



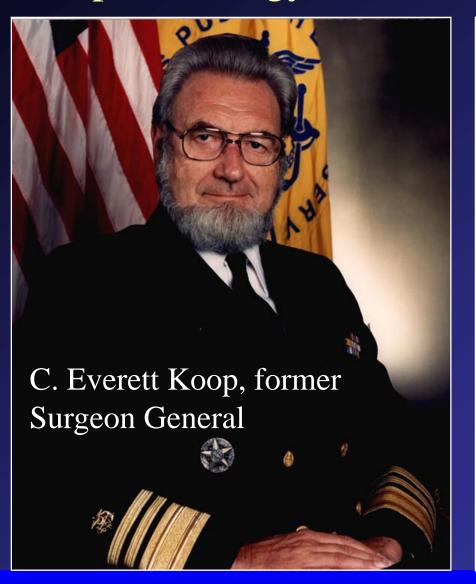
"Environmental Transport of Disease: Between Animals and Humans"

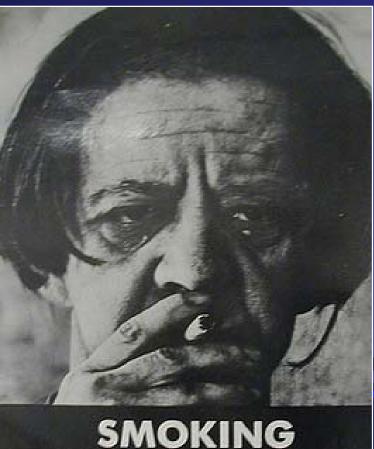
Val Beasley DVM, PhD, Diplomate ABVT with Help from Dr. William Karesh of WCS & many others....



For a Powerful Species Evolved to "get through the next winter or dry season"... Who Prescribed... Multiple Doses of **Ecological Simplification**, Innumerable Infectious Agents, Myriad Toxic Chemicals, Accelerating Mobility, and **Constantly Refined Distraction**?

Not Just Stethoscopes, Blood Tests, Forensics, Epidemiology, Vaccines, & Basic Research





VERY

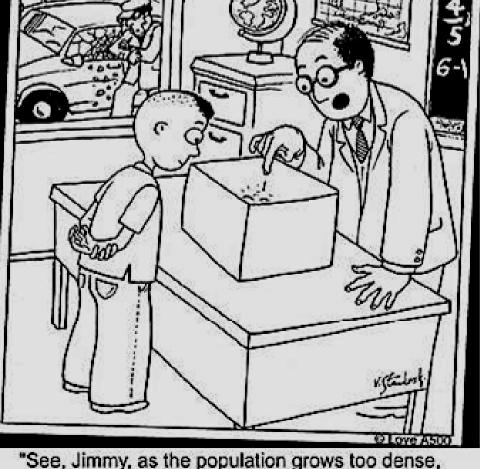
GLAMOROUS

IS

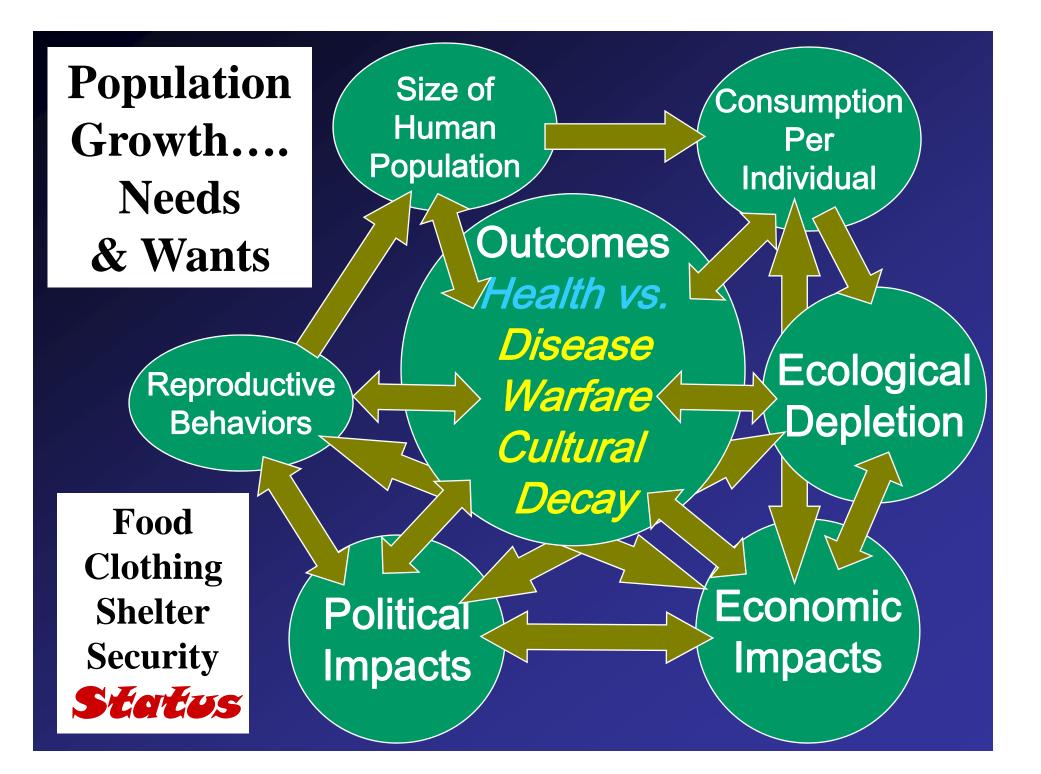
Should we worry about running out of people...in the short term?



If world population growth continues to increase at current rates, the weight of people will equal the weight of the Earth in the year 3343.



the rats begin to brutalize each other ... "



Impacts in the Real World? Percent Threatened Globally*

<u>Group</u>	of Described Spp.	of Evaluated spp.
Fishes	4%	39%
Amphibians	29%	31%
Reptiles	5%	30%
🖙 Birds	12%	12%
Mammals	20%	22%

Vertebrate animal, butterfly, & plant extinction rates are 100-1,000 times faster than before humans existed (for each newly evolved species, up to 1,000 become extinct). Peter Raven Missouri Botanic Gardens (1996).

- E.O. Wilson - 27,000 species lost/year = 3/hour

2/3 of world's coral reefs may be dying, & trends continue, 70% may be dead by 2050.

* From IUCN Red List 2007

Summary: BIGDRIVERS

- Human Population Growth.
- Resource Consumption per Individual ("the aspiration bomb").
- ✓ Manipulation, Militarism, & Terrorism → Wasting Resources Instead of Compassion for All Life & Learning from past mistakes.
- Alterred Hydrology.
- Over-fishing, Poaching = Overharvest by Human Populations.
- Introductions of Invasive Species.
- Inefficient Agriculture (erosion, "salinization").
- Pollution (nutrients, pesticides, industrial chemicals, construction chemicals, petroleum, effluents from mining, coal burning, metal smelting, vehicles, homes).
- Fragmentation, Degradation, & Loss of Natural Habitat.
 - ① due to agriculture, commercial forest, business, housing, roads.
- ✓ Stress, Crowding, Increased Contact Among Wildlife & Humans →
 Re-emerging & Newly Emerging Diseases (humans, buffalos, lions, frogs).
- Declining Species Diversity & Declining Genetic Diversity within Species.
- Global Warming & Microclimate Change.
- INTERACTIONS (Antagonistic, Additive, Synergistic).
- *Collective Denial, Ignorance, & Inertia!*

How Many of These are Influenced by Human Mobility?

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Traveling Humans, Their Animals, +Vectors & Microbes

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.... Their Technologies (including chemicals), Their Mindsets...

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Their Forms and Methods of Corruption...

- Human Population Growth.
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Christopher Columbus









- For centuries after Columbus landed, more native North Americans died annually from infectious diseases from European settlers than were born.
- Epidemic waves of smallpox, measles, influenza, bubonic plague, diphtheria, typhus, cholera, scarlet fever, chicken pox, yellow fever, & whooping cough.
- For North America, estimates of native populations in Columbus's day range from 2 to 18 million.
- ☞ By the end of the 1800s, the population was about 530,000.
- Hardest hit were native farmers in densely-populated permanent towns & villages along major rivers like the Mississippi, Missouri, Ohio, Gila & Rio Grande, where diseases spread widely.
- This devastation was hastened by European slave raids, warfare, & forced neglect of crops.
- Ted Turner's veterinarian thinks that bison were more devastated by cattle diseases than by white hunters.

Lord Jeffery Amherst, British Commander in Chief in North America during French & Indian War... Part of Seven Years War... Churchill called it "First World War"





Amherst College china plate

border design: mounted Englishman with sword chasing Indians on foot



Drawing by Terry R. Peters, Medical Illustrator, Topeka (Kansas) Veterans Administration Medical Center Amherst was "the most glamorous military hero in the New World in 1759."
By 1763, he had chosen a low cost way to help deal with Chief Pontiac's Ottawa Tribe with whom the British had been fighting this brutal war.

You will De well to try to Imoculate the Indiano by means of Blanketts, as well as to try Frery other method that can verve to Exterpate Scheme for Sunting them Down by Doge could take

http://www.jhsph.edu/preparedness/





Some Examples







- SARS
- (A paramyxovirus encephalitis, people get from pigs. 40% of affected humans can die.
- Nipah virus Thousands of pigs died; infected from fruit bats. Bats moved into new orchards.)
- Bat lyssavirus (Related to & much like rabies)
- **BSE** ("Mad cow" Prion Kreutzfeld Jacob Disease)
- Avian Influenza
- Foot and Mouth Disease

http://www.wildlifetrust.org/enter.cgi?p=news/2005/0901_slide_bats.htm

http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/nipah.htm



Flying fox – fruit bat. Dr. Jonathan Epstein

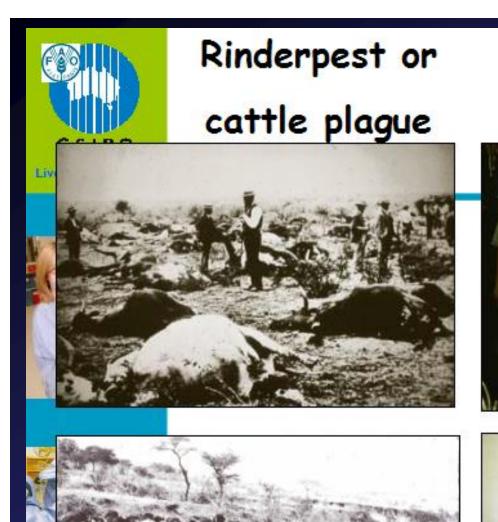
Avian Influenza 331 Human Cases, 203 Deaths

http://www.who.int/csr/disease/avian_influe
nza/en/

<u>http://www.cdc.gov/flu/avian/gen-info/qa.htm</u>

http://www.pandemicflu.gov/





plague known, belongs to a select group of notorious infectious diseases that have changed the course of history.

'the most

dreaded bovine

Morbilliviruses – Many Started with Rinderpest

- Is the ancestor of measles, peste des petites ruminants, & canine + phocine distemper.
- Can be deadly to cattle (over 90% can die).
- One of first diseases of animals effectively controlled (1712–1715), by controlling movement & quarantine—but the lessons learned were later forgotten (fragile in environment).
- Estimated 200 million cattle died from it in Europe in 1800s.
- Was associated with the first:
 - Demonstration of maternal immunity (1711).
 - Use of a clinical thermometer to detect fever (1865).
 - Establishment of Office International des Epizootics (OIE) after the 1920 outbreak in Belgium.
 - Establishment of veterinary services in Britain, Germany, Russia, & African colonies followed public & political concerns regarding its immense economic impacts.

Morbilliviruses – Many Started with Rinderpest

- Extremely lethal to wildlife. Cattle are reservoir for wildlife (over 40 species susceptible).
- *wildlife are <u>not</u> an important reservoir.*
 - Estimated up to 225 million wild herbivores died in Africa after it was introduced from Europe in 1880s.
 - Cattle in different parts of Africa have repeatedly infected & reduced wildlife populations.
- One vaccination confers life-long immunity to cattle.
- Efforts to eradicate it are well along reservoir – Kenya/Somali border.
 - Dr. Richard Kock

The Global Meat Trade is Highly Concentrated



Source: Center for Global Food ISSUES

Foot and Mouth Disease

United Kingdom, 2001









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adaging nnovations improve ottom line

Foot and Mouth Disease



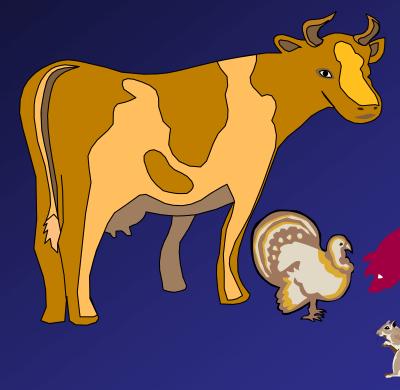
- One of the most contagious animal diseases, with important economic losses.
- Endemic in parts of Asia, Africa, Middle East, South America/
 - Sporadic outbreaks (more in recent years).
- Hosts include Bovids (cattle, zebus, domestic buffaloes, yaks), sheep, goats, swine, all wild ruminants, & suidae.
- Transmitted by direct or indirect contact (droplets), animate vectors (includes humans), & inanimate vectors (vehicles, implements).
- Airborne, especially temperate zones (up to 40 miles overland & 200 miles by sea).
- Sources of virus:
 - Breath, saliva, feces, urine, milk, & semen of clinically sick or incubating animals (up to 4 days before clinical signs).
 - Meat & by-products in which pH has remained above 6.0.
 - Carriers: particularly cattle & water buffalo; convalescent animals & exposed vaccinates (virus persists in oropharynx for up to 9 months in sheep, 30 months in cattle, & longer in buffalo).
 - African Cape buffalo are the major maintenance host of some serotypes.

