Applied Ecology
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Agro-ecosystem management
*Biodiversity conservation*
Biotechnology
*Conservation biology*
Ecosystem restoration
*Fisheries management*
Habitat management
*Invasive species management*
Protected areas management
*Rangeland management*
Toxicology
*Wildlife management*
DDT

dichlorodiphenyltrichloroethane
Paul Ehrlich

Population Control or Race to Oblivion?

The Population Bomb

While you are reading these words, poor people will have died from starvation. Most of their children.

Dr. Paul R. Ehrlich
Michael Soule
Population viability analysis

Who you callin’ non-viable?
Question

How many needed to provide reasonable assurance of survival (95-99%?) over some sufficiently long period of time (50-100 yrs?)?
PVA concepts

1. Examining extinction risk of single populations
2. Used to guide/inform management decisions:
   • Comparing risks of 2 populations or sites
   • Determining how large a population has to be to achieve adequate protection
   • Determining how many individuals to release into a new population
   • Setting appropriate “take” or harvest levels
Introduction: PVA concepts

• Basic Concept: what is probability (risk) of extinction, within a specified time frame, given assumptions about population dynamics and environmental variation?
Calculating Extinction Probabilities, Method 1: **Diffusion Approximation**

- An analytical approach that can be used for simple population models exhibiting stochastic dynamics.

- We want to calculate the probability that a population will hit a certain threshold (extinction, or quasi-extinction) within interval between the present and future time $T$.

- To achieve this, we represent $\log(N)$ as a particle within a gas cloud (it’s a Zen thing).
Random walk as a diffusion process

• A particle starting at a point in space that is moving randomly, will tend to “diffuse” out from its origin in a predictable way.
Population dynamics as a “diffusion” process

Population growth with Process Error

\[
\log(N) \quad \text{Time}
\]
Calculating Extinction Probabilities, Diffusion Approximation

- What is probability that a population with current size $N$ will hit QE at time $t$? Probability Density Fnct:

$$g(t | \mu, \sigma^2, d) = \frac{d}{\sqrt{2\pi\sigma^2}t^3} \exp\left[\frac{-(d + \mu t)^2}{2\sigma^2 t}\right]$$

where
Calculating Extinction Probabilities, Diffusion Approximation

\[ G(T \mid d, \mu, \sigma^2) = \Phi\left(\frac{-d - \mu T}{\sqrt{\sigma^2 T}}\right) + \exp\left(-\frac{2\mu d}{\sigma^2}\right) \cdot \Phi\left(\frac{-d + \mu T}{\sqrt{\sigma^2 T}}\right) \]
Calculating Extinction Probabilities, Diffusion Approximation Example: Yellowstone Grizzly Bears
Calculating Extinction Probabilities, Diffusion Approximation Example

Cumulative Probability at 100 years < 0.005. So is population safe? Probably, BUT...

\( \mu = 0.02134 \)
\( \sigma^2 = 0.01305 \)
Quasi-ext = 20
\( N_0 = 99 \)
Calculating Extinction Probabilities, accounting for parameter uncertainty

Yellowstone Grizzlies, Diffusion Approximation of Extinction Probability

Parameter uncertainty: 95% CI

Quasi-extinction threshold = 20
Exploiting natural populations

Fisheries
Wildlife
Forestry
Maximum sustainable yield (MSY)
\[ N_t = \frac{K}{1 + \frac{K - N_0}{N_0} e^{-rt}} \]
\[ \frac{dN}{dt} = rN(1 - N/K) \]

- **MSY**: Maximum Sustainable Yield
- **K/2**: Population size at which growth rate is maximized
- **K**: Carrying capacity
\[
\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right) - H
\]

\[
\frac{dN}{dt} = 0
\]

\[
rN\left(1 - \frac{N}{K}\right) = H
\]
Invasive species
# North American invasives

