# Lecture 15, 20 Oct 2003

Chapters 4, 5, 6, 7

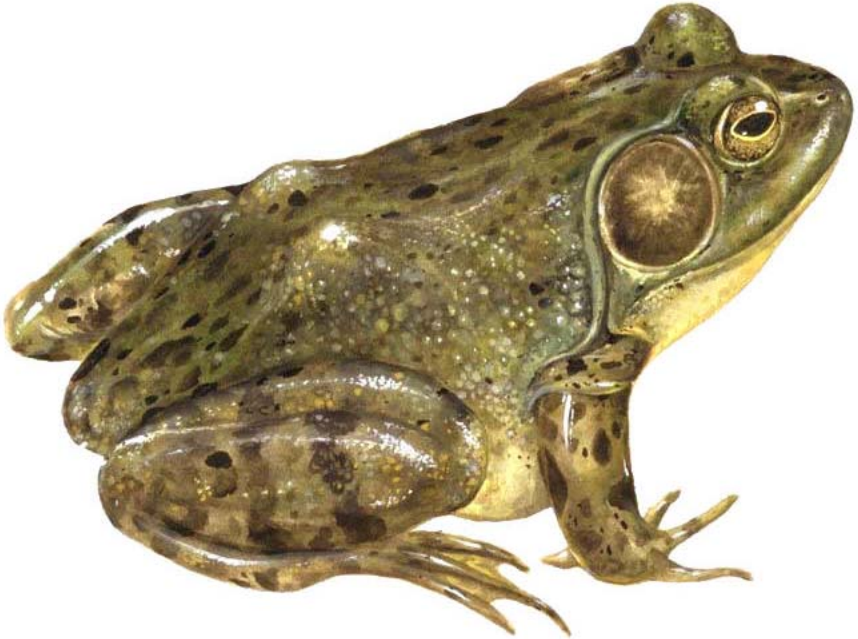
# Conservation Biology
# ECOL 406R/506R
# University of Arizona
# Fall 2003

Kevin Bonine

1. Biodiversity, Scale (Ch4)
2. Important Paradigms (Ch5)
3 Conservation Genetics (CH6)
4 Populations (CH7)

- (loose ends)
- Exam Wednesday
- Field trip
  - -readings (more to come)
  - -groups
  - -gear, cars

http://www.az.blm.gov/tfo/index.htm
= SanPedroInfo



American Bullfrog

http://endangered.fws.gov/esb/2002/03-06/12-15.pdf
= USFWS endangered spp bulletin, SDCP

NATURAL HISTORY LECTURE SERIES
International Wildlife Museum
Tuesday, October 21, 2003
7:00pm
The Wildlife Theater

"The Giant Moa Birds of New Zealand: Their History and Possible Survival"

Moas were large, ostrich-like birds that survived in New Zealand until hunted to extinction by the native Maori people about 500 years ago - or so it is thought. Mr. Greenwell will present the colorful history of the zoological discovery of moas, and both 19th and 20th century moa sighting evidence that indicates that small moa populations may yet survive on South Island.

Admission is $3 for non-members, free for members. The Oasis Grille opens at 5pm for dinner.
INTERNATIONAL WILDLIFE MUSEUM
4800 W Gates Pass Road
Tucson, AZ

5 miles west of Interstate 10
For Further Information call: 520 629-0100, ext 336
www.thewildlifemuseum.org

Exam 2 on Wednesday 22 Oct:

Biological Species Concept
alpha, beta, gamma diversity
  -scale
Community definition
Functional types/analogs
Species Richness/Evenness
Shannon Diversity Index
Madagascar Periwinkle
Mountain Lions as examples
Tuatara and endemism
Pricing Biodiversity
Biodiversity
  -where is it?
  -what contributes to it?
Role of disturbance in biodiversity
Habitat Heterogeneity
Species-Area Relationships
Rosenzweig's 3-step loss of biodiversity
Island Biogeography...

...Metapopulations
Habitat
  -quantity, quality, distribution, connectivity
Source vs. Sink
Invasive Species

(Relate chapter material to guest lectures)
Conservation Genetics:
  Rob Robichaux lecture and reading
  Melanie Culver lecture and reading

Population Viability Analysis:
  Margaret Evans
  exponential and logistic (understand)
  sensitivity and elasticity
  stochasticity
  what determines/affects population size?
  Florida Panther example

Loose Ends…

Umbrella Species
Indicator Taxa (or structure or function, redundancy)
Keystone Species (bison)

Areas of high endemism for one group may
not be high areas of endemism or BD for another group

Hotspots?

Where is biodiversity?

One tree in peru with same ant diversity as Britain

# Where is Biodiversity?

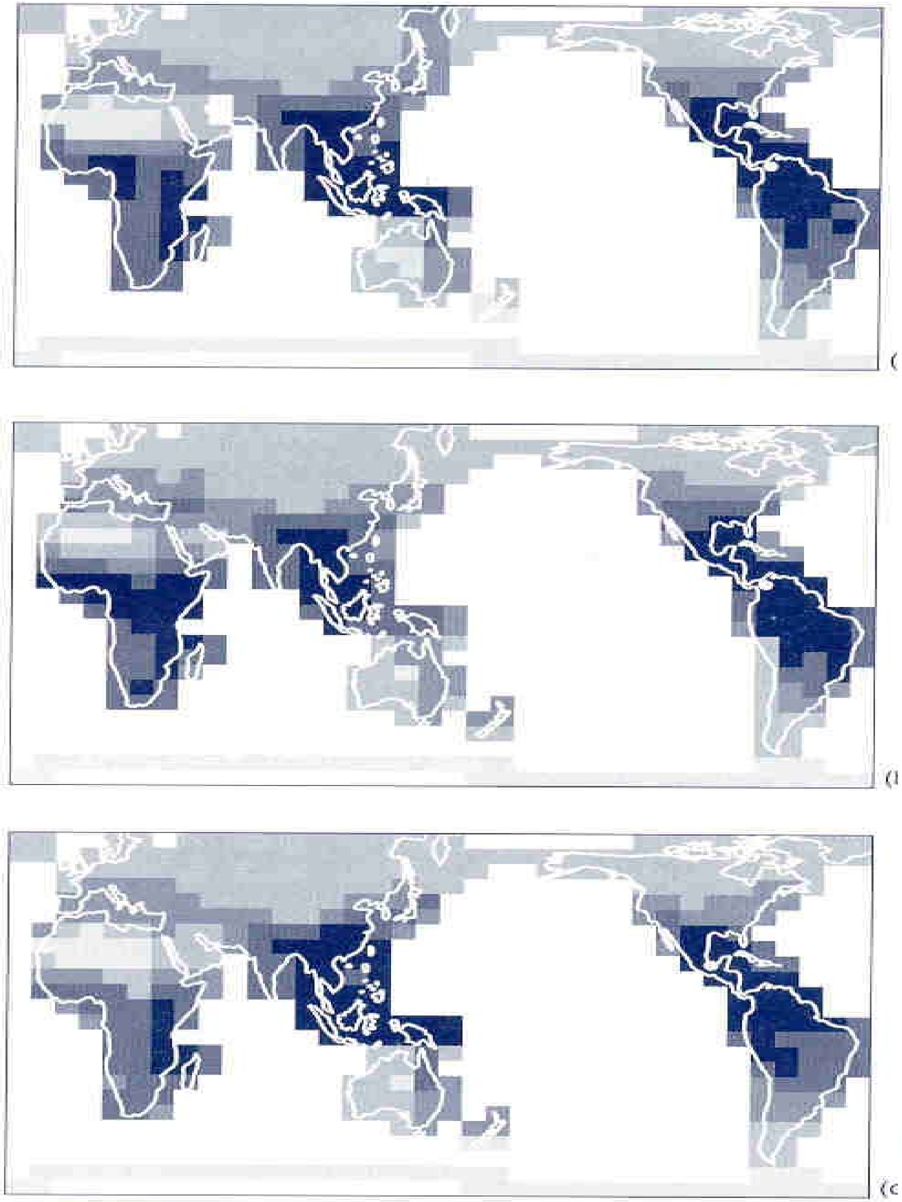


**Figure 4.13** Van Dyke 2003
Maps of combined family richness of terrestrial and freshwater seec plants, amphibians, reptiles, and mammals worldwide on an equal area grid map (grid-cell area ca. 611,000 km$^2$, for intervals of 10° longitude). Maps produced by summing (a) absolute family richness; (b) proportional family richness; and (c) proportional family richness weighted for species richness. Maximum scores shown in

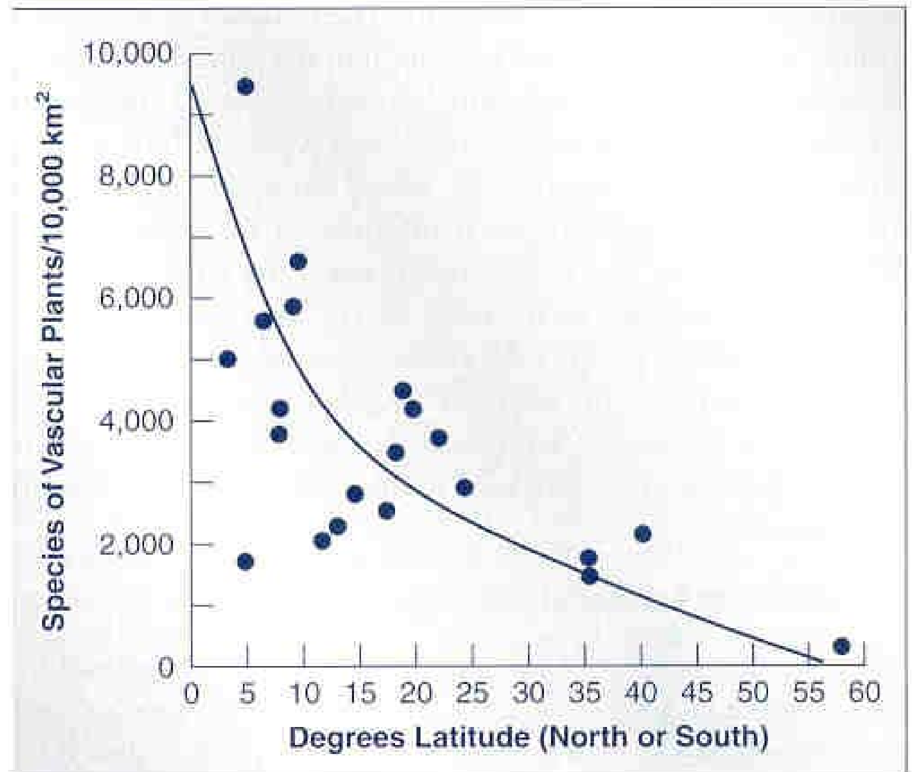



**Figure 4.12**
Latitudinal patterns in species richness from tropical to temperate regions. In most taxa the number of species increases from temperate to tropical regions.

