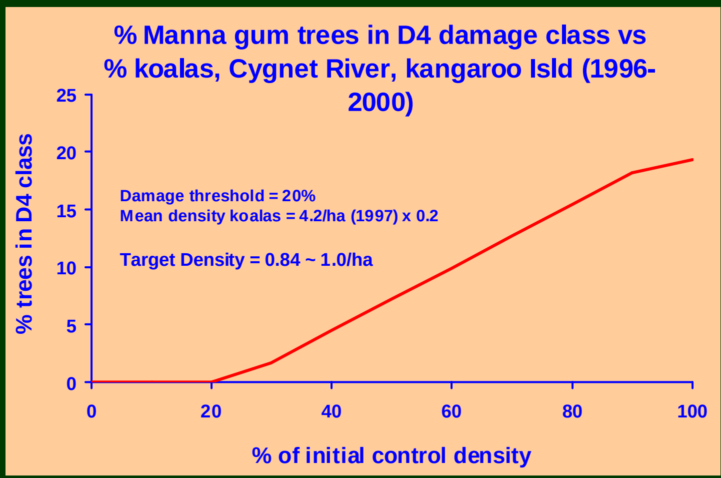
MESSAGE FROM DATA

Control program seems to be working in the Cygnet River catchment !


Damage – density relationships & thresholds
Density D4 trees vs Koala density kangaroo Isld (annual data, all Eucalyptus sp, 1996-2000)
D4 = 0.75KD - 0.21
R2 = 0.95, P<0.005
TD=0.28 / ha
D4 (nos/ha > 80% canopy loss)
Koala density (nos/ha)
Density D4 (> 80% canopy loss) Manna Gum Trees vs Koala Density Cygnet River (1996 - 1997)
D4 = 1.20KD - 2.05
R2 = 0.75, P<0.01
TD = 1.7/ha
D4 (nos/ha)
Koalas / ha
But confounding effect - koala density also a function of tree density (more trees more koalas more damaged trees) – use multivariate damage rate function or proportion of damaged trees


Manna gum damage rate, koala density & tree density
Damage rate (Classes 3 & 4 > 50% canopy loss) vs Mean Koala density - Manna gum habitat Cygnet River (KI), 1996 - 2000
Damage rate trees (nos/ha/yr)
Koala Density (nos/ha)
Trees/ha
T12
T20
T5
Damage rate = -1.23 + 0.96Mean KD - 0.26TD
(R2 = 73%, n=36, all coeffs sig, reg P<0.001)

Final model used to estimate threshold damage level & target density for control



Variation in threshold damage density across landscape & habitat

- Island-wide, across all species (TD = 0.3 / ha)
- Manna gum only in Cygnet River catchment (TD = 0.8 / ha)
- Site-specific variation – damage rate increases with decreasing Manna gum tree density (TD = 3.0 – 7.0 / ha)
- Management needs to account for habitat variations in composition of *Eucalyptus species* & tree density

Some koala habitat relationships

- GLM used to predict spatially explicit variables (Xs) that may influence patchy distribution & abundance of koalas (Y, density) on KI
- Source data - 119 survey sites across management units (catchments)
- Variables entered in model:
  - Management unit of site (catchment)
  - % composition of all *Eucalyptus* species
- Model: Koala density = *E. viminalis* + *E. leucoxylon* + Management Unit (Total R^2 = 57%; Manna gum R^2 = 29%)
- Tree density not initially entered but would explain large % residual

Decision support tools bioeconomic model

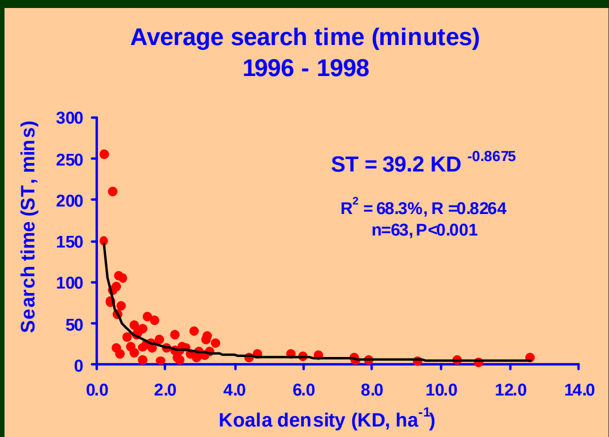
- Damage-density relationship = target density control
- Cost function ($ / koala) = fixed + variable costs
- Population response model (logistic model as 1st approx)
- Combined models - "What if" scenario simulator
- Simulate combinations of different management options (kill – shoot, euthanasia; translocate; sterilise)

