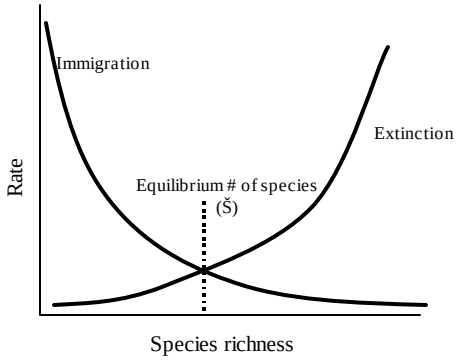
Island Biogeography

- Two major parameters characterize an island:
  - Distance From the Mainland or Species Source
  - Size
- How do size and distance from mainland affect the species richness of island communities ?
- Theory of Island Biogeography was proposed by Robert MacArthur and Edward Wilson in 1967 using a quantitative mathematical modeling approach to explain the number of species found on an island as a balance between immigration and extinction.

Terms

- Biogeography - The study of the distribution of species of organisms over the face of the earth.
- Edge Effect - A change in the physical and biological parameter of a habitat at its boundaries relative to what is found in the center.
- Emigration - Movement out of an area.
- Endemic - A species that is found in a certain region and nowhere else.
- Equilibrium - A steady state in population dynamics that is characterized by little or no change.
- Immigration - Movement into an area.
- Species Diversity – An index related to the number of species and their relative abundance.
- Species Richness - The total number of species in a community.

Island Biogeography



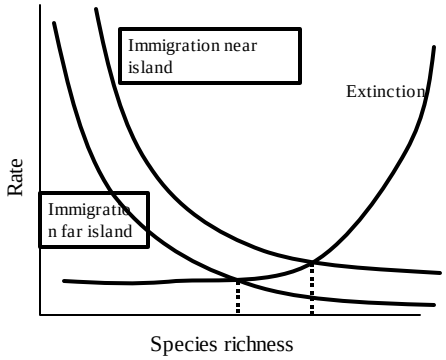
Immigration Rates to Islands

- The rate of colonization will be high initially because most species are new and because the island can be reached by those adept at dispersal.
- As more species occupy the island, fewer open niches will be available to new arrivals.
- As time passes, immigrants will increasingly belong to species that have already reached the island, so that the rate of new species drops off.
- Furthermore, the rate of immigration will be affected by the location of the island, as islands close to the source region will have higher rates of immigration, while islands far from the source region will have lower rates of immigration.

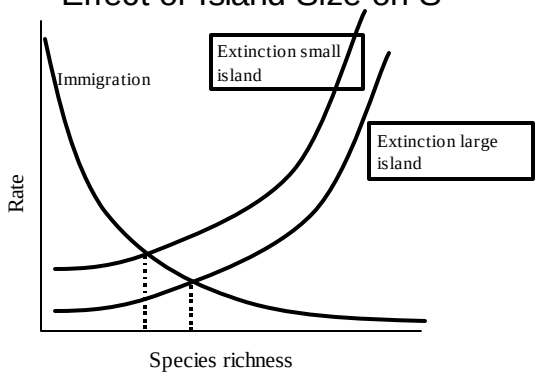
Extinction Rates on Islands

- The rate of extinction, will start at a low level but gradually rise because the more species, the greater the risk of extinction as populations of individuals become smaller due to competition.
- At first, the few species present can occupy a greater variety of ecological niches than would be possible on the mainland, with little competition from other species on the new island.
- As new species arrive, the rate of extinction rises, as smaller populations must be supported due to a constant food resource. Smaller populations have a greater chance for extinction.
- Extinction rates will tend to be higher on small islands, as small islands support small populations

Effect of Island Distance on Š



Effect of Island Size on Š



Equilibrium Number of Species on Islands

- Eventually, the number of species present will obviously be the result of a balance between the rate of immigration and the rate of extinction.
- The Theory of Island Biogeography provided a framework for a more structured approach to biogeographic studies, and has since been applied to studies conducted on mountain peaks, cave environments, and in designing nature reserves.