- Low mortality in adult animals, but often lose body condition & milk production.
- High mortality in young due to myocarditis. Incubation period is 2-14 days.
- Effects on cattle:
 - Fever, anorexia, shivering, reduced milk production for 2-3 days.
 - Smacking lips, grinding teeth, drooling, lameness, stamping or kicking the feet.
 - Vesicles (oral & nasal mucous membranes, between claws, coronary band, on mammary glands) which rupture leaving erosions.
 - Recovery typically within 15 days
 - Superinfection of lesions, hoof deformation, mastitis, permanently reduced milk production, permanent weight loss, loss of thermoregulation ('panters'). myocarditis.
 - Abortion, or death of young animals.
- Effects on sheep & goats:
 - Foot lesions may go unrecognized.
 - Lesions in dental pad of sheep.
 - Agalactia in milking sheep & goats.
 - Death of young stock.
- Effects on pigs:
 - May develop severe foot lesions.
 - High mortality in piglets.
- Can formulate the needed subtype vaccine antigens for outbreaks.
- Vaccines are somewhat effective.





Fundamental Mechanism of Ecosystem Disease: Domestication of Food-Producing Animals & Rodents Sustained close contact between animals & *Homo sapiens*—both under stress—gave rise to many of the major human pandemics.



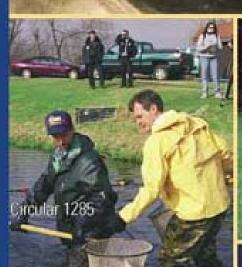
- Tuberculosis
- Influenza
- Plague
- Influenza again, again, again
- & Mobility hastens the spread.

Jared Diamond's Book: Guns, Germs, & Steel.



Prepared by the USGS National Wildlife Health Center in cooperation with the U.S. Fish and Wildlife Service

Disease Emergence and Resurgence: The Wildlife-Human Connection



U.S. Department of the Interior U.S. Geological Subsey





1,415 known pathogens....

61% of those are zoonotic Taylor, et al

Zoonoses are 3x more likely than nonzoonotic diseases to be emerging diseases Woolhouse





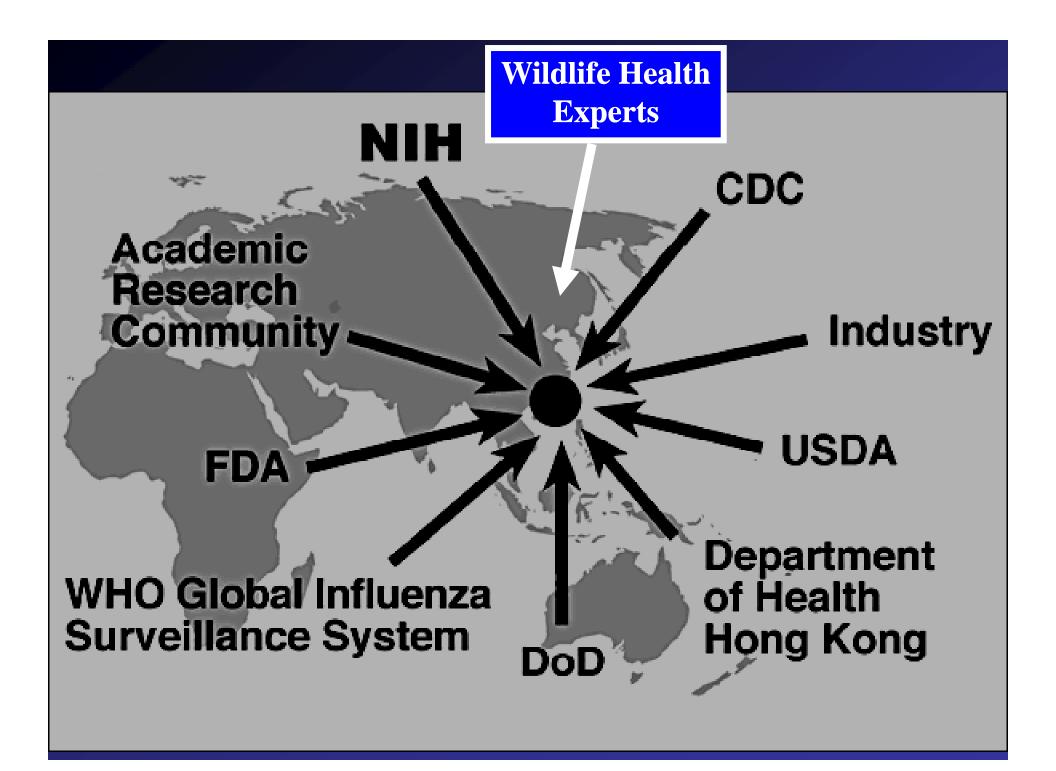
Photo by Colin Poole Photo by Elizabeth Bennett Risks in Asia may increase with increasing wealth & individual empowerment.....











Pre-SARS outbreak

 Millions of kg of wild animals traded annually without control.

Post-SARS outbreak

- Over 9,000 law enforcement cases.
- 930,000 non-domestic animals confiscated.
- 40,000 were "protected" species.





Invasion of Wildlife Habitat & Increased Contact between *Humans Under Stress* & Wildlife Under Stress + BUSHMEAT TRADE







Ebola viruses have killed far more gorillas & chimpanzees than humans.

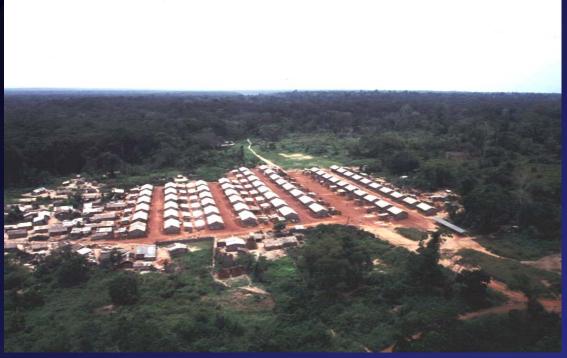
Accelerate Mobilitiy -> Increase Risks of Global Transm

Hemorrhagic Fevers

- Initially transmitted to humans when activities of reservoir hosts or vectors & humans overlap.
- Reservoir species for Ebola & Marburg not clearly known.
- Viruses in rodent reservoirs or infected primates transmitted when humans have contact with urine, fecal matter, saliva, or other body fluids/tissues.
- Viruses from arthropod vectors primarily spread to humans by a mosquito or tick bite, or when human crushes a tick.
- Some vectors may spread virus to animals, livestock, for example..... Humans infected by caring for or slaughtering the animals.
- Once an initial person is infected, Ebola, Marburg, Lassa, & Crimean-Congo hemorrhagic fever viruses can directly spread to other people.







Millions of Kg of Bush Meat/Year (Central & West Africa)



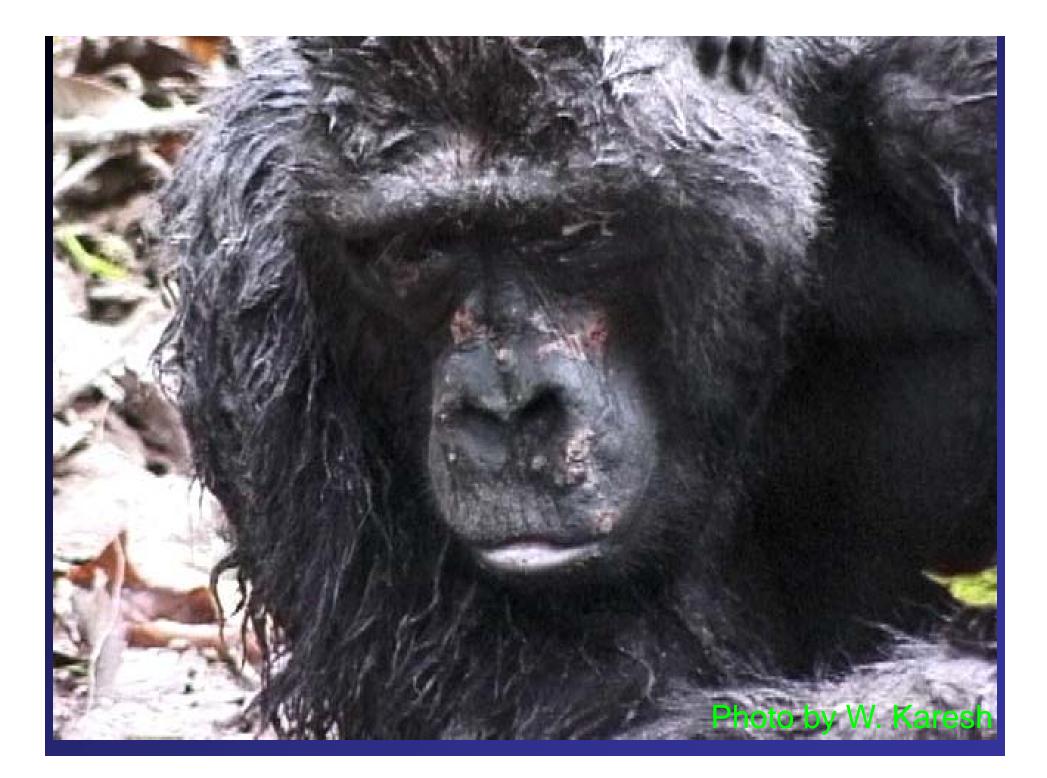




Photo by A. Kilbourn



Ebola Leptospirosis **Brucellosis Animals** Rabies Humans Salmonella Monkeypox Anthrax > 800 **Others**

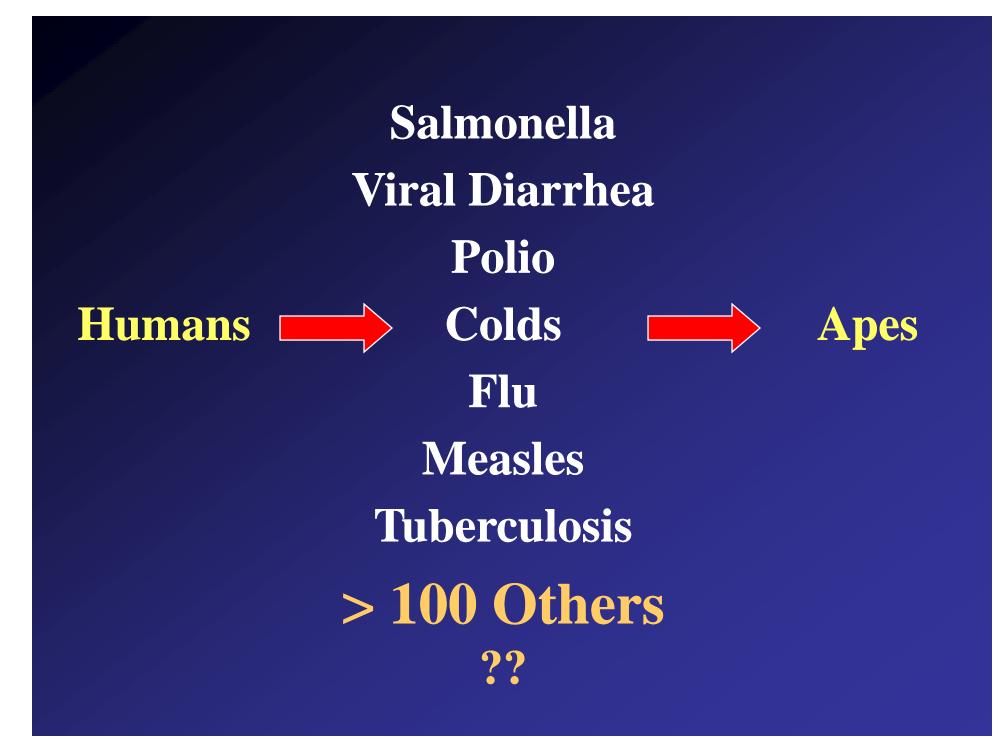




Photo by W. Karesh

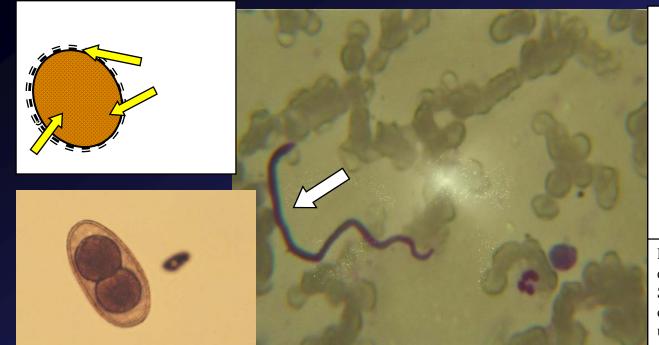


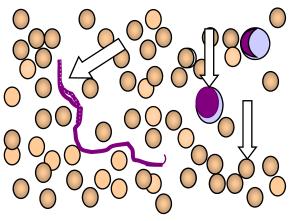


Capacity building

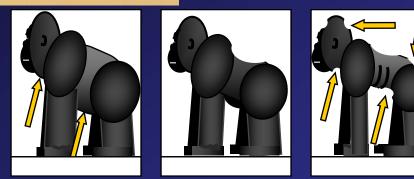
PERFECT "

10





Frottis sanguin montrant de longs organismes en filaments et des globules rouges et blancs. Sur un frottis frais ou avec un tube CRT avec couche leucocytaire, on note fréquemment une mobilité.



