Reserve Design

Nigel Maxted

SADC Crop Wild Relatives Regional training workshop
'*In situ* conservation of CWR including diversity assessment techniques'
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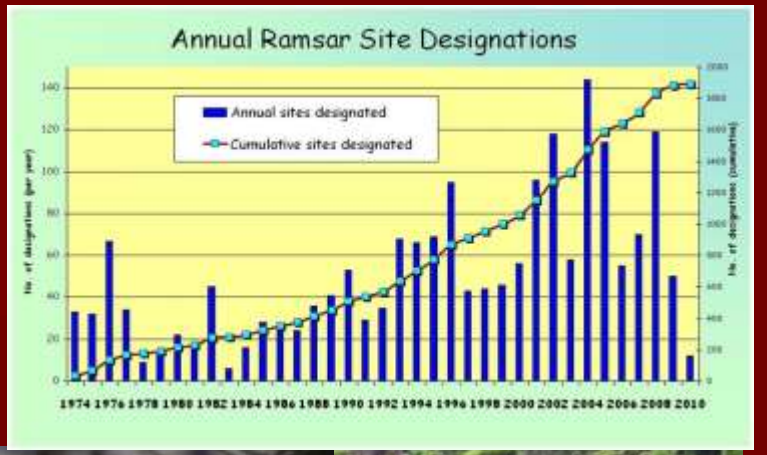
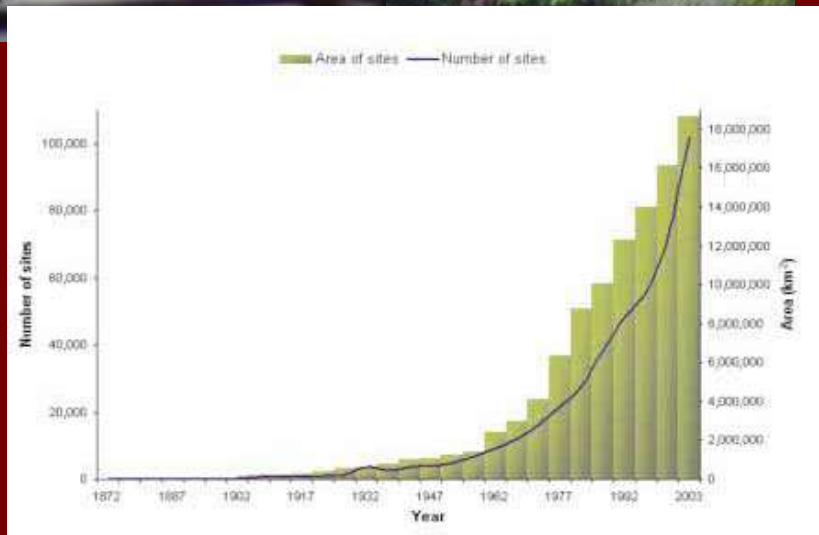
Introduction

- Publications
  - Groom, Meffe & Carroll (2006) Chp 14
  - Iriondo, Maxted and Dulloo (2008) Conserving Plant Genetic Diversity in Protected Areas Chp 2
  - Pullen (2002) Chp 9

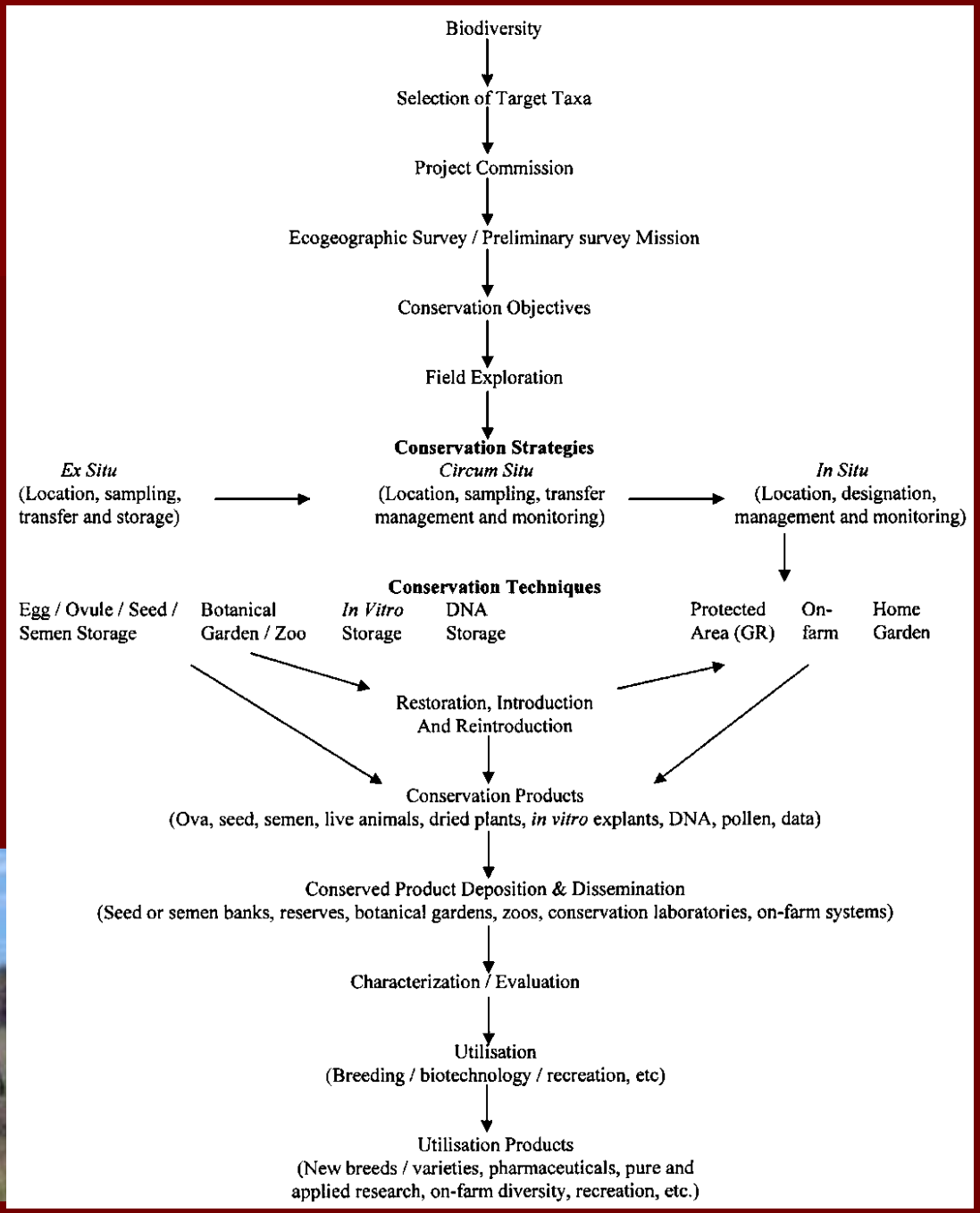
- *In situ* has priority post-CBD
  - Practical because of biodiversity complexity of interactions and ecosystem services
  - Ethical imperative to conserve *in situ*
  - But what about climate change?





