Introduction and Ecological basis and process for wildlife management: biological and social carrying capacities and the human dimension.
Ecological basis and ecological process for wildlife management: competition, prey and predator systems, dispersion and migration process, population systems (with examples on Bear , Wolf , Golden jackal).
Status, distribution, biology, , monitoring and censusing of game species (roe and red deer, chamois, wild boar, galliformes..).
Status, distribution, biology, monitoring and censusing of species (rare and endangered species; bear, wolf, lynx, otter and raptors..).
Principles of hunting management and definition of criteria for the hunting activities.
Analysis of complex systems in presence of hunting activities and without hunting and application of hunting planes.
Principles of conservation, conservation projects and management of the large carnivores at local and national level.

Working groups: from biology and ecological requirements to conservation, human dimension and stake holders. Application of communication strategies.
Methods for evaluating and techniques for reducing the impact of human activities on wildlife.
Working groups: analysis of cases studies: evaluation of incidence of power lines, wind farm and ski resort, highway on wildlife and mitigation measures.
Methods for evaluating and techniques for reducing the impact of wildlife (ungulates and carnivores) on human activities (animal and forestry productions) : electric and flandry fencing, guardian dogs , dissuasive feeding system and numeric control.
Working groups and analysis of case studies: evaluation of the impact of the wolf, golden jackal and bear presence and application of mitigation measures.
Conservation , Reintroduction , and restocking projects: wild ibex and chamois, bear, lynx and vultures.
Conservation projects: working groups on case studies (Dinalp and Life Ursus and Wolfalps), analysis and evaluation.
Innovative monitoring systems to improve the management and methods to promote the coexistence.

The ecological and social basis for the wildlife management and the conservation

Stefano Filacorda
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Individual requirments

Lynx (*Lynx lynx*)

Sites with optimal temperatures for resting (thermoregulation)

Sites for hiding

Prey Avaibility

From Individual to communites

Individual

Different level

open

Population

closed

Migration and dispersion

Competition

Other species

Predation

mutualism

simbiosis

Communities

Ecological requirements

Resources

Condition

Food and space

Ph, temperature, salinity e……. cover

Individual, population and species

Resources Avaibility

Requirments

Process: migration, movements intra ed interspecific competion parassitism, disease, predation

Aims: understand, where and why wildlife lives and which kind of interactions exist between them , with humans and which management we can apply to improve the coexistence and biodiversity

Agriculture system: simplified

20-30 kg

10-16 kg

3-6 kg

8-12 kg

Aims: understand, where and why wildlife lives and which kind of interactions exist between them , with humans and which management we can apply to improve the coexistence and biodiversity

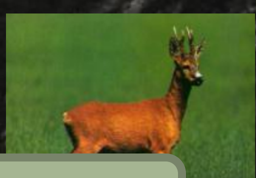
Mountain system: complex

100-200 kg

30-40 kg

80-200 kg

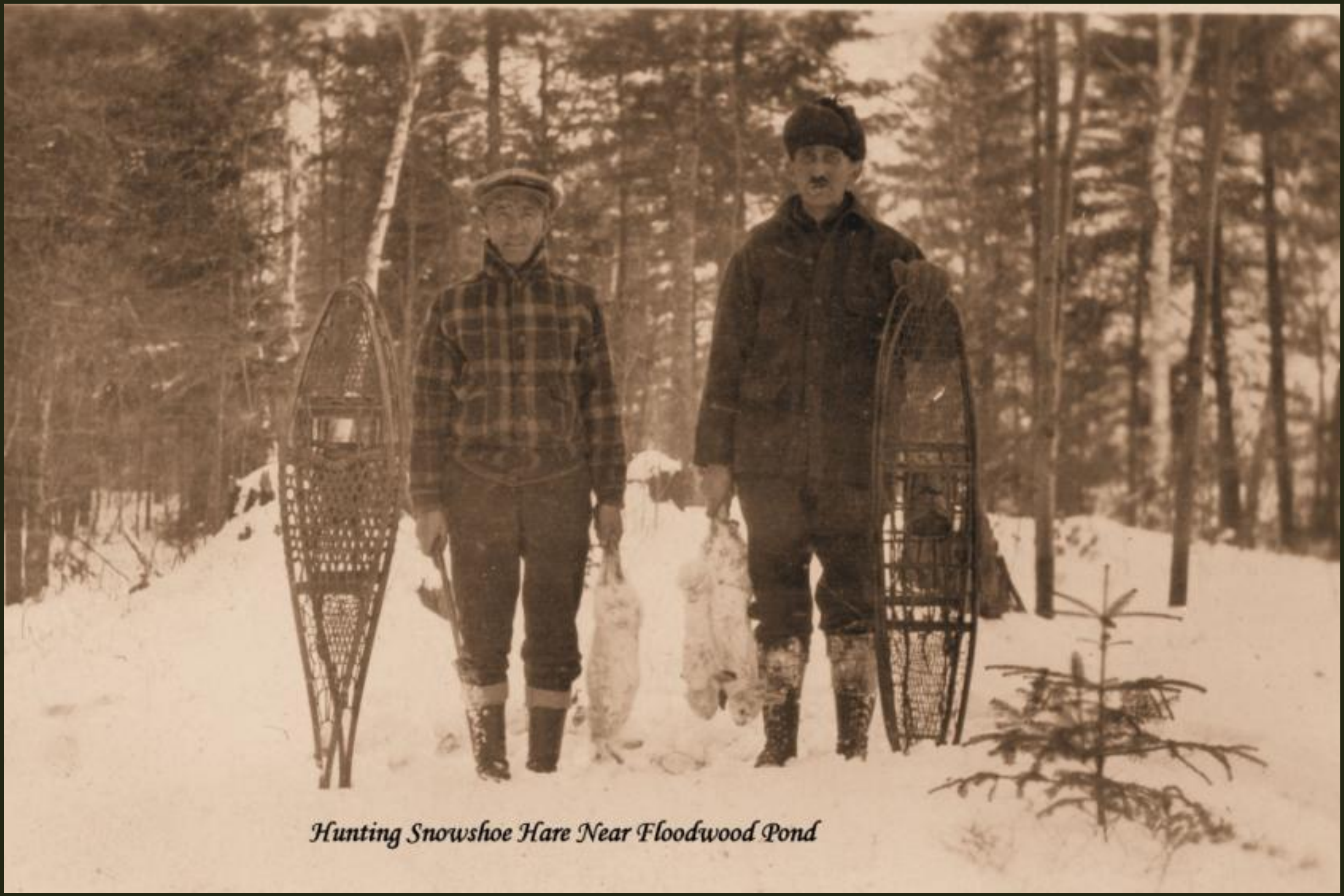
10-16 kg



20-30 kg

3-6 kg

8-12 kg

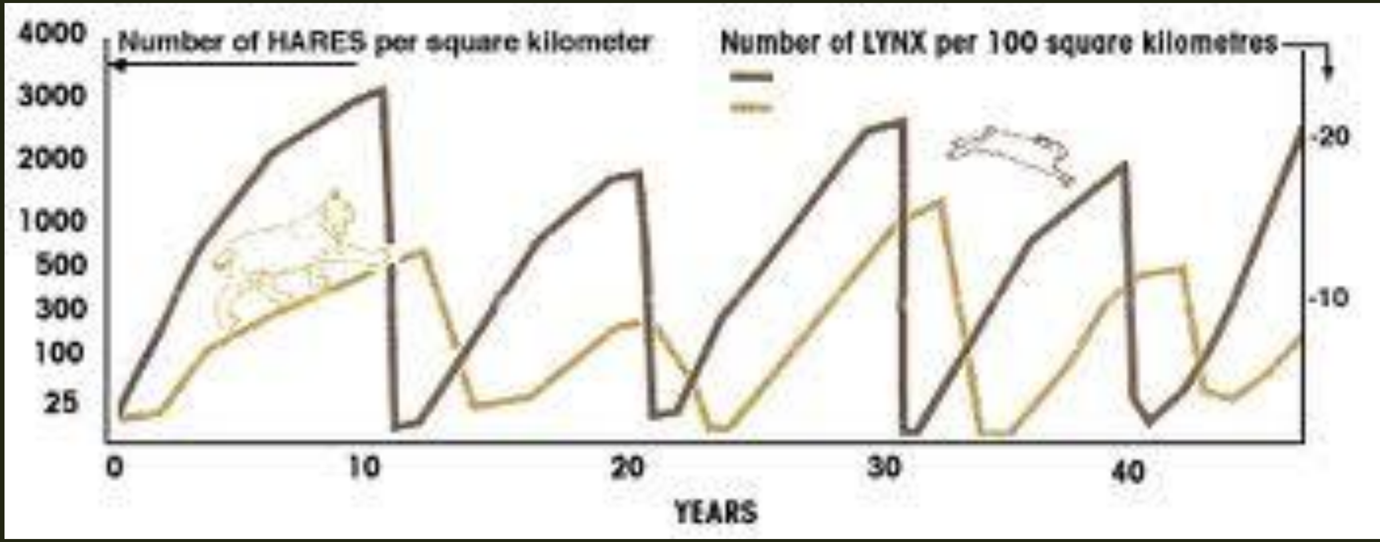


The hunting bags can explain the generale trend of prey and interaction between prey and predators

It ‘s important to study the dynamics


ARKive
www.arkive.org
© Tom & Pat Leeson / www.ardea.com

The peak of predators follows, with different delay time , the peak of prey



The system considers only hares and lynx ? And the secondary prey ? And hunters ?

The aims of wildlife manager

Know the ecological requirments

Analyse and describe the communities

understand the natural systems and the interaction

To interpreter the process and manage them we have to consider

Optimal foraging theory → Which are the main constituents of the diet and why

The functional responses → How much the predator eat in relation to the density of prey

What is the impact of predator on the prey

The marginal value theorem → How much time and why the predator spend in different patches

Optimal foraging theory

Eurasian lynx

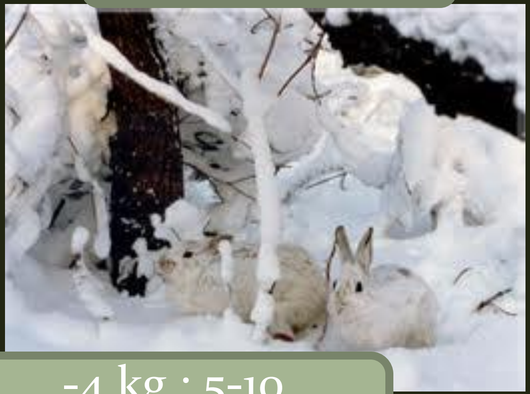
Value of prey=Energy of prey/(time spent for handling + time spent for searching)

Elective prey

The cost of handling

The cost for searching

Seconday prey



-4 kg : 5-10 head/100 ha

20-25 kg : 10-15 head/100 ha

The theory of optimal foraging

The predator choices the best prey: easy to found and to catch and with a high energy to extract

When the elective prey becomes scarce, the predator shifts to less profitable prey, but abundant, with low or zero time of searching

Dormouse (*Glis glis*)

The theory of optimal foraging

The horse is not a elective prey (too difficult to prey – handling)

The predator choices the best prey: easy to found and to handle and with a high energy to extract

The livestock can represent a secondary prey o elective prey for subadult (or single) predator

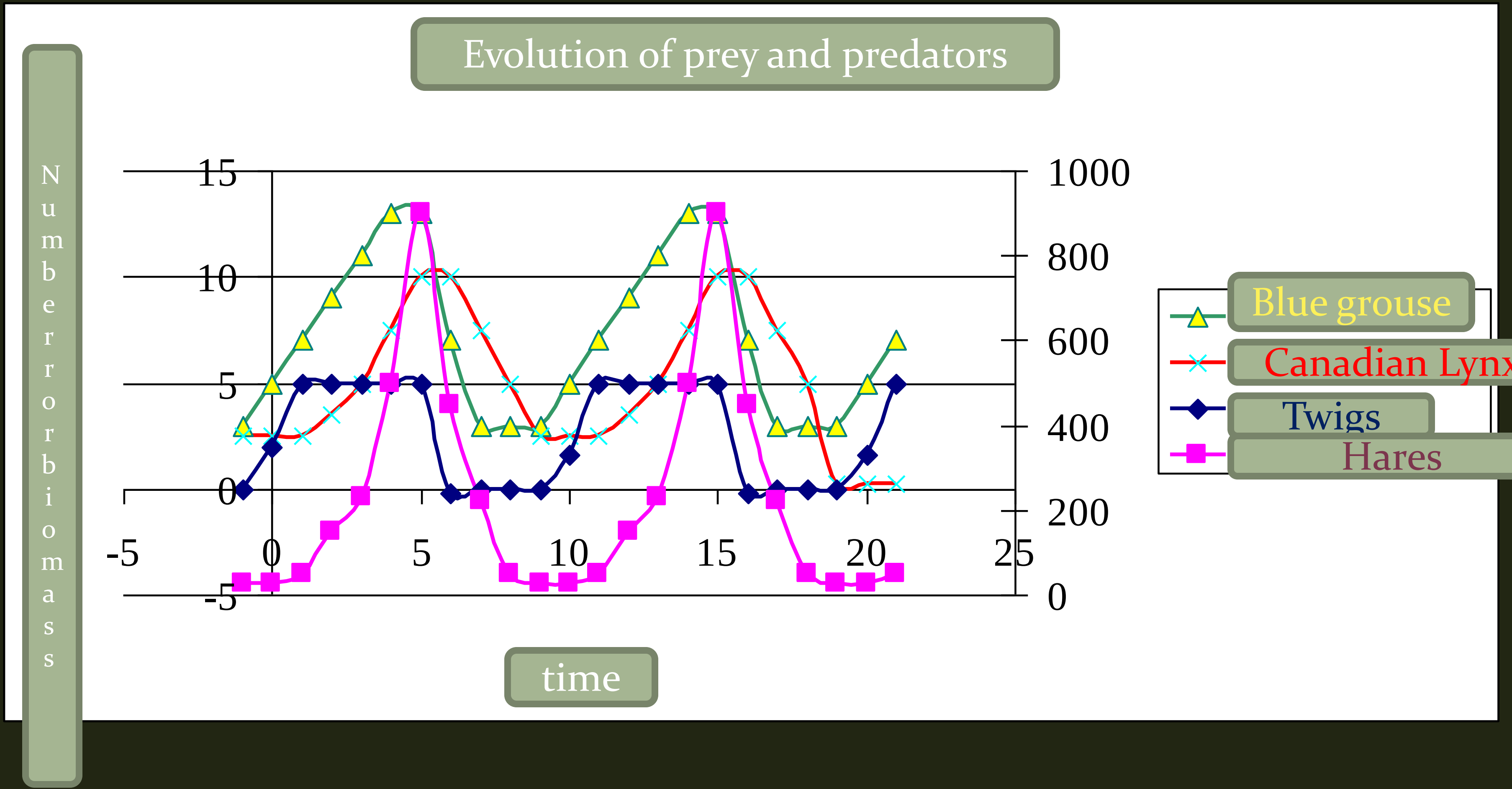
When the optimal prey become scarce (or difficult to catch) the predator shifts to less profitable prey but abundant

North American system

Grouse: secondaty prey

Hares: elective prey

Canadian Lynx



Do you consider the fluctuations in the wildlife management ?
Are you sure that the nature isn't able for self regulation ?