Nom de l'animal Espèce N° d'identification Date (écrire le mois)

Observations sanitaires, Collecte, Préservation et Analyse des Échantillons Biologiques

Hands-on work



Health examinations



Serology - Positives

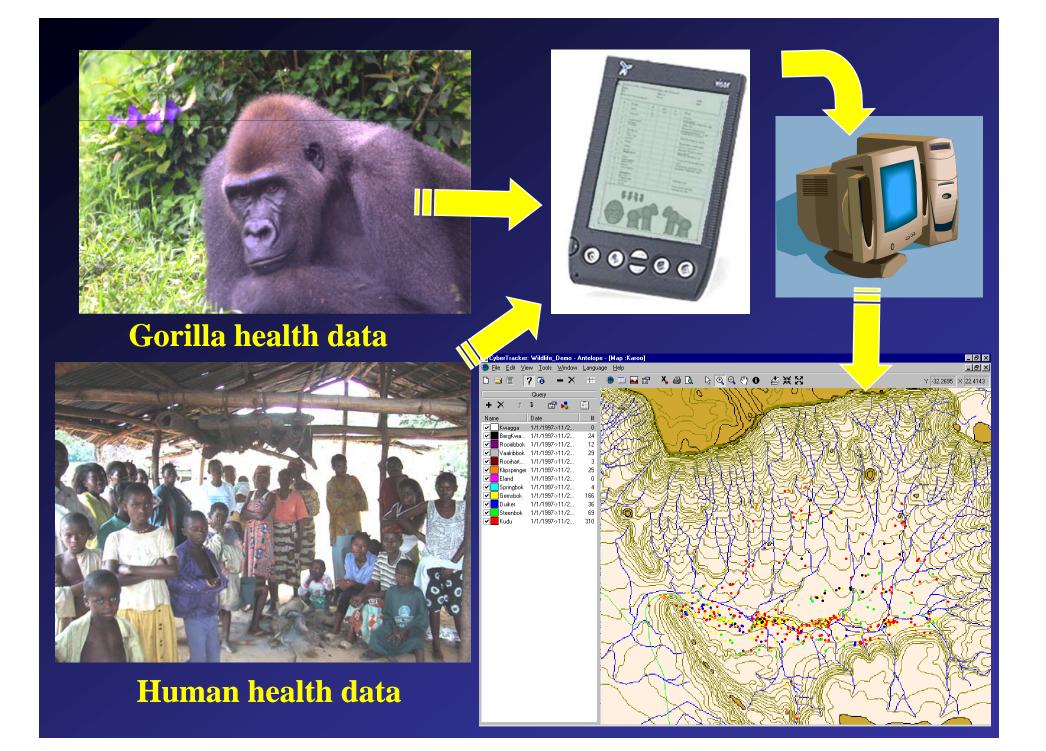
- Herpes Simplex 1
- Epstein Barr
- Rubella
- **Hepatitis A**
- Hepatitis B (sAb)
- Treponema

Data suggest animals have **already** been exposed and have **some** immunity following exposure

Serology - Negatives

- Polio
- Measles
- Ebola
- Dengue Fever
- **Reovirus**
- **Parvovirus**
- Monkey Pox

Data suggest animals have **NOT** been exposed and have **NO** immunity



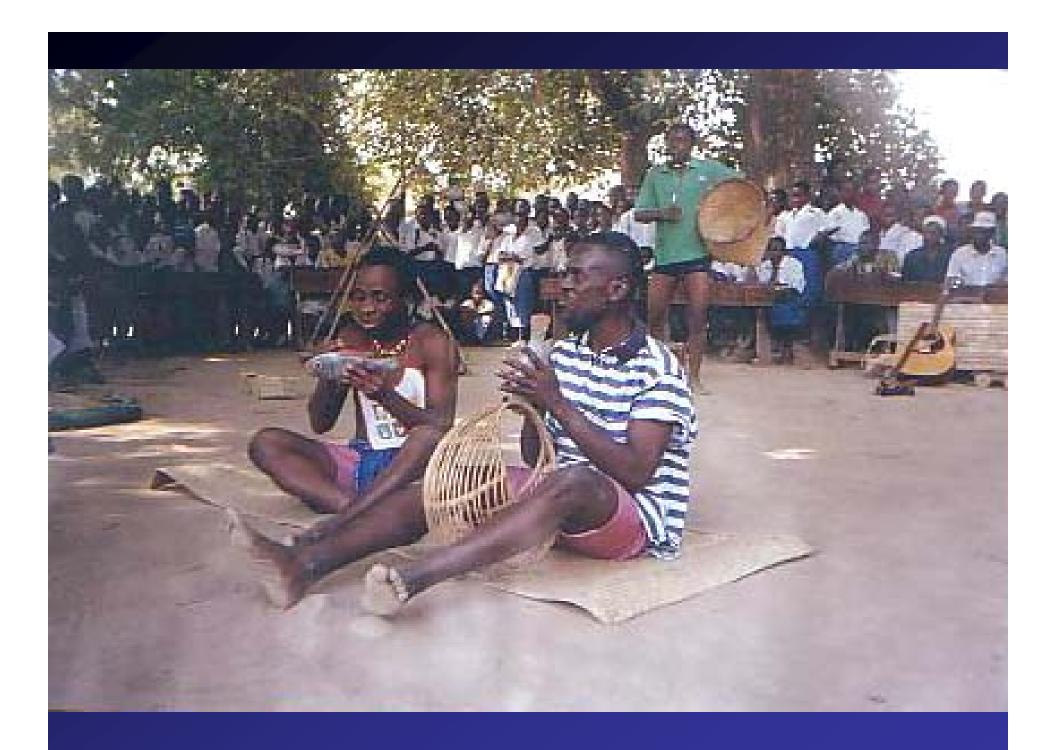




Disease outbreak investigations with post-mortem studies







Healthy People

Healthy Animals



Where does animal hygiene begin?

- Through cultural norms & religious practices?
- Through governmental policies?
- In developed countries?
- In developing countries?
- Via economic incentives related to global export/import pressures?

The Case for Confinement

- Protect profitability of production animals.
- Ensure humane treatment of the animals:
 - Protected from weather, predators.
 - Can be "happy, healthy, entertained."
- Protect wildlife from pathogens in the domestic animals & vice versa (screen out flies).
- Protect livestock-induced compaction of soils, erosion, trampling of plants, pathogen dissemination.
- Prevent environmental damage by locating production facilities & ensuring appropriate animal densities, feeding, & manure/urine management so that wastes are desirable fertilizers.

Extensive Rearing of

Livestock

- Cattle can be surrogates for wild ruminant communities that:
 - Contribute organic material that builds soil, increases H2O retention.
 - Pass seeds through gut to enhance germination, make divots that start seeds.
- Maintain pastoralist cultures.
- Use "New Ranch method"- short-term heavy grazing & "startle."
- Bomas & guard dogs to fend off predators & species that may serve as sources of infectious agents.
- Develop & deploy effective vaccines.
- Enhance disease-resistance genes through natural selection, genetic manipulation through breeding & biotechnology.

Extensive Rearing of Wildlife ("Sustainable Utilization")

- Wildlife extensively managed so that they fulfill historical ecological roles & meet human needs:
 - Traditional hunting cultures can be maintained.
 - Pro-fauna's work in Brazil is an example.
- Convert livestock ranching to ranching with native wildlife for meat, hides:
 - Ted Turner.
- Wildlife ranching to support hunting revenues:
 - Southern Africa.
 - USA.
 - Other parts of the world.

As animal numbers grow, risks of extinction decrease.

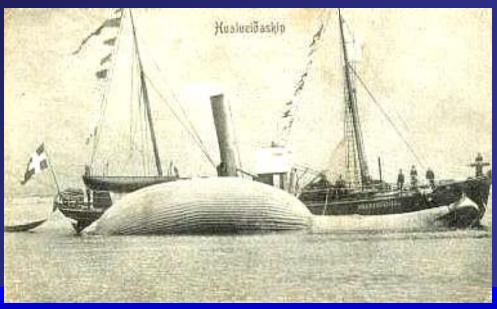
Whaling Ship Essex 1820



- In November 1820, the Essex rammed twice & sunk by a sperm whale.
- Twenty men salvaged food & equipment as ship sank.
- They set out in 3 whale boats to try to reach coast of S. America.
- Inspired the conclusion of Melville's "Moby Dick".

Modern Japanese Whaling Ship

- Since the early explorers, wealth of Antarctica's marine resources have been pursued by extractive industries.
- Fur seals were slaughtered by the tens of thousands during 1820s driving populations to the brink of extinction.
- Then came whalers, who for about 20 years in the early 1900s, processed more than 40,000 whales/year reducing populations to a fraction of their former abundance.





Modern Japanese Whaling Ship





Species Average Brain Weight (grams)

- Sperm whale
- The Elephant
- Bottle-nosed dolphin
- Adult human
- Twee Walrus
- 🖙 Gorilla
- Chimpanzee

7,800 6,000 1,500-1,600 1,300-1,400 1,020-1,126 465-540 420

 Blue whales are the largest mammal, but sperm whales have the largest brain.

Neuroscientist Lori Marino (Emory University in Atlanta, Georgia, USA) reports that whales with huge brains have been swimming in the oceans for more than 15 million years.

Modern Fishing Vessel



In the 1970s, exploitation of fish in the Antarctic accelerated.

Years of overzealous harvesting of cod in Antarctica prompted closure of fisheries.

What are the impacts of modern fishing vessels on food availability for marine mammals?

Mobility and Exotic Species: Mesopredators: *Felis domesticus*

Human & domestic animal health threats.

- Toxoplasma gondii.
 - Infected cats transiently shed millions of oocysts.
 - Incredibly resistant in environment.
 - One spore potentially lethal.
- Wildlife health threats.
 - ♦ Toxoplasma gondii.
 - Predation on birds, including endangered species.

Solutions:

- Birth control & prevention of abandonment.
- Capture & adoption or placement in indoor or outdoor enclosures.
- ◆ Euthanasia.
- Return of native large predators.
 - Re-establishing corridors, immigration, &/or reintroductons...





Increased Mobility – Range Expansions Related to "Management" **Mesopredator Release Phenomena:** Opossums, an invasive spp. in much of the US



Sarcocystis neurona.

- Domestic animal health threat.
 - Protozoal myelitis in horses.
- Wildlife health threat.
 - Sarcocystis infection.
- One Solution:
 - Return of native large predators.
 - Increased mobility...
 - Re-establishing corridors, immigration, &/or reintroductions...



Toxoplasma & Sarcocystis in Sea Otters Studies at UC-Davis.



Otter Skins, Boston Ships, and China Goods



- Otters hunted to near extinction. Slow recovery.
- Cat colonies on coast of California.
- Opossums moved north.