Van Dyke 2003

*After Reid and Miller (1989). Reprinted from Huston (1994).*

## Table 4.9 Areas of Disproportionately High Plant Biodiversity (Hot Spots) in Tropical Forests

| HOT SPOT | AREA OF FOREST ($KM^2$) ORIGINAL | PRESENT (PRIMARY)* | PLANT SPECIES IN ORIGINAL FORESTS | NUMBER OF ENDEMICS IN ORIGINAL FORESTS (PERCENTAGE) | | ENDEMICS AS PERCENT OF EARTH'S TOTAL PLANTS | PRESENT FOREST AREA AS PERCENT OF EARTH'S LAND SURFACE |
|---|---|---|---|---|---|---|---|
| Madagascar | 62,000 | 10,000 | 6,000 | 4,900 | (82) | 1.96 | 0.00675 |
| Atlantic Coast Brazil | 1,000,000 | 20,000 | 10,000 | 5,000 | (50) | 2.00 | 0.0135 |
| Western Ecuador | 27,000 | 2,500 | 10,000 | 2,500 | (25) | 1.00 | 0.0017 |
| Colombian Chocó | 100,000 | 72,000 | 10,000 | 2,500 | (25) | 1.00 | 0.0486 |
| Uplands of western Amazonia | 100,000 | 35,000 | 20,000 | 5,000 | (25) | 2.00 | 0.0236 |
| Eastern Himalayas | 340,000 | 53,000 | 9,000 | 3,500 | (39) | 1.40 | 0.0358 |
| Peninsular Malaysia | 120,000 | 26,000 | 8,500 | 2,400 | (28) | 0.96 | 0.0175 |
| Northern Borneo | 190,000 | 64,000 | 9,000 | 3,500 | (39) | 1.40 | 0.04 |
| Philippines | 250,000 | 8,000 | 8,500 | 3,700 | (44) | 1.48 | 0.0054 |
| New Caledonia | 15,000 | 1,500 | 1,580 | 1,400 | (89) | 0.56 | 0.001 |
| Totals | 2,204,000 | 292,000 | † | 34,400 | | 13.8 | 0.2 |
| **For comparison:** | | | | | | | |
| Hawaii | 14,000 | 6,000 | 825 | 745 | (88) | 0.30 | 0.004 |
| Queensland | 13,000 | 6,300 | 1,165 | 435 | (37) | 0.17 | 0.004 |

*Some, though not many, primary forest species can survive in degraded forests.

†It is unrealistic to sum these figures for plant species, on the grounds that there is some overlap between adjacent regions (e.g., some plants occur in peninsular Malaysia, northern Borneo, and the Philippines).

Source: After Myers 1988.

Van Dyke 2003

# Genetic Diversity (terminology)

- $N_e$
- stochasticity
- drift
- loss of heterozygosity
- inbreeding depression
- Hardy-Weinberg Equilibrium

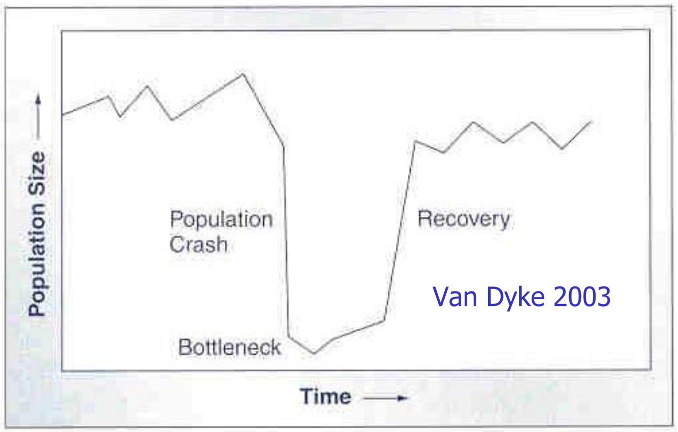



**Figure 5.2**
A graphical representation of population size before, during, and after a population bottleneck.

maternal effects

# Bottlenecks:

Van Dyke 2003

**Table 5.1** Percent Change in Genetic Variation and Proportion of Rare Alleles Lost from a Population at Bottlenecks (Minimum Sizes) of Different Magnitudes. Values of $p$ represent proportions of each of 4 alleles

| NUMBER OF INDIVIDUALS IN SAMPLE ($N$) | PERCENT CHANGE IN GENETIC VARIATION | PROPORTION OF RARE ALLELES LOST | |
|---|---|---|---|
| | | $p_1 = 0.70, p_2 = p_3 = p_4 = 0.10$ | $p_1 = 0.94, p_2 = p_3 = p_4 = 0.02$ |
| 1 | 50.0 | 0.6300 | 0.7200 |
| 2 | 25.0 | 0.4950 | 0.6925 |
| 6 | 8.3 | 0.2125 | 0.5900 |
| 10 | 5.0 | 0.0925 | 0.5000 |
| 50 | 1.0 | 0.0025 | 0.1000 |
| $\infty$ | 0.0 | 0.0000 | 0.0000 |

Source: After Frankel and Soulé 1981.

# Inbreeding Coefficient

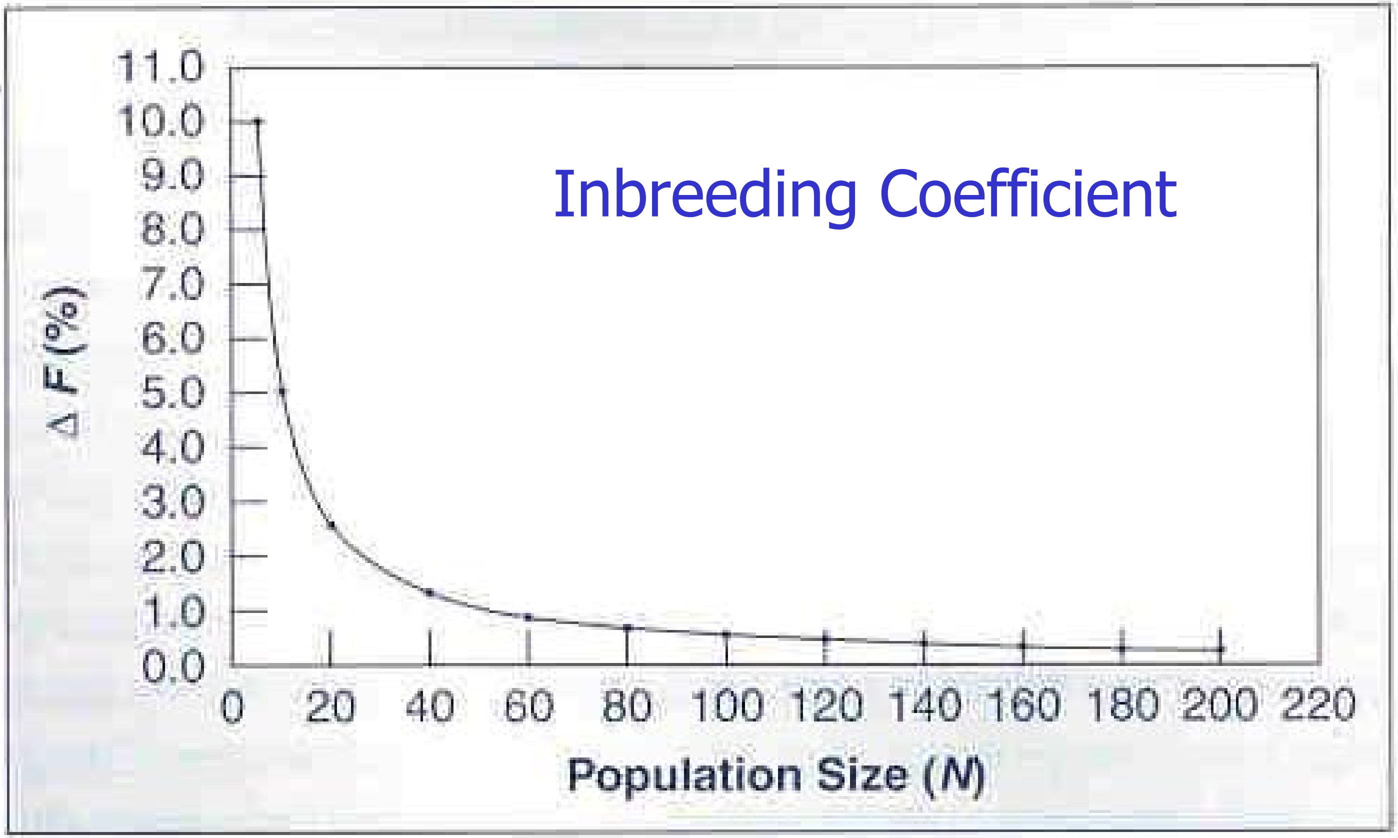



**Figure 5.3**

Percent change in the inbreeding coefficient ($\Delta F$) at different population sizes. Note that the value of the inbreeding coefficient increases as population size declines.

*After Frankel and Soulé (1981).*

Van Dyke 2003

# Island Biogeography
(MacArthur and Wilson 1967)

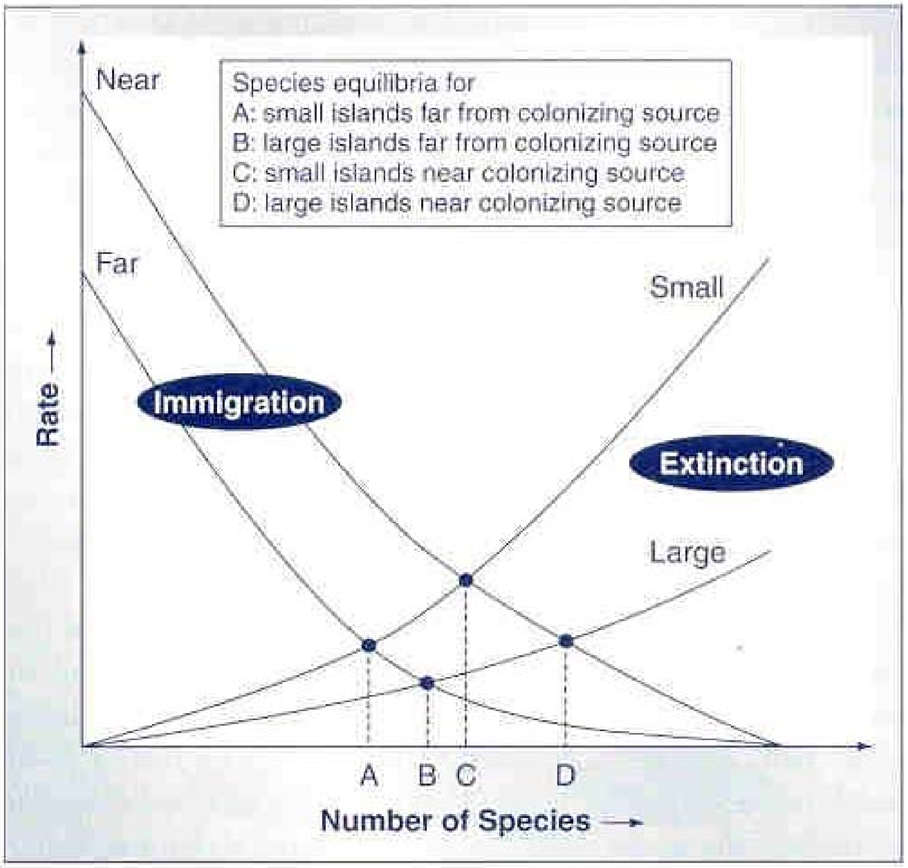



**Figure 5.9**
The equilibrium model of island biogeography predicts that numbers of species on an island represent an equilibrium between rates of immigration and extinction. Immigration rates increase with decreasing distance from an island's colonizing source. Extinction rates increase with decreasing area of the island. The four equilibria shown (A, B, C and D) depict different combinations of island size and distance from its colonizing source. The equilibrium theory of island biogeography predicts that large islands near a colonizing source will have more species than small islands far from a colonizing source.