Introduction

Must fit within overall model of genetic conservation



Site Selection Criteria

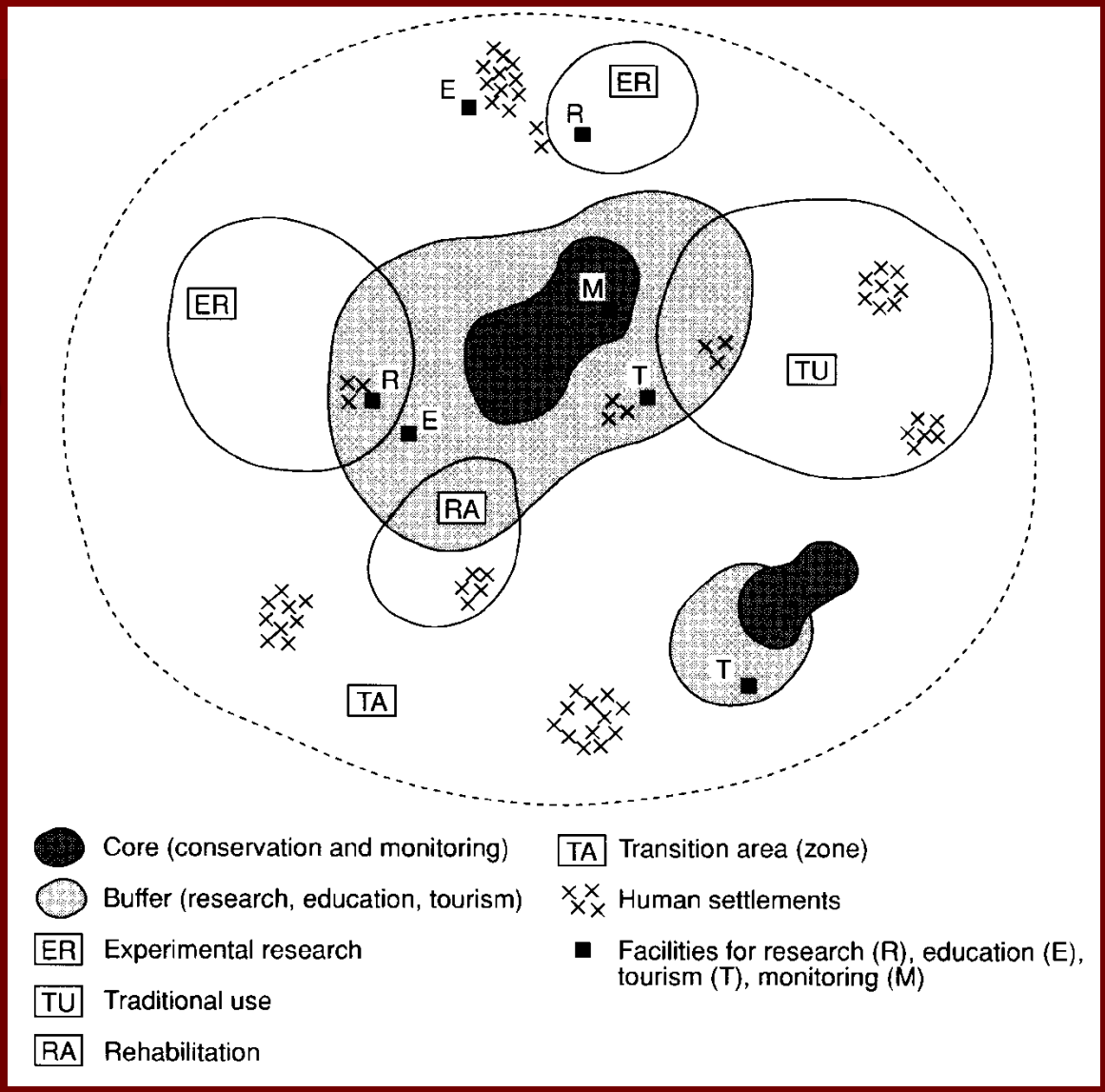
- Ecogeography / gap analysis
- Web site for Biodiversity Action Plans
  - **http://www.ukbap.org.uk/**
- Protected area network (Pressey *et al.*, 1997)
  - Minimum number of sites to represent one occurrence of each feature (habitat / species population)
  - Minimum total area of sites to represent one occurrence of each feature
  - Minimum number of sites to represent 5% of total regional occurrence of each feature
  - Minimum total area of sites to represent 5% of total regional occurrence of each feature