**Plants**

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Species</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acroptilon repens</em></td>
<td>Russian knapweed</td>
<td><em>Elaeagnus angustifolia</em></td>
<td>Russian olive</td>
</tr>
<tr>
<td><em>Ailanthus altissima</em></td>
<td>Tree of heaven</td>
<td><em>Elaeagnus umbellata</em></td>
<td>Autumn olive</td>
</tr>
<tr>
<td><em>Albizia julibrissin</em></td>
<td>Silk tree</td>
<td><em>Eucalyptus globulus</em></td>
<td>Blue Gum Eucalyptus</td>
</tr>
<tr>
<td><em>Alliaria petiolata</em></td>
<td>Garlic mustard</td>
<td><em>Euphorbia esula</em></td>
<td>Leafy spurge</td>
</tr>
<tr>
<td><em>Ardisia crenata</em></td>
<td>Coral ardisia</td>
<td><em>Fallopia japonica</em></td>
<td>Japanese knotweed</td>
</tr>
<tr>
<td><em>Arundo donax</em></td>
<td>Giant reed</td>
<td><em>Hedera helix</em></td>
<td>English ivy</td>
</tr>
<tr>
<td><em>Berberis thunbergii</em></td>
<td>Japanese barberry</td>
<td><em>Heracleum mantegazzianum</em></td>
<td>Giant hogweed</td>
</tr>
<tr>
<td><em>Bromus tectorum</em></td>
<td>Downy brome, cheatgrass</td>
<td><em>Hieracium aurantiacum</em></td>
<td>Orange hawkweed</td>
</tr>
<tr>
<td><em>Butomus umbellatus</em></td>
<td>Flowering rush</td>
<td><em>Hydrilla verticillata</em></td>
<td>Hydrilla</td>
</tr>
<tr>
<td><em>Carduus nutans</em></td>
<td>Musk thistle</td>
<td><em>Imperata cylindrica</em></td>
<td>Cogon grass</td>
</tr>
<tr>
<td><em>Casuarina equisetifolia</em></td>
<td>Australian pine</td>
<td><em>Liquisorum sinense</em></td>
<td>Chinese privet</td>
</tr>
<tr>
<td><em>Caulerpa taxifolia</em></td>
<td>Cauerpa, Mediterranean clone</td>
<td><em>Ligustrum vulgare</em></td>
<td>Eurasian privet</td>
</tr>
<tr>
<td><em>Centaurea diffusa</em></td>
<td>Diffuse knapweed</td>
<td><em>Lonicera japonica</em></td>
<td>Japanese honeysuckle</td>
</tr>
<tr>
<td><em>Centaurea maculosa</em></td>
<td>Spotted knapweed</td>
<td><em>Lonicera maackii</em></td>
<td>Amur honeysuckle, bush honeysuckle</td>
</tr>
<tr>
<td><em>Centaurea solstitialis</em></td>
<td>Yellow star thistle</td>
<td><em>Lonicera morrowii</em></td>
<td>Morrow's honeysuckle, bush honeysuckle</td>
</tr>
<tr>
<td><em>Cinnamomum camphora</em></td>
<td>Camphor laurel</td>
<td><em>Lonicera tatarica</em></td>
<td>Tartarian honeysuckle, bush honeysuckle</td>
</tr>
<tr>
<td><em>Colocasia esculenta</em></td>
<td>Wild taro</td>
<td></td>
<td>(Japanese climbing fern)</td>
</tr>
<tr>
<td><em>Conium maculatum</em></td>
<td>Poison hemlock</td>
<td><em>Lygodium microphyllum</em></td>
<td>Old World climbing fern</td>
</tr>
<tr>
<td><em>Cortaderia selloana</em></td>
<td>Pampas grass</td>
<td><em>Lymnachia nummularia</em></td>
<td>moneywort</td>
</tr>
<tr>
<td><em>Cosmos sulphureus</em></td>
<td></td>
<td><em>Lythrum salicaria</em></td>
<td>Purple loosestrife</td>
</tr>
<tr>
<td><em>Cynanchum rossicum</em></td>
<td>Dog-strangling vine</td>
<td><em>Melaleuca quinquenervia</em></td>
<td>Melaleuca</td>
</tr>
<tr>
<td><em>Cytisus scoparius</em></td>
<td>Common broom, Scotch broom</td>
<td><em>Microstegium vimineum</em></td>
<td>Asian stilt grass</td>
</tr>
<tr>
<td><em>Dioscorea bulbifera</em></td>
<td>Air potato</td>
<td><em>Mimus pudica</em></td>
<td>(Mimosa)</td>
</tr>
<tr>
<td><em>Egeria densa</em></td>
<td>Brazilian waterweed</td>
<td><em>Myriophyllum spicatum</em></td>
<td>(Eurasian watermilfoil)</td>
</tr>
<tr>
<td><em>Eichhornia crassipes</em></td>
<td>Water hyacinth</td>
<td><em>Onopordum acanthium</em></td>
<td>Cotton thistle</td>
</tr>
</tbody>
</table>
North American invasives (Cont)

**Paederia foetida** (Skunk vine)  
(Torpedo grass)  
**Pastinaca sativa** (Wild parsnip)  
**Persicaria perfoliata** * (Chinese tearthumb)  
**Phragmites australis** (Common reed)  
**Potamogeton crispus** (Curly-leaf pondweed)  
**Pueraria montana** var. *lobata* (Kudzu)  
**Rhynchelytrum repens** (Natal grass)  
**Rosa multiflora** (Multiflora rose)  
**Rubus armeniacus** (Blackberry)  
**Rubus phoenicolasius** (wineberry)  
**Rumex crispus** (curled dock or curly dock)  
**Salvinia molesta** (Giant salvinia)  
**Sapium sebiferum** (Chinese tallow)  
**Schinus terebinthifolius** (Brazilian pepper tree)  
**Solanum viarum** (Tropical soda apple)  
**Spartina alterniflora** (Smooth cordgrass)  
**Spartina alterniflora** * (Witchweed)  
**Tamarix** spp. (Saltcedar)  
**Trapa natans** (Water caltrop, water chestnut)  