# Metapopulations
# Spatial Relationships
# Nature Reserves

# Landscape-scale or metapopulation models

- amount of habitat
- quality of habitat
- distribution or configuration of habitat
- connectivity of habitat

# Landscape-scale or metapopulation models

**Patch size matters**

populations in smaller habitat patches (‘islands”) are more likely to go extinct than populations in larger habitat patches

**Patch isolation matters**

the more isolated an unoccupied habitat patch is from occupied habitat patches, the less likely that it will be colonized

The Theory of Island Biogeography (MacArthur and Wilson 1967)
Metapopulation Theory (Levins 1969 and others)

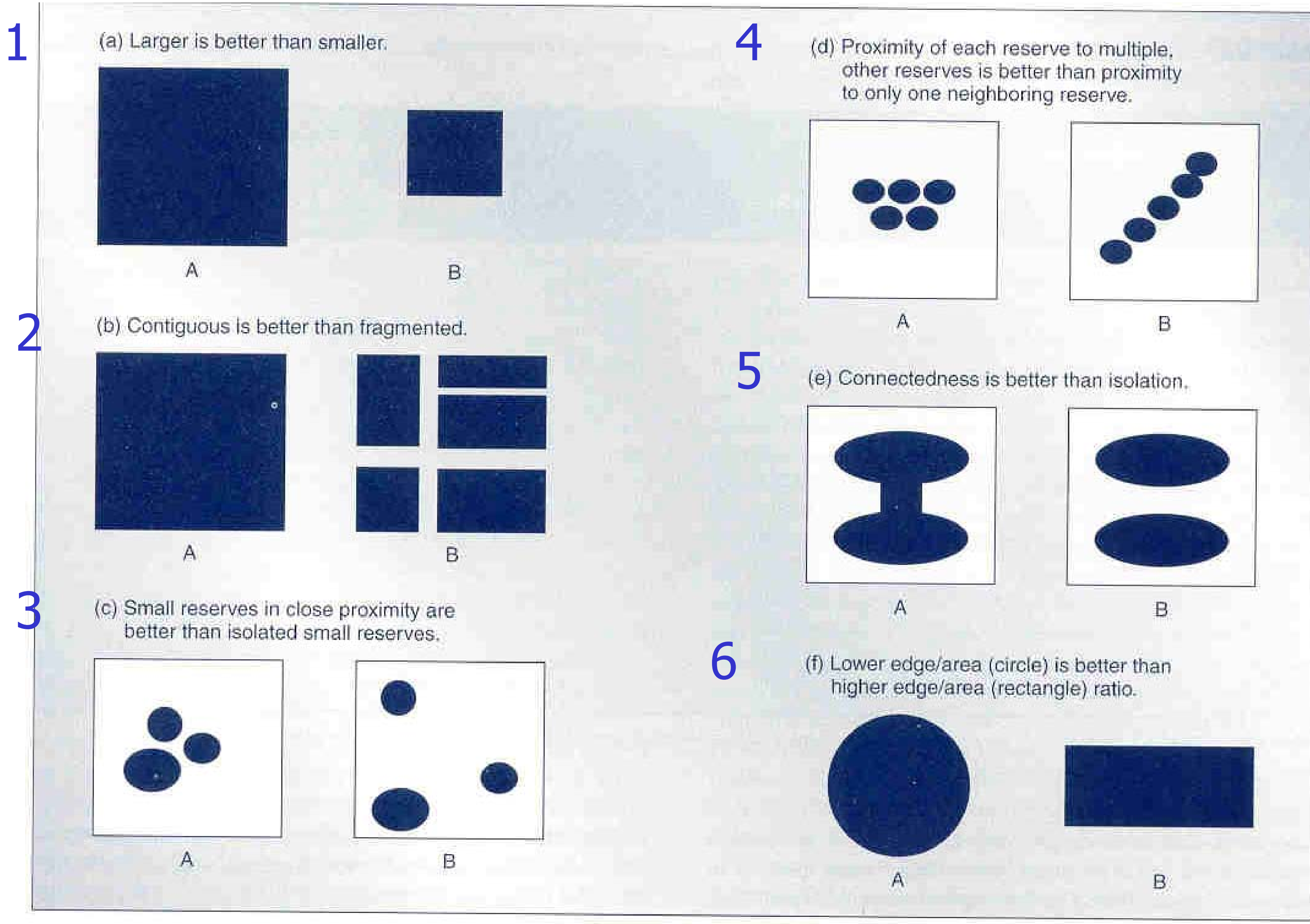
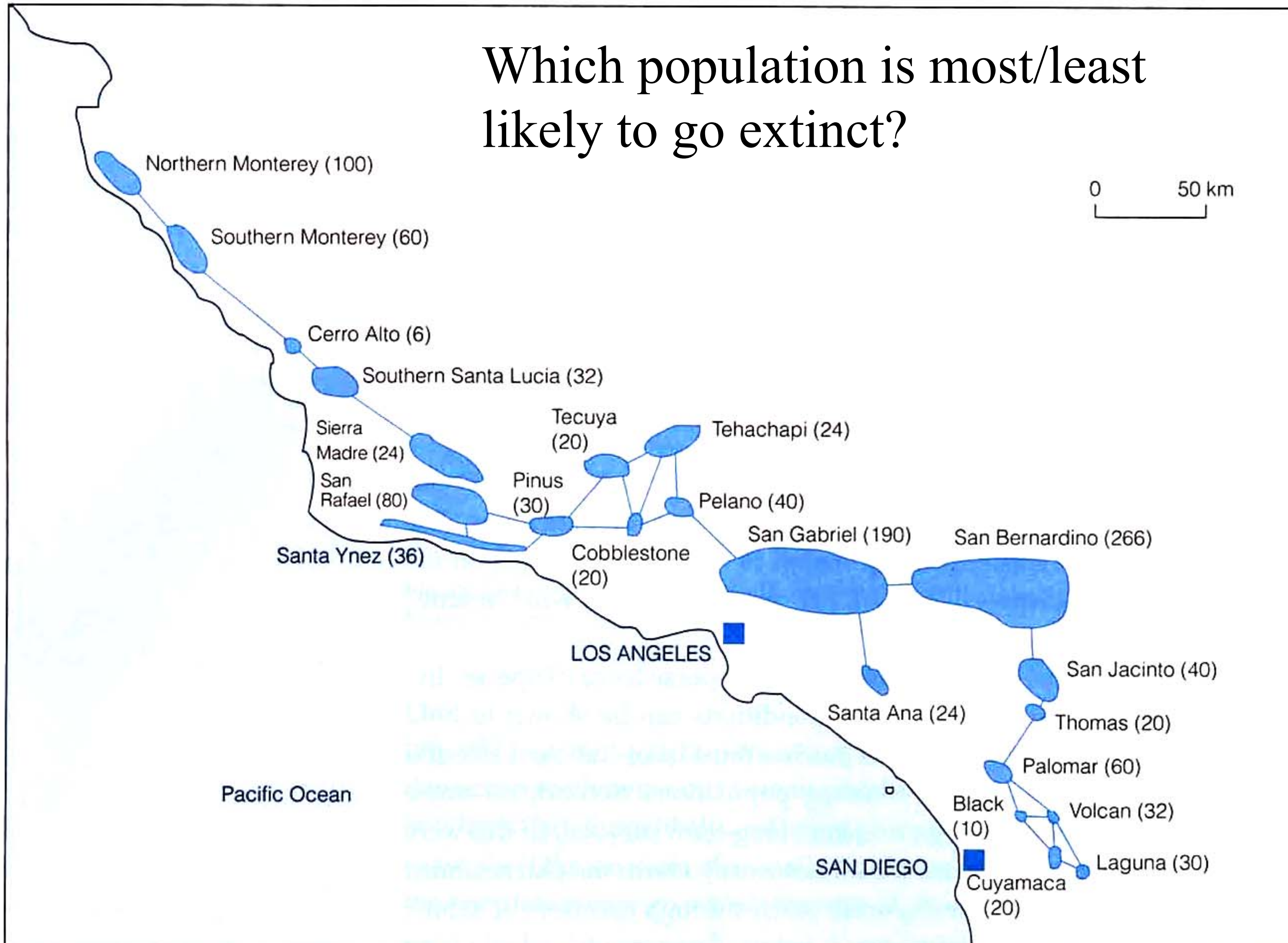



**Figure 5.10**

A graphical representation of the "rules" of island biogeography applied to nature reserves. In each case, design A is considered superior to design B.

# Landscape-scale or metapopulation models

Which population is most/least likely to go extinct?



# Landscape-scale or metapopulation models

**Patch quality matters**

populations in habitat patches of higher quality are less likely to go extinct than populations in patches of lower quality

A “**source**” is an area where b>d.  Excess individuals may emigrate from a “source” patch.

A “**sink**” is an area where d>b.  Populations in sink patches are certain to go extinct.  Sink populations may be “rescued” by immigration from source populations (the **rescue effect**).