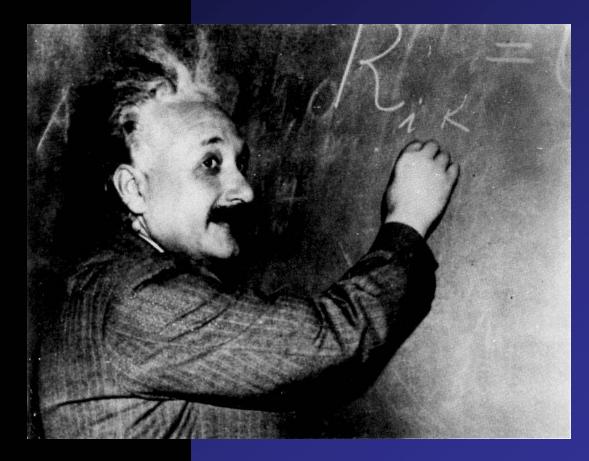
THE MARITIME FUR TRADE OF THE NORTHWEST COAST, 1785-1841 James R. Gibson

- Too few cougars & no longer wolves to keep these invasive spp. in check.
- Feces enter ocean environment.
- Toxoplasma & Sarcocystis concentrated by shellfish \rightarrow otters
 - (and likely increased risks to human populations that eat shellfish.)
- Endangered southern sea otters \rightarrow brain & heart impaired.
 - Direct death losses.
 - Increased impacts of shark attack.
- ✓ Sea urchins no longer eaten by otters → population explosion.
- ✓ Kelp overgrazed by urchins → fish lack cover → populations fall.

Our Choices

- Continue muddling along without a plan.
 - Gradual degradation/depletion of resources.
 - Resource wars with gradual degeneration into anarchy/feudalism.
- Learn from past mistakes & accommodate human nature.
- Study the ecology, plants, & animals, plus human knowledge, needs, wants, & expectations.
 - Develop a management PLAN to address ecological & human goals, using appropriate education, incentives & disincentives.
 - IMPLEMENT the management plan.
 - STUDY the response.
 - -REFINE the management.





Albert Einstein.... "Perfection of means © confusion of goals seem to characterize our age"





to Address First Priority Goals REGARDING the Greatest Crises of Our ERA



Some Tools & Ideas to Take on the Road in the US & Around the World

Ecosystem Health as a Discipline

...focuses on sustaining structural & functional integrity & thus, the services of ecosystems, *including*.....

- 1. Largely natural regions.
- 2. Transitional zones.
- 3. Areas greatly altered & intensively managed to fulfill human aims.

Ecosystem Health as a Condition

- Many healthy ecosystems are characterized by high organismal & genetic diversity that confer functional redundancy, which makes them resilient.
- Thus, their services typically "bounce back" after:
 - Climatic extremes
 - Emissions of biodegradable toxicants.
 - Small-scale changes from human activity.
 - Periodic changes in animal populations e.g. migrations.
 - ...without expensive management intervention...

To Restore Resilience & *Productivity* to Ecosystems & Improve the Health of Human, *Domestic* Animal, & Wildlife **Populations**

Educate all ages of the public (infants-elders) so that governments acquire public lands & waters & implement needed business incentives, disincentives, laws & regulations – to achieve all of the following Features of Healthy Ecosystems

- Chemical contaminants are below threshold concentrations (for direct & indirect toxic effects).
- Exotic & invasive species introductions are prevented & exotic species are eliminated when possible & desirable.
- Emerging & re-emerging diseases in wildlife are prevented by facilitating biodiversity-driven disease control, reduced crowding & stress, increased distance from humans, better vaccinations.
- Wild animals are harvested only at rates that permit recovery of robust populations.

- Food animal production is scaled to farm land, so wastes fertilize their food plants; the animals are treated humanely; & diseases are avoided through proper isolation and husbandry.
- Plant content of human diets & organic production are increased to reduce impacts of nutrient & pesticide pollution.
- Agriculture & forestry are building soil, & not depleting the water of aquifers, streams, or lakes.
- Estuaries & coastal zones are rehabilitated/restored.
- Atmospheric CO₂ & methane concentrations are declining; & solar, wind, & other clean renewable energy sources are increasing.

- Natural areas are large enough to sustain larger native carnivores & other species with large ranges.
- Natural landscapes are reconnected even in intensively managed areas –e.g. along streams, across uplands, so that human activity areas are again within networked natural ecosystems (HUMANS in the FRAGMENTS).
- Ample buffers are reestablished with native plants, & animals—to offset effects of human activities.
- Areas intensively managed for human needs/wants exist as small & large islands linked with one another by road & rail systems that allow animal movements, preserving gene flow within species & interspecies dynamics.
- Margins of safety for wild plant & animal sustainability have recovered through largely unobstructed natural evolution.

Agricultural Product Labeling for Coordinated Global Stewardship

Adapt for other industries apart from agriculture.

- Think locally & globally & Act locally & globally.
- Labels that reveal:
 - 1. Animal health.
 - 2. Animal welfare.
 - 3. Ecological stewardship (for animal and crop land husbandry).
 - Habitat loss, design.
 - Soil erosion.
 - Pollution (including CO2).
 - 4. Fair trade treatment of workers.
 - Rights.
 - ♦ Wages.
 - Benefits.
- Voluntary & later refuse products produced unethically.
- Develop global stewardship eligibility for trade depends on responsible behavior.
- Denmark exports vast numbers of canned hams for profit.
- Could African countries export canned ("free-range") antelope, buffalo, & other meat for profit?

Use Powerful "New Tools" to..... Grow Collective Knowledge & Wisdom

- Newspapers/Magazines/Books.
- Radio/Television.
- World Travel.
- The Modern Scientific Literature
 - Physics/Chemistry/Geology/Paleontology.
 - Biological & Biomedical Sciences.
 - Ecology.
- Modern Research Universities.
- Engineering if we pay attention to downsides.
- Satellite Images/Remote Sensing/GIS & Spatial Analysis.
- The Internet.
- Theology.
- Political Sciences.



GIS & Spatial Analysis for Planning in Ecosystem Health & Conservation Medicine



- * Land use
- Land cover
- & Landscape:
 - Wetlands
 - Pastures/hayfields
 - * Forests
 - Crop fields
 - Buildings
 - * Roads
- Fragmentation
- Connectivity
- "Hard or soft" transitions

10 km buffers around 4 study sites

Land cover within each buffer

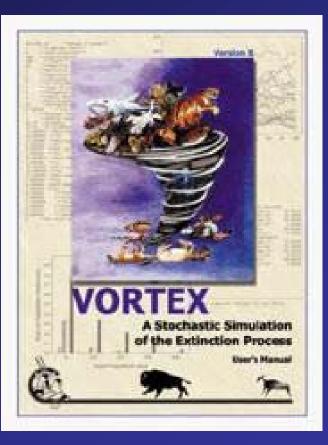
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Population Viability Analysis (PVA)





Community Conservation

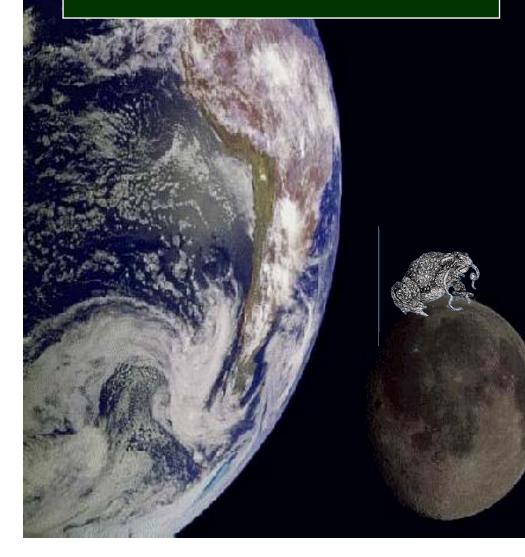
- Must support:
 - -Local economic gain.
 - Cultures that relate to native species (plants, animals).
- Must prevent & compensate for losses from wildlife-induced:
 - Crop losses.
 - -Livestock losses.
- *The Must prevent human injury & death.*

Respect for & Support of Tribal Cultures



Work with Native Peoples, Including Subsistence Hunters,... who may be strong advocates for: Abundance/Sustainability **Protection of Animal Health Prevention of Over-harvest Control of Pollution**

One Health



 Should help society move more rapidly toward a world that reconciles political, economic, & ecological goals.



April 16, 2007: \$4.95

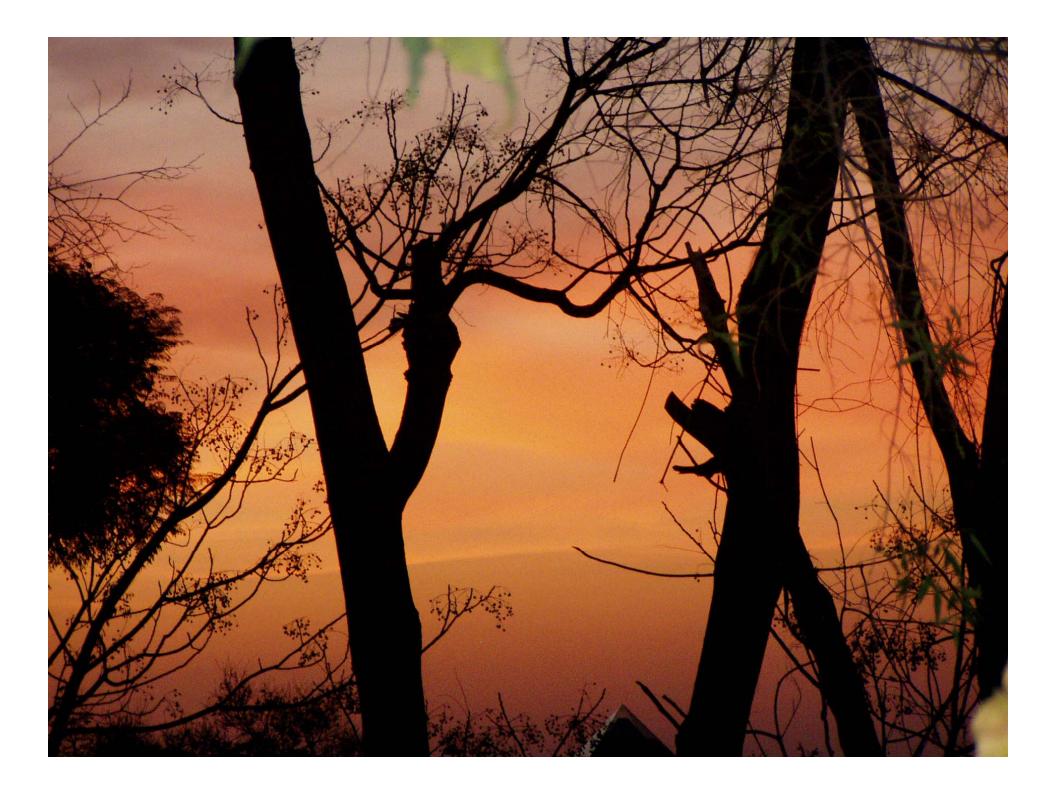
Save the Planet-Or Else

LEADERSHIP & THE ENVIRONMENT

Things Worth Remembering

- The Value of Time
- The Pleasure of Working
- The Dignity of Simplicity
- The Worth of Character
- The Improvement of Talent
- The Influence of Example

- The Obligation of Duty
- The Wisdom of Economy
- The Virtue of Patience
- The Joy of Originating
- The Power of Kindness



Thank You....



Blesbock & Giraffe, Back-to-Africa Project, Swaziland, August, 2005



Defeating the Race to the

Bottom

- Mews media exposure of polluters.
- Sews media exposure of sweat shops.
- Labeling of products wages paid, contaminants emitted.
- \sim Taxing emissions of CO₂.
- Taxing depletion of non-renewable energy sources.
- Managed incentives to balance work with workforces to decrease the need for emigration & immigration.
- Incentives/disincentives to move intensive animal production to regions where food crops produced.
- Global unions.
- Global human rights.
- Global governance with nested continental & regional governance.



Overcome Humar Overpopulation

Educate women → independence/enable careers Increase security in old age to decrease birth rate Offer existing birth control options Develop new birth control options (vaccines, surgical or chemical ligations/nanotech?) Engage the religions

Conclusions/Opportunities

- Ecological Services: everything that distinguishes Earth from Mars, Venus, & the moon.
- Ecosystem Health & Major Threats: "Mankind"
 our numbers, our appetites, our lack of vision,
 & our current poor leadership.
- Huge beckoning opportunities!!

Great jobs – rich with adventure – in ecotox, infectious diseases, endangered species conservation, public health & ecosystem health!

Endocrine Disruption

- Sensitive because endocrine systems effect major impacts from low concentrations of chemicals (e.g. sex steroids, thyroid hormone).
- Receptors are "promiscuous."
- Abnormal functions caused by natural & manmade xenobiotics that may be agonists or antagonists at receptors, or that alter synthesis, distribution, or metabolism or endogenous hormones.

Epigenetics & Pollution

- Multiple generations impacted by exposure of a single generation.
- Damage not through mutagenesis.
- Damage through altered reading of the genome.
- Altered protein confirmation.