**Insects**

**Adelges tsugae** (Hemlock woolly adelgid)  
**Aedes albopictus** (Asian tiger mosquito)  
**Agrilus planipennis** (Emerald ash borer)  
**Anoplodora glabripennis** (Asian long-horned beetle)  
**Apis mellifera scutellata** (Africanized honeybee)  
**Bemisia argentifolii** (Silverleaf whitefly)  
**Cactoblastis cactorum** (Cactus moth)  
**Coptotermes formosanus** (Formosan subterranean termite)  
(Asian citrus psyllid)  
**Epiphyas postvittana** (Light brown apple moth)  
**Halyomorpha halys** (Brown marmorated stink bug)  

**Aquatic arthropods**

**Bythotrephes cederstroemi** (Spiny water flea)  
**Carcinus maenas** (European green crab)  
**Eriocheir sinensis** (Chinese mitten crab)  

**Mollusks**

**Ampullariidae** (Apple snails)  
**Bithynia tentaculata** (Faucet snail)  
**Cipangopaludina chinensis** (Chinese mystery snail)  
**Corbicula fluminea** (Asian clam)  
**Dreissena polymorpha** (Zebra mussel)  
**Potamopyrgus antipodarum** (New Zealand mud snail)  
**Rapana venosa** (Veined rapa whelk)  
**Deroceras reticulatum**  
**Limax maximus**  
**Lehmannia marginata**, previously known as **Limax marginatus**  
**Milax gagates**  
**Helix aspersa**  
**Theba pisana** (White garden snail)
North American invasives (Cont)

Fish
- *Alosa pseudoharengus* (Alewife)
- *Channa argus* (Northern snakehead)
- *Cyprinus carpio* (Common carp)
- *Gymnocephalus cernuus* (Eurasian ruffe)
- *Hypophthalmichthys molitrix* (Silver carp)
- *Hypophthalmichthys nobilis* (Bighead carp)
- *Monopterus albus* (Asian swamp eel)
- *Neogobius melanostomus* (Round goby)
- *Oreochromis aureus* (Blue tilapia)
- *Petromyzon marinus* (Sea lamprey)
- *Pylodictis olivaris* (Flathead catfish)

Reptiles and amphibians
- *Boiga irregularis* (Brown tree snake)
- *Bufo marinus* (Cane toad)
- *Caiman crocodilus* (Spectacled Caiman)
- *Iguana iguana* (Green iguana)
- *Python molurus bivittatus* (Burmese python)
- *Rana catesbeiana* (Bullfrog)
- *Varanus niloticus* (Nile monitor)
- *Osteopilus septentrionalis* (Cuban treefrog)

Birds and Mammals
- *Columba livia* (Rock pigeon)
- *Cygnus olor* (Mute swan)
- *Felis catus* (Domestic cat)
- *Myocastor coypus* (Coypu, nutria)
- *Passer domesticus* (House sparrow)
- *Sturnus vulgaris* (European starling)
- *Sus scrofa* (Wild boar)

Pathogens
- *Avipoxvirus* (Fowlpox)
- *Cryphonectria parasitica* (Chestnut blight)
- *Flavivirus* (West Nile virus)
- *Myxobolus cerebralis* (Whirling disease)
- *Ophiostoma ulmi* (Dutch elm disease)
- *Paramyxovirus* (Exotic Newcastle disease)
- *Phakopsora* spp. (Soybean rust)
- *Phytophthora ramorum* (Sudden oak death)
- *Potyvirus* (Plum pox)

ivana scortino
Eradication of invasive species
Removing introduced predators to restore Alaska islands: from species to ecosystems

J.A. Estes
Department of Ecology and Evolutionary Biology, UC Santa Cruz

G.V. Byrd
Alaska Maritime National Wildlife Refuge, US Fish & Wildlife Service
Government agent checking fox furs, Atka Island, 1920s
“It soon became apparent that the most important problem... was a conflict between fox farming and the preservation of the Aleutian avifauna.”

(O.J. Murie, 1936)

Recognizing the problem!
Aleutian Cackling Goose
*(Branta hutchinsii leucopareia)*
Remnant Breeding Populations of Aleutian Geese*

Chagulak Island
Fox Removal

- Eradication methods refined to insure success even on large islands*
- Islands strategically selected

*Ebbert 2000, Ebbert and Byrd 2002
Restoring Geese
Population Recovery

Number of Geese

Year


Mark-Resight

Census
Rewilding and reconnecting nature
Valuation

Example—Natural Capital Project—”Aligning economic forces with conservation”

InVEST--a family of tools to map and value the goods and services from nature

To learn more-- http://www.naturalcapitalproject.org/about.html
Careers in ecology

• What?
  – Natural Resource Management
  – Natural Resource Conservation

• Where?
  – Academia
  – State, federal and international agencies
  – NGO’s
  – Business and industry