Site Selection Criteria

- How to achieve?
  - Level and pattern of genetic diversity of the target species' populations (wild lentils)
  - Presence in protected area or biodiversity hotspots or centres of crop origins or diversification
  - Size of reserves (depends on species characteristics)
  - Number of populations (depends on species characteristics)
  - Number of individuals within the population (MVP > 5000)
  - Political and socio economic factors (local community support, sustainability, legal protection)
  - Current conservation status (gap analysis)

Optimal Reserve Design

- Man and Biosphere programme (UNESCO)
  - Cox (1993, modified from Batisse 1986)
- Core/Buffer/Transition



Optimal Reserve Design

- Core
  - Assumes core area with (1000-)>5000 potentially inter-breeding individuals (MVP - minimum viable population)
- Buffer
  - Extension buffering - effective extension of the core area with similar management regime to the reserve core and is open to non-destructive researchers, educationists and special ecotourists.
  - Socio-buffering, involves the separate management of the core and the buffer, because some sustainable agriculture and forestry is permitted within the buffer zone.
- Transition zone
  - Outside of the buffer zone, the transition zone, will be available for research on ecosystem restoration and similar studies, limited human settlements and sustainable utilisation, as well as general tourist visits

Biological & social benefits of buffers

Biological Benefits		Social Benefits (to mostly local people)	
a.	Provides extra protection from human activities for the protected core zone	a.	Gives local people access to traditionally utilized species without core loss
b.	Protects the core of the reserve from biological change	b.	Compensates people for loss of access to the protected core zone
c.	Provides extra protection from storm damage	c.	Permits local people to join in conservation
d.	Provides a large forest or other habitat unit for conservation, with less edge effects	d.	Makes more land available for education, recreation, and tourism
e.	Extends habitat and thus population size for target species	e.	Permits conservation of plants and animals to form part of development plans
f.	Allows for a more natural boundary - one relating to movements of animal species	f.	Safeguards traditional land rights and conservation practices of local people
g.	Provides a replenishment zone for core area species including animals essential to some plants	g.	Increases conservation-related employment

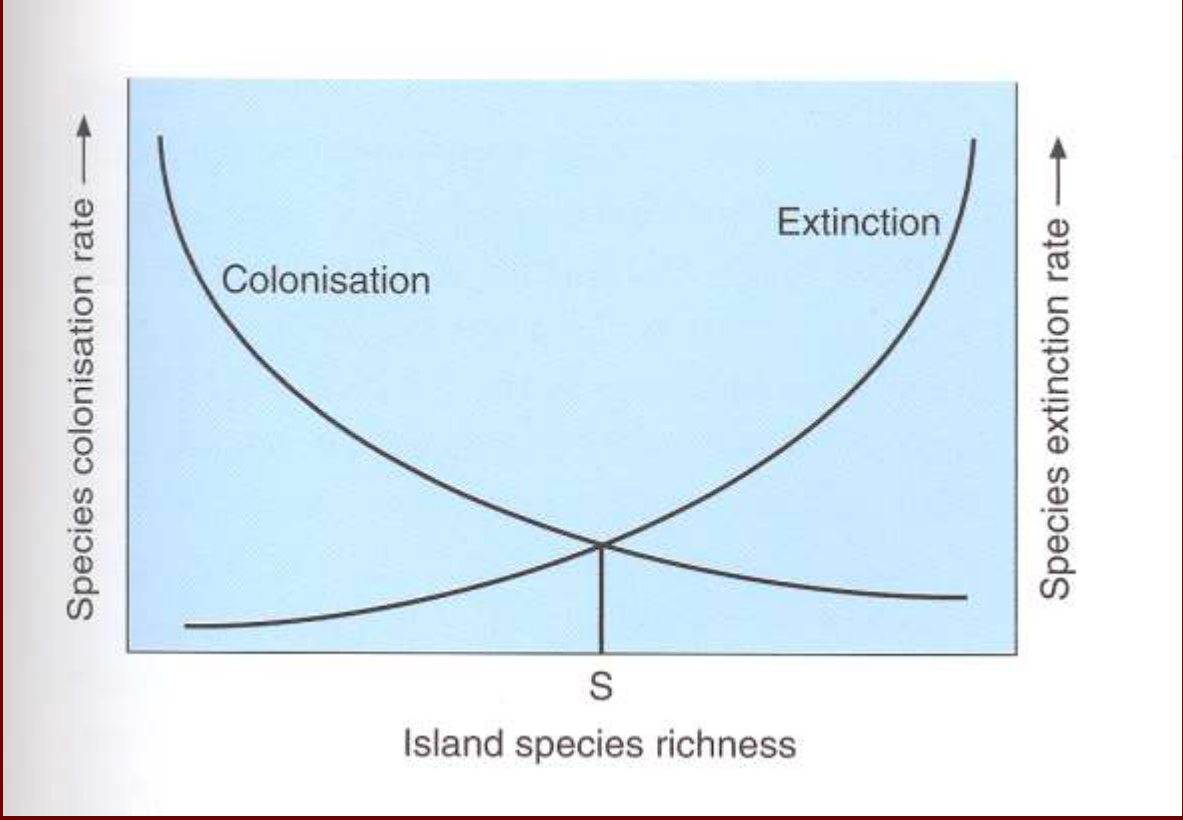
Reserve Size

- Size is often dictated by the relative concentration of people and the suitability of the land for human exploitation.
- Worlds largest reserves
  - Greenland National Park – 7,000,000 km^2 of frozen land mass
  - Bako National Park - Malaysia set on nutrient-deficient soils
- Largest 15 reserves in USA all on agriculturally marginal areas
- Unlikely to be a natural correlation between marginal agricultural land and biodiversity hotspots and distribution of species worthy of conservation