Interaction system

Heather Twigs, under feeding pressure of hares reduce the nutrient availability with the production of defence substances

Step 1

Hares: predators of twigs and prey of lynx

Step 2

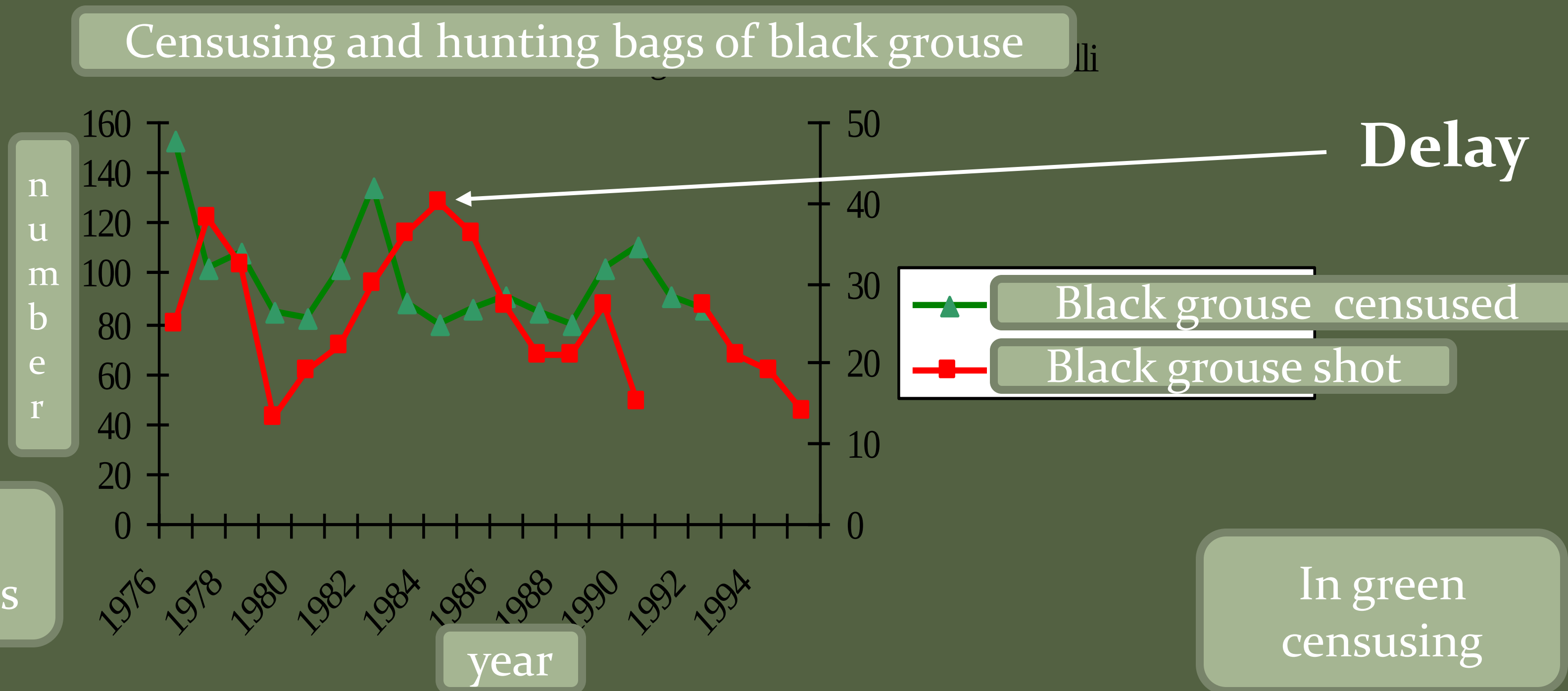
Canadian Lynx: predator, depends from the hares and grouse and regulate them

Blue grouse: secondary prey for the lynx, became the prey when the hares are in low number

Step 3

The eastern alps : black grouse and hunter in the 80 (free hunting with not limit for the quotas)

Grouses fluctuate, with a 4-6 years of period



In red: hunting bags

In green censusing

The fluctuation depends from parasites, predators, hunting pressure and climatic change

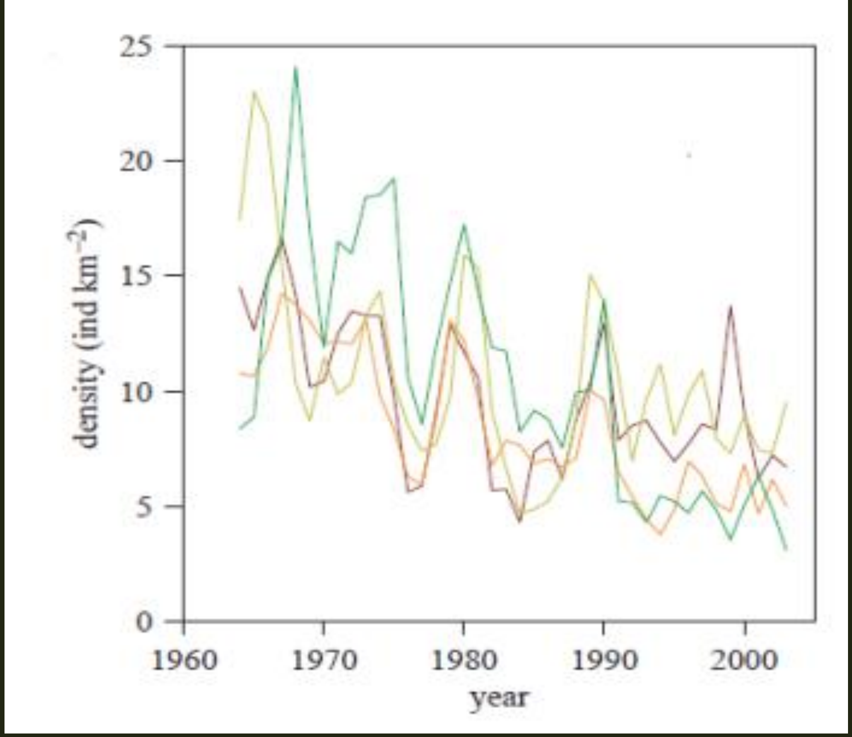
The fluctuations are not synchronized between the species and for the same species in different areas

Why the grouses are more vulnerable to the hunting during the declining, after the maximum ?

worm

Pointing dogs

Black grouse



In some areas the black grouse has stopped to fluctuate , when it has reached low numbers

The fluctuations could be the indicator of a healthy population

The chaos theory can help to understand

The hunting can smooth the fluctuation s

http://blackgrouseresearch.jyu.fi/survival.html

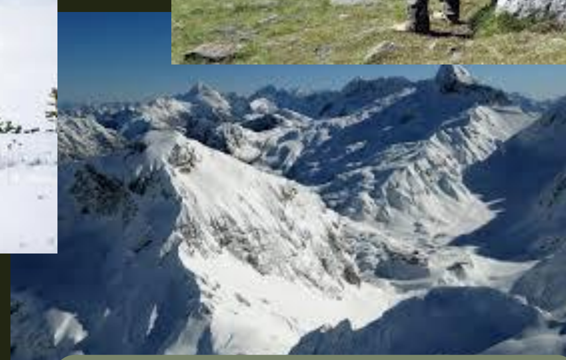
Beech nuts

worm

Black grouse (*Tetrao terix*)

micrommamals

Fox (*Vulpes vulpes*)



Snow cover , rainfall

dormouse

The aim of wildlife managers

Know the ecological theories

Consider the evolution of prey and predators over the time

Interpeter the fluctuations

Analyse the predator behavior

The intraspecific competition

Mute swan(Cygnus olor)

With resources limited and competition between individuals of the same species populations show regular cycles. The snowshoe hare (*Lepus americanus*) in norther

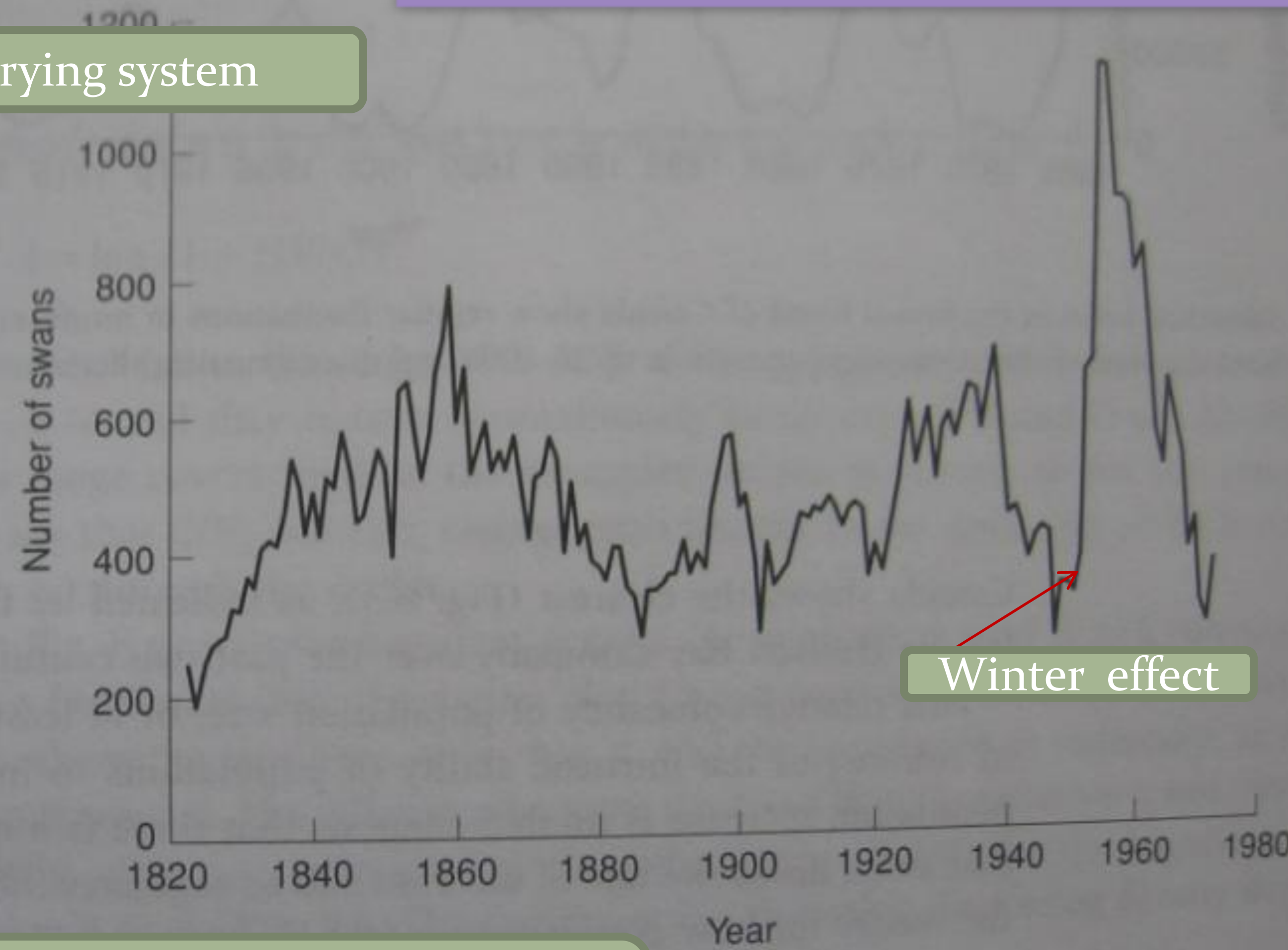


Fig. 8.1 Some populations remain within relatively close bounds over long time periods. The mute swan population of part of the river Thames, England (estimated by total counts) shows a steady level or gentle increase despite some perturbations due to severe winters, for example in 1946–47 and 1963–64. (Data from Cramp 1972.)

Wildlife, Ecology, Conservation and Management, A. R. E Sinclair, J.M, Fryxell and Grome Caughley, second edition, Blackwell Publishing Chapter 8. 2005

Alpine hares (*Lepus timidus*)

Foto di Mauro Arzillo

K carrying capacity

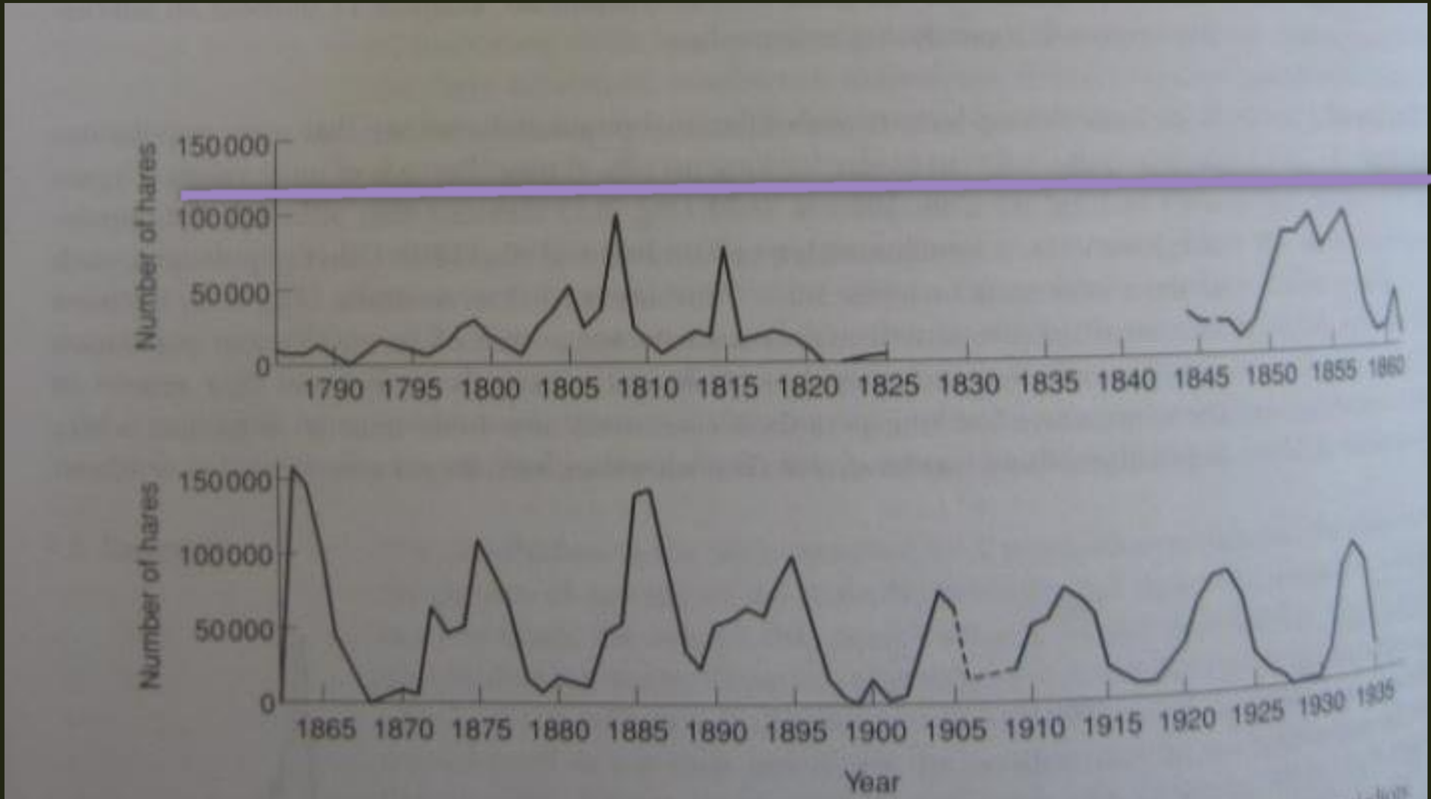


Fig. 8.3 Snowshoe hares in the boreal forest of Canada show regular fluctuations in numbers with a 10-year periodicity. Data are from the Hudson Bay Company fur records up to 1903 and questionnaires thereafter. (After MacLulich 1937.)

K

Intraspecific competition

Density dependence model

$$dN/dt = RN(K-N)/K$$
$$dN/dt = rN$$

Con dN/dt= increment of population per time unit

N_t= population size at time t

R= costant growth rate (depends from the species, population and areas)

r= variable- instant growth rate (change from 0 to R in respect to the distance from K)

con K=carrying capacity (maximum number of population in respect to the suitabilty of areas)

The effect of intraspecific competition

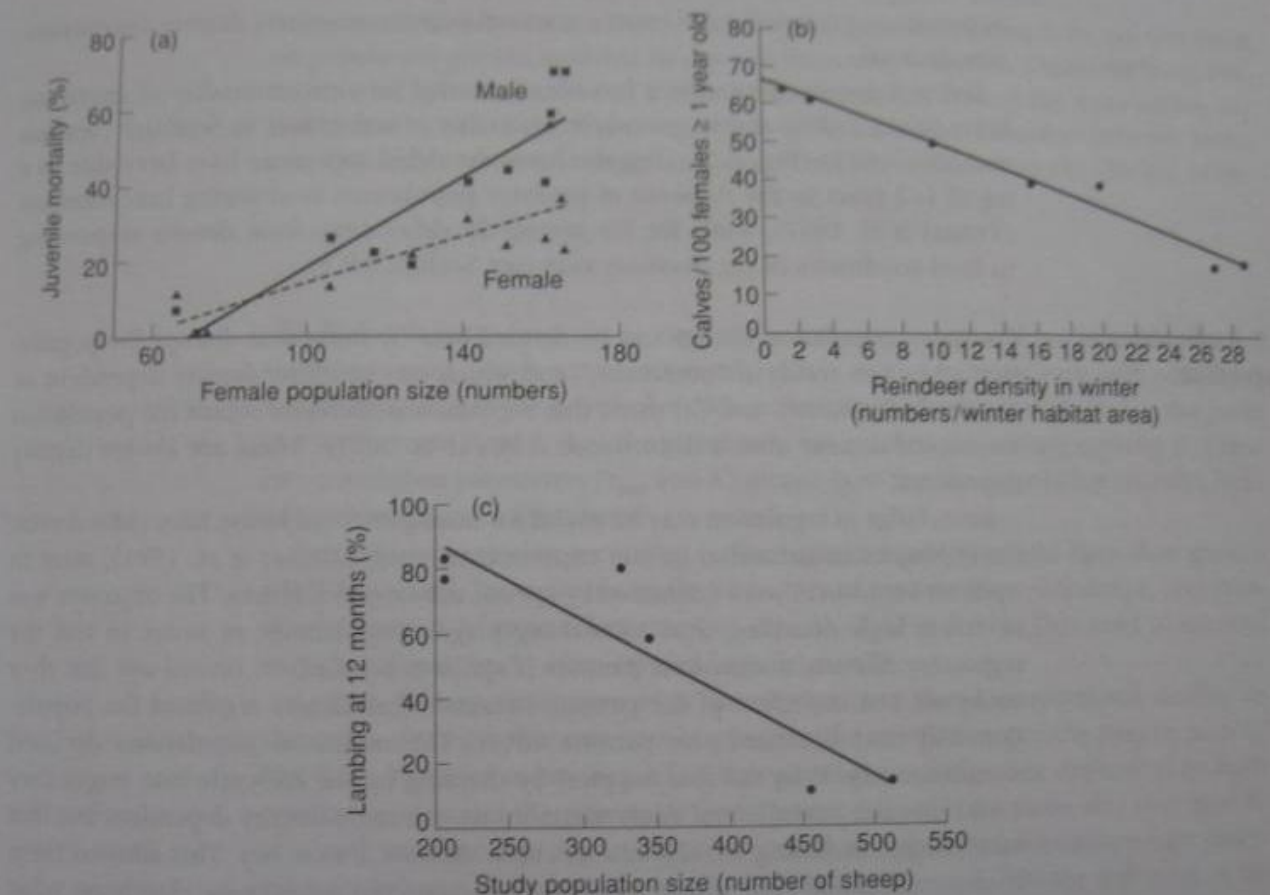
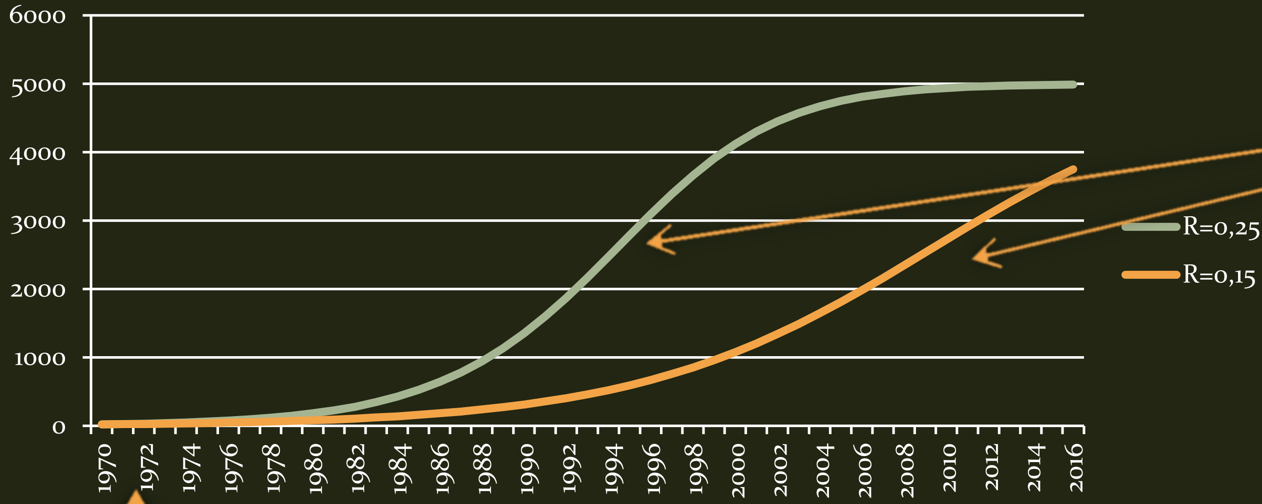