Cost functions

Program Management	
Manager (& on-costs)	$48,100 p.a.
Equipment basics	$10,000 p.a.
Office costs	$12,000 p.a.
Monitoring	
Survey team	$645 p.day
Vehicle	$42 p.day
Total / day	$686 p.day
Total 6 vweeks	$20,595 p.6 weeks
Others	
Vet surgical procedure	$50 p.koala
Translocation flight	$45 p.koala
Extra handling time KI	$5 p.koala
Handling time - release	$5 p.koala
Ammunition (.223)	$2.50 p.koala

1. Fixed costs

2. Variable costs – search effort vs density



Catching team (3 people)	$65 p.hour
Vehicle cost	$5.50 p.hour
Vet time lethal injection	$110 p.hour
Marksman	$30 p.hour
Marksman assistant	$21 p.hour

Catching team cost $65/hr *hrs/koala @ density +other costs

Management scenarios

Model inputs for simulation run

1. Initial cull &/or fertility control

1	Year 6 Month
0.8	Proportion culled
10	Years post-initial control
50	Simulation interval (yrs)

2. Maintenance cull control

0.5	Proportion culled
5	Interval (years)
25	Number of cull ops

3. Fertility control

0.00	Proportion sterilised
100	Longevity of sterility (years)
5	Interval (years)
20	Number of fertility control ops

4.Target density 1.00 ha^{-1}

5. Density floor = 0.00 ha^{-1}

6. Only cull without eartags

n Y or N

7. 1 if euthanasia 0 if shoot = 1

8. Prop. of 'cull' translocated = 0.00

9 1 Habitat or control site

2000 Control area (ha)

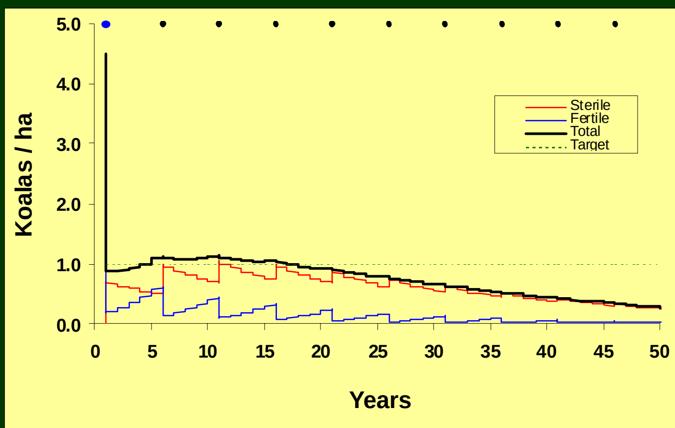
Logistic population sub-model

0.26	= r_m p.a.	3.0	= Theta
0.00	= i_{max} p.a.	0.33	= Max birth rate p.a.
0.000	= min density / ha		
4.50	= K, carrying capacity / ha		
0.07	= death rate p.a. in absence of births		

Manna gum tree damage sub-model

20.5	Mean % of Class 5 dead trees
19.3	Mean % of Class 4 trees (>80% defoliation)
0.7	Density (/ha) of Class 5 dead trees
2.5	Density (/ha) of Class 4 trees (>80% defoliation)
8.7	Mean tree density/ha
27.0	D4 damage rate (% p.a.) in absence of removal
24.0	D5 damage rate (% p.a.) in absence removal

Combining lethal & sterilisation control options to get below target density rapidly