Colloidal Pool, Yellowstone

Reserve Size

Size is commonly related to theories of Island Biogeography and relative rates of colonization and extinction per unit area



colonization = extinction per unit area

SLOSS debate

- **S**ingle **L**arge **O**r **S**everal **S**mall
- For example is it better to have on large reserve of 15,000 ha or a network of five each of 3,000 ha?
- Large reserves - advantages and disadvantages
- Network of smaller reserves - advantages and disadvantages

Relative advantages of Single Large and Several Small Reserves

Reserve Size	Advantages	Disadvantages
Single Large	. More ecogeographically diverse . Minimal edge effect . Easier to maintain species and population diversity . Maintain physical integrity of ecosystem (e.g. watersheds, drainage system) . Suited for low-density species (e.g. forest trees, elephants, big cats, k-strategists)	. Impossible to cover all genetic diversity of widely distributed species
Several Small	. Site each reserve in a distinct environment . Conservation value of multiple small reserves can be greater than the sum of its individual components (= meta-population) . Annual plants often naturally found in dense but restricted stands (r-strategists) . Usually sited near urban areas so good for public awareness	. Usually sited near urban areas so need more effective buffering . Require more intensive management & monitoring . Impossible to include real habitat diversity . More susceptible to human or natural trauma . Too small or too isolated a population less likely to remain unviable

Optimal Number and Size

- Depends on the characteristics of the target species i.e. breeding system, migration patterns, natural distribution, etc.
- Ideal - A number of reserves, located in different segments of the distribution area of the target species
- Size is frequently not the question!

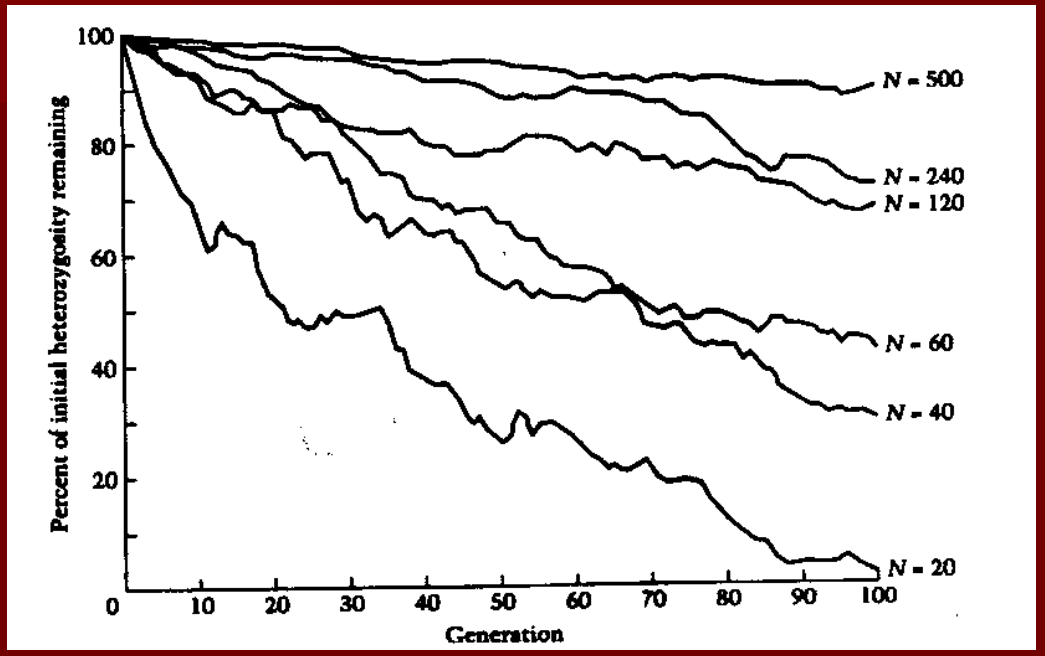
Population and Reserve Size

- The answer is what number of individuals form a viable population (i.e. minimum viable population size - MVP) without inbreeding depression, where mutation rate = genetic drift (e.g. Siberian Tiger)

- Shafer (1990) maintains that the minimum population size (MPS) for any given habitat is defined as the smallest population having a 99% chance of remaining extant for 100 years

- But what size is the MVP? - No accurate answer

Population and Reserve Size



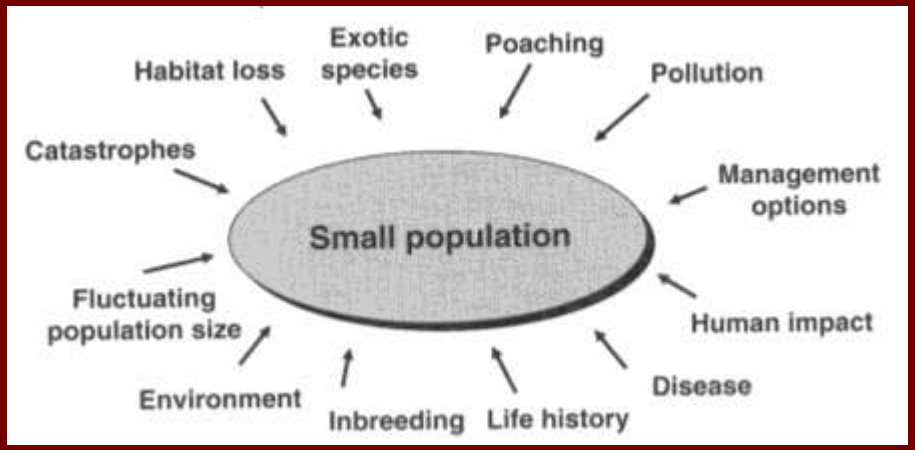
- Factors that effect are:
  - Breeding success
  - Predation
  - Competition
  - Disease
  - Genetic drift
  - Interbreeding
  - Founder effect
  - Natural catastrophes (stochastic events) such as fire, drought and flooding
- Some of these avoided by establishing reserve where natural populations of the target species already exist
- Any significant drop in population size will result in loss of alleles and genetic drift (e.g. Siberian Tiger)