Small Area Relation to Extinction

- As a result of human action, island birds have been 40-times more likely to become extinct within the last 400 years than continental birds, while altogether about 80% of documented animal species extinctions in this period have been of island species.

The Song of the Dodo:

Island Biogeography in an Age of Extinctions

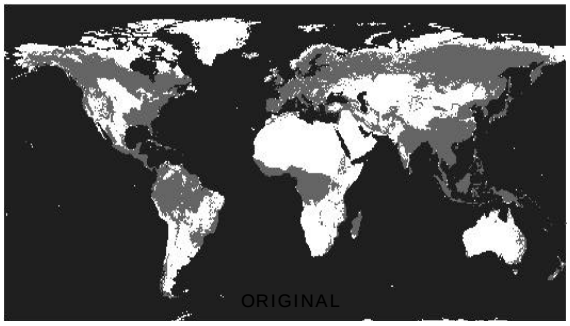
David Quammen

A book review by Danny Yee - © 1997 http://dannyreviews.com/

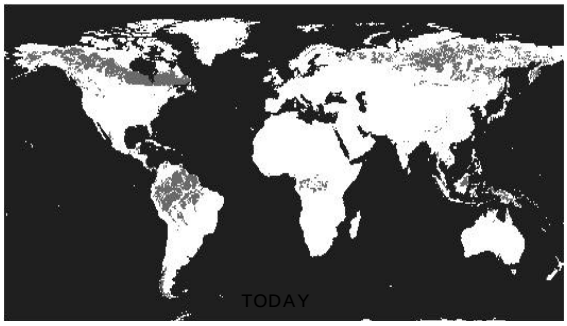
Dodos and extinctions are dinner-party topics, but island biogeography sounds like the domain of academic monographs. In Song of the Dodo Quammen writes about the popular topics for a popular audience, but sneaks in some real science on the sly. He offers a mix of travel narrative, natural history, and biography – and highlights the significance of islands in the geographical distribution of species around the planet.

Quammen begins with the role biogeography played in the origins of evolutionary theory, following Alfred Russell Wallace on his expeditions around the Malay Archipelago. He then explores the "signature features" of island species and communities (such as dispersal ability, size change, and adaptive radiation), using as examples iguanas in the Galapagos, lemurs in Madagascar, Komodo dragons, and lizards on islands in the Gulf of California, among others.

Frontier Forests



Frontier Forests



Exotic Species - What are they?

- They are species that have been transplanted, usually with man's help, to habitat's outside their normal range, regardless of political boundaries.
  - These include plants, animals, fungi, bacteria, protists, and viruses
  - Some are obvious (purple loosestrife, zebra mussels, kudzu, Ebola), but most probably go undetected (many microbes, and colonists that do not successfully invade)
  - They can have beneficial (biocontrol agents) and/or negative impacts on communities. An introduced species can become a resource for some natives, or an enemy of others
  - Most countries have on the order of 100's to 10,000 exotic species
  - Often reach nuisance abundance because they lack natural enemies

How do Exotic Occur?

- Natural -
  - plate tectonics. Mixing of marsupial and placental mammals 3 mya
  - migrations
  - storms

How do Exotic Occur?

- Human-aided
  - Accidentals
    - Waterways - a lot of aquatic examples. In aquatics, entire communities are often introduced together
      - » Suez Canal
      - » Chicago River
      - » Trans-mountain diversions
    - Hitchhikers
    - Ballast water - zebra mussels
    - Ship hulls
    - Wooden crates
    - Imported fruits, vegetables, soils
    - Island rats
  - Failed quarantines
    - Whirling disease
    - Ebola viruses

How do Exotic Occur?