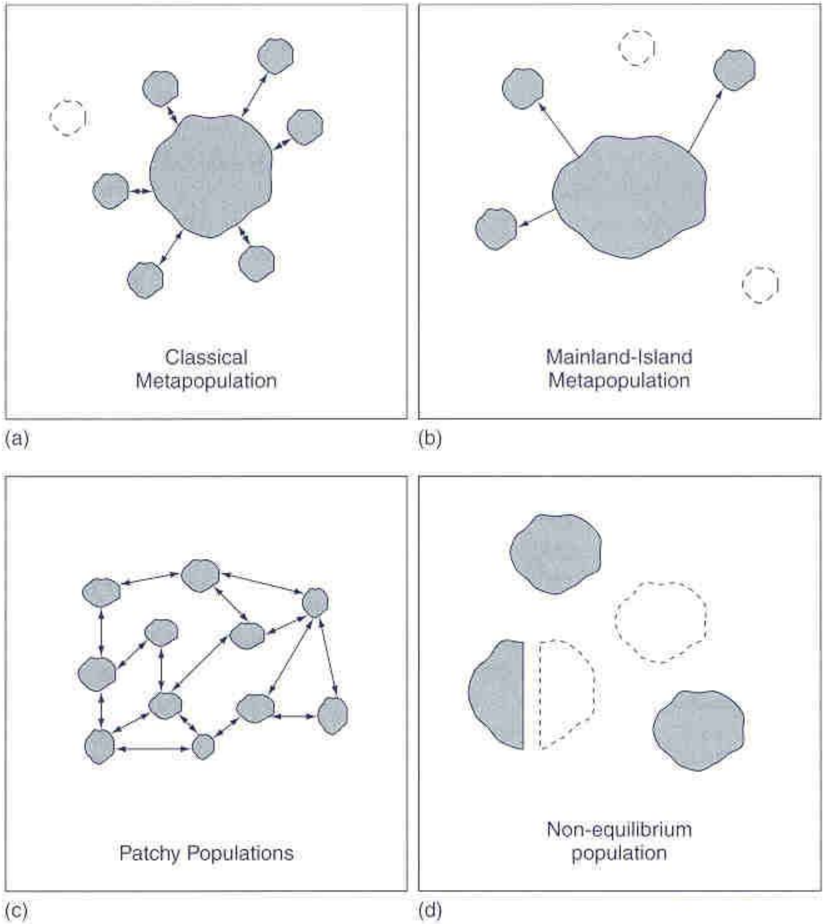



**Figure 5.16**
Types of metapopulation models. In a *classical metapopulation*, (a) some colonies may not exhibit high rates of movement for long periods of time. Also, colonization may unite several patches within a larger patch as a single entity that contributes to other sinks. Colonies farthest from the source are most prone to extinction. The *mainland-island metapopulation* (b) depicts local extinctions occurring mainly among a subset of populations. The mainland/source, resistant to extinction, functions as the major provider of colonists. The island and sink metapopulations have little effect upon regional persistence. In *patchy populations* (c), because of the high levels of emigration and immigration, the patches function as a single unit. It is rare that discrete local populations become extinct. The absence or insufficiency of recolonization to balance extinction distinguishes *nonequilibrium populations* (d). Extinction of metapopulations occurs as part of an overall regional decline (i.e., a product of the reduction, fragmentation, or deterioration of a habitat).

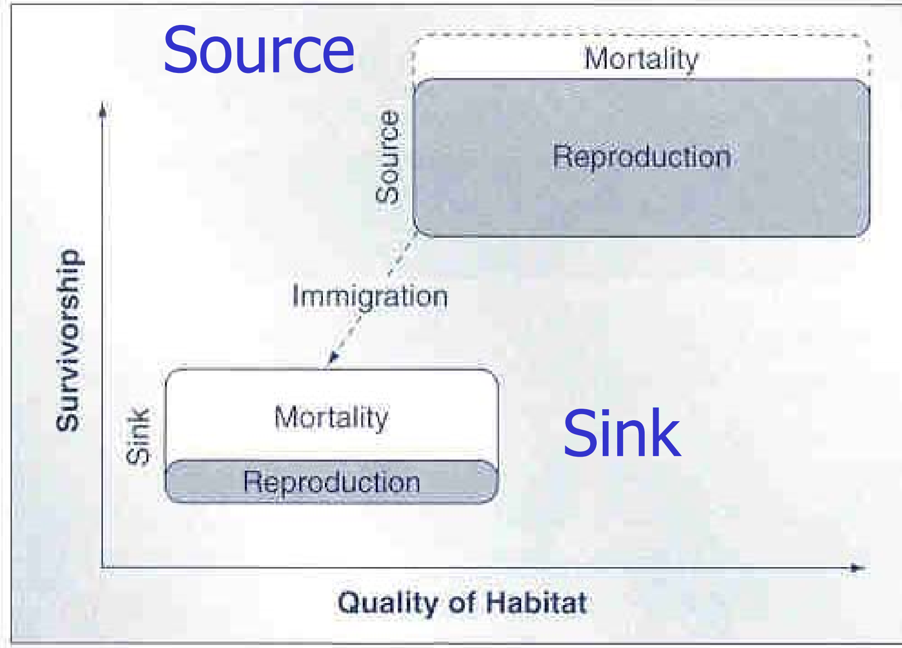
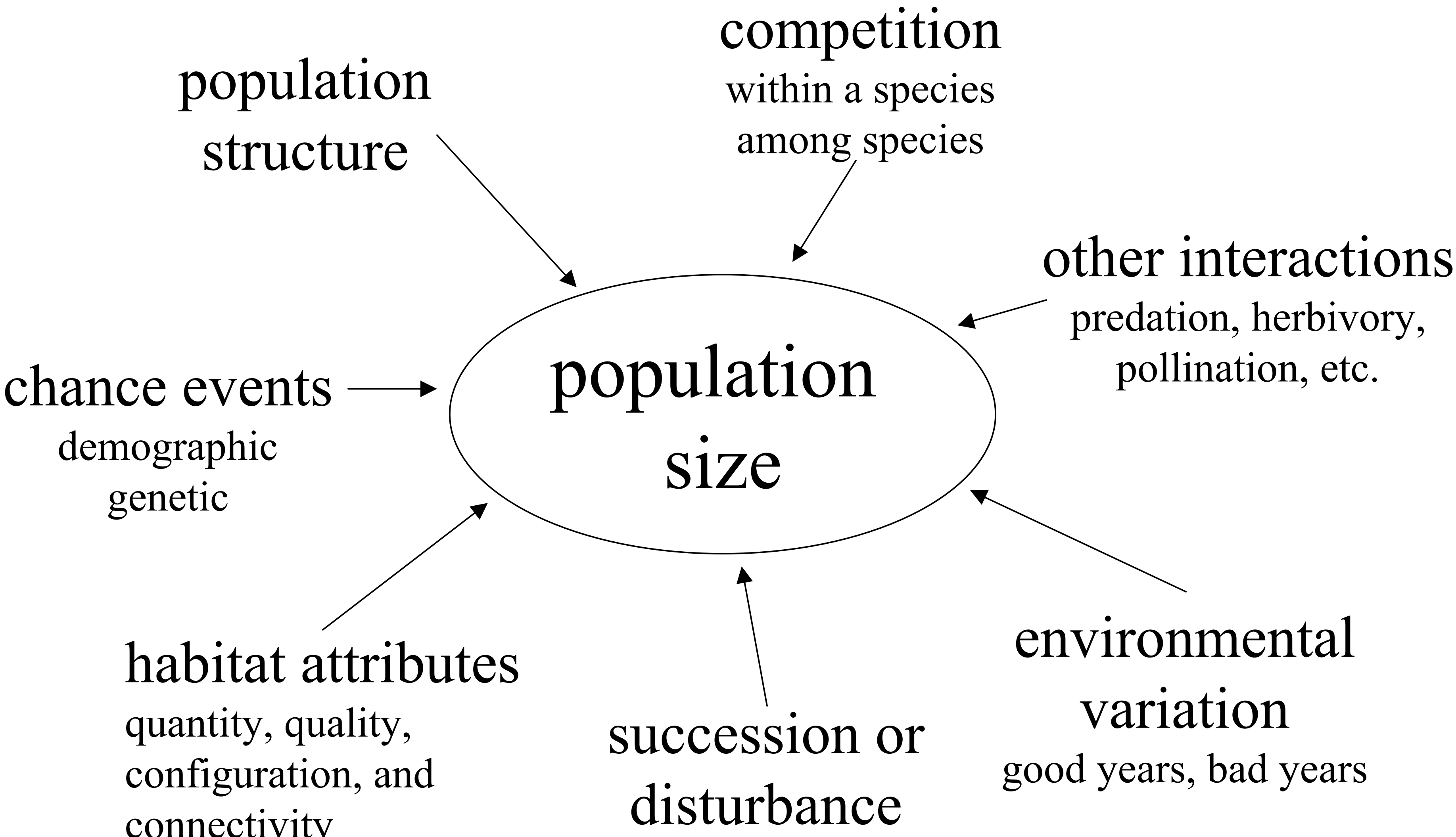



**Figure 5.17**
A visual representation of the source-sink model of habitat distribution. In source habitats, reproduction produces a population surplus (i.e., mortality does not decrease the number of individuals because of overcompensation through reproduction). Surplus individuals move to sink habitats where mortality exceeds survivorship. Sink habitats cannot be maintained by reproduction, but depend on immigration to maintain a population.

# Many things affect population size



Metapopulation:

“Spatially disjunct groups of individuals with some demographic or genetic connection”

“largely independent yet interconnected by migration”

1. All local populations must be prone to extinction
2. Persistence of entire population requires recolonization of individual sites.