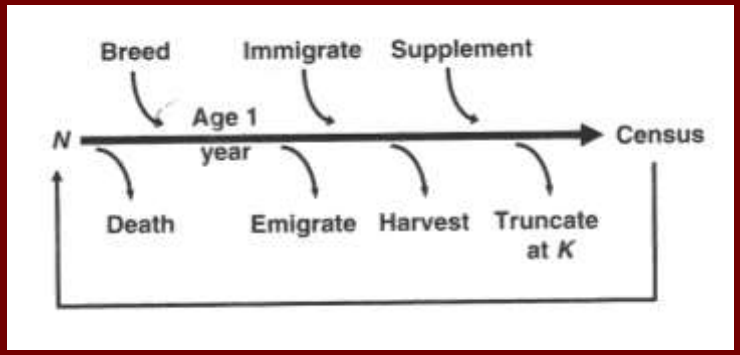
Population and Reserve Size

- But what MVP number do we need?
  - Franklin (1980) 50 to 500 individuals for MVP
  - Frankel & Soule (1981) 500 to 2000 individuals for MVP
  - Hawkes (1991) 1000 individuals for MVP
  - Lawrence and Marshall (1997) 5000 individuals for MVP
- Theoretical minimal size - Practical size (up to 10,000 are desirable), unless there is specific knowledge that points to lower number being adequate

Population Viability Analysis

- Provides a means of calculating MVP based on deterministic (human and predictable) and stochastic (natural and unpredictable) variables





- *VORTEX* – Free package provided by Bob Lacy (2005) at Chicago Zoo

- … but the algorithm has been criticised and you need a lot of data to make the prediction, maybe once you have the data you don't need to do the analysis

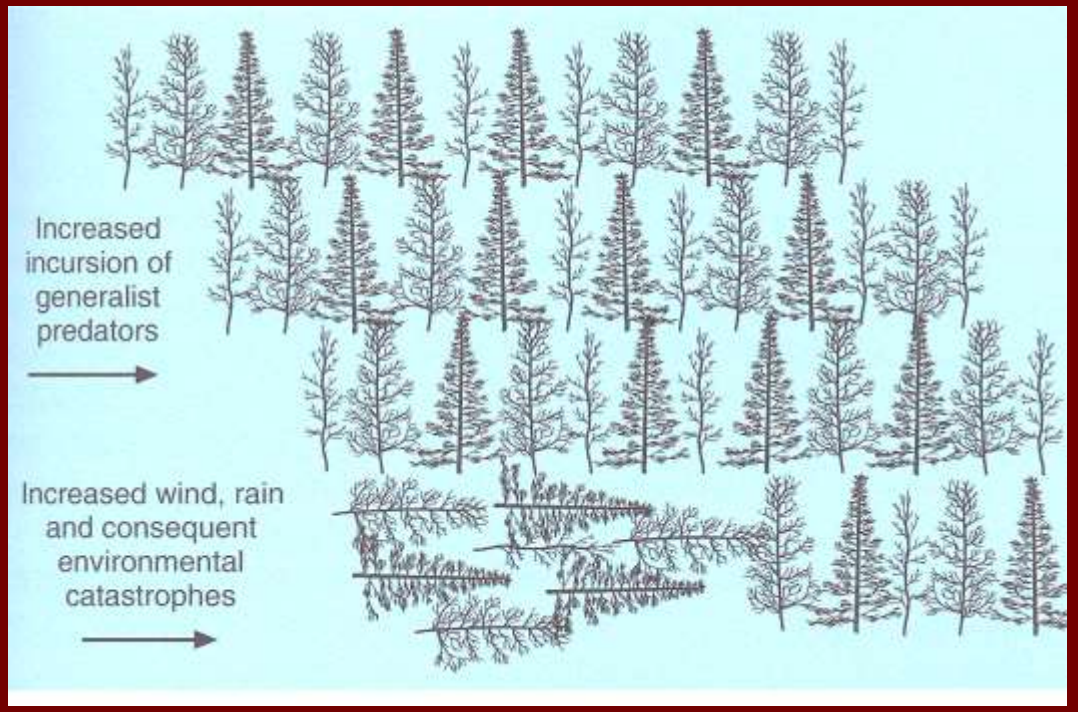
Problems of small populations

- Elephant seal (*Mirounga angustirostris*)
  - Hunted extensively
  - Late 1800's < 100
  - Today 130,000
  - Genetic bottleneck
    = vulnerable to disease

- Florida panther (*Felis concolor* subsp. *coryi*)
  - Historically found over SE USA
  - Now just central Florida
  - Today <50 animals
  - Incest, v low sperm count and congenital cardiac abnormality