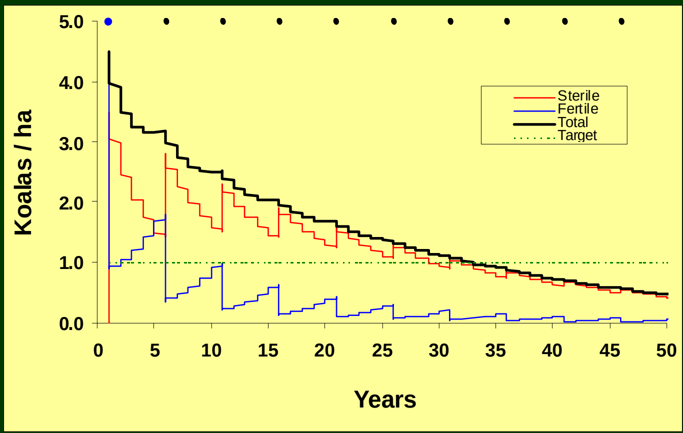
80% initial kill

80% sterilisation at 5 yr intervals for 50 yrs

Total cost =$1.5M

TD reached 1st year

Sterilisation only option



No initial cull

80% sterilisation at 5 yr intervals for 50 yrs

Total cost = $1.7M

TD reached 33 yrs

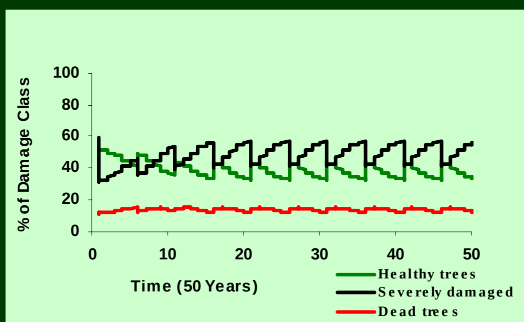
(>extinction rates trees)

Model outputs for simulation run

Post control efficiency

3.08	Average post-control density ha^{-1}
1	Years to 1st reach or pass target density
50	Years above target density
0	Years leas than or equal to target density

Recovery of Manna gums



Cost of control

	Costs/ha	Total costs
Initial cost ($/ha)	$43.95	$87,906
An. maintenance cost ($/ha/yr	$27.70	$55,398
Total cost ($/ha) for 50 Years	$1,401.21	$2,802,425

Validation of koala bioeconomic model

- Model used Cygnet River catchment data (1996-1999) then compared with 2001 data
- Generally predictive (=useful):
  - post-control koala density (2.00 vs 1.97 ± 0.15 / ha)
  - % healthly MG trees (73% vs 81%)
  - % severely damaged MG trees (7% vs 7%)
  - % dead MG (20% vs 12%)
  - Predicted & actual costs about same (~$600,000)
- But what about the other 20,000 koalas in other catchments?

POSSUMS

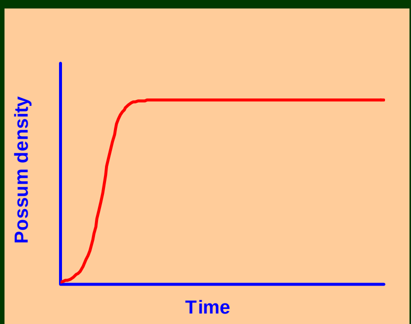
in New Zealand

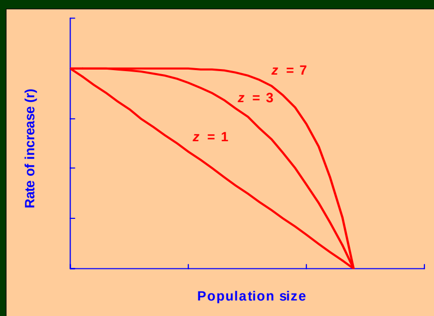
Comparing koalas on KI with possums in NZ

- Possum max rate of increase =0.25 p.a cf Koala =0.26 p.a. (mainland data, Chlamydia free pop); similar body weights
- Possums have erupted & crashed after 150 yrs; koalas still erupting after 78 yrs
- Small numbers of both released on islands with superabundant food – vacant habitat
- Interactive plant - herbivore model predicts that populations will crash after vegetation crashes
- Main management aim Koalas on KI is to avoid vegetation crash (& death & starvation of thousands koals) - nip the problem in the bud

What population model do Kiwis use?