- Human-aided
  - Intentionals
    - Citizens/uncontrolled releases
      - Released pets
      - Ornamental plants (purple loosestrife)
      - Bait buckets
      - Goats on islands
      - Game reserves (boar)
    - Government releases/'controlled releases'
      - Game fishes
      - Food resource (Nile perch)
      - Biocontrol agents
        - » classical biological control - introduction of exotic to control a pest exotic
        - » neoclassical biological control - introduction of and exotic to control a pest native
        - » a better method? conservation biological control

Effects of exotics to society

- Allowed success of European imperialism
  - Disease
    - Black and brown rats killed 30% of Europeans in 1500's
    - HIV
    - Ebola
- Costly/Economics
  - Costs the USA <$137 billion/yr
  - $200 million /yr studying them
  - Zebra mussel ($<5 billion in great lakes region)
  - Wild oats reduce crop yields by 13 million tons. Enough to feed 50 million people
  - Med fly in California - $1 billion/yr
  - Gypsy moth (Eurasian) costs $764 million/yr
  - Foot and mouth disease cost Britain $30 billion
  - EO 13112, National Invasive Species Council

Is biological control a solution to pest control?

- Biological control: the use of living organisms to control the population size of pest usually via predation or parasitism
- Many pests are exotic species
- Classical biological control
  - going to the pest's native range to find a predator
  - treating an exotic species with a different exotic species
- Conservation biological control
  - control of exotic pest using a native biocontrol agent

World land use

11% cropland (growing 1.8%)
26% range and pasture (declining 2.4%)
30% forest
Temperate (increasing 0.1%)
Tropical (decreasing 0.8%)
33% other (tundra, desert, urban, wetlands) (increasing 1%)
4% reserved for wildlife

Land use in the USA

Wild lands have been greatly reduced - in USA
- 50 of wetlands lost
- 95% of old growth cut
- 98% of streams have been dammed
- Prairies and savanna converted to crop lands and rangelands

- In USA, most protected land is rock and ice, originally set aside for geologic beauty, with little consideration for biological importance

What is Conservation Biology?

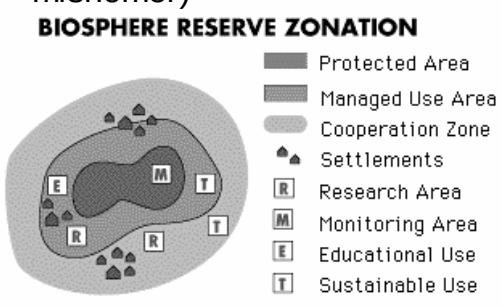
- "Conservation biology is a synthetic discipline that focuses on the application of biological principles to the preservation of biodiversity; it represents a fusion of relevant ideas from ecology, genetics, biogeography, behavior, reproductive biology, and a number of applied disciplines such as wildlife management and forestry." (Brussard 1991)

Some Reserve Design Terms

- Core area or reserve. A strictly protected area managed to maintain or restore its biological integrity.
- Buffer zone. A region surrounding a core reserve designed to minimize stresses on the core that would decrease its biological integrity. For political reasons, some choose to call these zones transition areas, zones of cooperation, multiple-use zones, ecosystem management zones, or sustainable development zones.
- Corridor. An area that provides for the natural movement of individuals among core reserves. The primary purpose of corridors is to provide biological connectivity. Therefore, they are sometimes called "connectivity zones" or "landscape linkages" to avoid the false impression given by the term "corridor" that connectivity is achieved only through long, narrow passageways.

Reserve Design (a misnomer)

- Core areas
- Buffer zones
- Cooperation Zone



Roads in the U.S.