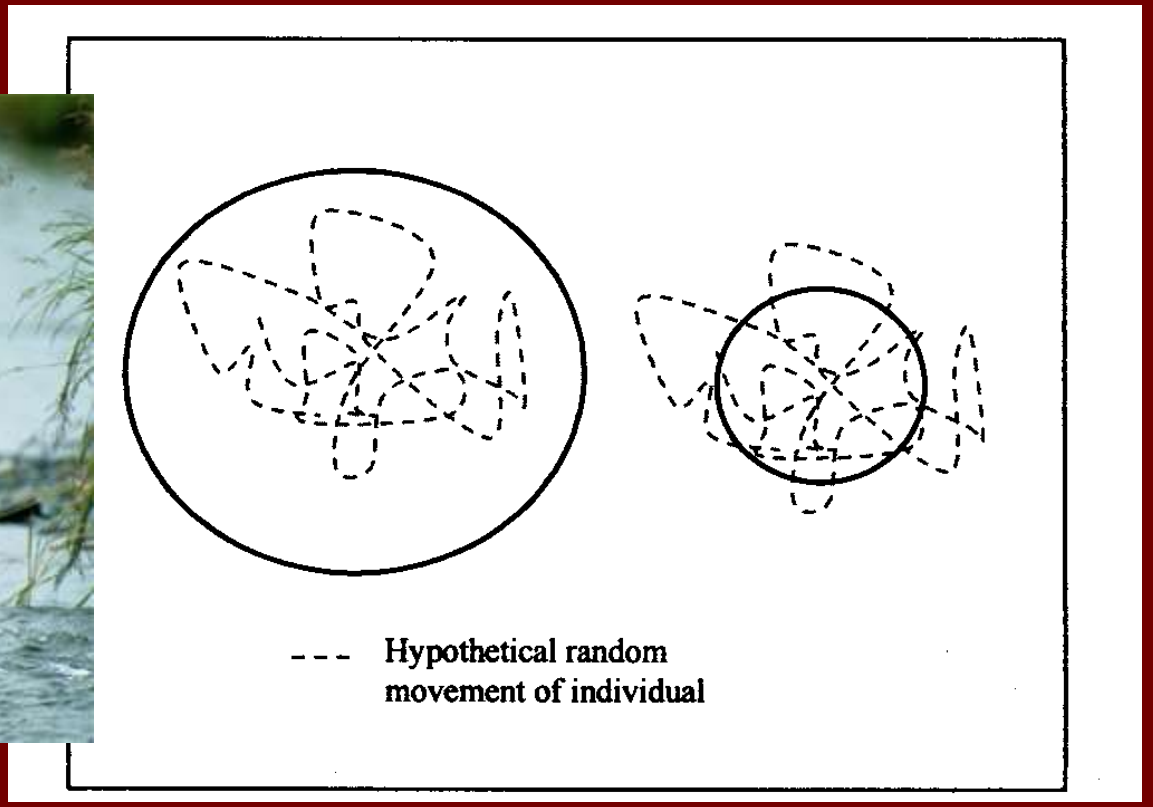
Reserve Shape

- Keep edge to a minimum to avoid deleterious micro-environmental effects = edge effect
  - Altered climate changing light, temperature levels
  - Increase environmental catastrophe wind, fire
  - Increase incursion of predators and competitors alien species, grazing, predation
  - Increase passive emigration from site
  - Increase deleterious anthropomorphic impacts



Reserve Shape

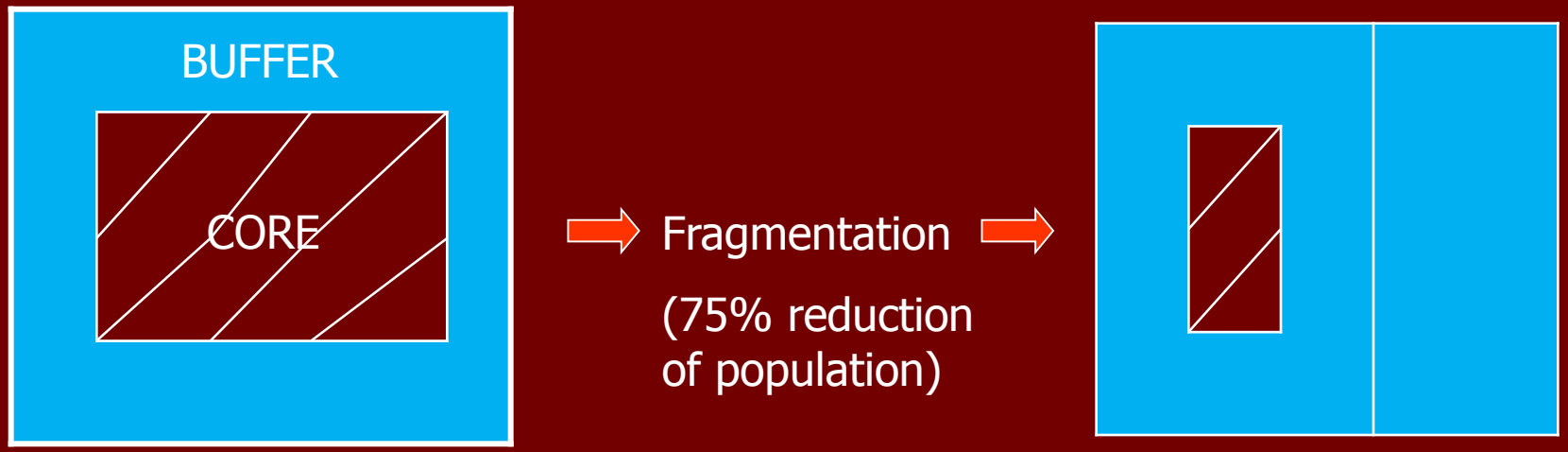
- Ideal - round (minimum edge to area ratio)



- Range size e.g. bears or elephants

Reserve Shape

- Avoid fragmentation by roads, fences, pipelines, dams, agriculture, intensive forestry and other human activities