Fig. 8.10 Density dependence in large mammals. (a) Juvenile mortality of male and female red deer on the island of Rhum, Scotland. (After Clutton-Brock *et al.* 1985.) (b) Juvenile recruitment per 100 female reindeer older than 1 year in Norway. (After Skogland 1985.) (c) The fertility rate of 1-year-old Soay sheep on St Kilda island. (After Clutton-Brock *et al.* 1991.)

With high density ,
the mortality increases
and the birth rate decreases

Theoretical evolution of roe deer population (K=5000, R=0,25 and R=0,15) with intraspecific competition

n



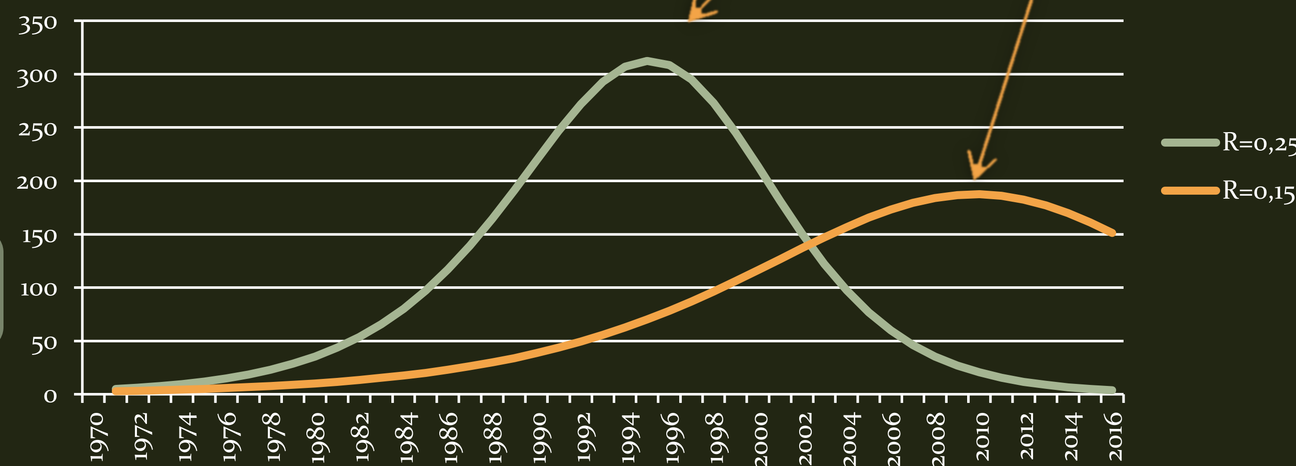
Maximum increment at K/2

Allee effect

With a minimum number of population

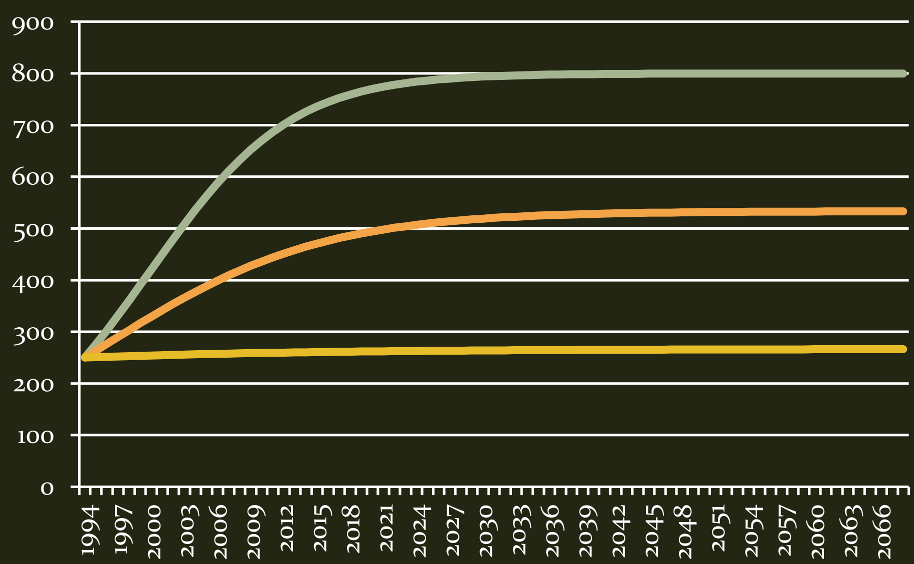
Theoretical evolution of roe deer increment per year (K=5000, R=0,25 and R=0,15) with intraspecific competition

Dn/dt



Social, Economic and biological carrying capacities; the effect of control with culling

Theoretical evolution of brown bear population (K=800, R=0,15) with intraspecific competition and different culling for population control



In some situation it is need (perhaps) to cull some animals from the population to diminishing the damages and to give “security message” to the local people different R for different species ? Why ?

Different number of off spring – litter size, survival, and age at the first reproduction

Maximun sustainable culling (only intraspecific competition)

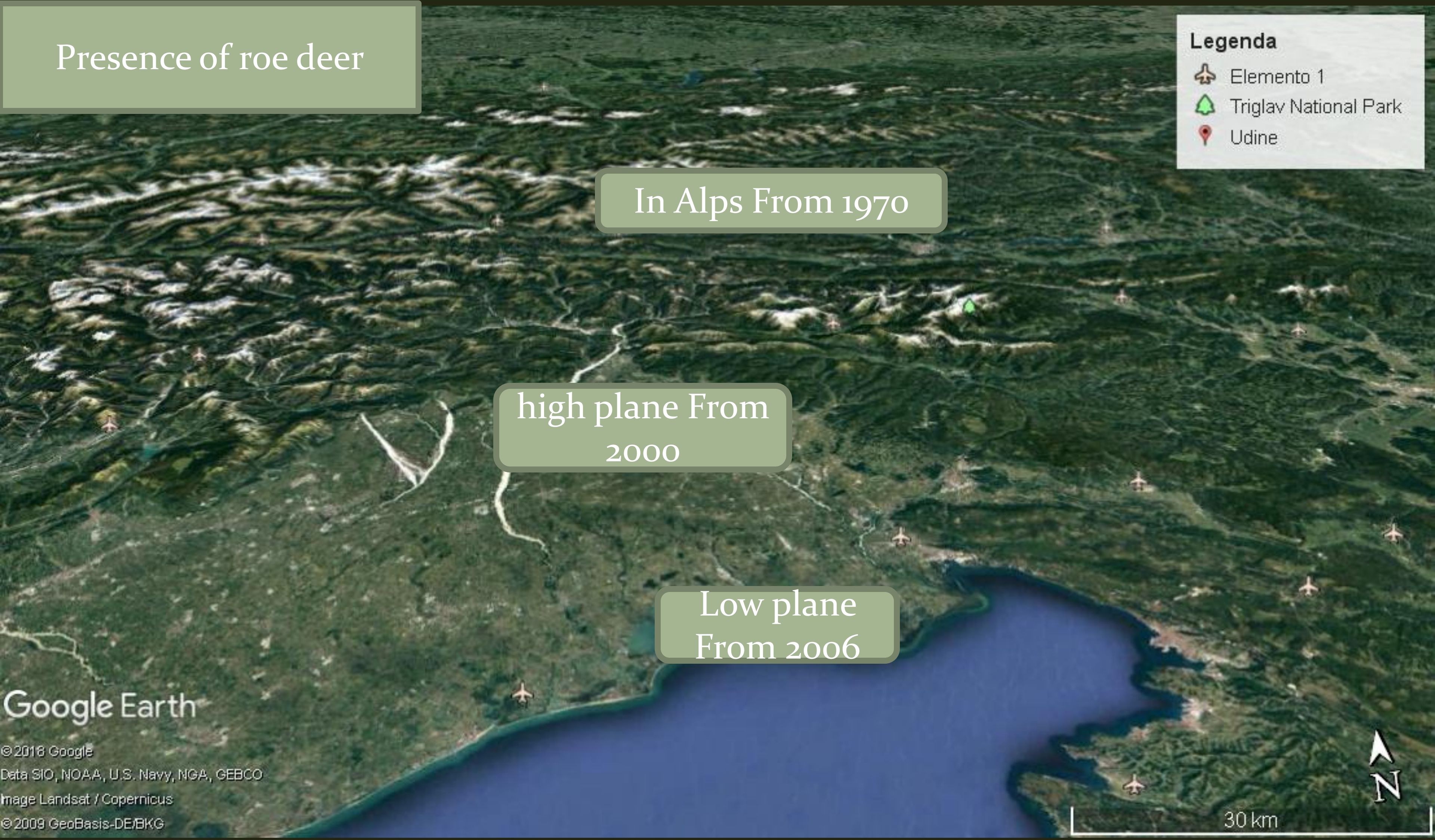
Example of MPS (MSC)

Roe deer- -
R=0,4, K=100, N=20
MPS=? How many roe deer s to shot ? dN/dt=?

Red deer-
R=0,2, K=40, N=30
MPS=? How many red deers to shot ? dN/dt=?

Wild boar-
R=1, K=100, N=50
MPS=? How many wild boars to shot ? dN/dt=?

Presence of roe deer

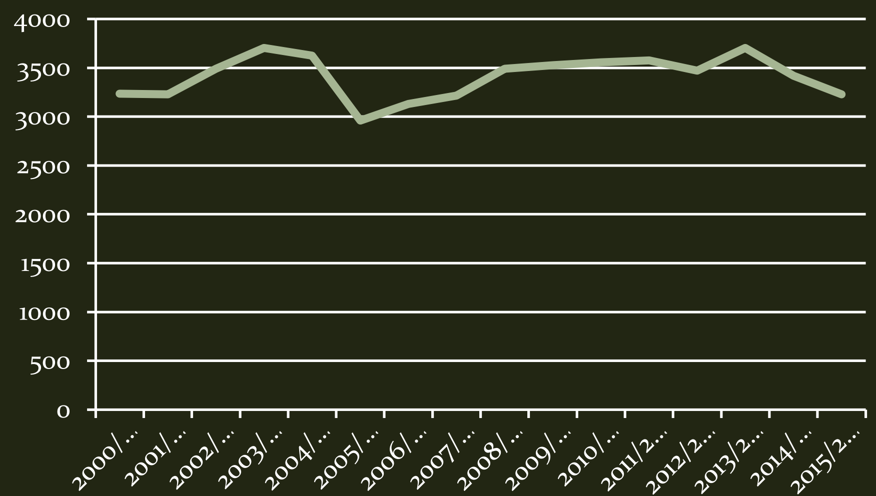


Alpine areas

The population has reached the carrying capacity (few decades ago) and now suffer the change of habitats and red deer competition

Stable and fluctuating scenarios (and decreasing in some parts)

Evolution of roe deer population in hunting district 1-alpine areas (last 16 years)

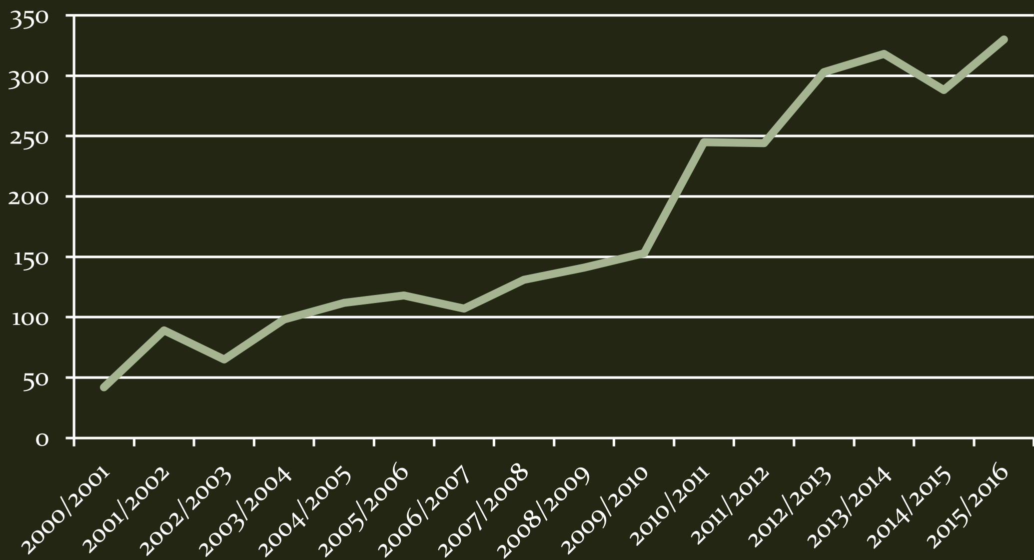


Old time of colonization

Scenarios near the carrying capacities (to confirm),

The high plane

Evolution of roe deer population in hunting district 9 - high plain (last 16 years)