Same as for koalas





Generalised logistic model

- Assumes vegetative food resources have no dynamics
- Hides ecological processes rather than exposes them
- Inappropriate for modelling complex ecological processes

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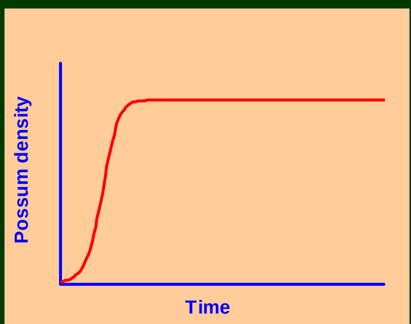

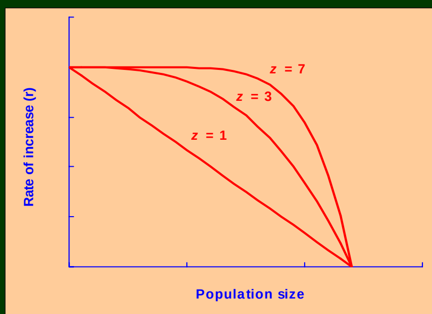

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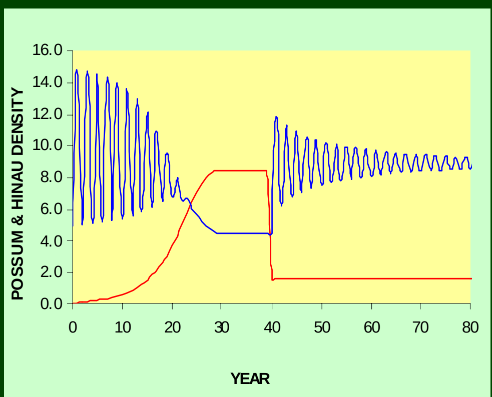
New Possum – Plant Model

- Hinau (*Elaeocarpus dentatus*) - endemic NZ hardwood, lives to about 400 years
- Possums eat hinau fuit
- Hinau has fruit MASTING cycle of 2 +years
- Possum rate of increase positively correlated to annual crop of hinau fruit
- Strong interaction - hinau fruit production increases dramatically where possums eradicated

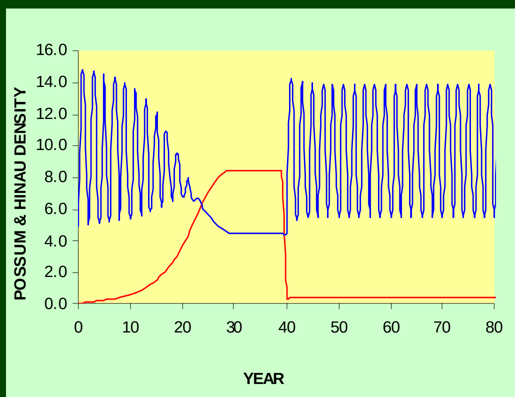
Importance of damage-density thresholds

What target density to restore "masting" cycle in hinau fruit production?

Target = 80% reduction



Target = 90% reduction

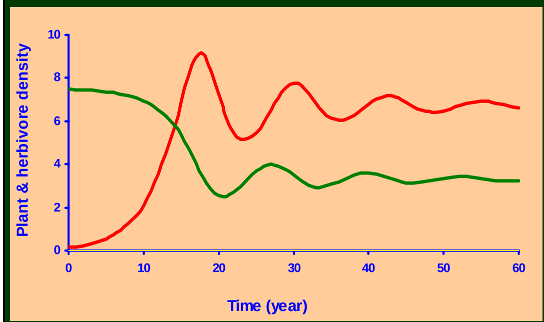


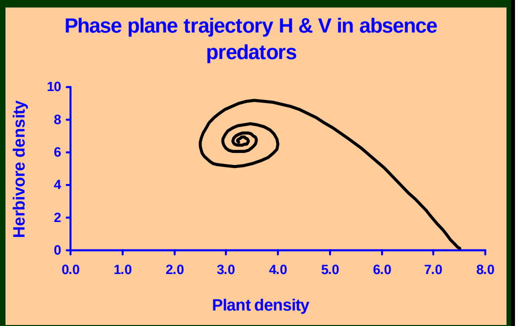
Possums **Hinau**

Where to next for koalas?

- Temporal dynamics complex – abandon Logistic model & progress to interactive plant - herbivore (koala – tree) model - possible
- Spatial dynamics complex – link temporal dynamics to habitat processes across landscapes (= landscape complementation)
- Koalas on KI are a closed population – so tractable
- Assume increased model realism & predictability leads to increased utility – is this really true?