See p.193 in VanDyke text

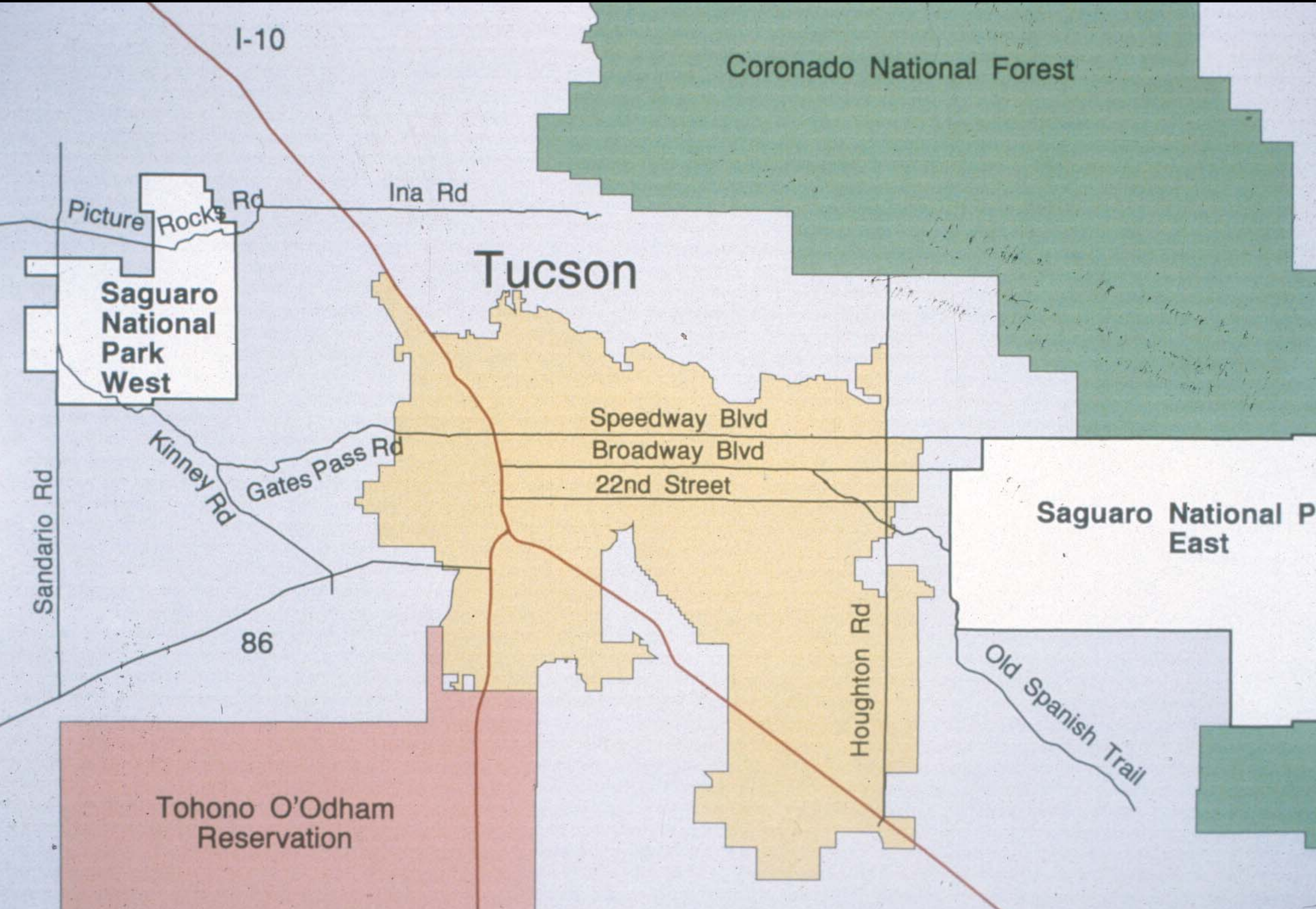
*Rana yavapaiensis*

Lowland Leopard Frog

(Thanks to Don Swann, SNP)

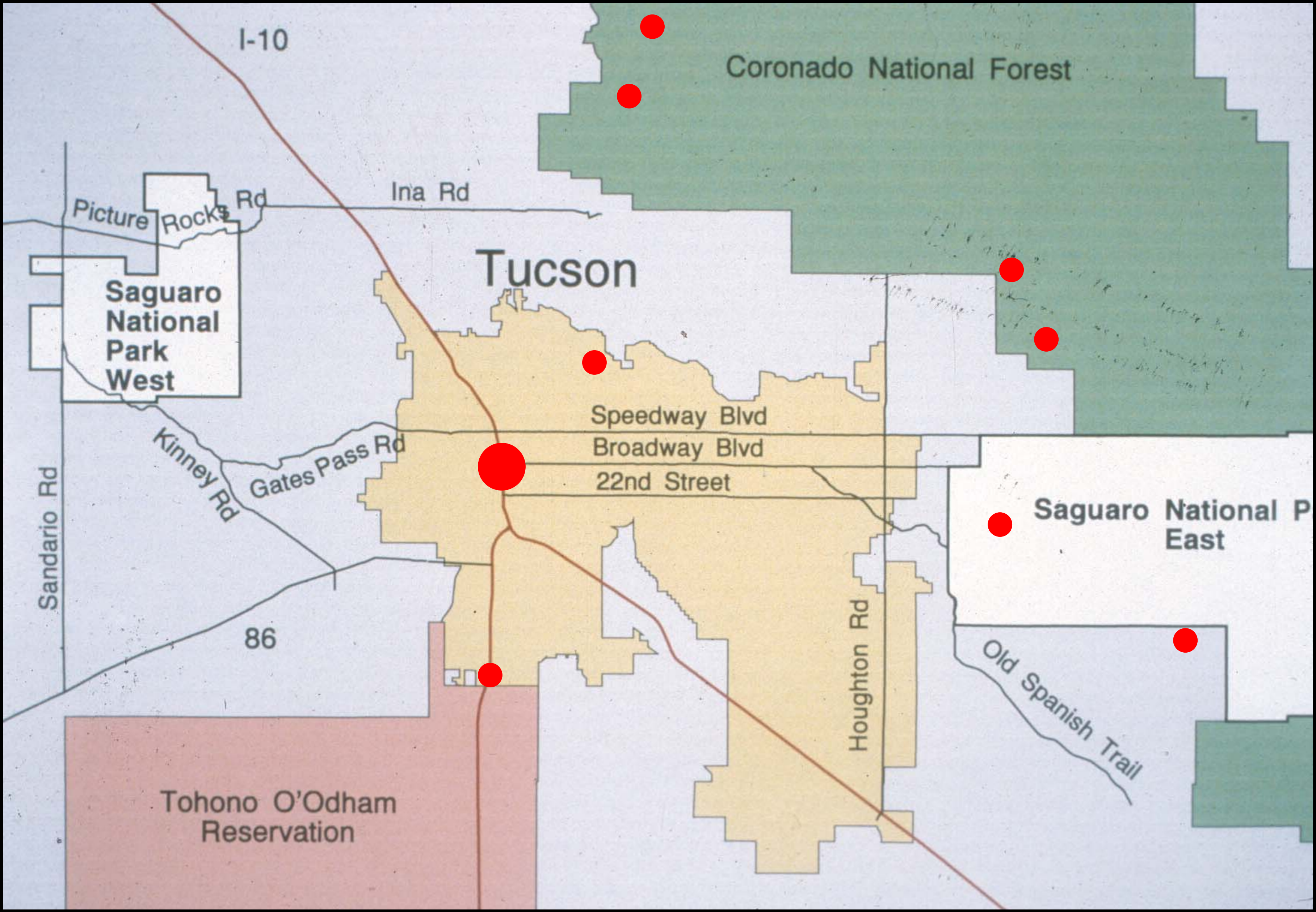
Metapopulation?

Habitat Loss
Alien species
Disease (chytridiomycosis)



I-10
Coronado National Forest
Ina Rd
Picture Rocks Rd
Tucson
Saguaro National Park West
Speedway Blvd
Broadway Blvd
22nd Street
Kinney Rd
Gates Pass Rd
Sandario Rd
86
Houghton Rd
Saguaro National P
East
Old Spanish Trail
Tohono O'Odham Reservation

Santa Cruz River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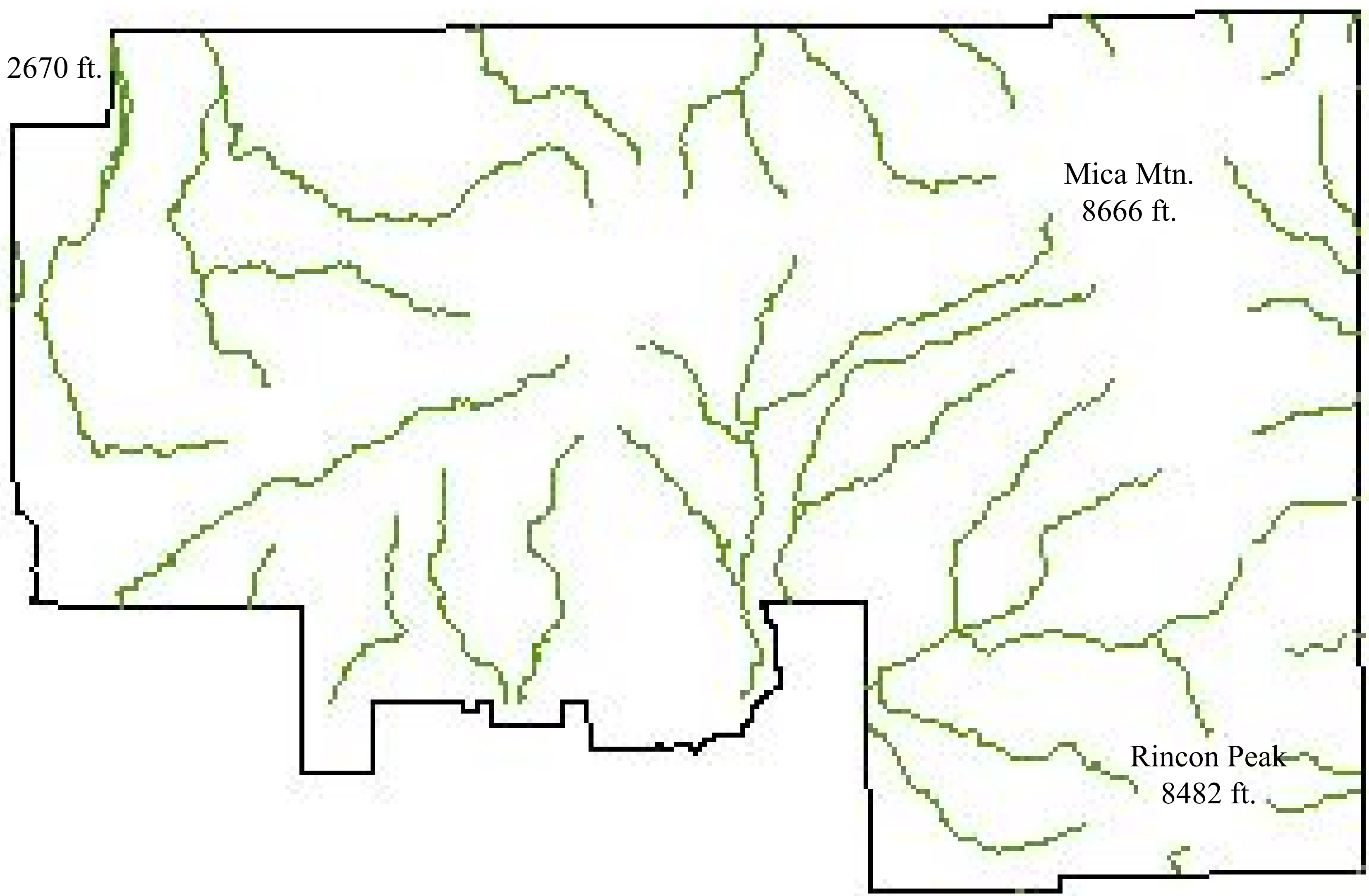
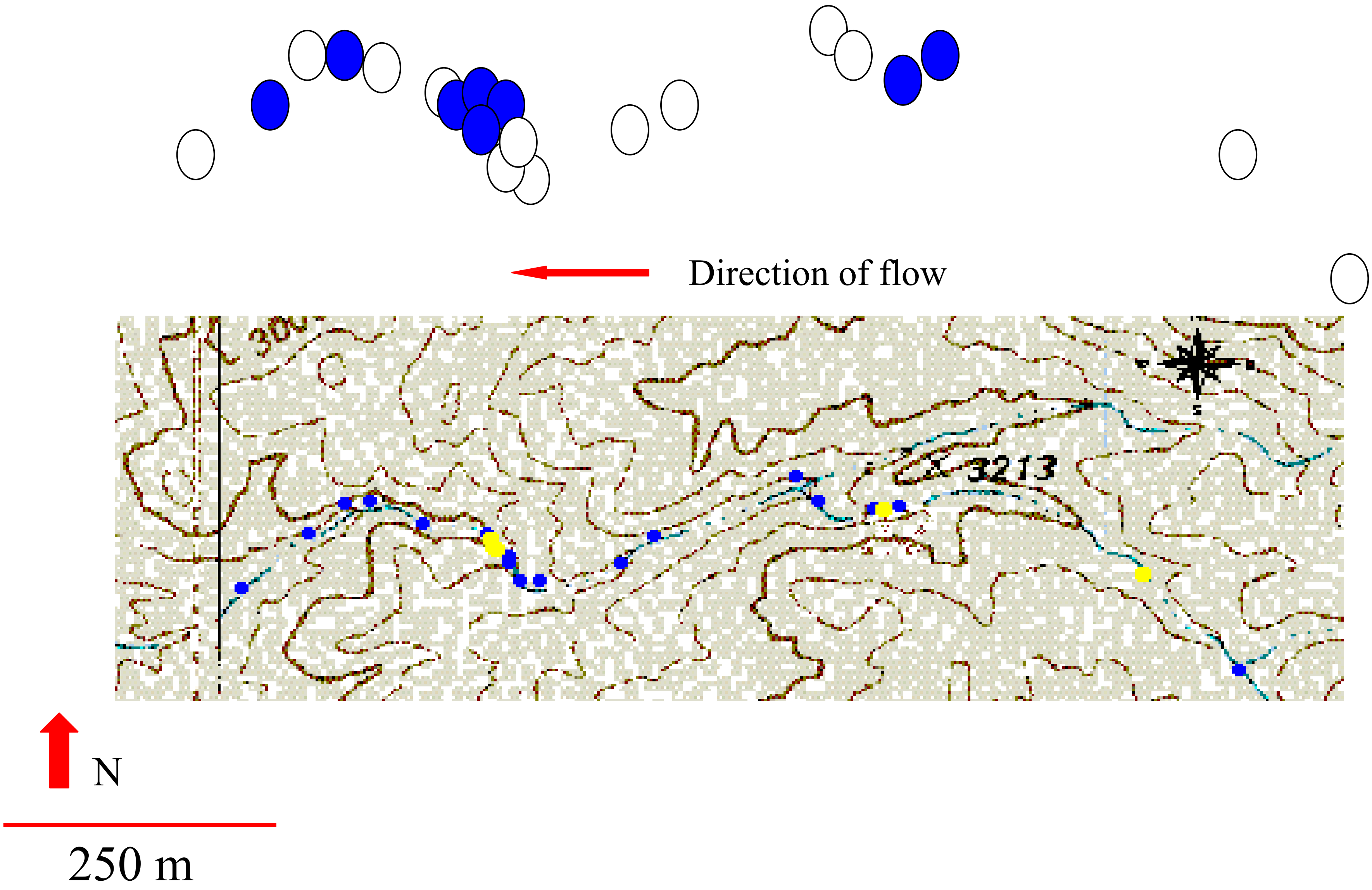
22nd Street
Kinney Rd
Gates Pass Rd
Sandario Rd
86
Saguaro National P
East
Houghton Rd
Old Spanish Trail
Tohono O'Odham
Reservation