- US DOT/Federal Highway Administration: There are 4 million miles of public roads in the United States in 2000, of which 3 million miles were in rural communities
- Currently more than 400,000 miles of road exist in our national forest lands
- US Forest Service plans to build or reconstruct 600,000 miles of roads in the next 50 years
- An estimated 20% of the U.S. land is directly impacted ecologically by roads
- A 1996 survey found that no point in the contiguous 48 states is more than 30 miles from a paved highway or dwelling

- Roads can have major negative impacts on flora and fauna:
  - Mortality (vehicle collisions & construction)
  - Behavioral modifications
  - Habitat alteration (fragmentation, pollution)
  - Exotic species introduction
  - Human access
- Mitigation efforts are increasing with awareness, but are not always effective

Road Kill

- HSUS: Estimates derived decades ago put the daily death toll at one million animals
- The RoadKill Project
  - Involves schools and private individuals throughout New England
  - Gather data for 8-week period each year
  - **1993 Data - March 15 - April 30** involving 25 schools ***1923*** animals killed
  - **1994 Data - March 14 - May 15** involving 45 schools ***5985*** animals killed
  - **1997 Data - March 10 - May 4** involving ? schools ***3962*** animals killed
- Most animals counted are those that can easily be seen/identified (most insects/small animals not counted)

Road Kill - Effects on endangered species

- Florida Panther:
  - Critically endangered
  - Only ~60 left in wild
  - Roadkill is the #2 cause of mortality
- American crocodile:
  - Endangered species
  - Roadkill is a leading cause of death
- Florida Black Bear:
  - Threatened
  - 2-3 killed by vehicles in 1970's, 44 in 1989

Behavior Modification

- Road aversion
  - Elk and mule deer in Montana and Colorado
    - Prefer spring and winter feeding areas away from visible roads
  - Wolves
    - Will not establish themselves in areas exceeding road density threshold (region-dependent)
  - Grizzly and black bears in Rocky Mountains
    - Shift their home ranges away from areas with high road densities
  - Bald eagles, Golden eagles
    - Prefer to nest away from roads
    - Reproductive success declines in proximity to roads

Behavior Modification (cont)

- Altered patterns of animal movement
  - Caribou in Alaska
    - prefer to travel along cleared winter roads
    - may enhance movement, but increases mortality from collisions and predation
  - Some species refuse to cross roads
    - White-footed mice, prairie voles
    - Land snails
    - Black bears (won't cross highways)
    - Frogs
  - Others have difficulty
    - Tortoises
    - Wart hogs
    - African elephants

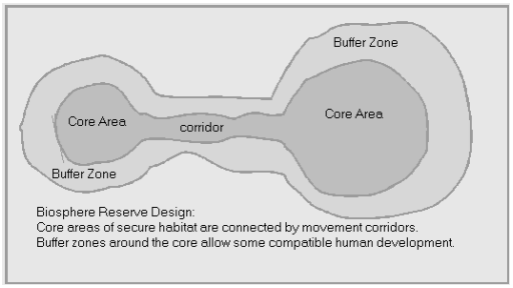
Habitat Fragmentation

- Roads can fragment populations when organisms can't or won't cross the road
- The resulting small populations are vulnerable to genetic drift, inbreeding, bottleneck effects
- Dispersal, range expansion, migration may be negatively affected

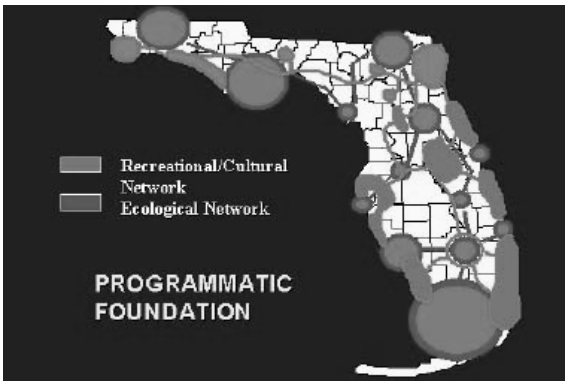
Human Access

- Harassment via noise/disturbance
  - Snowmobiles
  - ATV
  - Hikers/dogs
  - Mnt. bikes
- Roads increase the efficiency with which natural resources can be exploited
  - Hunting
  - Logging
  - Mining
- Development
  - Industrial, residential