Interactive koala - tree model



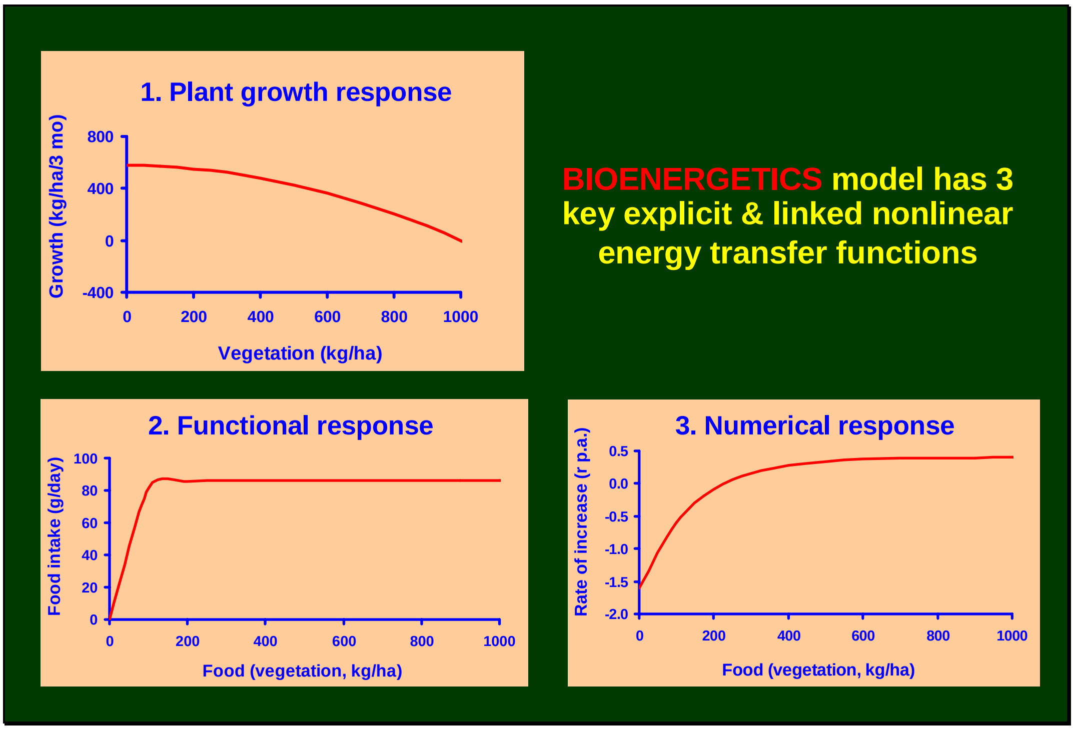


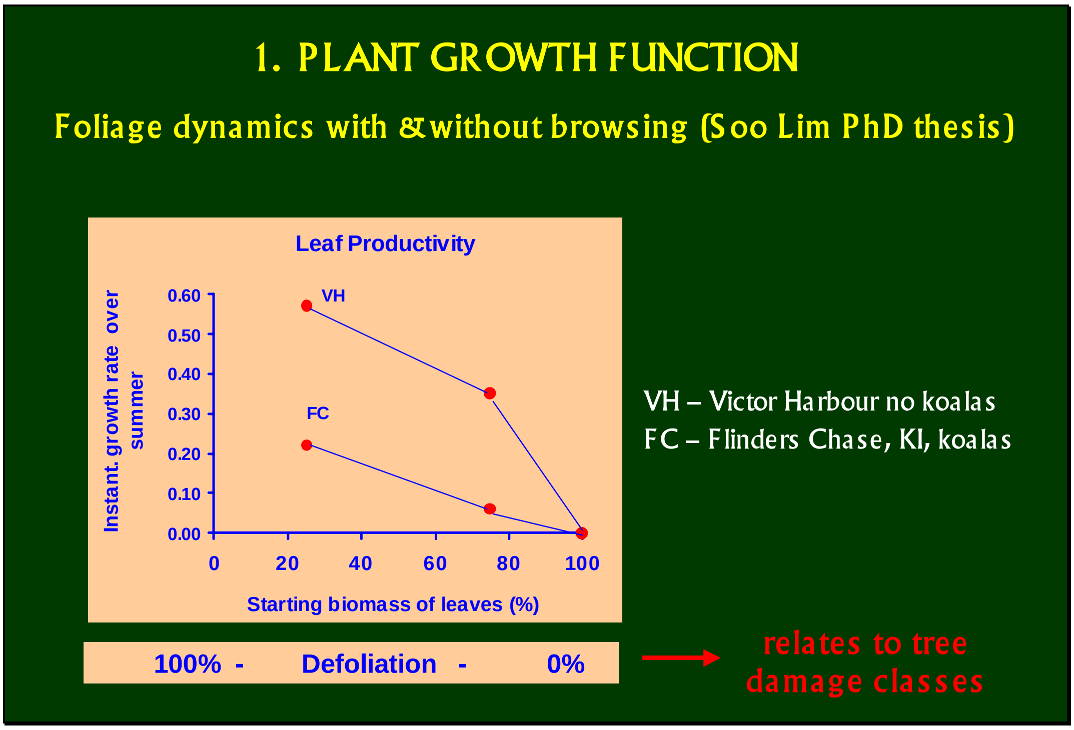
Explicit model functions

- Plant growth function
- Functional response herbivores
- Numerical response herbivores

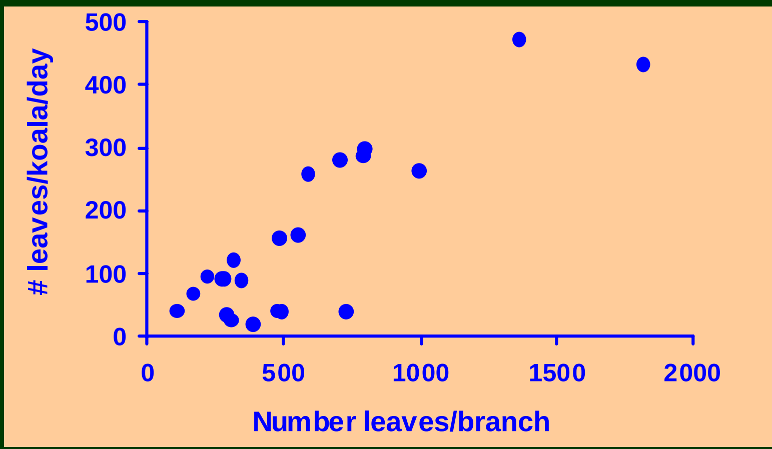
$$\frac{dV}{dt} = r_{mV}V\left(1-\frac{V}{K_V}\right) - c_1H\left(1-e^{-d_1V}\right)$$

$$\frac{dH}{dt} = H\left[-a + c_2\left(1-e^{-d_2V}\right)\right]$$


1. Plant growth response
Growth (kg/ha/3 mo)
800
400
0
-400
0
200
400
600
800
1000
Vegetation (kg/ha)
BIOENERGETICS model has 3 key explicit & linked nonlinear energy transfer functions
2. Functional response
Food intake (g/day)
100
80
60
40
20
0
0
200
400
600
800
1000
Food (vegetation, kg/ha)
3. Numerical response
Rate of increase (r p.a.)
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0
200
400
600
800
1000
Food (vegetation, kg/ha)


1. PLANT GROWTH FUNCTION
Foliage dynamics with & without browsing (Soo Lim PhD thesis)
Leaf Productivity
Instant. growth rate over summer
0.60
0.50
0.40
0.30
0.20
0.10
0.00
VH
FC
0
20
40
60
80
100
Starting biomass of leaves (%)
100% - Defoliation - 0%
VH – Victor Harbour no koalas
FC – Flinders Chase, KI, koalas
relates to tree damage classes

2. Functional Response
Food intake vs availability (Soo Lim PhD thesis)

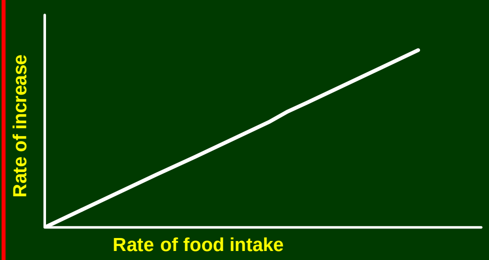


Need to convert number leaves to biomass (dry weight kg)