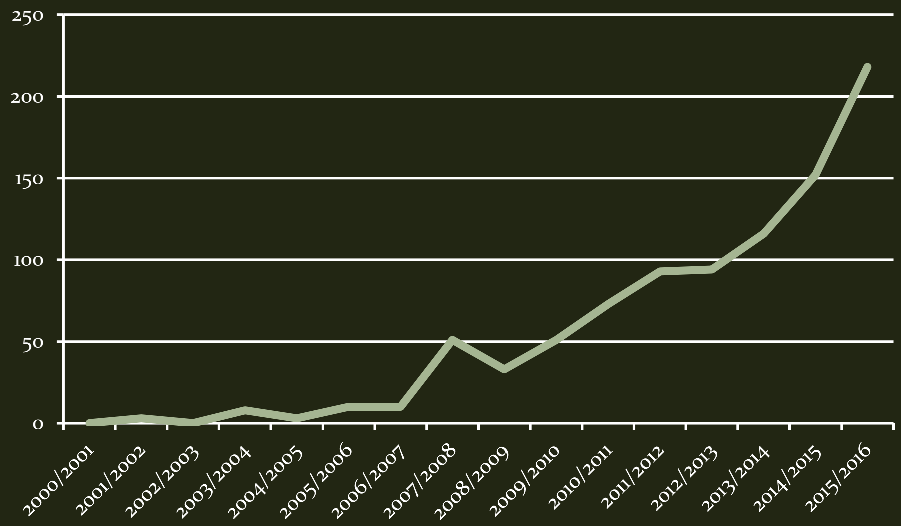
Consolidation phase

The population is going to reach the carrying capacity

Colonising scenarios

The lagoon and plane near Adriatic sea in North east of Italy

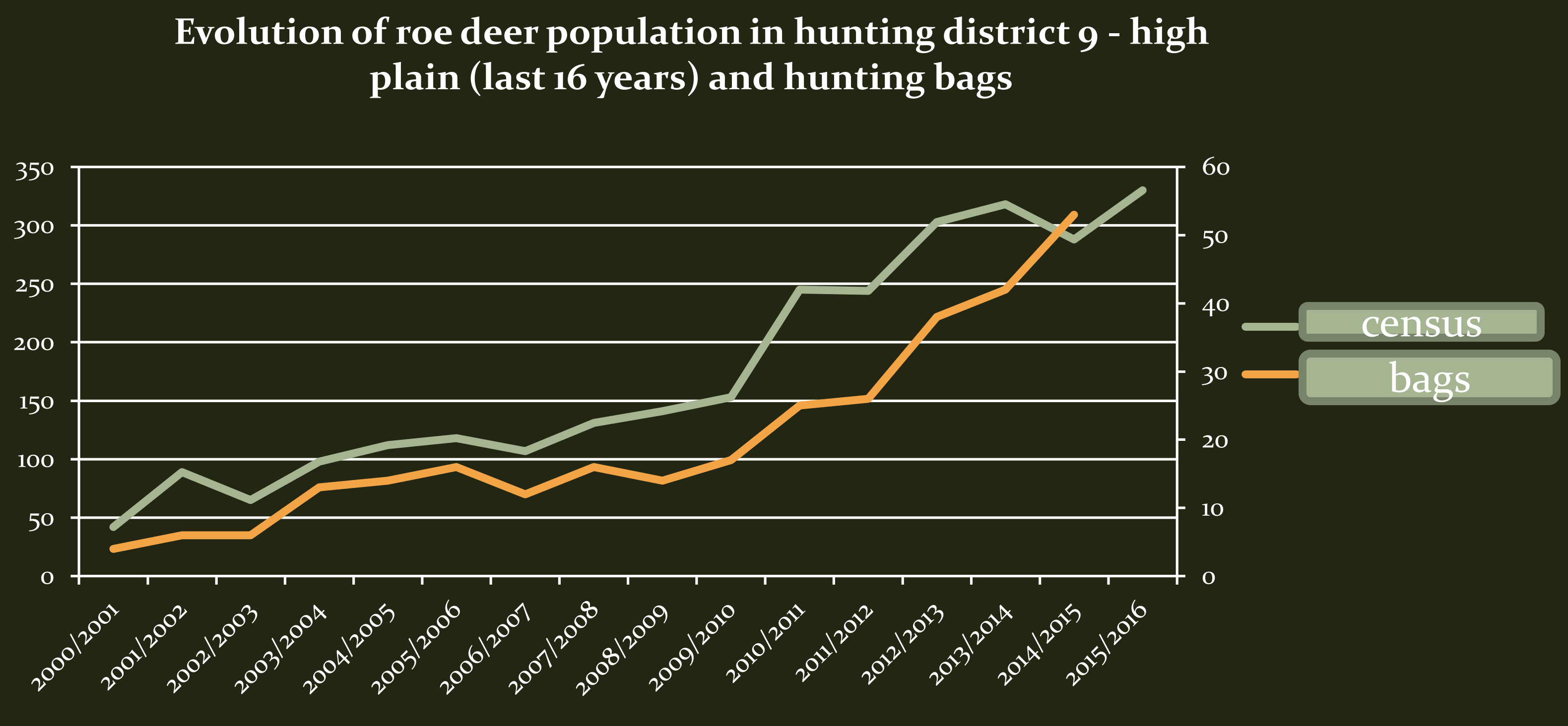
Evolution of roe deer population in hunting district 11 - lagoon (last 16 years)



Colonization phase

The population is colonizing and is raising

The hunting bags can describe the trend of population and can be useful to describe some parameters



The hunting management considers only the density dependent model (intraspecific competition)

In other way considers only the intraspecific competition without consider different rate of increment and other process as interspecific competition and predation

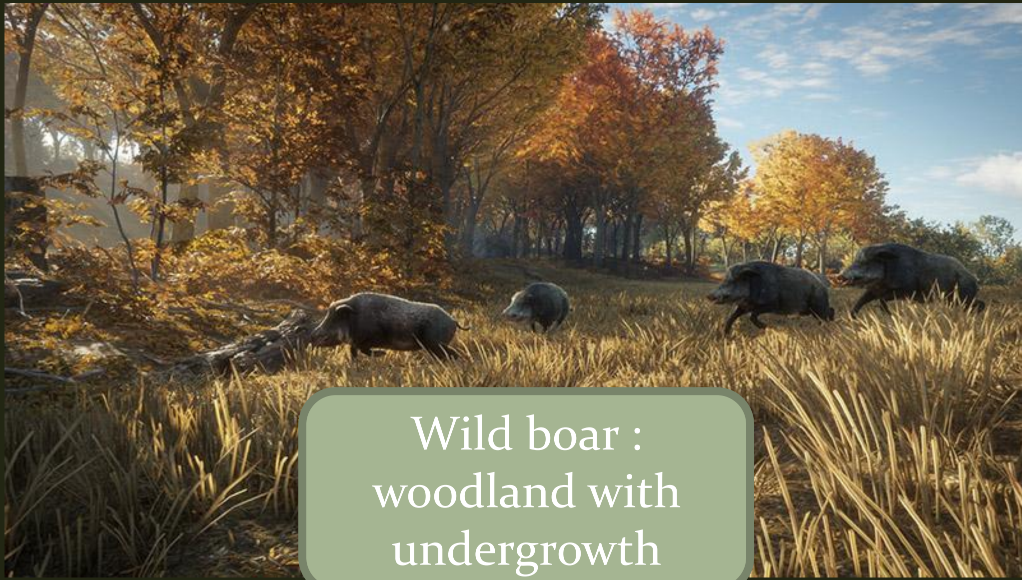
Why is important to define the K – carrying capacity ? And R- growth specific rate?

The carrying capacity depends from the habitats , human presence and fragmentation

The GIS technique

Each species present specific requirements in terms of habitat

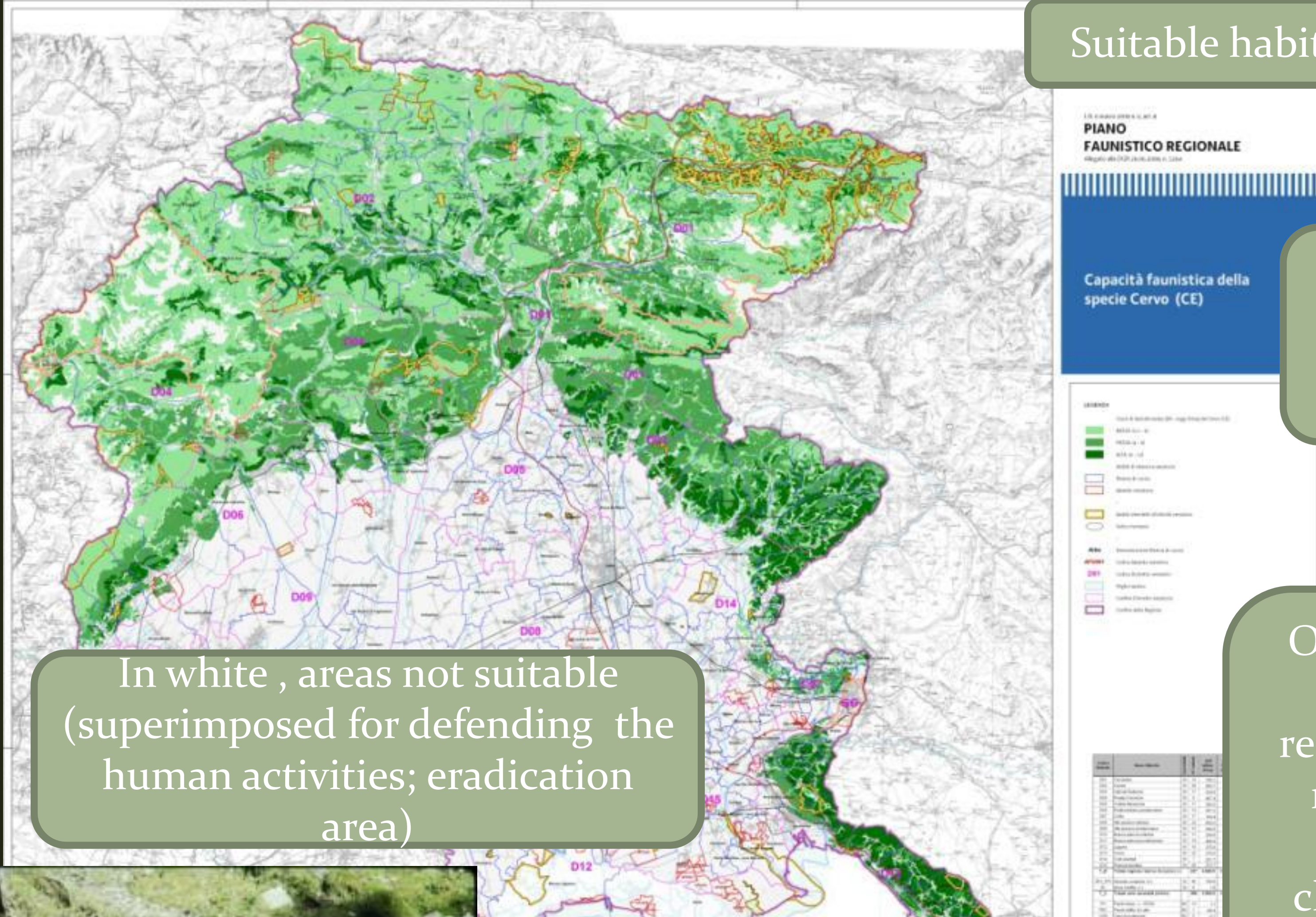
Red deer : old and large forest and pastures



Wild boar : woodland with undergrowth

Roe deer: Shrubland and small woodland and pastures

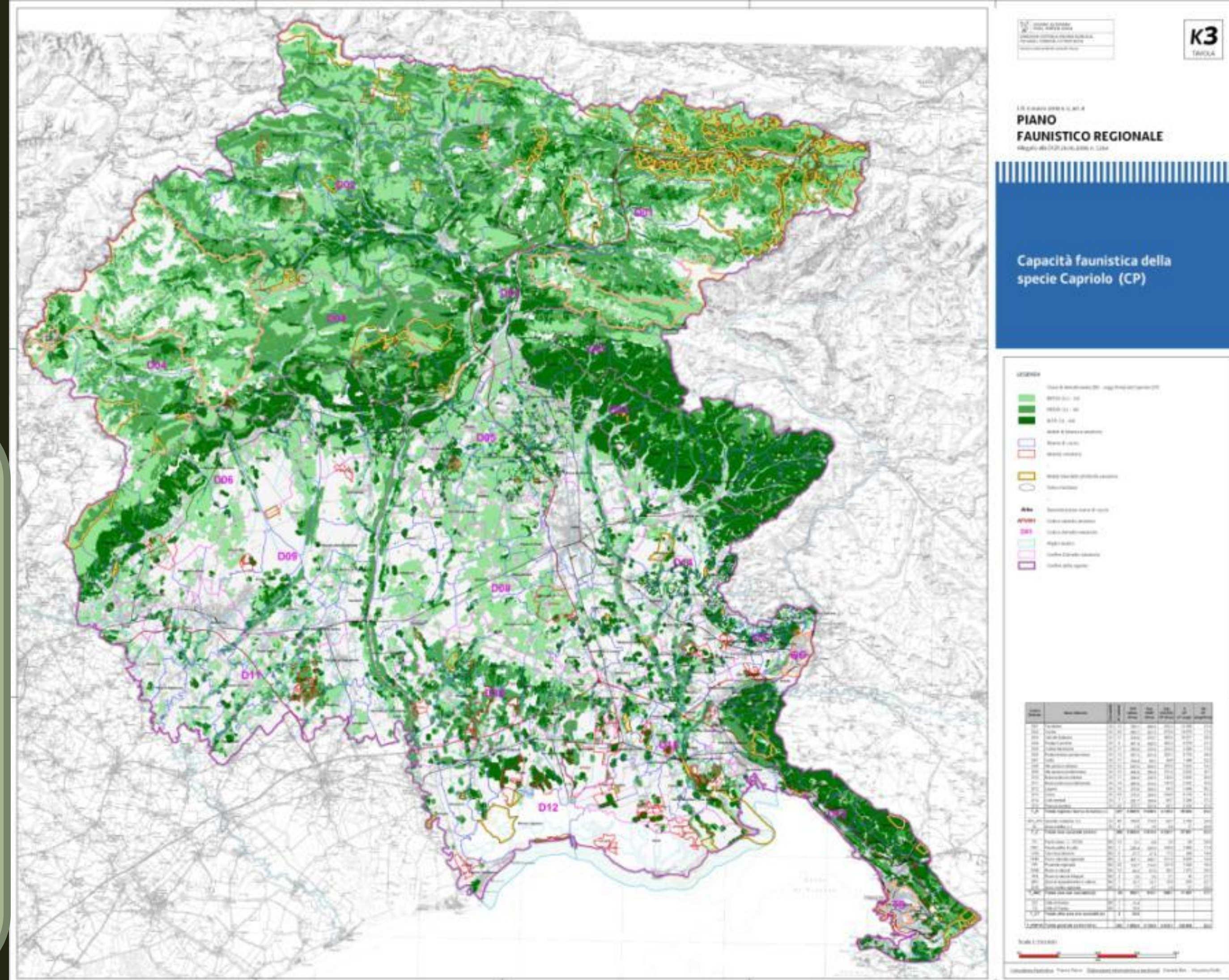
Suitable habitat for red deer



With dark green more suitable areas

On the basis of ecological requirements of red deer and habitat characteristics and geomorphology has been built a suitability model

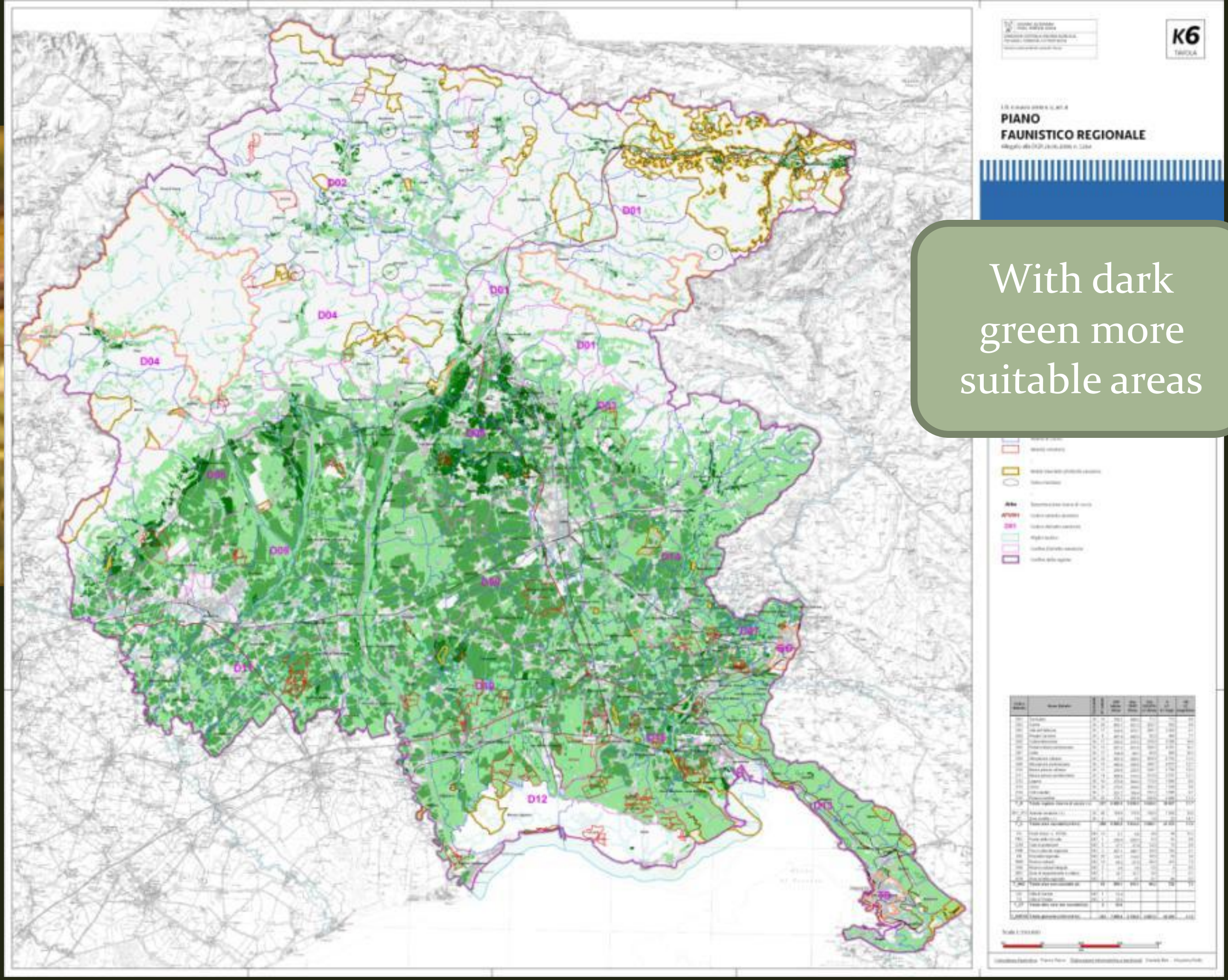
In white , areas not suitable (superimposed for defending the human activities; eradication area)