.... Their Respect for Creation/Evolution, Biodiversity,

- Human Population Growth.
- Resource Consumption per Individual (*"the aspiration bomb"*).
- ✓ Manipulation, Militarism, & Terrorism → Wasting Resources Instead of Compassion for All Life & Learning from past mistakes.
- Alterred Hydrology.
- Over-fishing, Poaching = Overharvest by Human Populations.
- Introductions of Invasive Species.
- Inefficient Agriculture (erosion, "salinization").
- Pollution (nutrients, pesticides, industrial chemicals, construction chemicals, petroleum, effluents from mining, coal burning, metal smelting, vehicles, homes).
- Fragmentation, Degradation, & Loss of Natural Habitat.
 - ① due to agriculture, commercial forest, business, housing, roads.
- ✓ Stress, Crowding, Increased Contact Among Wildlife & Humans →
 Re-emerging & Newly Emerging Diseases (humans, buffalos, lions, frogs).
- Declining Species Diversity & Declining Genetic Diversity within Species.
- Global Warming & Microclimate Change.
- INTERACTIONS (Antagonistic, Additive, Synergistic).
- *Collective Denial, Ignorance, & Inertia!*

.... Their Individual & Collective Wisdom, Spirituality??

- Human Population Growth.
- Resource Consumption per Individual (*"the aspiration bomb"*).
- ✓ Manipulation, Militarism, & Terrorism → Wasting Resources Instead of Compassion for All Life & Learning from past mistakes.
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Worksites



Mobility & **Introductions** of Exotic Species Accidental introductions of plants: – Poison hemlock. ♦ Teratogen. Purposeful introductions of plants: - Halogeton. ♦ Renal failure. – Water hyacinth. Crowds out other plants. ◆ Deters fishermen.





Monoculture Agriculture, Clear-cutting & Monoculture Forestry



Removal of biodiverse plants to produce genetically similar plants, susceptible to attack by fungi, & insects triggers use of toxic pesticides, plus depletes nutrients, prompting fertilization which increases free *nutrients* \rightarrow harmful algal blooms in lakes, streams, estuaries, coastal zones.

Since Publication of "Silent Spring".... We Have Witnessed 40 Additional Years of Contamination of Ecological Resources Major Adverse Effects on Wildlife Populations! Where Were/Are the Veterinarians, Toxicologists,

Government Regulators Legislators, Informatical

Brown pelicans

Rachel Carson

Other Notes from Amherst, in 1763 – during the French & Indian War

- "...Measures to be taken as would Bring about the Total Extirpation of those Indian Nations."
- "...their Total Extirpation is scarce sufficient Attonement...."
- "...put a most Effectual Stop to their very Being."
- Amherst's other correspondence during this time reflects a normal focus on routine matters.
- None of the other letters indicate derangement or or an obsession with cruelty.

Thank You for Your Attention!



Coastal Development & Agriculture



Clearing of land, road building Sewage & animal waste loading **Road building** Filling estuaries Dredging & levee construction for shipping Eliminate nursery areas needed by fishes Reduce filtration \rightarrow expose coral reefs to warm water, metals, organic contaminants, particulates, nutrients, & toxigenic cyanobacteria Coral Reef Die-Offs

Decreased Coastal Fisheries

Decreased Hurricane/Tsunami Protection

Excessive Reliance on Fossil Fuels (Natural Gas, Petroleum, Oil Sands, Coal) & *Clearing of Forests*



GLobal

Warming

-CO₂ & methane build up →
"greenhouse effect."
-Polar ice caps melt → coastal
flooding + more water vapor in air.
-Climates become erratic:dry
→ fires... &.... wet → floods.
-Reduced salinity, impaired ocean
escalator, Parodoxical cooling (N.
Europe).

-Release of trapped CO₂, CH₄.
-Expansion of arthropod vectors (mosquitoes, ticks) → diseases.
-Wildlife need to move their rangebut rivers, lakes, seas, mountain ranges, deserts, agricultural fields, cities, highways are often in the way.



Major... Oil Spills







Fundamental Mechanism of Ecosystem Disease: Industrial & Municipal & Mining-related Releases of Elemental, Inorganic, & Organic Contaminants







- ✓ Mining & drilling that pollute air, water, & soil → direct & indirect toxic effects of metals, drilling mud chemicals, petroleum, other hydrocarbons.
- Interactions between acid runoff & acid precipitation & metals > direct effects of acid + increasedy impacts of aluminum & iron.
- Destruction of locally-adapted biodiversity in refugia provided by tributary streams.

Fundamental Mechanism of Ecosystem Disease: Overemphasis on Defense - Underemphasis on Resources Defense Goal: Prevention of Losses of Life, Control, Freedoms

Nuclear Warfare

Blast force injury
Thermal injury
Radiation injury





- Conventional Warfare:
 - Munitions
 - Guns, artillery, rockets, mines
 - Smokes/obscurants
- Chemical Warfare:
 - Neurotoxic chemicals
 - ◆ OPs, Botulinus toxin
 - Potent mucosal irritants
 - Emetics
 - Crowd control agents
- Biological Warfare:
 - Anthrax
 - Smallpox



Plague Means of Warfare Control Us Instead of People Controlling Warfare Necessity for Global Governance – with Nested Continental, Regional & Local Stewardship

Warfare & Weapons of Mass Destruction

Must we endure more wars before we develop the will to ensure a far stronger, more efficient, more effective, better funded, more widely accepted United Nations, with global disarmament treaties, a strong world court, & a multinational police force to remove despots & terrorists?

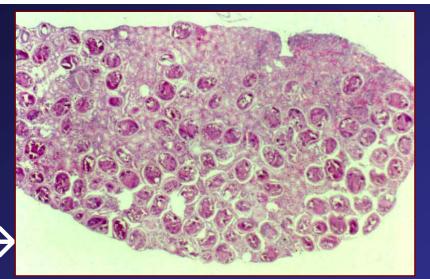
"Ours is a world of nuclear giants and ethical infants. We know more about war than about peace, more about killing than we know about living."Omar Bradley



Fundamental Mechanisms of Ecosystem Disease *REACTIVE MANAGEMENT* the limitation of the current mindset...

Where is Proactive management scaled to counteract human population growth?..

Potential Mechanisms of Amphibian Declines Infectious Diseases • Trematodes *Echinostoma* -



Kidney of cricket frog metamorph from Southern Illinois with abundant *Echinostor*

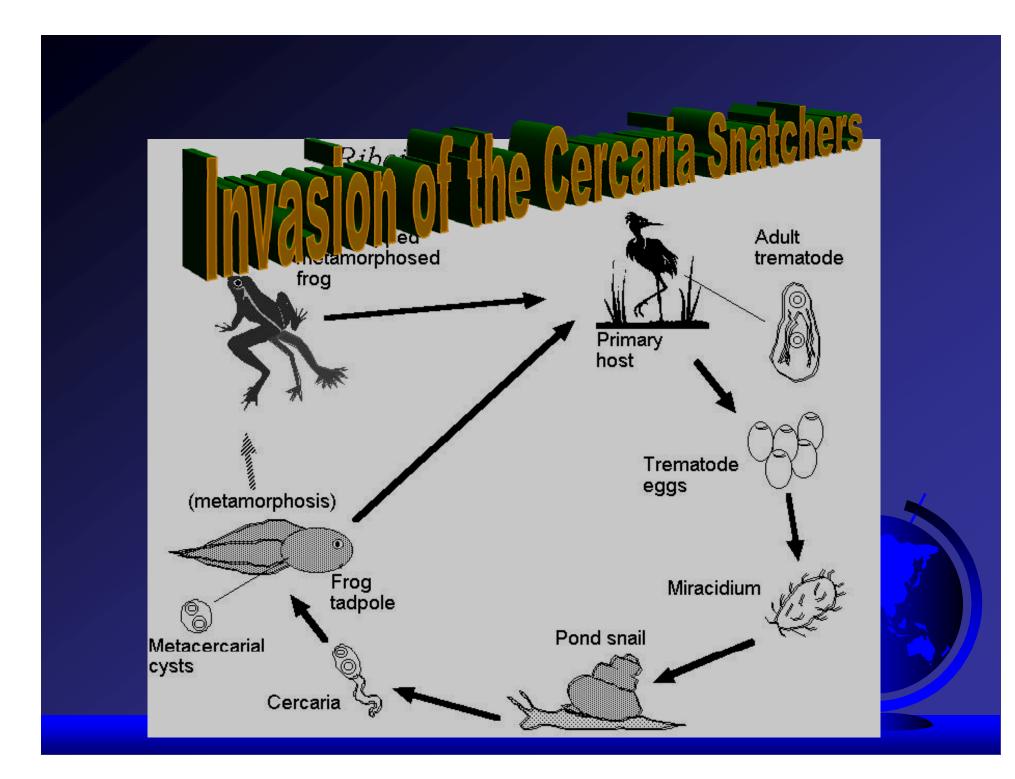
Ribeiroia



Ribeiroia sp. in tail resorption site



Bullfrog metamorph from suburban Urbana, Illinois with abundant *Ribeiroia*



.... Their Grace Toward On e Another?....

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Some Definitions & Context in Ecosystem Health.....

Ecology, Toxicology, Ecotoxicology

- Ecology: Science of all living organisms, & all their interactions among one another & with the environment.
- Toxicology: Science of all the adverse effects of all chemicals on all life forms.
- Ecotoxicology: Science of all the adverse effects of all chemicals on all living organisms & on all their interactions among one another & with the environment.
- Extremely broad & complex but problems controllable, by limiting contamination so environmental concentrations do not harm prokaryotic & eukaryotic life.

Ecotoxicology - Shortcomings

- Decisions sometimes unduly influenced by political & economic pressures.
- Research & policy can be *too disconnected* from the problems.
 - Decisions often fail to address greatest needs.
- Research is focused on environmental residues, but too little attention to pathophysiology & diagnostic residues in animals!
- Complex mixtures rarely studied.
- Research insufficiently targets indirect effects of contaminants.
- Much risk assessment—but *little follow* through to assess accuracy of predictions!
- Much information generated for approval by government agencies is proprietary.

Ecotoxicology - Value



- *Triggered new environmentally-benign manmade chemicals* (astute choices).
- Helped basic & applied ecology become problem driven.
- Helped set stage for conservation medicine.
- Complemented other components of ecological restoration.

Ecotoxicology - Editorial

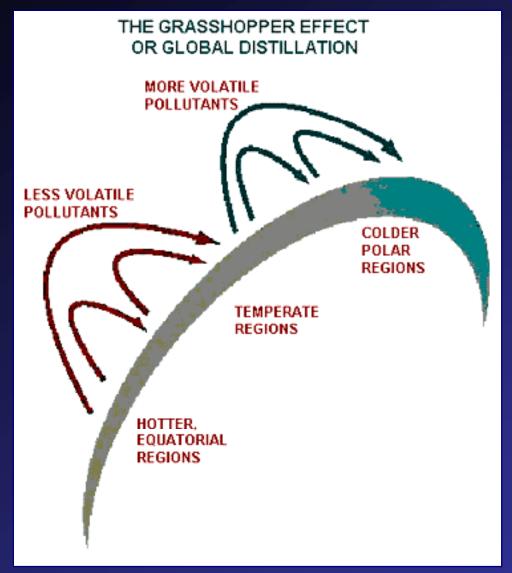
Should exist within a balanced ecological & biomedical context.

Needs to be far more humble about unmeasured effects!

Needs to be much *more* of a *preventive* than a remediative enterprise.

Local to Global Transport of Environmental Contaminants

Volatilization & Re-volatilization



When semi-volatile, persistent organic pollutants (POPS) reach the Arctic....

→ <u>Cold Condensation:</u>

Particulates dropout with rain & snow.

Low evaporation traps POPS in Arctic.

Dissolve in lipids of surface microlayer, sediments, plants, animals → food chain.

Similar grasshopper distillation effect from low to high altitudes.