3. Numerical response: rate of increase vs food level

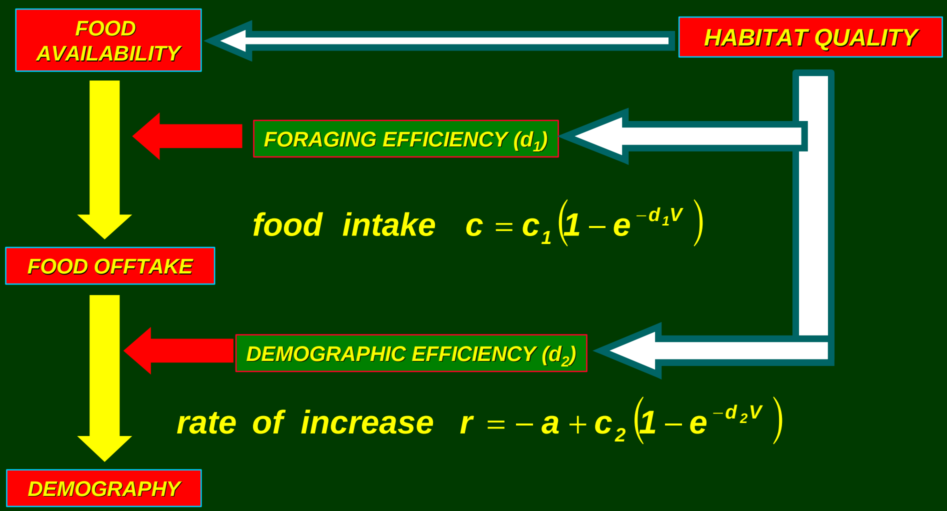
- No data on max rate increase (r_m) for KI koalas
- No data on rate of increase over range of food availablities
- Use the “back door” approach to derive numerical response function

Biomass conversion principle



Spatial Dynamics – coarse grain

How does "habitat quality" affect interaction between animal populations and their food resources ?



Landscape complementation approach

- Shows importance of biomass conversion principle
- Yield insights into consumer-resource interactions, especially between behavioural tradeoffs & habitat quality (e.g. foraging, thermoregulation)
- Implications for metapopulation analysis & linking population processes to landscape scales
- Multiple limiting factors supported

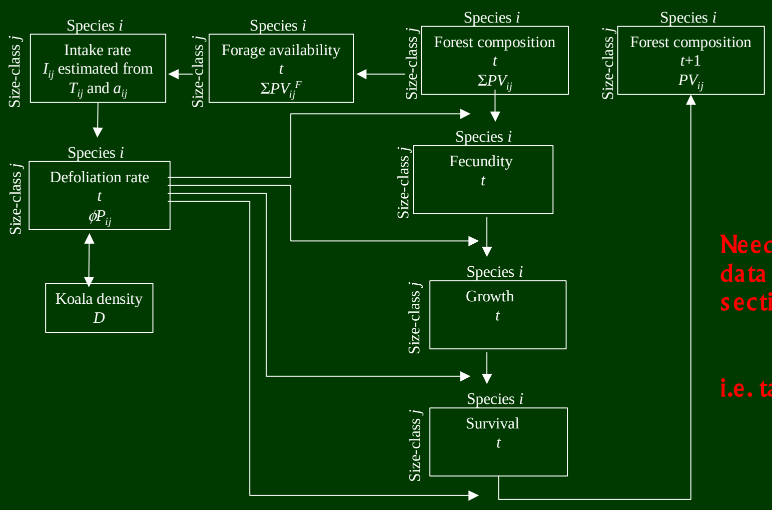
Spatial Dynamics – fine grain

(impacts of koala browsing on forest dynamics)

- Koalas selectively browse Eucalyptus species according to their relative palatability & availability in the landscape
- Koalas influence dynamics of Eucalyptus forests by selective browsing, which in turn affects species plant growth & survival rates
- Hence, composition of forests inhabited by koalas is influenced by koala browsing
- Which in turn influences koala browsing (negative feedback loop – regulation)

Forest Dynamics & Koala Browsing

(species & size composition matrix embeded deep in the food axis)



Need longitudinal tree data c.f. to cross-sectional data

i.e. tag many trees

Wildlife Management Upshot

- Aesthetic values judgments – no right or wrong, just rights
- Challenge - resolve conflict between dichotomous views

- Technical value judgments – there is a right & a wrong
- Challenge – being right

THE END