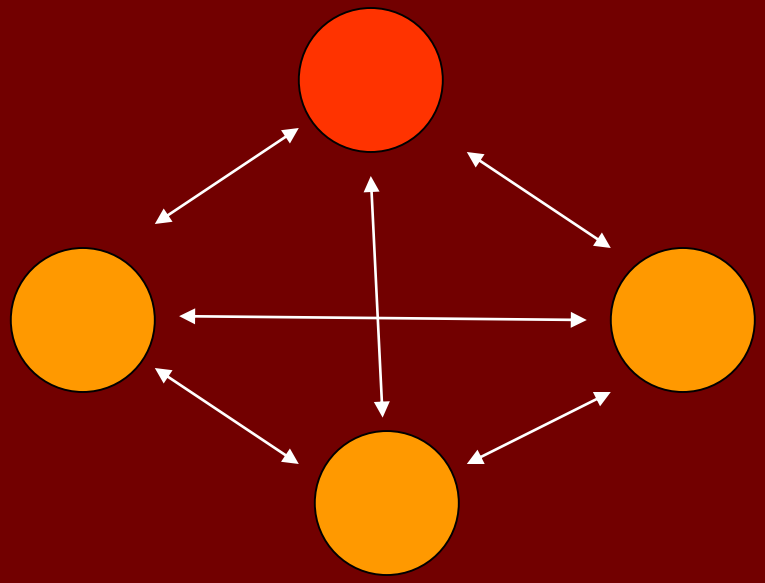
Corridors

- Small multiple reserve conservation improved by corridors facilitate gene flow and migration between the component reserves
- Meta-population management
- But habitat corridors have a high edge to area ratio and facilitate the rapid distribution of pest and disease between the reserves

Rouge Green Corridor, Birmingham

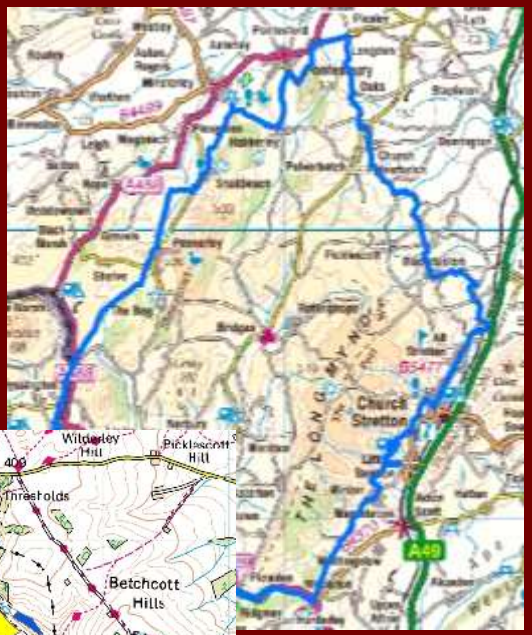
Metapopulation Theory

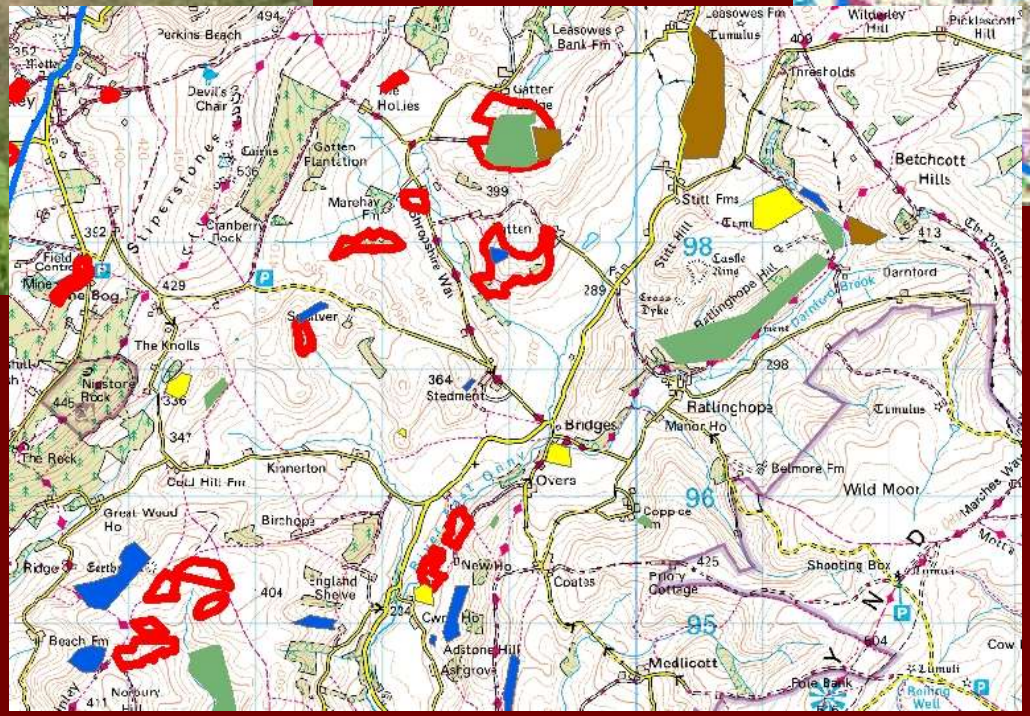
- Each population is discrete but connected facilitating migration
- Persistence of metapopulation is a function of equilibrium between colonisation and extinction
- Species survive even if individual populations go extinct because of recolonisation of empty patches