Water Quality and Environmental Sampling











Saint Lawrence beluga whales: post mortem examination program: 1982-now

Stranded carcasses transported to necropsy room (CVM, U of Montreal, 300 miles)



Beluga whales. Cancer. 1983 – 2004

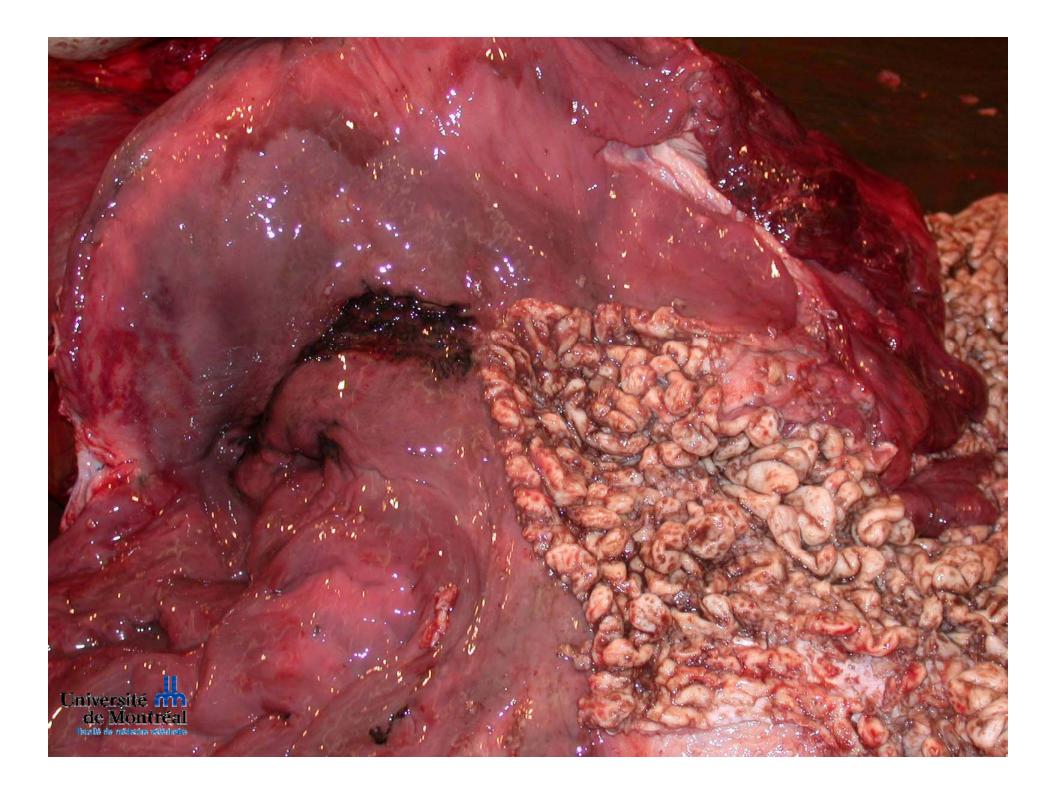
- 14 cancers linked to digestive tract

Université n de Montréa

- 8 in proximal intestine - Martineau et al 2002

Digestive system (14)

Intestinal adenocarcinoma (8) Gastric adenocarcinoma (3) Hepatocellular carcinoma (1) Bile duct carcinoma (1) Salivary gland adenocarcinoma (1)



Beluga. Cancer, proximal intestine (adenocarcinoma)

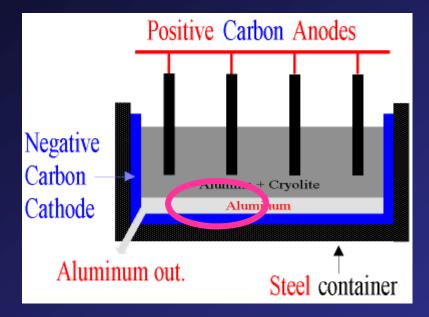


Production of aluminum

- 1) Chemical extraction of alumina from bauxite
- 2) Electrolysis of alumina

Anodes = mixture of tar







Alcan. Alma

Warfare & Ecotoxicology

Overemphasis on Defense - Underemphasis on Resources Defense Goal: Prevention of Losses of Life, Control, Freedoms

Nuclear Warfare

- Blast force injury
- Thermal injury
- Radiation injury





- Conventional Warfare:
 - Munitions
 - Guns, artillery, rockets, mines
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- Chemical Warfare:
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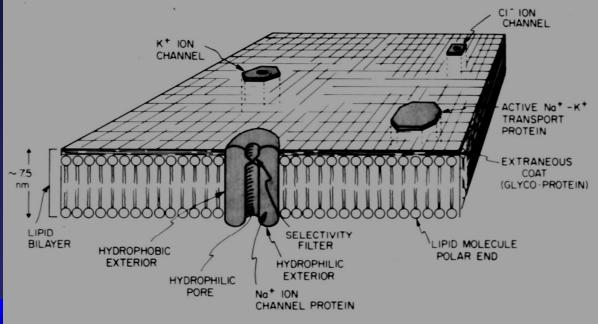
Plague Means of Warfare Control Us Instead of People Controlling Warfare Necessity for Global Governance – with Nested Continental, Regional & Local Stewardship

Ecotoxicology: DDT & Fish-eating Birds

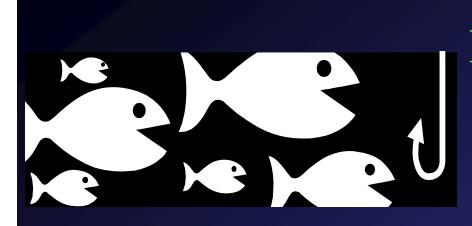
- Bald Eagles,
- Spreys, &
- Brown pelicans failed to reproduce due to extreme egg shell thinning.







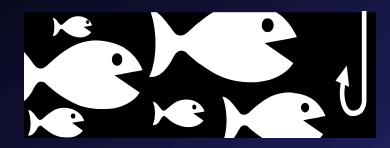
Neurotoxicity of DDT is due to the propping open of sodium channels & impairment of the opening of potassium channels.



Processes that Influence Concentrations of Contaminants in Aquatic Animals

Biomagnification: Slow biodegradation (usually due to bulky halogen atoms) & high lipid solubility (generally molecules with no charge) cause vast increases in net uptake as chemical passes from lower trophic levels to higher trophic levels, resulting in successively greater residue concentrations in consuming organisms.

- In adipose low blood supply & slow biodegradation.
- Nursing young of top predators feeding in contaminated aquatic food webs are often massively exposed.



Compounds Classically of Concern from Biomagnification in Food Webs

- Organochlorines:
 - Much is in adipose tissue, mobilized to body during catabolism.
 - Many organochlorine insecticides:
 - ◆ DDT, toxaphene, myrex, kepone, chlordane, others.
 - Hexachlorobenzene (fungicide).
 - Polychlorinated biphenyls (PCBs).
 - Polychlorinated dibenzodioxins.
 - Polychlorinated dibenzofurans.

Methyl mercury (most is in muscle not adipose tissue; crosses placenta, blood brain barrier, nervous tissue—& blood vessels in the brain—are important targets).

Ecotoxicology of an Insecticide: DDT & Fish-eating Birds

Mechanism of egg shell thinning:

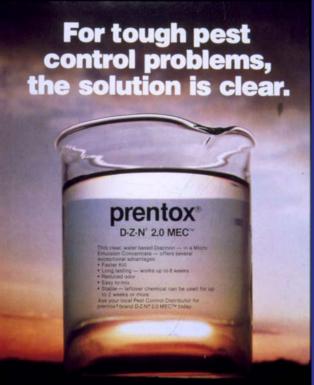
- Inhibition of Ca-ATPase in oviduct.



- Reduced transport of calcium to site of eggshell formation (Peakall *et al.*, 1973).
- But details of pharmacodynamics involved in inter-species variation (more susceptible/less susceptible bird species) remain unclear.
- Even today's pre-registration studies required by EPA would be "unlikely to have found this adverse effect of DDT."

Acute Diagnostic Toxicology of Cholinesterase-Inhibiting Insecticides Direct Effects on Birds from Organophosphorous & Carbamate Insecticides

- Concentrated agricultural products.
- Malicious use to kill "pest" birds.
- Most are not especially persistent in environment.
- Detect parent compounds in source materials, baits, stomach contents or, for OPs in liver.
- Acetylcholinesterase (ACh) inhibitors.
- Inhibition is reversible with carbamates. Can use diagnostically.
 - Run AChase.
 - Incubate.
 - Re-run AChase.
 - Reactivation suggests a carbamate.
 - No reactivation suggests an OP.
- ACh inhibition can be reversed with most OPs. Can use diagnostically (may need to ask or do it yourself).
 - Oxime (e.g. 2-PAM) may remove OP from ACh if OP has not aged on enzyme.
 - Run AChase.
 - Incubate with oxime.
 - Re-run AChase.
 - Reactivation suggests a OP.



() prentis

Prentiss Drug & Chemical Co., Inc. 18 2000, Dept. A. Ficora Park, NY 11001 (518) 235-1919 spect Ave. PO Bos 707, Park Holgo. 14, 6068 (321) 825-0021 PO Box 40301, PL Worth, TX 76140 (817) 293-9649 Sharlowford Pd., N.E., Astanta, GA 20340 (404) 458-1056 Also Los Angeles, CA

Diazinon has often been implicated in avian death losses. Some uses (golf courses) banned.

Relay Toxicosis: Case Report on an OP Insecticide Affecting Raptor Populations...

Swainson's Hawks in Argentina:

Satellite radiotracking to find dead birds. Monocrotophos (OP) to kill grasshoppers. Relay toxicosis to the hawks. Stopped use & death losses ceased.





Indirect Effects of Insecticides on Animals

- May *starve* birds & mammals that eat insects, annelids, or other prey species highly susceptible to the insecticide.
 - Decreased fertility.
 - Decreased survival of young.
 - Increased infectious disease: May kill dung beetles, that remove feces, helminth ova, & bacteria from surface.

Indirect Effects of Insecticides on Ecosystems, & the Economy

Insecticides kill soil organisms (ecologic & economic impacts).

The May kill soil arthropods, that break down plant debris, to help soil fertility.

Insecticides kill not only target pest insects, but also insects that prey on them.

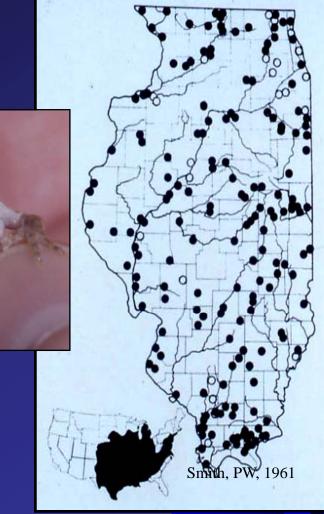
- Insect pests released from predation pressure & their numbers increase.
 - Insecticide "addiction."
 - «Economics: good (for pesticide manufacturers).

*•*Economics: bad (for farmers, home owners that use lawn/garden insecticides).

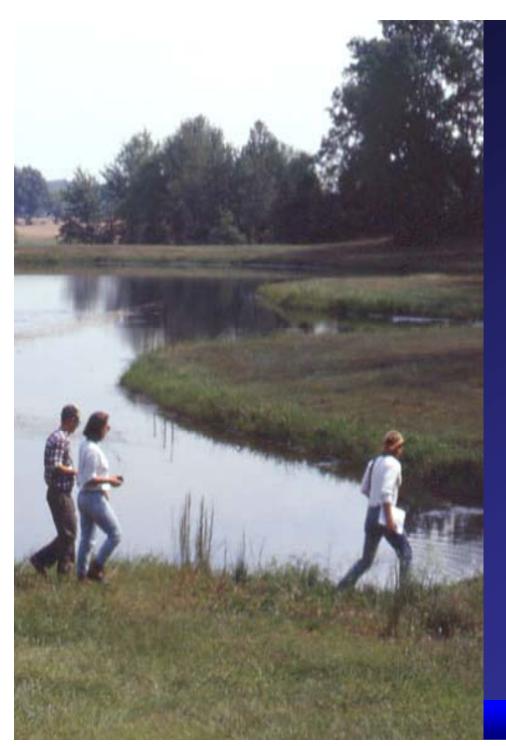
Some Direct & Indirect Effects of Herbicides: Research Findings from the Field

Cricket Frog Population Trends

•1961 Most abundant frog, readily found throughout Illinois. •1981 Endangered Species List Wisconsin. •Mid-1990s Believed extinct in Minnesota, Ontario. Populations decreased in Iowa, northern Indiana. Only 3 populations identified in northern Illinois. Still abundant in southern Illinois, Missouri.



Distribution of *Acris crepitans* throughout Illinois. Solid circles indicate localities represented by specimens examined during a study reported in 1961; open circles reflect published records believed to be valid at that time. The lower map depicts the local range of the species in the United States.



Initial Research Team



Beasley et al 2005 Reeder et al 1998 Cricket Frog Study Design

- Calling surveys May/June.
- Visual encounter surveys August.
- Metamorph studies August:
 - Gross & histologic lesions.
 - Parasites.
- Habitat characterizations:
 - Site histories.
 - Aerial photography.
 - Local plant communities.
 - Water quality assessments.
 - Toxicant analyses June & July:
 - ◆ Water & sediment.