On the basis of ecological requirements of roe deer and habitat characteristics and geomorphology has been built a suitability model

suitable habitats for roe deer

With dark green more suitable areas



With dark green more suitable areas

On the basis of ecological requirements of brown hear and habitat characteristics and geomorphology has been built a suitability model

suitable habitats for brown hares

The aim of wildlife managers

Analyse the trend of species

Estimate the growth rate, carrying capacities and the population status

Estimate the biological, economic (agro-forestry) and social carrying capacities

Evaluate the suitability of habitats and build a model

Estimate the Maximum sustainable culling (with intraspecific model) in respect to different species and population

Interspecific competition

Interference-competition

Aggressive behaviour

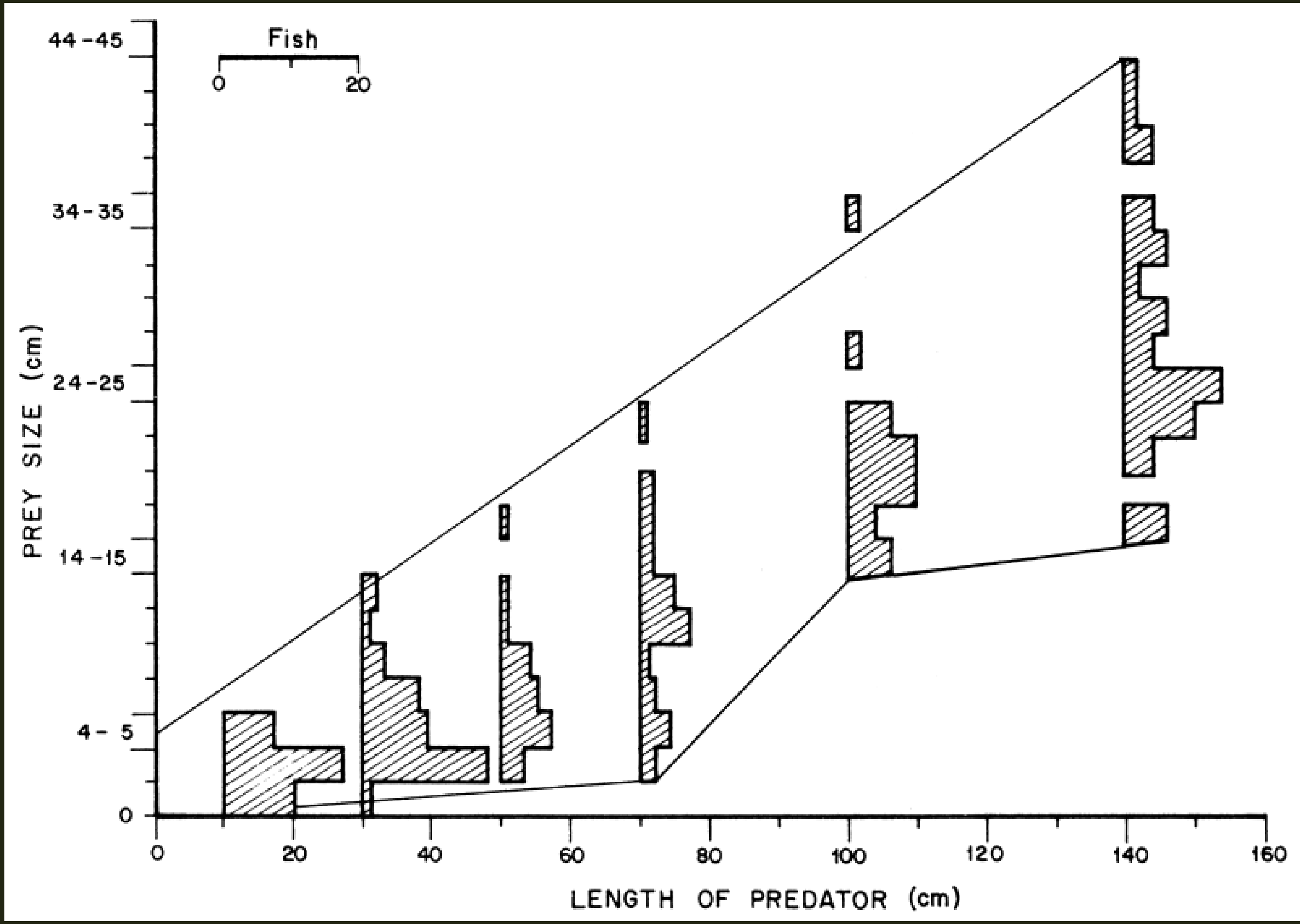
Exploitation of Resource - competition

Same feeding behaviour or habitats use

Exploitation of Resource -competition

The wildlife try to reduce the overlapping in terms of diets and habitats in respect to other species but in the same time needs to maintain a broad niche for reducing the intraspecific competition

The correlation between the size of predator and size of prey; low competition among the predators



browsers

grazers

Roe deer, until 30 kg

Red deer, until 200 kg

Different size, different feeding behavior

Interspecific competition

$dN_1/dt = R_1N_1(K_1-N_1-alfa_{12}N_2)/K_1$

Roe deer

$dN_2/dt = R_2N_2(K_2-N_2- alfa_{21}N_1)/K_2$

Red deer

Con dN_1/dt=increment for unit of time for species 1
con R_1=fixed growth rate per species 1
con K_1=carrying capacity of species 1
$Alfa_{12=}$ coefficient of conversion – competition-vicariance of species 2 in respect to the species 1

A system with two equations and vicariance-competition coefficients

$Alfa_{12=}$ coefficient of conversion- competition-vicariance

One red deer can be considered as how many roe deers ?

how many roe deer sare equivalent to one red deer?

we have to consider, in the management , the total amount of the ungulates

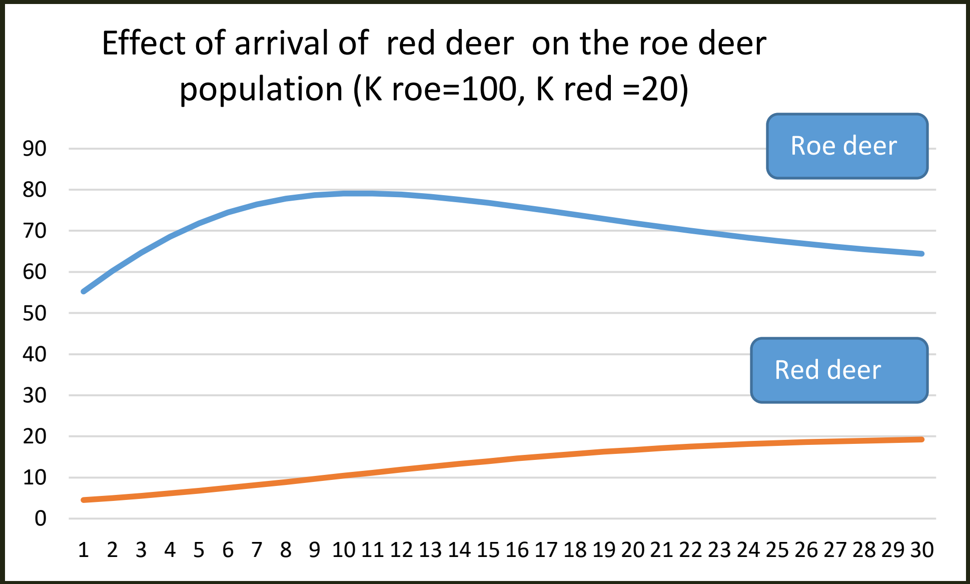
The inter specific competition can influence the reproductive capability ?
Mortality and birth rate ?
But when ?

What happens if the red deer comes to an area where deer live?

The areas can support a maximum of 100 roe deer (K=100, R=0,25) and the population of roe deer is 50

Each red deer is equivalent of 2 roe deer .

The areas in theory can sustain 20 red deer (R=0,15)



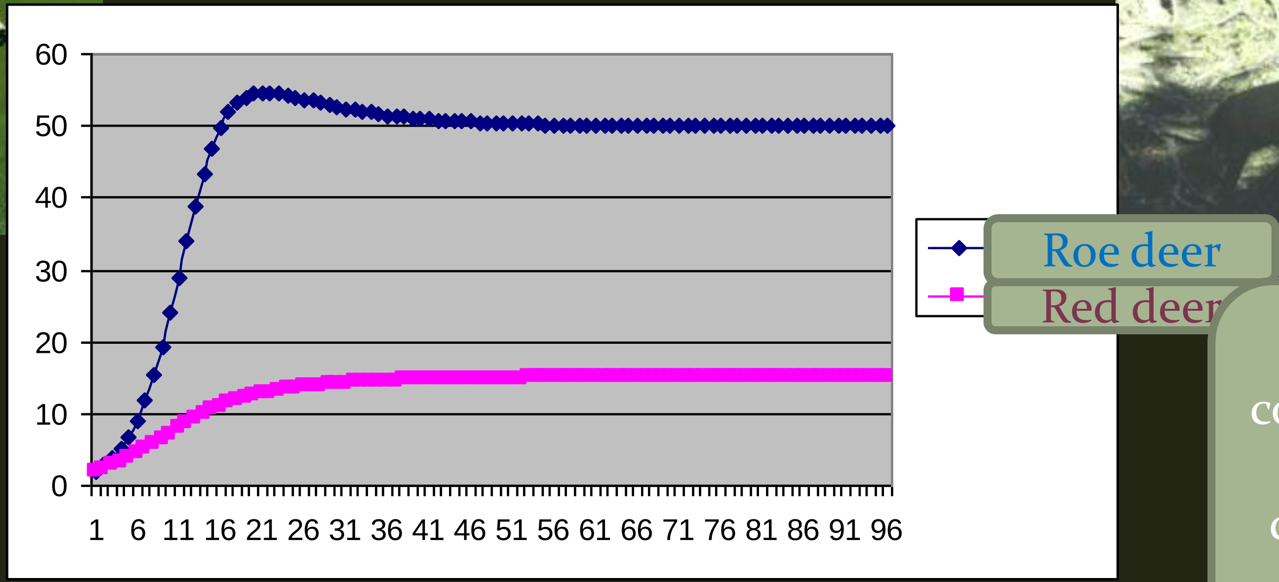
The most important parameter is “K”, carrying capacity, to evaluate the real effect of competition

Old forest: high K for red deer

Shrubland : high K for roe deer

In this habitats the roe deer suffers the presence of red deer

In this habitat the roe deer tolerates more the red deer



K with out competition = 80 ; with competition =50

K with out competition = 20 ; with competition =15

		roe deer	red deer			
	K	80	20		carrying capacity	
	R	0,4	0,2		growth rate	
	alfa 12 e 21	2	0,1		competition rate	

The carrying capacity influences the future trend of the species

The copresence of different species can modulate the effective carrying capacity

Interference competition

Golden jackal (10-16 kg)

Wolf (30-40 kg)

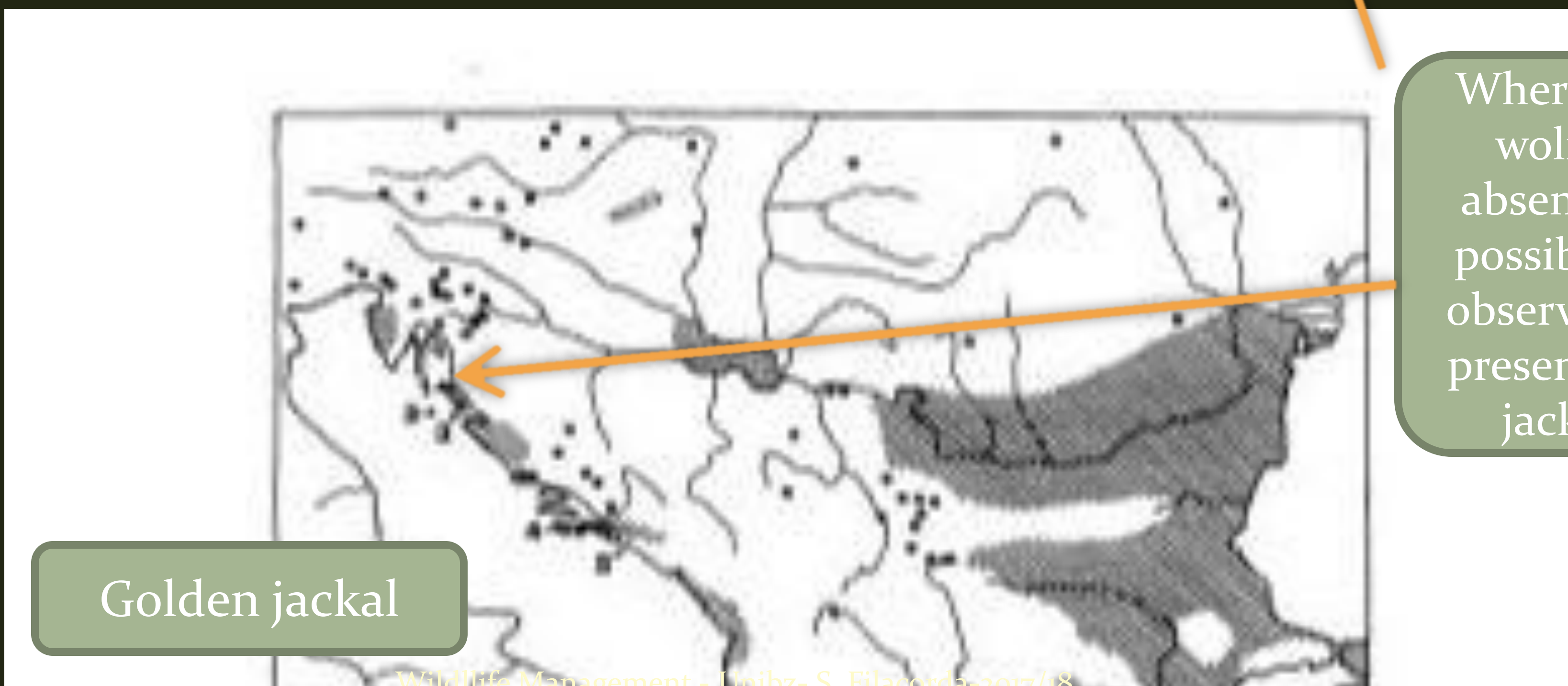
Red fox (<10 kg)

Different size and
Different diets

Distribution of wolf (not update)

Distribution of the Golden jackal (not update)

Wolf



Where the wolf is absent, is possible to observe the presence of jackal

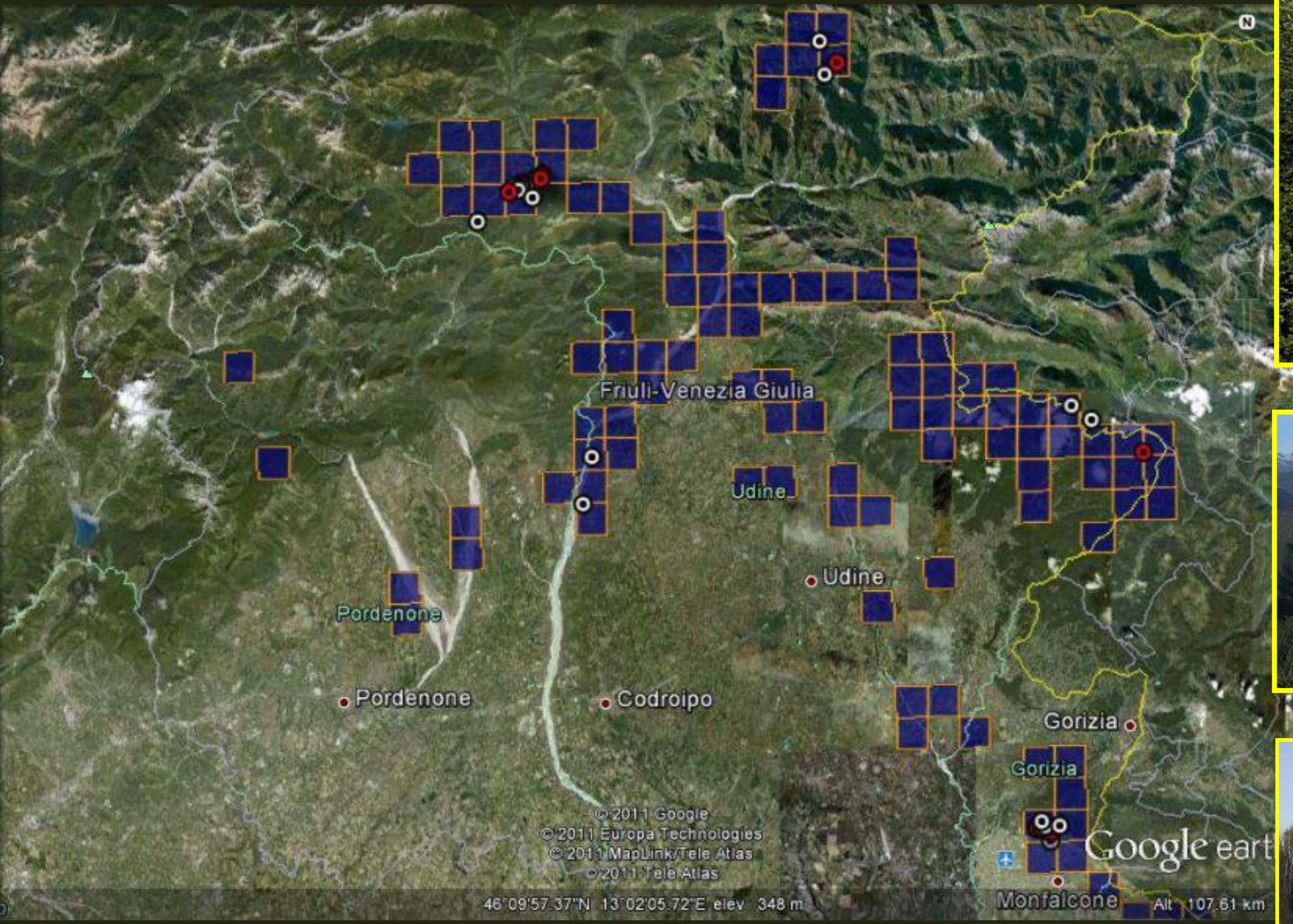
Golden jackal

Not overlapping of the diets and not overlapping of the home range (the golden jackals stay in peripheric areas in respect to the wolf)