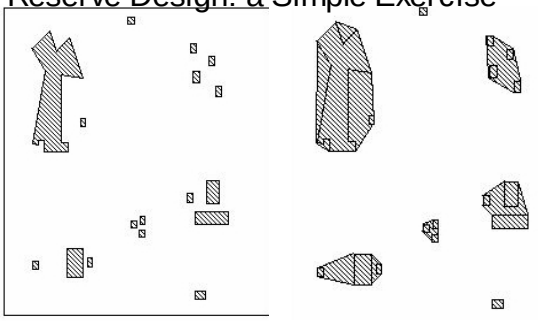
Corridors Increase Immigration Rates



A Reserve Network

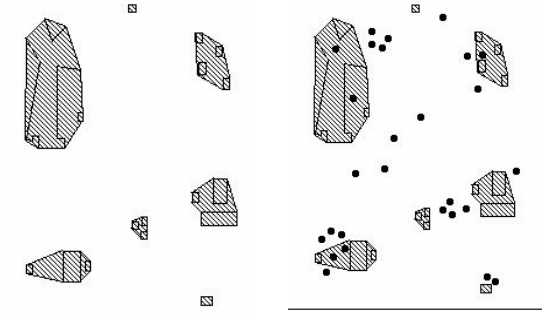


Reserve Design: a Simple Exercise



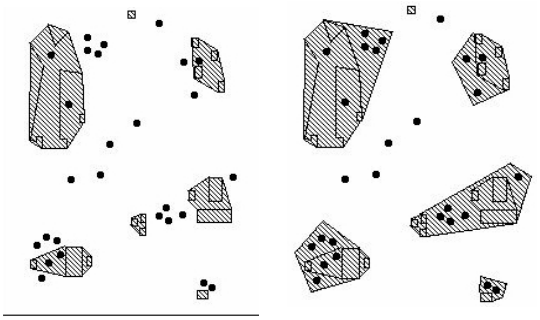
1. Minimize edge effects

Reserve Design



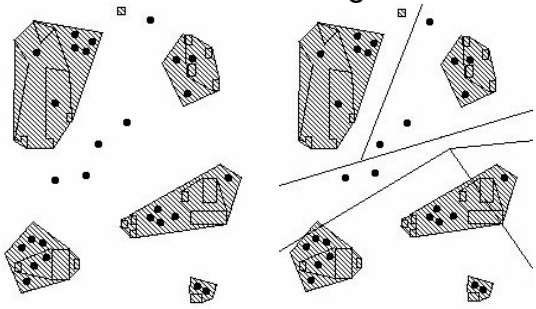
2. Identify RTE's (rare, threatened, and endangered elements)

Reserve Design



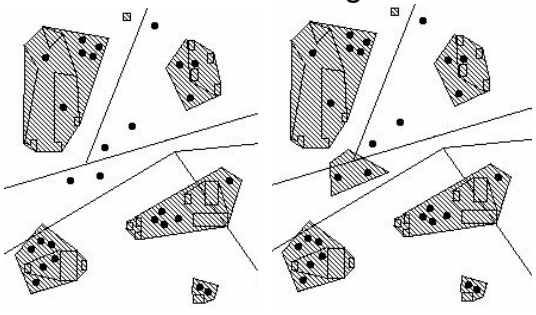
3. Protect RTE's (rare, threatened, and endangered elements)

Reserve Design



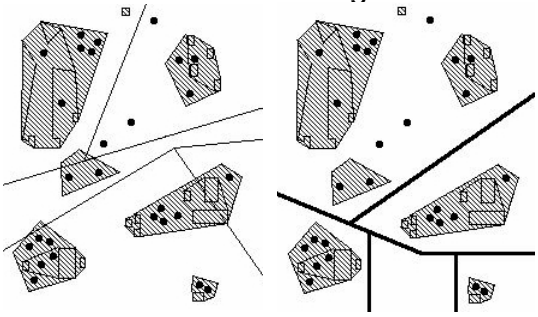
4. Identify ecosystem types

Reserve Design



5. Protect underrepresented ecosystem types and RTEs

Reserve Design



6. Identify roadless areas