TOXICANT ANALYSES

Animal Disease Laboratory – Centralia – WATER Profile

<u>Herbicides</u>

Insecticides

Alachlor Ametryn Atrazine Barban Bifenox Bromacil Butachlor Butylate Chloropropham Chlorothal Cyanazine Diclofop isomers Dinitramine Dipropetryn Diuron EPTC Fluchloralin Hexazinone Linuron

Metolachlor Metribuzin Monuron Napropamide Naptalam Oryxalin Pebulate Pendimethalin Profluralin Prometon Prometryn Pronamide

Propanil Propazine Propham Simazine Terbuthylazine Terbutryn Trifluralin

CARBAMATES **OPs OCs** Chlorpyrifos Aldrin Aldicarb Aminocarb Diazinon Chlordane Dimethoate DDD Bendiocarb Carbaryl Disulfoton DDE Carbofuran Ethoprop DDT Methiocarb Ethyl parathion Dieldrin Fenthion Endosulfan Methomyl Oxamyl Fonofos Endrin Isofenphos Heptachlor Hept epoxide Malathion Lindane & **Methidathion** Fungicides Methyl parathion Methoxychlor Mevinphos Mirex Benomyl Thiobencarb Phorate Hexachlorobenzene Terbufos CBs Trichlorfon Lead

Aerial Photographs for "Basic Spatial Analysis"

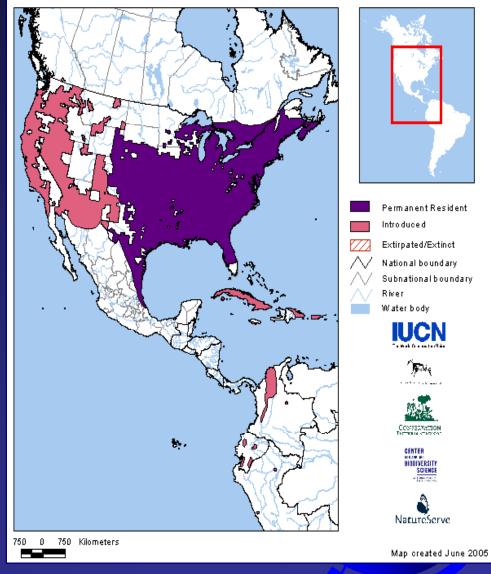


Direct Effect Apparent Endocrine Disruption

Mobility & Amphibian Declines

Introductions of other exotic invasive predators/competitors (& their pathogens)

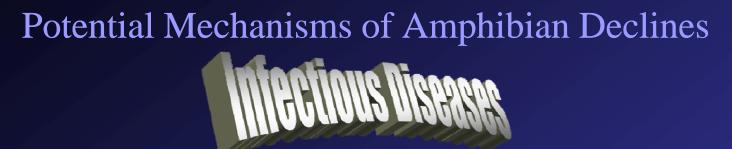




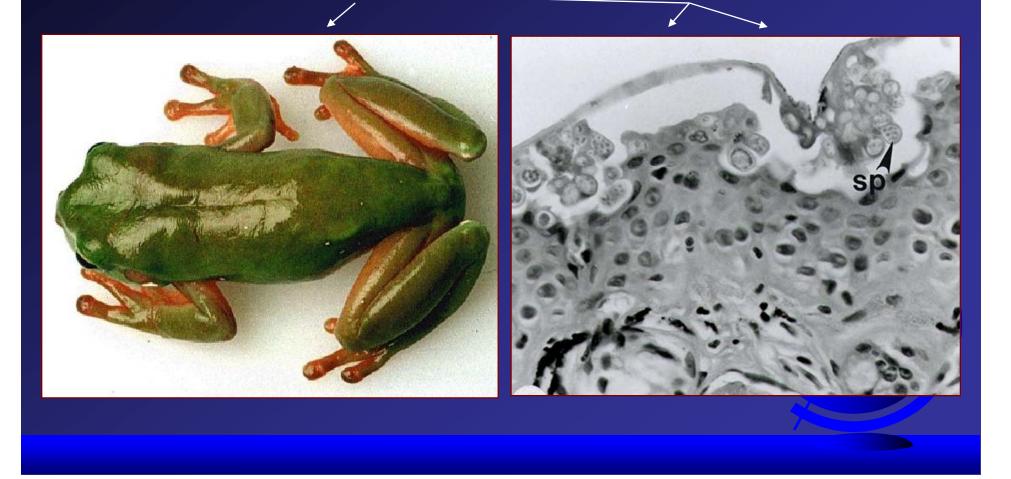
Bullfrog photo & Distribution Map, 2005

Site Visits Site 11- Summer 1994 Dead Water Primrose (Jussiaea repens)





Chytridiomycosis



Panama "Chytrid" Study



Karen Lips, Southern Illinois University, Affiliate, Smithsonian Tropical Research Institut





Malformation Schoff et al 2003 Polymelic











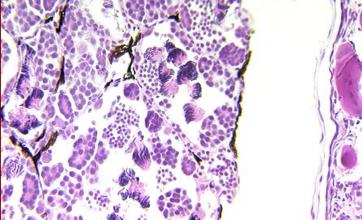
Fundamental Mechanism of Ecosystem Disease Ecological Illiteracy: Profound ignorance of ecosystem functions

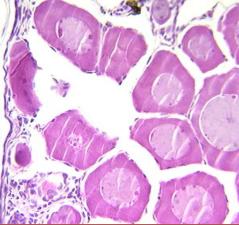


Where are We Headed?

- Massive & continuing elimination of wetlands.
 Filling of estuaries.
- 80,000 sq miles of tropical forest destroyed each year.
- If the human population doubles by 2050, 90% of existing natural habitat will have been lost.
- Iost during this same period of time.

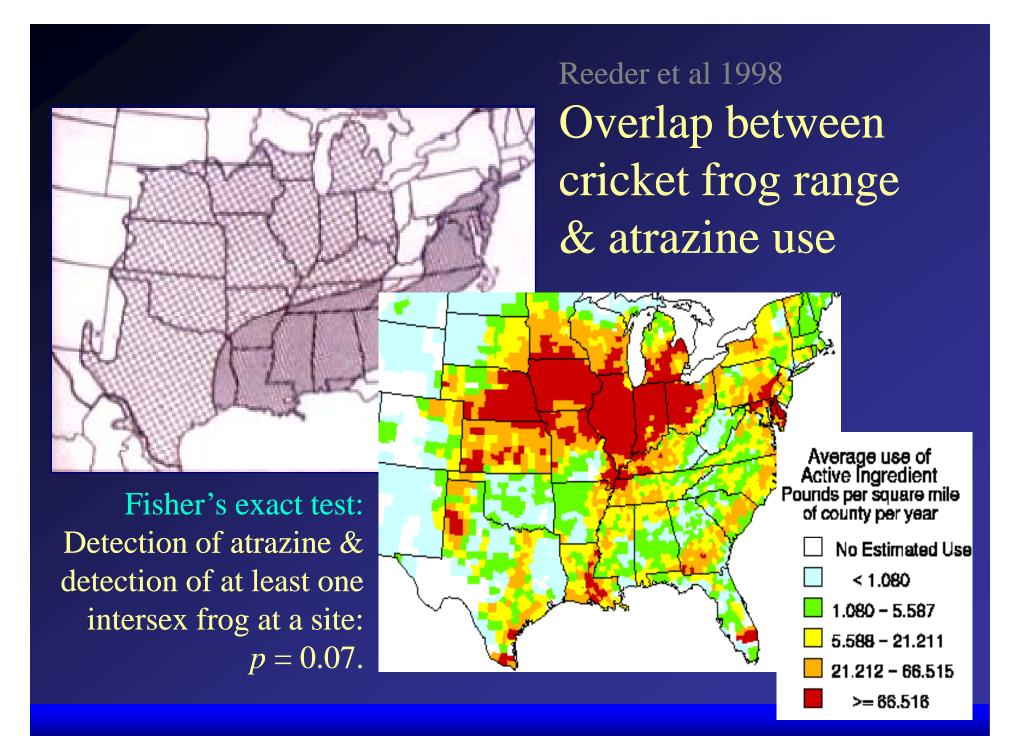
Mechanisms of Amphibian Declines: Endocrine Disruption? Cricket Frogs: Initial Field Collections 1994: Collected 242 frogs (May & June) from 8 sites: Intersex Males – <u>6 of 89 Adult Males (6.7%)</u>





•Occasionally - normal testis (left) & small ovary (right) of a cricket frog

Mainly – ovotestis = ova in functional testes.
Small numbers of cricket frogs affected per site, but relatively small numbers targeted for collection.



Possible Direct Effect (Immunosuppression) & Probable Indirect Effects (Reduced Cover, Increased Predation, & Increased Parasitism)

Site Visits & Follow up Lab Studies

Water primrose (Jussiaea repens)

Site Visits Site 11- Summer 1994 Dead Water Primrose (Jussiaea repens)







Site 20 = 0.30 = 1.66 ISR-5.50 (Atrazine-water 0.003 mg/L)

Site 23 23.96 (No pesticides detected)

Site 5 0.24 15.02 ISR-63.22 (Atrazine-water 0.003 mg/L)

Site 12 0.40 7.27 ISR-18.32 (Atracine-water 0.002mg/L) (Chlorpyrifos-water 3.1 µg/L)

Site 11 0.31 0.98 ISR-3.20 (Atrazine-water 0.006 mg/L; sediment 0.07, 0.04 mg/Kg) (Metolachlor-water 0.002, 0.001, 0.002 mg/L; sediment 0.04 mg/Kg)

Site 15 0.25 4.67 ISR-19.50 (No pesticides detected) (Nitrate-water 2 mg/L)

Site 15 = 0.28 = 13.16 ISR-46.31 (No pesticides detected; copper sulfate used 2x/summer) (Nitrate-water 2 mg/L)

Site 19 0.09 22.57 ISR-249.67 (No pesticides detected)

Number of adult males/m² of suitable habitat in late spring Number of juveniles/5m² of suitable habitat in late summer

1994

Mean value for 1994 excluding Sites 23 and 4 for the number of juveniles per 5 square meters of suitable habitat in late summer.

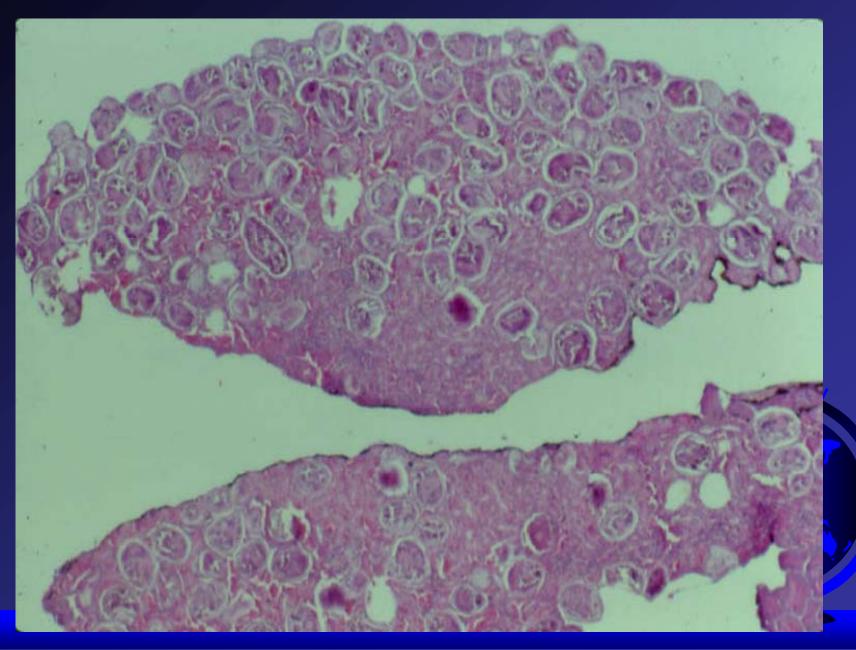
Mean Values for Juveniles & Adults

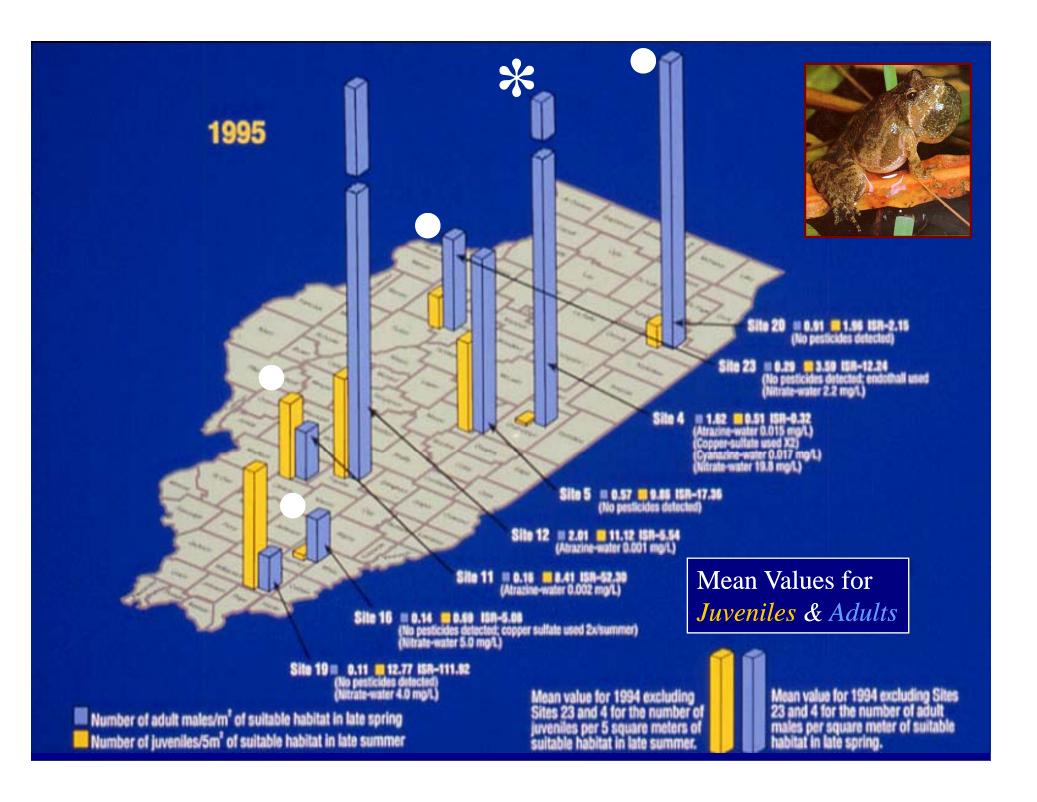
> Mean value for 1994 excluding Sites 23 and 4 for the number of adult males per square meter of suitable habitat in late spring.