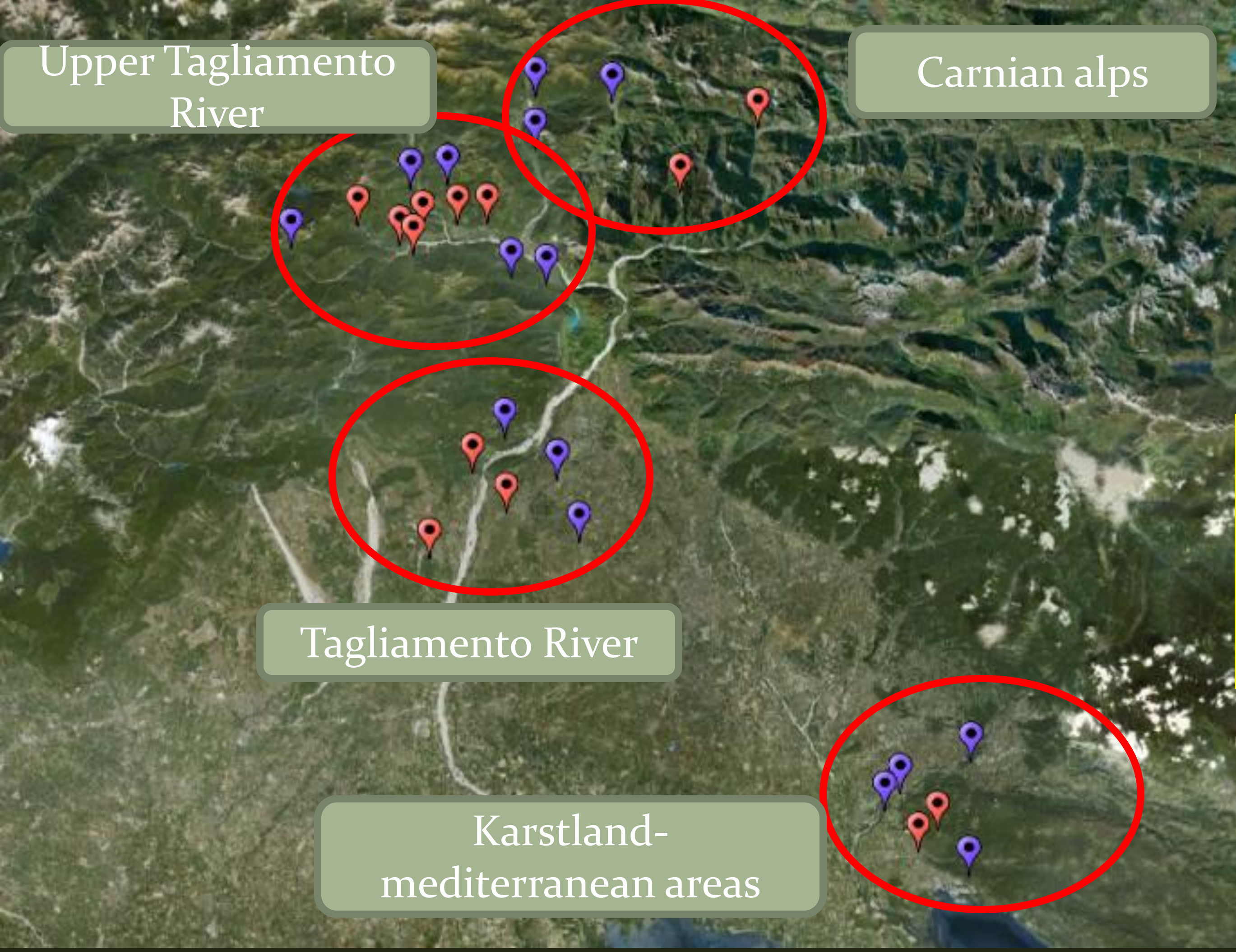
Wolf prey

Golden jackal prey

But exclusive competition and possible predation



Monitoring areas and jackal presence in north east of Italy, in 2010-14: in white reproductive groups and in red single animal



With red hunting preserve with jackal presence, with blue, hunting preserve without jackal . We have divided in 4 different areas

With Jackal presence

Low density of hares

Low density of foxes

Easier to hunt the foxes

Why ?

Aim of Wildlife managers

Observe the presence and trend of species in potential competion

Evaluate the real presence of competition

Define the impact of competition

Estimate the K and parameters of competition

Define management strategies to minimize the competion (forestry and hunting activities)

Estimate the Maximum sustainable culling (with intraspecific model) in respect to different species and population and competition

The predation

The predation: the man (hunter) is not the only and exclusive predator

...that wolf densities are positively related to moose densities in Alaska and Yukon (i.e. ...
...he highest moose density). This suggests
...pply. Second, when wolves are removed

Wildlife, Ecology, Conservation and Management, A. R. E Sinclair, J.M, Fryxell and Grome Caughley, second edition, Blackwell Publishing Chapter 10. 2005

Table 10.1 Density of caribou and reindeer populations in relation to the level of predation.

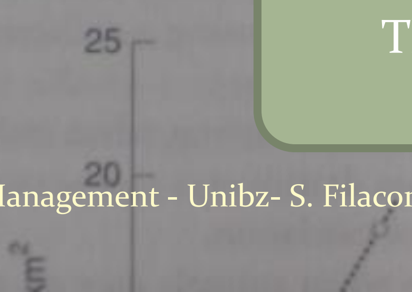
Category	Location	Density/km²
Major predators rare or absent	Slate islands	4–8
	Norway	3–4
	Newfoundland (winter range)	8–9
	South Georgia	2.0
Migratory Arctic herds	George River	1.1
	Porcupine	0.6
	Northwest Territories	0.6
Mountain-dwelling herds	Finlayson	0.15
	Little Rancheria	0.1
	Central Alaska	0.2
Forest-dwelling herds	Quesnel Lake	0.03
	Ontario	0.03
	Saskatchewan	0.03

After Seip (1991).

Low density of caribou in presence of wolf and grizzlies

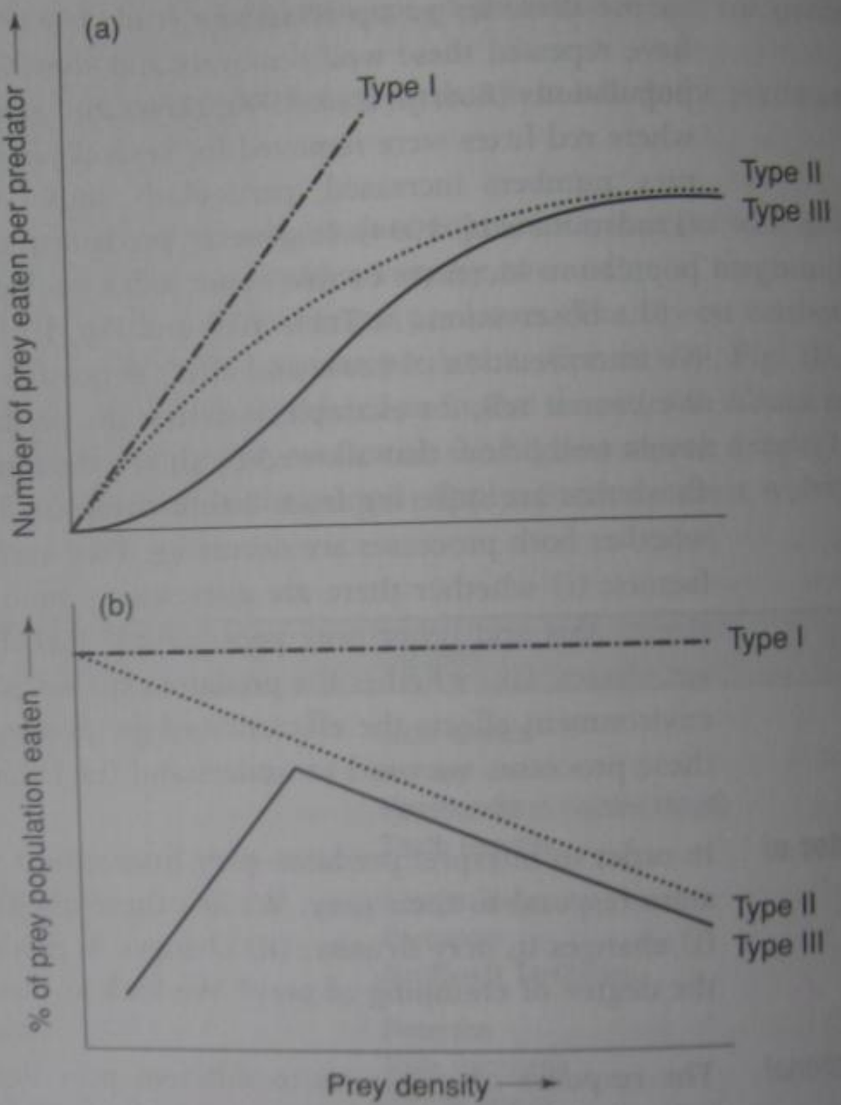
The influence of predators on prey

Fig. 10.1 Wolf density is related to moose density in Alaska and Yukon. In areas where wolves are culled (●) moose can reach higher densities than in areas ...



The functional responses

Fig. 10.2 (a) Types of functional response shown as the number of prey eaten per predator per unit time relative to prey density. (b) As for (a) but plotted as the percentage of the prey population eaten.



The rate of consumption for the predator not always is linearly correlated to the availability of prey: depends form the time of handling and searching

The reindeer is a (not real) predator

The reindeer and lichen

Type 1

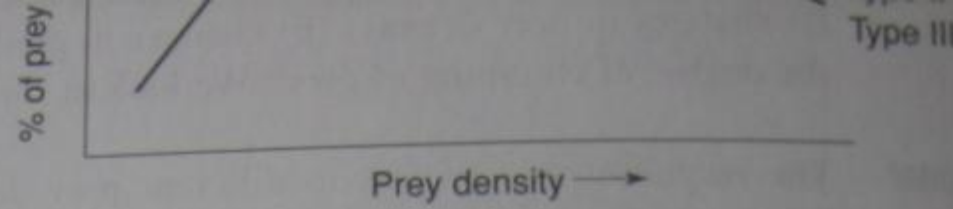
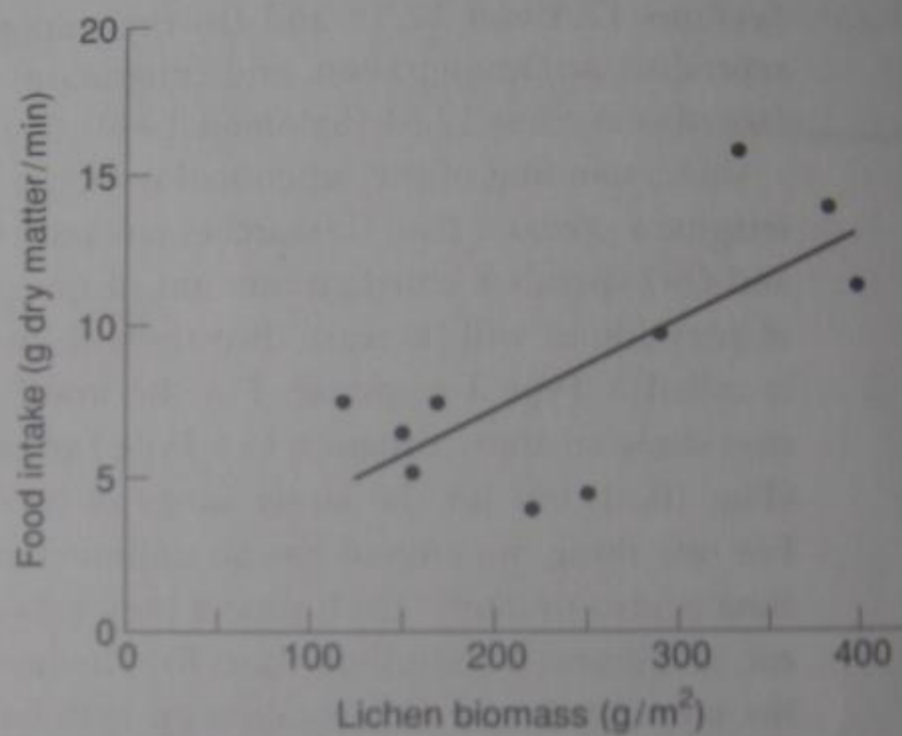


Fig. 10.3 The linear (Type I) functional response of reindeer feeding (dry matter intake) on lichen. (After White *et al.* 1981.)



The searching efficiency or attack rate of the predator, *a*, depends on the area searched ... ssful attack, p_s, so that:

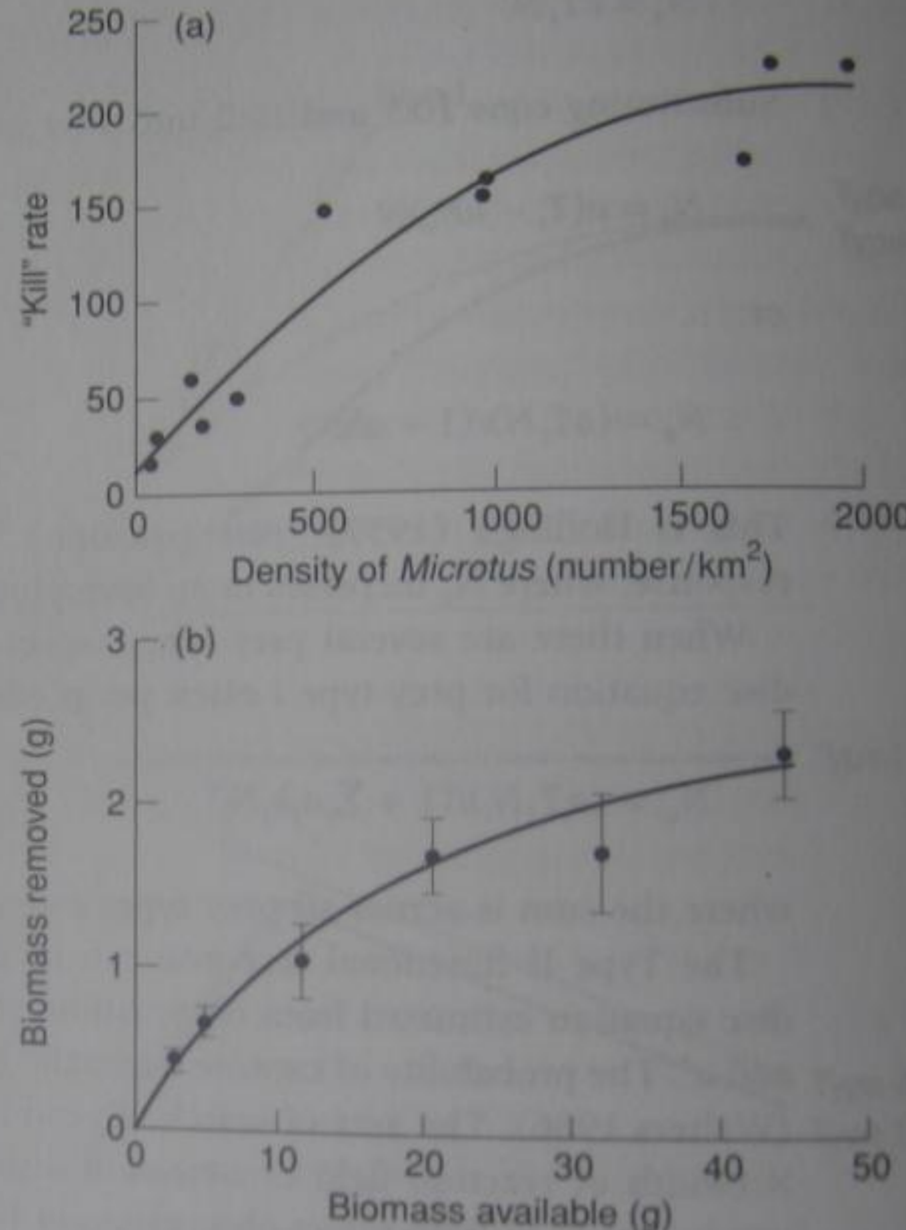
(10.3)

The ... unit time (N_a) increases with search time, search efficiency, and prey density, so that:

Wildlife, Ecology, Conservation and Management, A. R. E Sinclair, J.M, Fryxell and Grome Caughley, second edition, Blackwell Publishing Chapter 10. 2005

European kestrel (*Falcus tinnunculus*) and voles

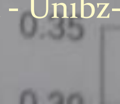
Fig. 10.4 The Type II functional response of: (a) European kestrel feeding at different densities of voles (*Microtus* species). "Kill" rate is voles eaten per predator per breeding season. (After Korpimäki and Norrdahl 1991.) (b) Bank voles feeding on willow shoots. (After Lundberg 1988.)