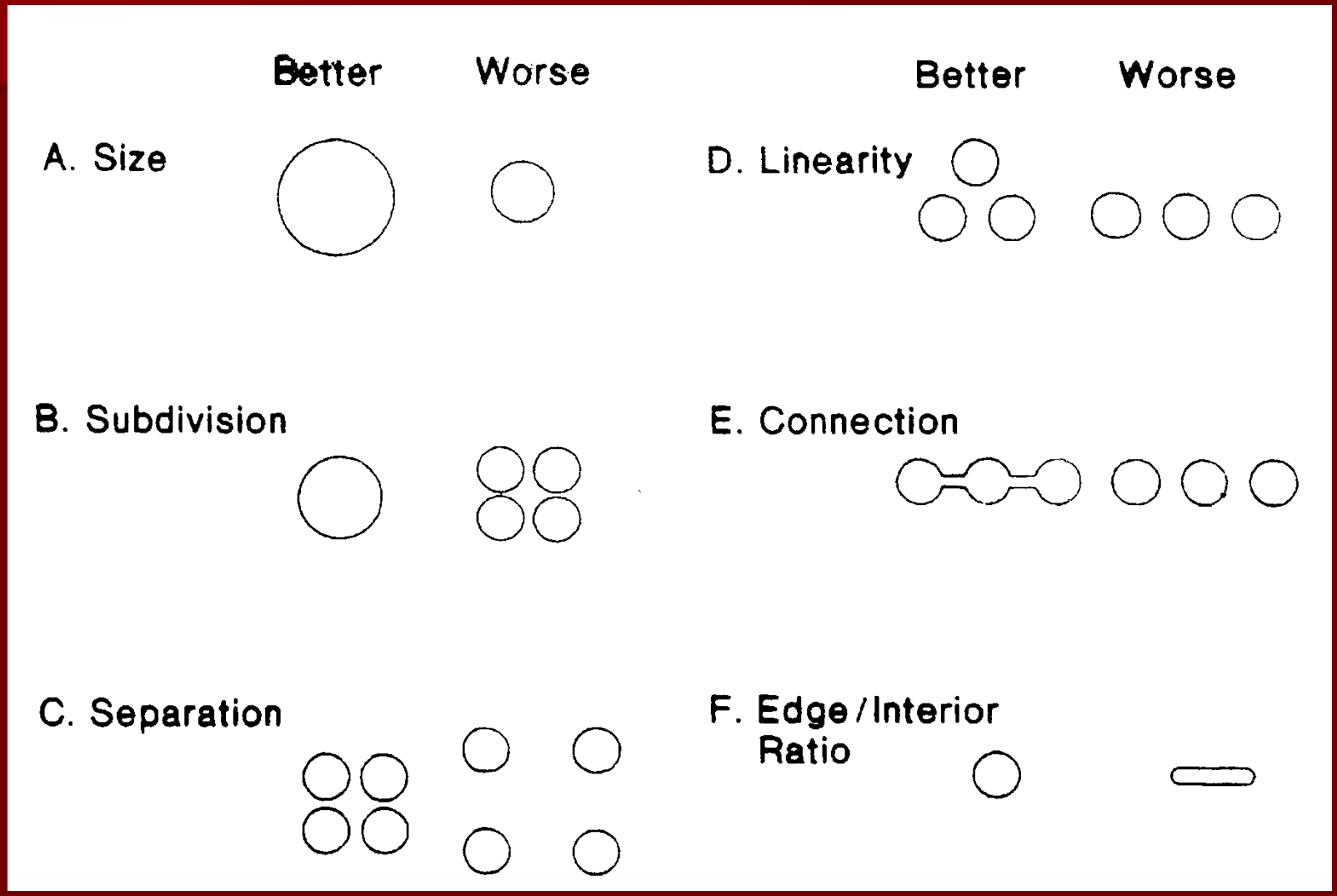
Corridors or Stepping Stone?

Shropshire case study: Long Mynd and Stiperstones





Reserve Design Summary



Habitat Diversity

- Choose sites with spatial or temporal heterogeneity to preserve ecotypic differentiation leading to more effective conservation of genetic diversity

- Management may include habitat disturbances (fires, storm damage, pest and disease epidemics, herbivory, floods and droughts). Leading to successional or cyclical change

- Pickett and Thompson (1978) - minimum dynamic area, which is the smallest area with a complete, natural disturbance regime

Political and Economic Factors Affecting Reserve Design

- Reserves rarely located on the basis of biological expedience
- Often on public land with conflicting or multiple land uses
- Idealized reserve design is pragmatically applied, allowing complementary use as an agricultural, industrial or recreational use build into design
- Relative cost and ease of establishing will affect selection of reserve sites and their design

Reserve Utilisation

- Four distinct categories of user's may utilise the reserve:
  - local (indigenous) people
  - general public
  - reserve visitors
  - scientists

Local Indigenous People

- Design must take account of local communities, local farmers, land-owners and other members of the local population which may utilise the proposed reserve site should be considered
- Consultations and agreements (hunter-gatherer community, shifting cultivation and wild plant 'harvesting')
- Meffe and Carroll (1994) Guanacaste National Park in Costa Rica - "biocultural restoration"
- Reserve staff should be recruited locally and the whole community should be encouraged to take pride in local conservation work

General Public

- Who funds conservation?
- Population at large, whether local, national or international and its support may be essential to the long-term political and financial viability of the reserve

- Increase public awareness = support of conservation issues

Reserve Visitors

- Ecotourists
- Promote income for local people
- Design reserve to meet visitors requirements,
  - visitors centres
  - natural trails
  - lecture hall
  - reserve information packs etc.

Scientific Community

- Research platform for conservationists and other biologists
- Characterisation and initial evaluation of the target taxon - link to utilisation

Qal'at Sala Hadeen, Syria