Environmental Stochasticity

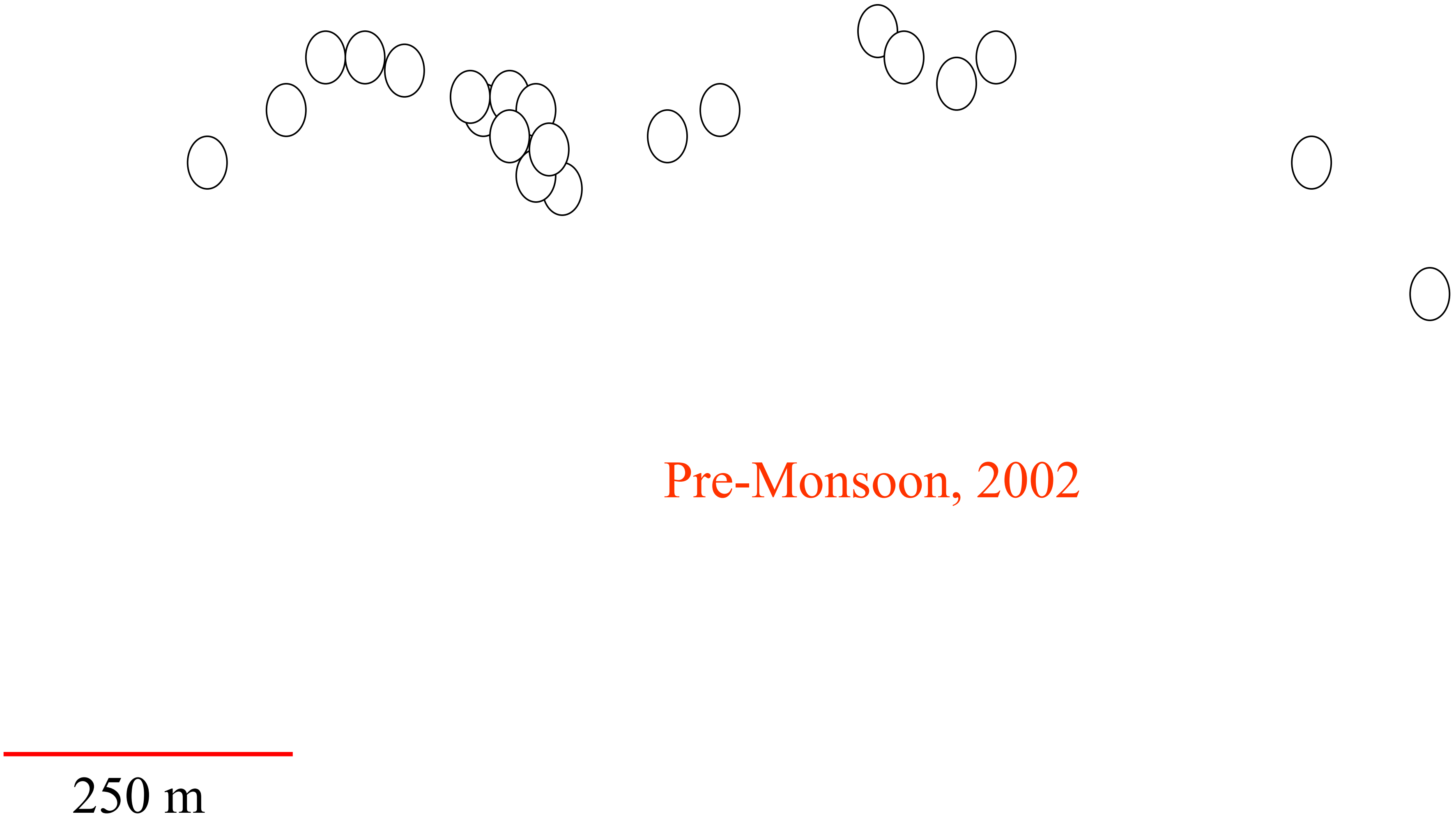
# Saguaro National Park - Rincon Mountain District