Type II

The handling time is key time

Fig. 10.5 The Type III functional response of hen harriers feeding on



Hen harrier (*Circus cyaneus*)and red grouse (*Lagopus lagopus scotica*)

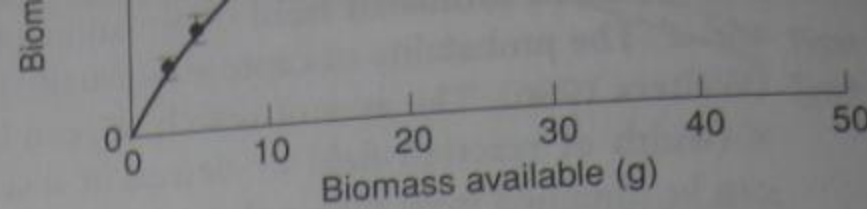
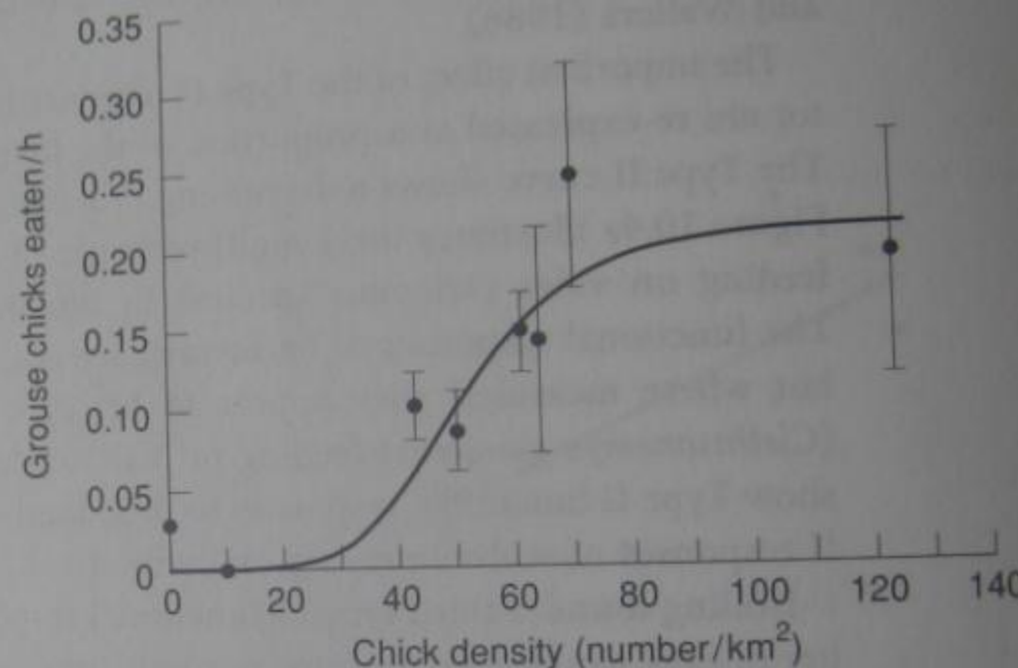


Fig. 10.5 The Type III functional response of hen harriers feeding on red grouse chicks in Britain. (After Redpath and Thirgood 1999, with permission.)

Type III



a search image of a prey species such that they concentrate on one prey type whil ignoring another. As the rare prey (A) becomes more common, birds (such as chick adees (*Parus* species) searching for insects in conifers) will accidentally come acros A often enough to learn a new search image and switch their searching to this species

In practice, it is often difficult to determine whether there is a Type II or III respons because the differences occur at low densities of prey and measurements are usuall imprecise. The most robust evidence comes from determining whether predators ignor prey until there is a sizeable prey density available; that would indicate a Type I

The numerical response

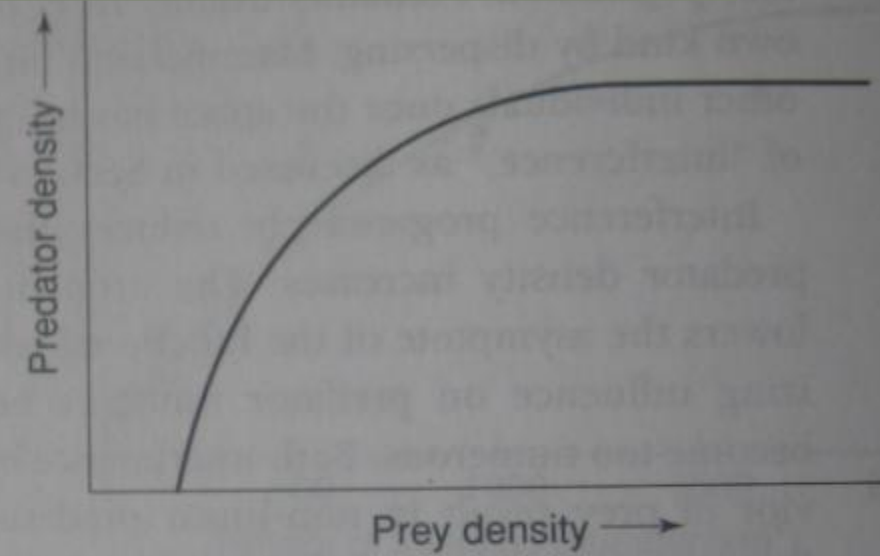


Fig. 10.6 The numerical response may be depicted as the trend of predator numbers against prey density.

The number of predators reaches a limit

has been observed in northern Canada when numbers of their primary
shoe hares, collapse.

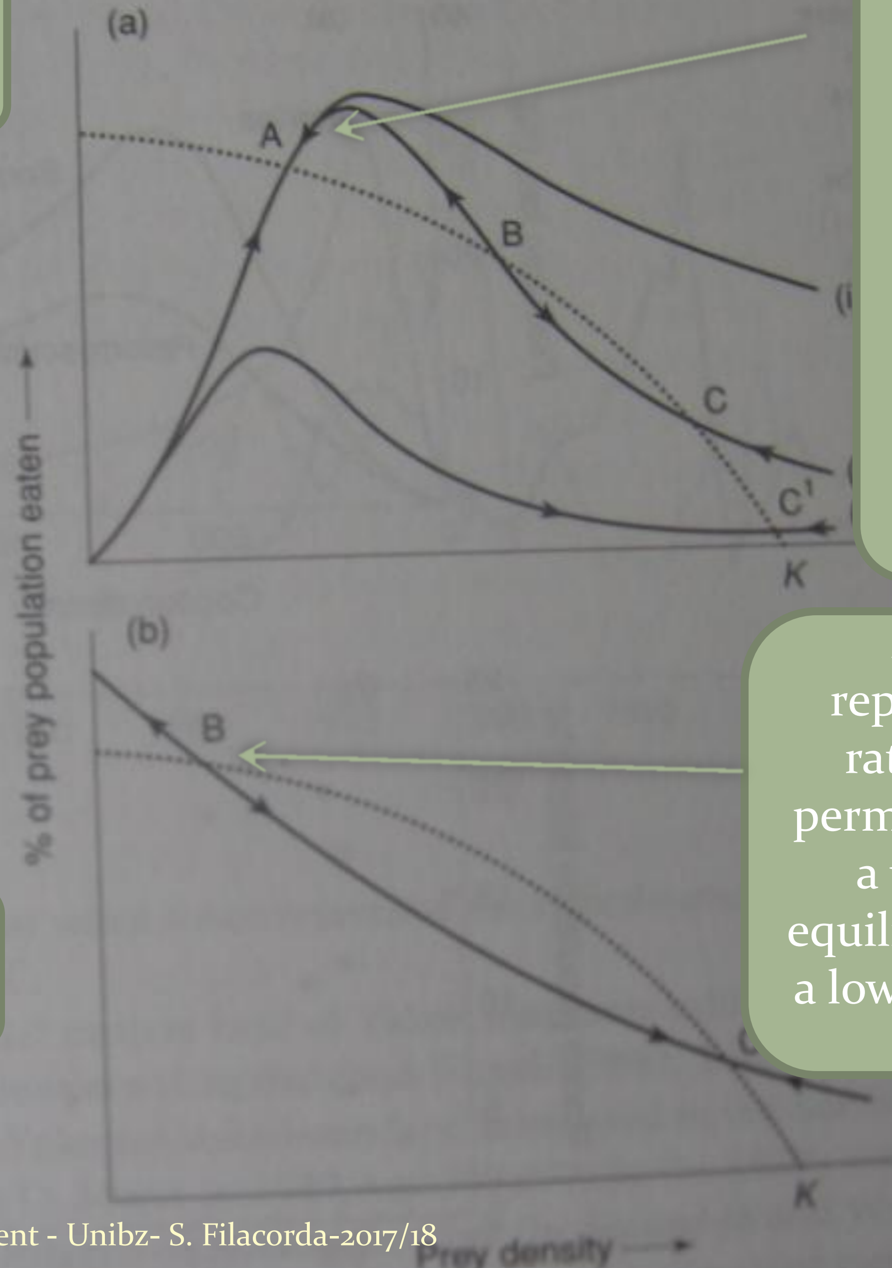
The initial increase in numerical response may or may not be density
However, because of the asymptote, the numerical response at higher p
can only be depensatory (inversely density dependent). This means it ha
izing effect on the prey population, by either driving the prey to e
allowing it to erupt. This is an important characteristic of populatio

Total response curves

Fig. 10.7 Theoretical total response curves (solid lines) of a predator population, measured as the percentage of prey population eaten, in relation to prey at different densities, (a) when there is density dependence in either the functional or numerical response, and (b) when there is no density dependence. The broken line represents the per capita net recruitment of prey $(dN/dt)(1/N)$ assuming logistic growth (i.e. after effects of competition for food have been accounted for). K is a stable point with no predators; A, C, and C^1 are stable with predators, and B is an unstable boundary point.

Density dependence

Not Density dependence

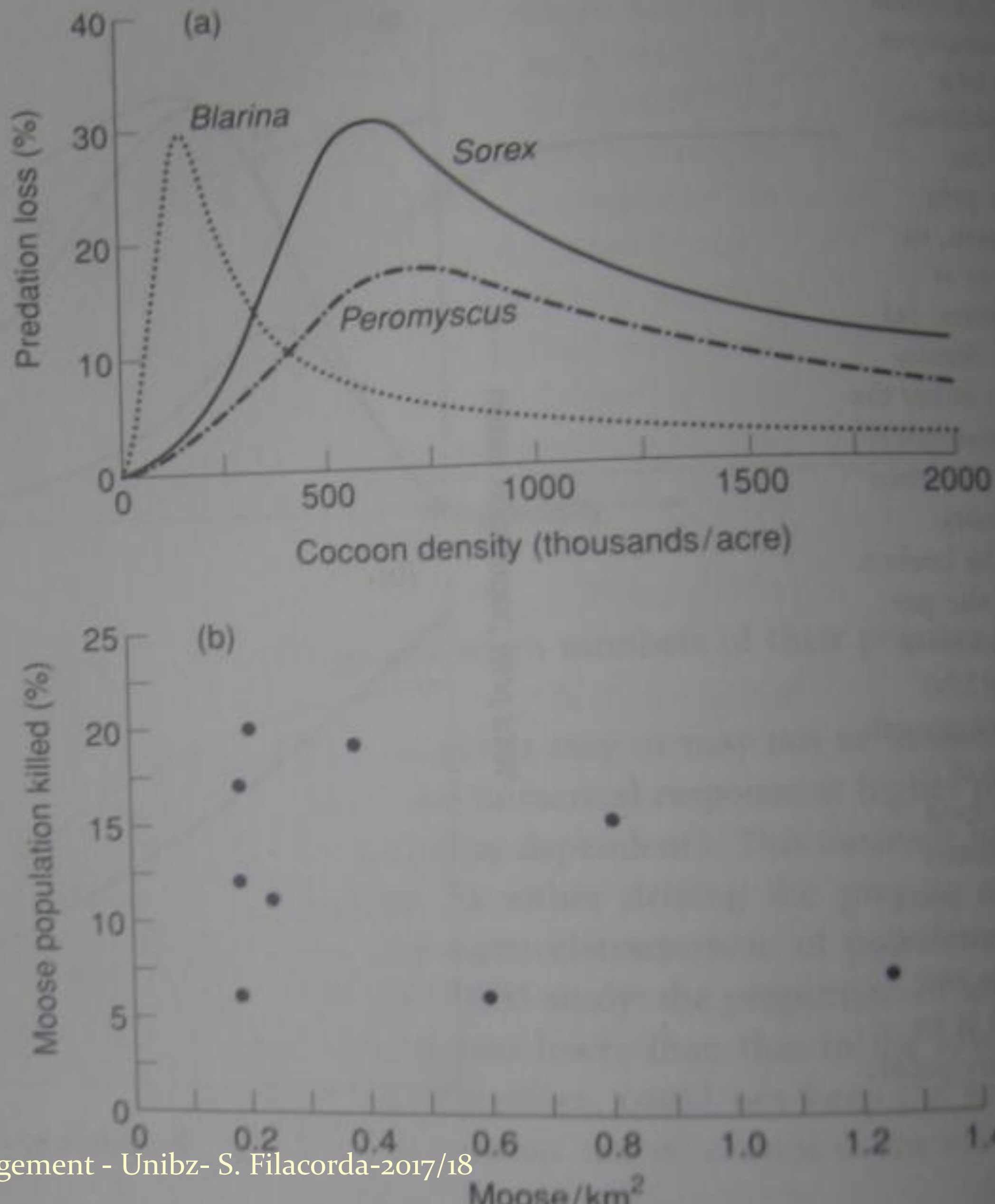


A high reproductive rate of prey permits to reach a stable equilibrium with a low number of prey

A high reproductive rate of prey permits to reach a unstable equilibrium with a low number of prey

Regulatory effect of predation

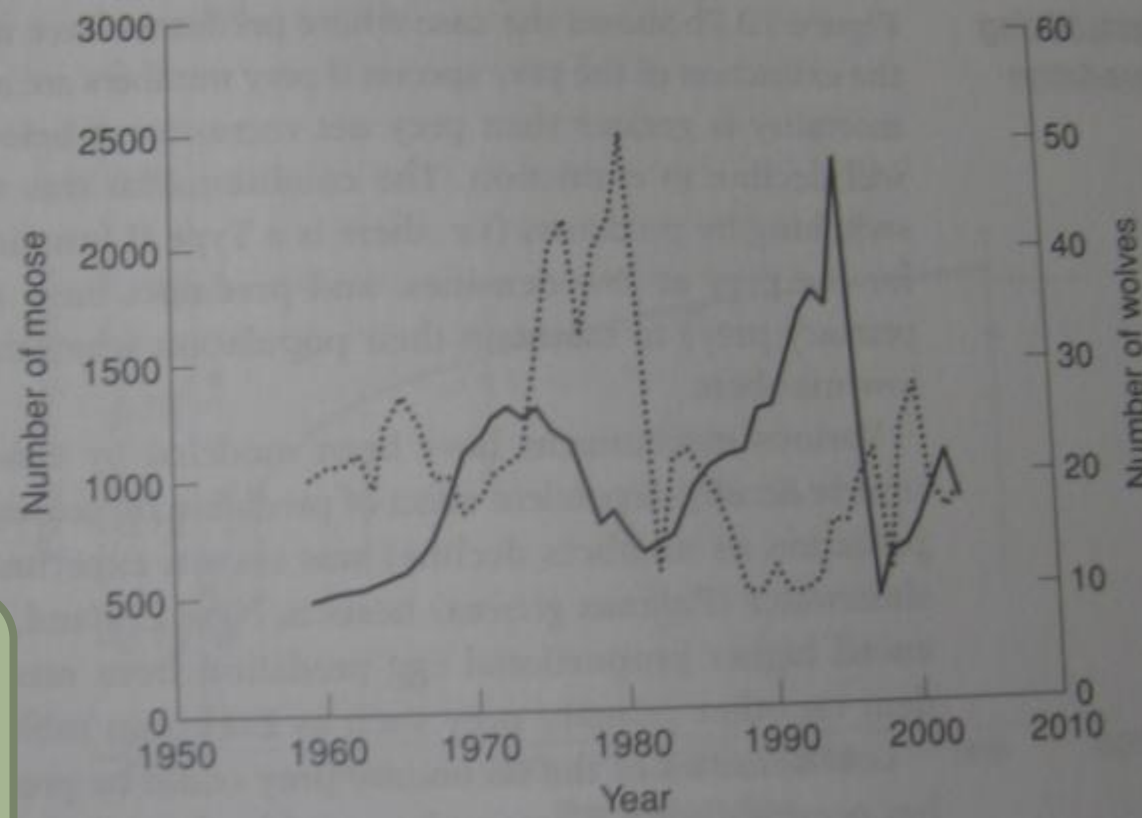
Fig. 10.8 Total response curves of predators at different prey densities. (a) Two shrews (*Blarina*, *Sorex*) and the deermouse (*Peromyscus*) eating European sawfly cocoons. (After Holling 1959.) (b) The proportion of moose populations killed by wolves in different areas of North America. (After Boutin 1992.)



The number of animals killed changes with density: at low density the % is higher

Jackal and European brown hare

ig. 10.9 Wolf (broken ine) and moose (solid ine) numbers on sle Royale, during 1959–2003, show that he wolf population ollows the fluctuations f moose, which are imited by food. (After Peterson and Vucetich 003, with permission.)

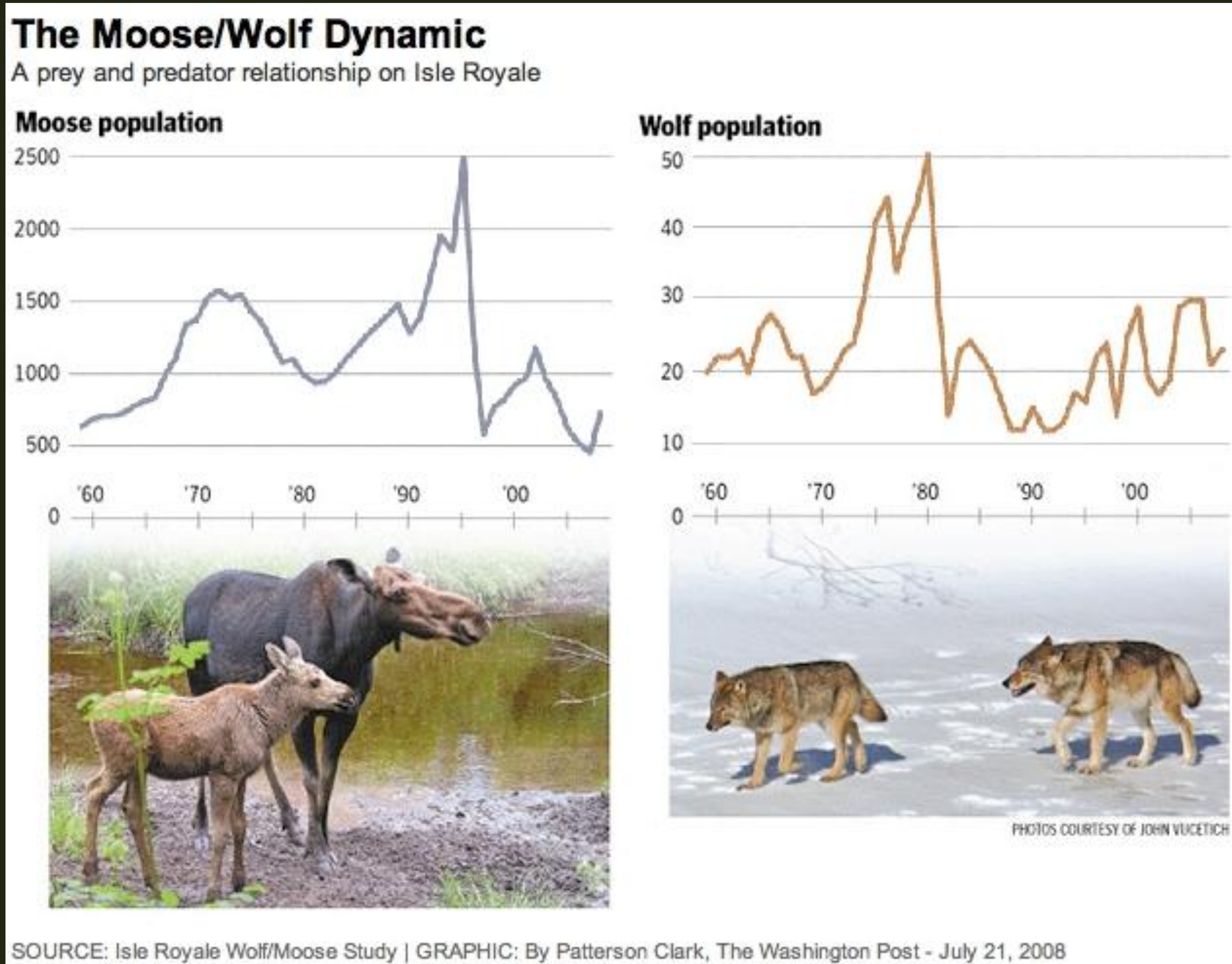


The wolves follow the fluctuations of moose and induce the fluctuations

density, B, so that when foxes reinvaded the experimental area rabbit numbers continued towards C.

may have exhibited behavior characteristic of multiple stable states (Urquhart and Farnell 1986). Traditionally, this herd,

numbered in the hundreds of thousands


The Moose/Wolf Dynamic
A prey and predator relationship on Isle Royale
Moose population
2500
2000
1500
1000
500
0
'60
'70
'80
'90
'00
Wolf population
50
40
30
20
10
0
'60
'70
'80
'90
'00
PHOTOS COURTESY OF JOHN VUCETICH
SOURCE: Isle Royale Wolf/Moose Study | GRAPHIC: By Patterson Clark, The Washington Post - July 21, 2008

Predation

Without intraspecific competition

$dN/dt= RN-aCN$

$dC/dt=faCN-qC$

With intraspecific competition

$dN/dt= rN-aCN$

$dC/dt=faCN-qC$

dN/dt= change of the prey population per unit of time

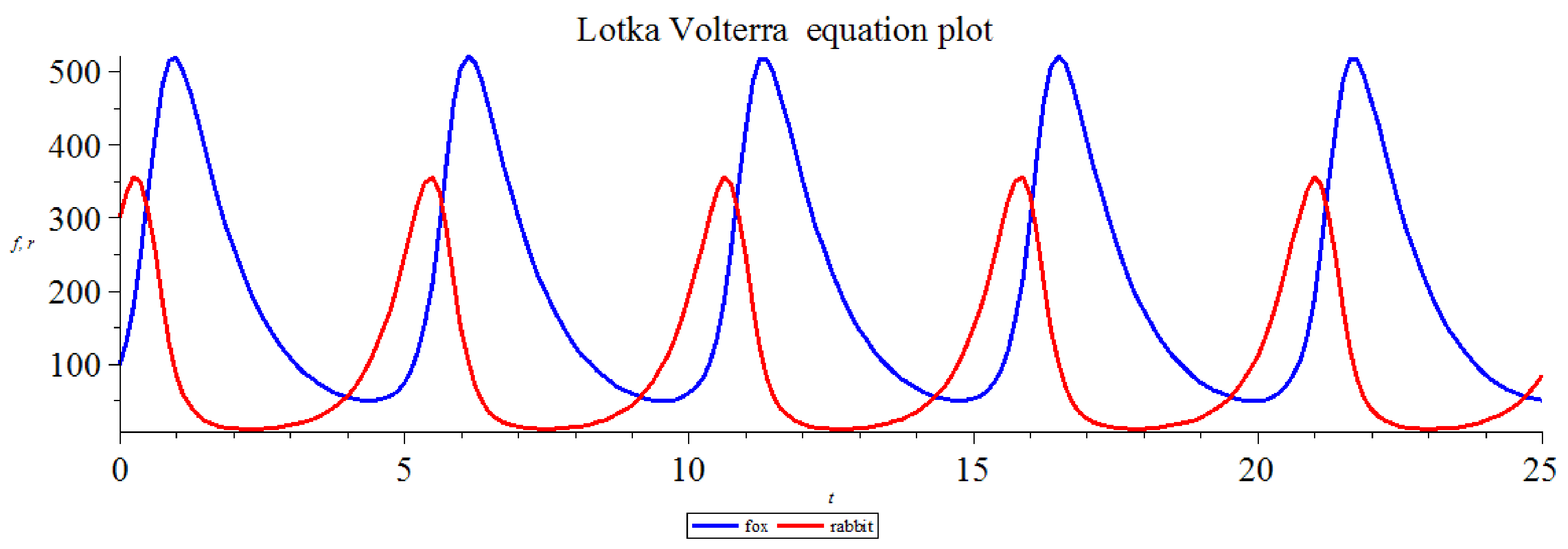
dC/dt= change of the predators population per unit of time

R=growth rate of prey (constant)

a= kill rate (success of predation)

f=coefficient of transformation of the prey killed in the newborn of predators

q =mortality of predators

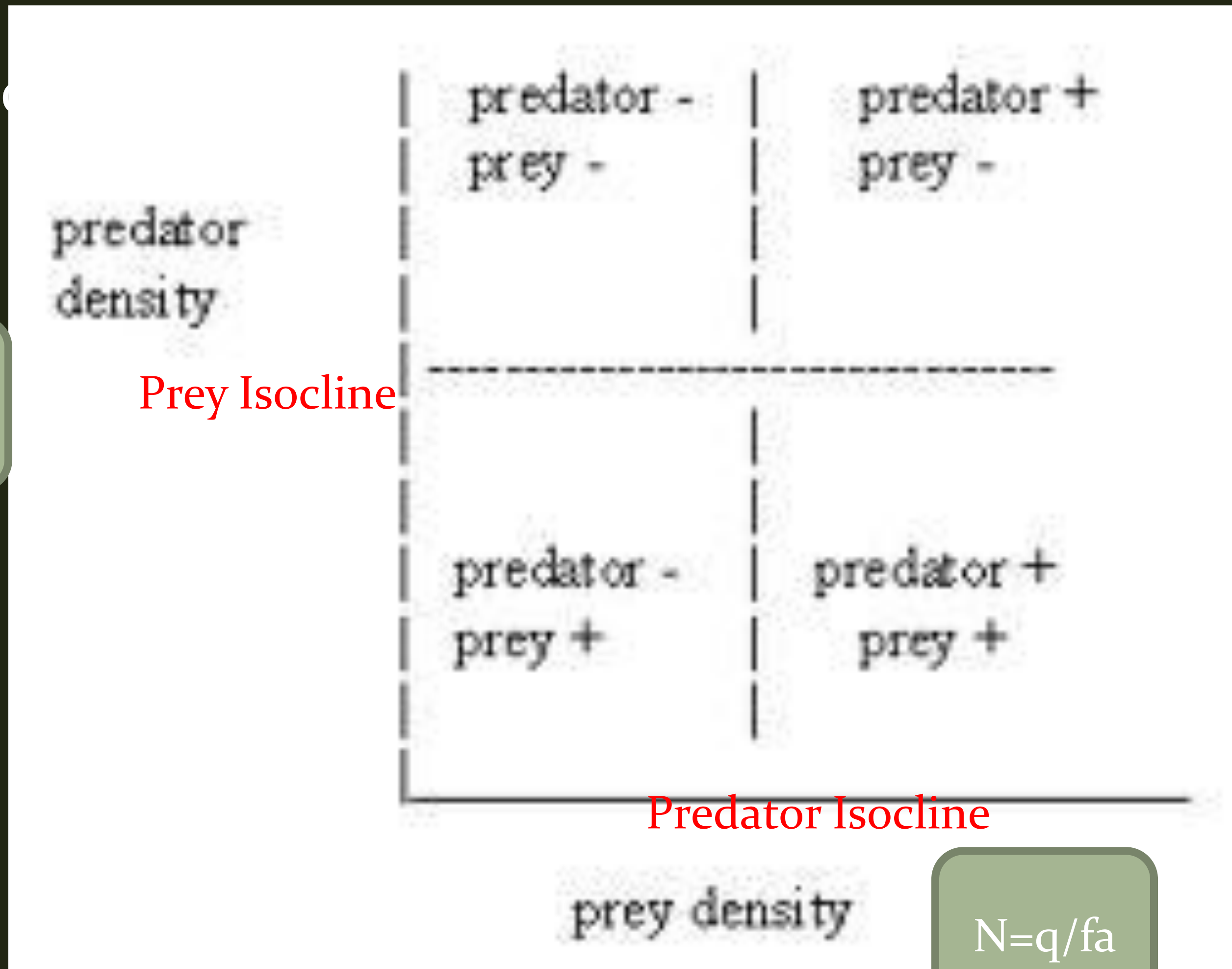


The lynxes follow the fluctuations of hares and induce the fluctuations

Theoretical stable system

Number
of Predator (

C=R/a



Are the predators always in equilibrium with prey ? NO

Destabilizing effect of predation

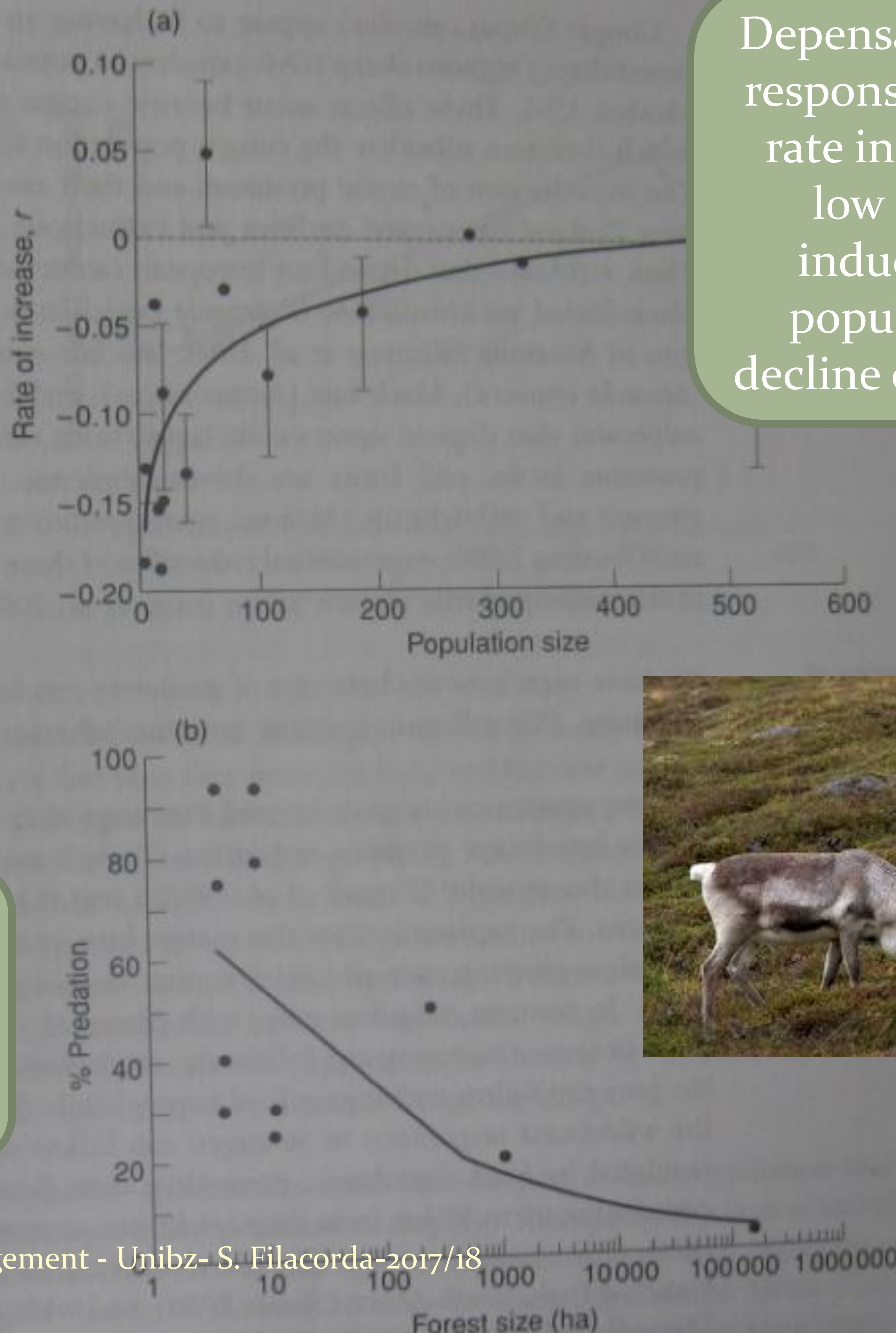
Fragmentation increase the impact of predator (but also the mortality of prey and predators)

At low densities and low reproductive success of prey high predation from predators

Prey without antipredators behavior in short time

Alternative prey maintain high number of predators and prey

Fig. 10.10 Depensatory total responses. (a) Wolf predation on different woodland caribou herds in British Columbia. Predation rate increases as caribou density declines, causing the populations to decline even faster. (After Wittmer *et al.* 2005.) (b) Various mammal and bird predators on passerine bird nests as a function of forest patch size. These patches are an index of prey population size. (After Wilcove 1985.)



Depensatory total responses: the kill rate increases at low density inducing the population to decline even faster

The habitat characteristics influences the rate of predation

The predators can induce a local extinction for specific species and in specific habitats

Mouflon (*Ovies musimon*)

Introduced species in Alpine areas without anti predator efficient behaviour

Chamois (*Rupicapra rupicapra*)

Species vulnerable in forest habitats with out refuge (rocks)

It is important to observe the feeding behaviour , % of consumption and the distribution of predations

The % of consumption of carcass and the time spent for hunting

In the recent areas of colonisation the predator needs less effort to kill (the consequence: lower consumption and short movements-small home range)

Lynx	Distance for the core areas (km)		Distance from the previous predation (km)			% of consumption
	mean	se	mean	se	max	
Male inner	10,9	5,1	10,3	8	22,4	82,6
Females inner	6,3	3,5	4,1	4	13,8	73,2
Males during colonisation	2,3	2,3	2,6	1,7	5,7	77,1
Femals during colonisation	4,5	2,5	2,8	3,1	10,9	57,9