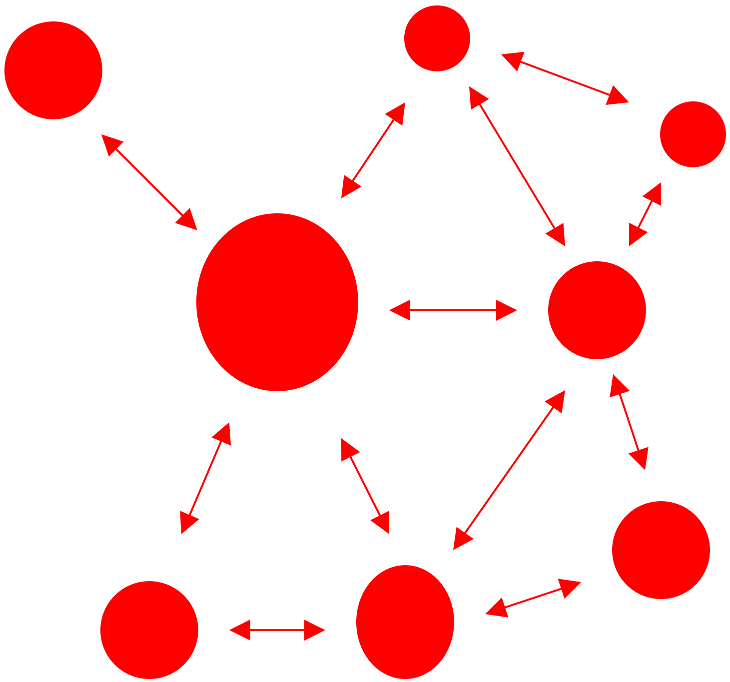


# Schematic of Study Canyon, Saguaro NP

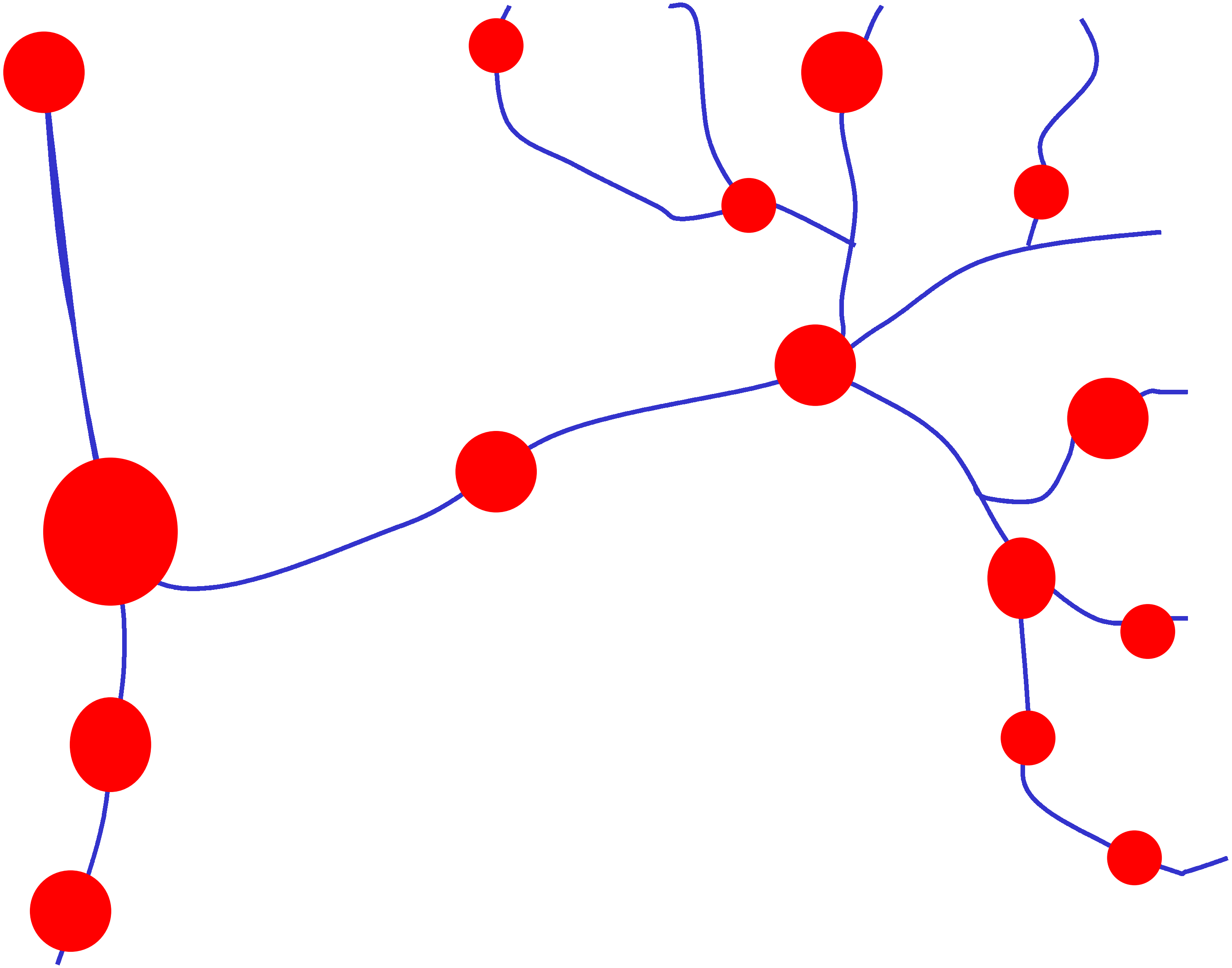


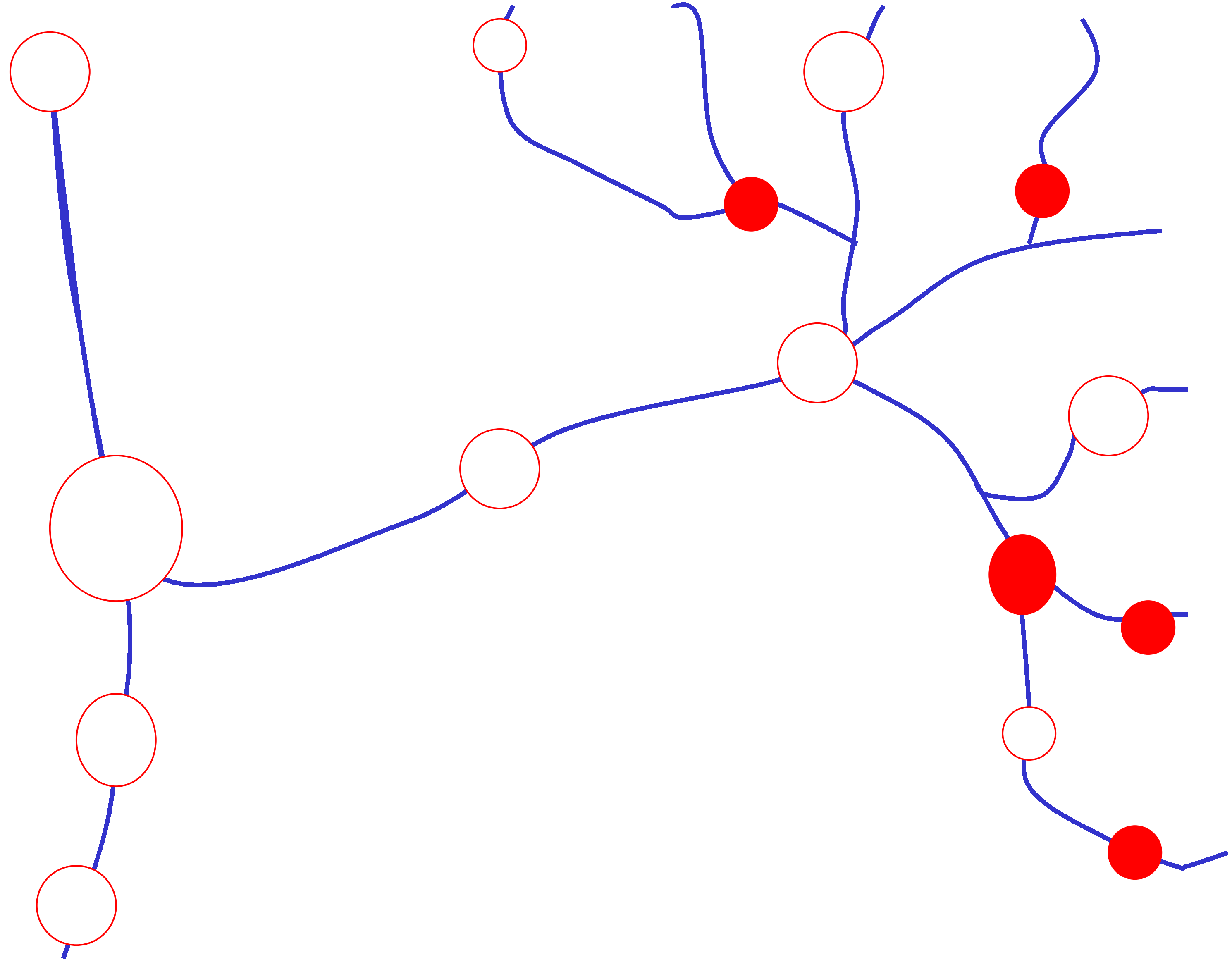
Environmental Stochasticity
Human Influences?


Pre-Monsoon, 2002
250 m

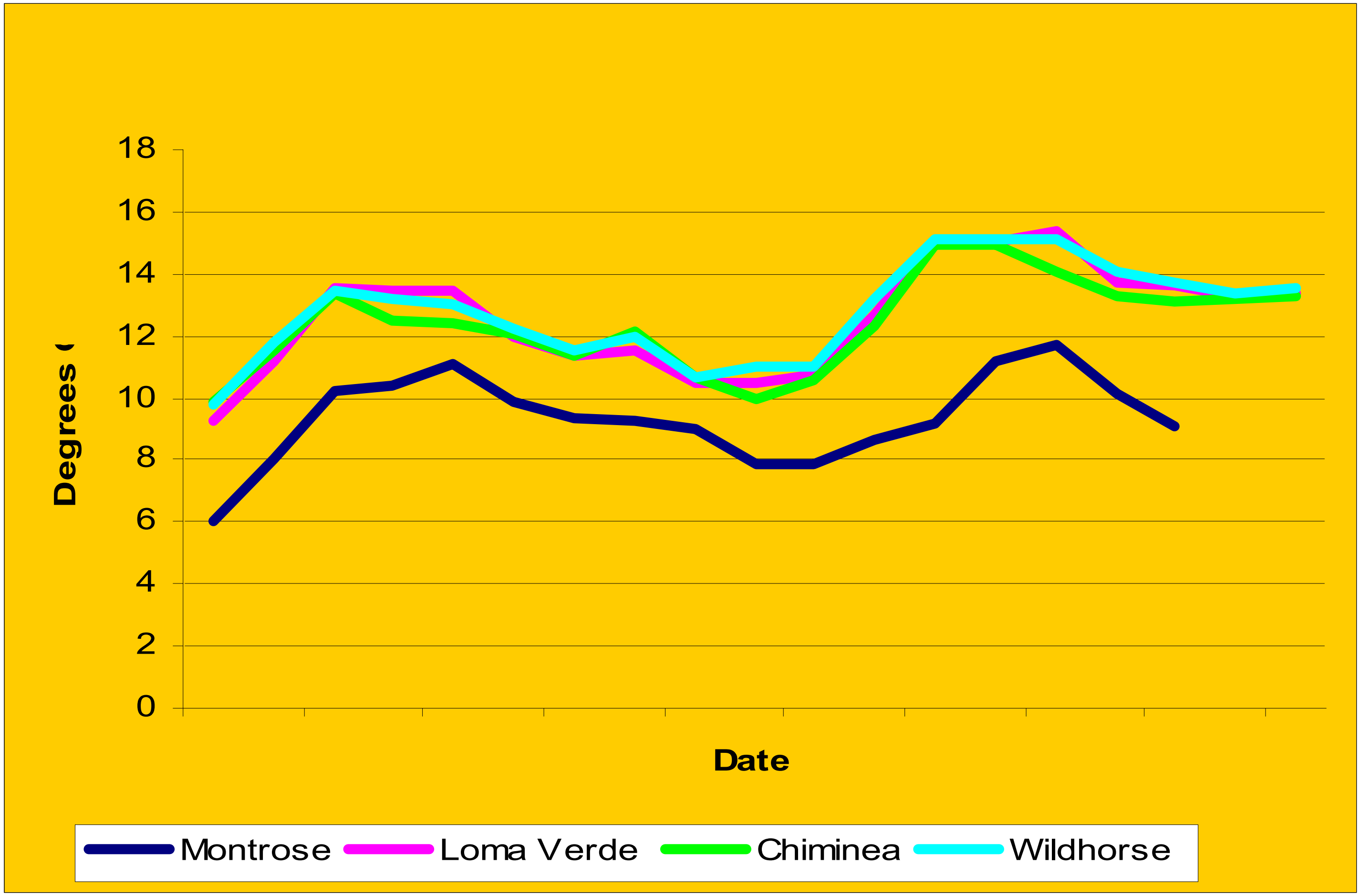


# Metapopulation Dynamics





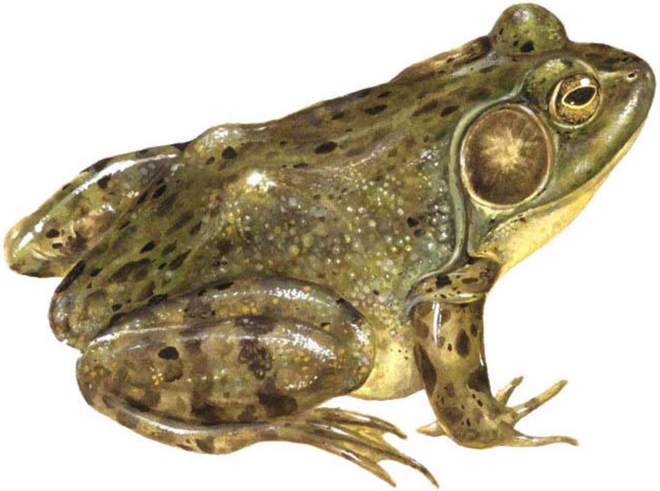
# Mean Daily Temperatures in Four Canyons
# 27 Dec. 2001 - 31 Jan. 2002




## Multiple Synergistic Causes…

Invasives:

- Brown Tree Snake
- Tamarisk
- Bullfrog
- Buffelgrass
- Cane Toad



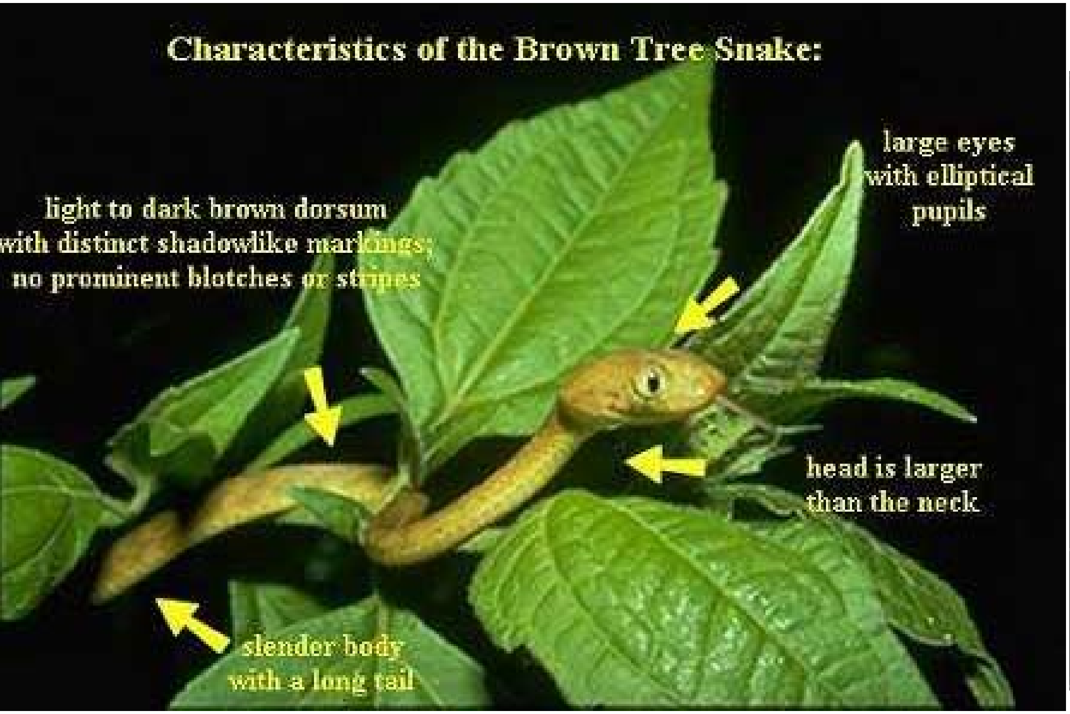
The Brown Tree Snake (*Boiga irregularis*) was accidentally introduced to Guam in the late 1940's or early 1950's on U.S. military cargo. The native range of the snake is Northeastern Australia, New Guinea and some of the island around New Guinea. It is thought that the Guam snakes originated from the island of Manus, a small island in the Solomons.

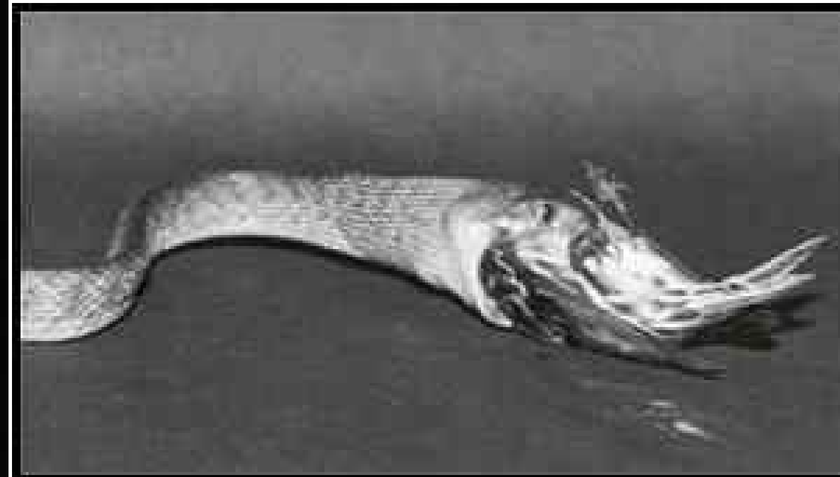
By the late 1950's/early 1960's it was well known that Guam had a snake population, often referred to as the "Philippine Rat Snake". What was not known was the devastating effect this introduced snake was having on Guam's native species, especially birds.

Not having evolved with a nighttime arboreal (tree climbing) predator, the native birds had no behavioral or physical defenses. As a result, birds began disappearing with the smaller species being affected first. By the mid 1980's, 9 of 11 native forest birds were gone from Guam's forests. Two of these birds, the Micronesian Kingfisher and the Guam Rail, were found only on Guam (endemic) and to this day only exist in zoos. Guam's forests had become silent.

In addition to this the snakes also cause many power outages (on average once every 3 days). Sometimes this is island-wide but more often it is smaller localized outages. This costs money in repair bills and lost business revenue. The snakes do this by crawling on the power lines or getting into the transformers.

Due to the loss of bird life, insect populations are much higher on Guam (many birds eat insects). Because many birds pollinate plants and spread seeds, Guam will probably exhibit vegetation changes in the forests. Guam is rightly termed one of the modern day eco-disasters.



A brown tree snake eating a bird.

Electrical Outages: Approximately every third day there is a snake-caused power outage somewhere on Guam. While most of these affect a limited area, some are widespread or island-wide blackouts. Everything from school lighting, computers used by retail outlets, traffic signals, to refrigeration of perishable goods are subject to these power interruptions. The costs due to direct damages and lost productivity are conservatively estimated at $1-4 million dollars each year.

Rodda, Fritz, Chiszar 1997...

Guam
*Boiga irregularis*
Brown Tree Snake
Not really a special animal

-power outages, gnawed on babies
-wiping out native vertebrates

-Lack of shared evolutionary history
-Ecologically naive
-Human commerce etc.

Other islands? Other species?

# Tamarisk

4/28/2005

**Arizona & The West**

## Natural weapon against salt cedar

Researchers have released about 600 leaf beetles in southeastern New Mexico in hopes of containing the problem-atic salt cedar that has invaded waterways throughout the West.


### Battle in the bushes

▶ Salt cedar, also known as tamarisk, came from Asia to assist in erosion control, build windbreaks and provide shade.

▶ It is drought-hardy and can tolerate damaging floods.

▶ It grows 5 to 20 feet tall. Its seeds germinate in 24 hours, and it produces as many as 500,000 seeds a year.

▶ One shrub can consume 200 gallons of water a day, taking


bushes

▶ Salt cedar, also known as tamarisk, came from Asia to assist in erosion control, build windbreaks and provide shade.

▶ It is drought-hardy and can tolerate damaging floods.

▶ It grows 5 to 20 feet tall. Its seeds germinate in 24 hours, and it produces as many as 500,000 seeds a year.

▶ One shrub can consume 200 gallons of water a day, taking

needed water from other native plants and destroying a river's natural habitat.

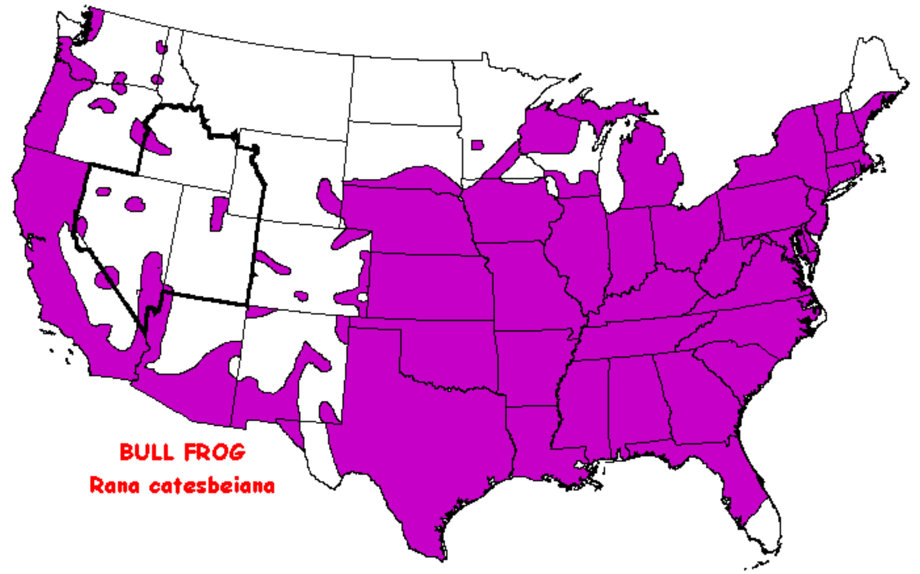
▶ While killing native vege-tation, salt cedar grows into impenetrable stands that become fire hazards.

SOURCES: National Park Service; Associated Press AP

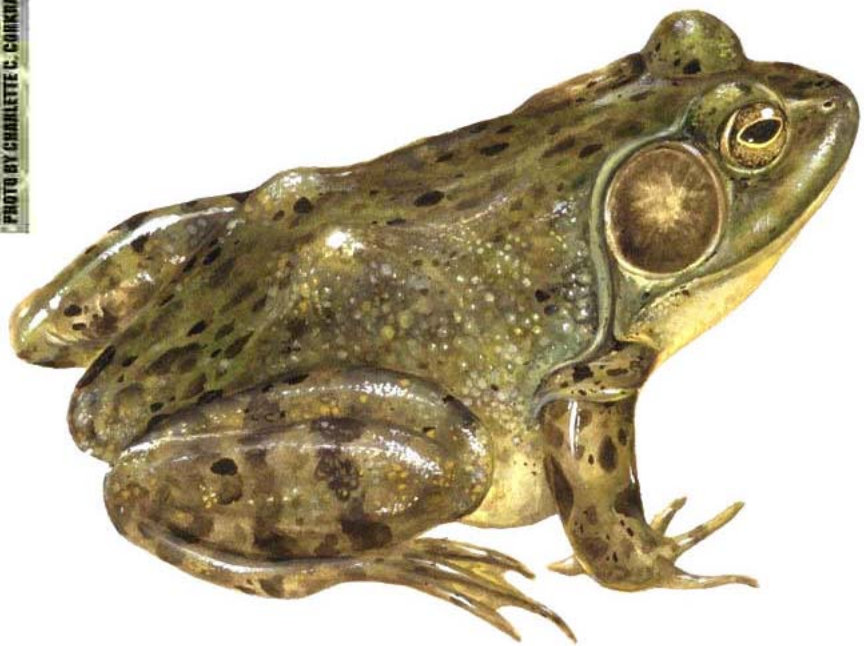
## Tiny beetle enlisted to kill tough salt cedars

Cane Toad?

# Bullfrog







Buffelgrass and Saguaro, SNP-E

END