Cricket frog kidney with Echinostoma trivolvis



Cricket frog kidney with Echinostoma trivolvis





Site 4, Near Fisher, Illinois



Site 4, Near Fisher, Illinois

Beasley et al 2005 Statistically Significant Findings

Severe trematode infections associated with:

 Phytotoxic concentrations of herbicides
 Absence of water primrose (*Jussiaea repens*)
 Low summer recruitment of cricket frogs
 Low ratio of juveniles/calling males

 Low summer recruitment also associated with:

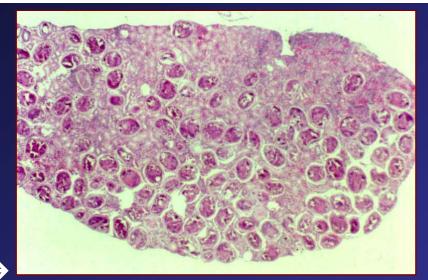
 Absence of water primrose (*Jussiaea repens*)

Potential Mechanisms of Amphibian Declines

Infectious Diseases

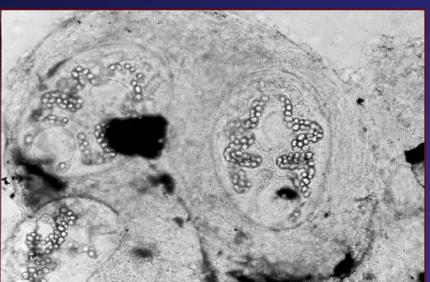
Trematodes

Echinostoma



Kidney of cricket frog metamorph from Southern Illinois with abundant *Echinostoma*

Ribeiroia \rightarrow



Ribeiroia sp. in tail resorption site



Bullfrog metamorph from suburban Urbana, Illinois with abundant *Ribeiroia*

Anna Schotthoeffer Field & Laboratory Studies of Ribeiroia &Echinostoma



Trematode Life Cycle



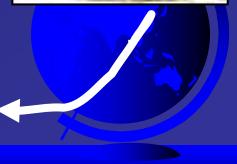




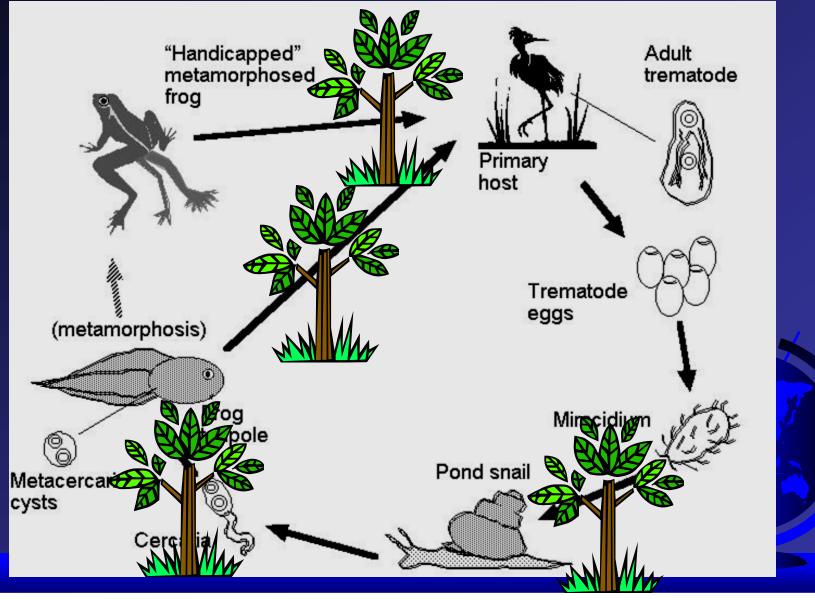








Echinostoma & Ribeiroia Infections & Herbicides?



Some Elements & Salts Mobilized by Irrigation \rightarrow Leaching \rightarrow Evaporation \rightarrow High Concentrations

 \rightarrow moves through soil & may crystallize in soil & sometimes on animals.

•Salinization of soils

•Reduced plant growth.

•Salinization of water bodies

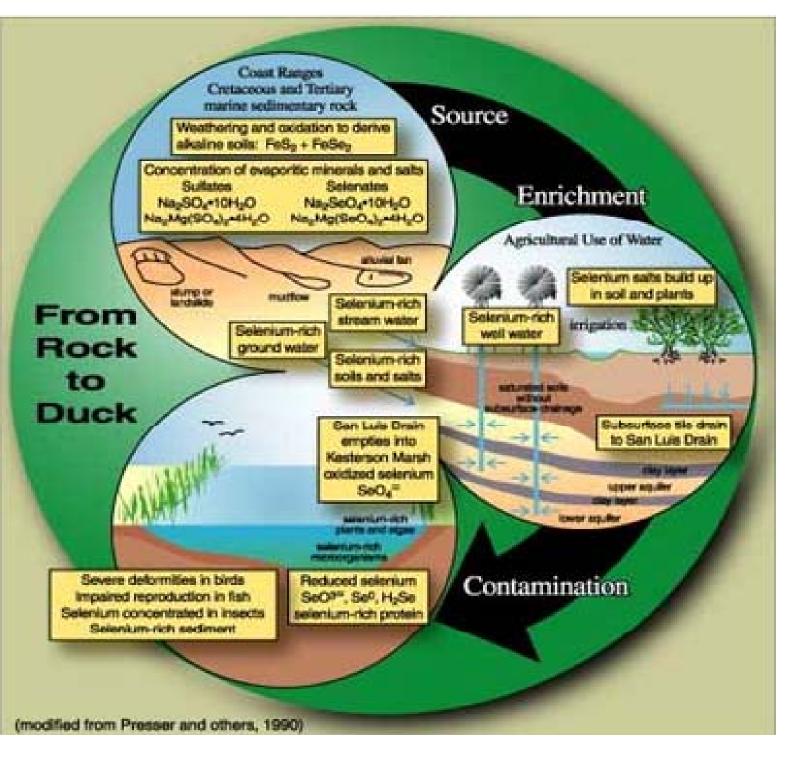
• Altered disease ecology

(.e.g Salton Sea in southern California) Salt encrusted birds.

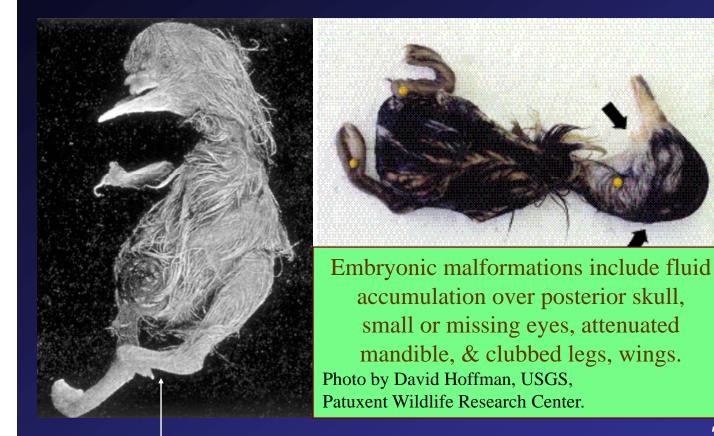
Severity of impacts depends on extent of salinization, rainfall to wash out, scale of impacted area, duration of contamination, availability of organisms to recolonize the area.

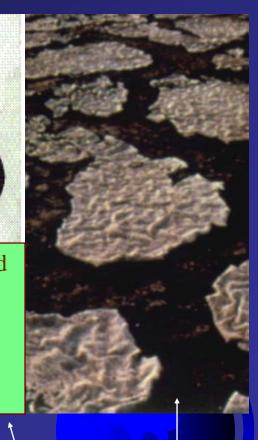
Selenium

Irrigation mobilizes elements \rightarrow moves them in soil & surface waters \rightarrow Evaporation concentrates **Invertebrates** may reach toxic concentrations e.g. \rightarrow at Kesterson National Wildlife Refuge.



Irrigation, Leaching, Evaporation, Environmental Concentration & Bioconcentration of Selenium





- Chicken embryo from contaminated grain diet (Left).
- Mallard embryo from Kesterson National Wildlife Refuge (Middle).
- Dried selenium-rich sediments at Kesterson (Right).

Minerals & Fossil Fuels Mining, Drilling, Extraction, Transport, Uses, & Disposal

Direct Exposure to Herbivores/Omnivores Via Food Cadmium Sources Effluents taken up by Plants



Rice fields irrigated with water from zinc mine.

- Associated with zinc in environment.
- Effluents from zinc mines.
- Smelting of zinc, copper, & lead.
- Industries that use cadmium in batteries, alloys, & paints.
- Sewage sludge from cities with those industries.

Direct Exposure to Herbivores/Omnivores Cadmium Sources <u>Via Food</u> Effluents Applied to Agricultural Plots

Leafy plants (green leafy plants) take up toxic amounts of cadmium when grown in contaminated soils/water.

Some cadmium-contaminated grains, such as rice, may result in severe cumulative toxicity,

<u>Direct Exposure</u> <u>Via Food</u> Cadmium



- Initially retained by liver, then moves to kidney where it gradually builds up.
- Binding to metallothionein limits toxicity.
- ✓ At high enough doses, capacity to maintain Cd bound to metallothionein is overwhelmed, liver "dumps" Cd → kidneys exposed & renal damage results.
- Because of kidney failure & direct effects on bone cells, Cd causes osteoporosis, pain, & deformity.
- Multiparous women are predisposed: Itai-itai (ouch-ouch) disease in Japan.
- Anemia.
- Some area of world & resident wildlife (e.g. parts of Canadian Arctic & resident belugas) are naturally high in Cd due to the local geology.

Cyanide Contamination from Gold Mining/Extraction

✓ Cyanide from gold extraction at Baia Mare Mine – January 20, 2000
✓ Tisza R. Romania → Hungary → Danube R. → Detox → Black Sea

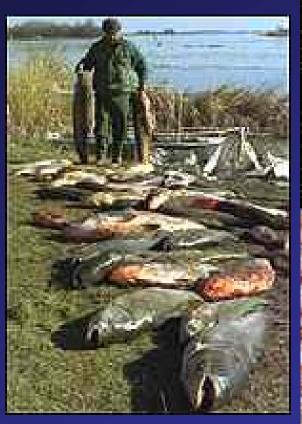


Tisza/Danube Cyanide Spill Death Losses - Species:

- All the fish.
 - Sturgeon.
 - Salmon.
- Rare giant mayflies.
- Eagles, other birds.

Otters.







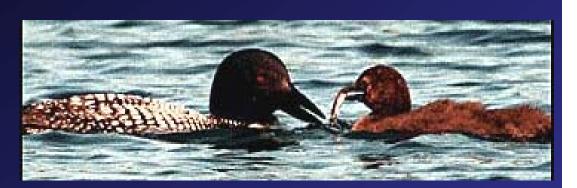
Coal & Combustion Products

Coal burning produces particulates, CO, CO2, ozone, sulfur oxides that form acids, polycyclic aromatic hydrocarbons, &

mercury.

 Strip mining of coal releases inorganic acids, heavy metals, complex aromatic hydrocarbons, & a range of particulates into the environment.

Mercury



Environmental concentrations are increasing in much of world, including the US, from:

- Sormal degassing of the Earth "Mercury cycling."
- Chloralkali plants (produce chlorine using Hg) declining.
- Household batteries burned in incinerators declining (new formulas).
- Thermostats, switches, broken & dumped instead of recycled.
- Fluorescent tubes dumped instead of recycled.
- Dentist's offices amalgum dumped instead of recycled.
- A great deal of Hg is trapped in coal. Coal burning is major source of increased Hg in biosphere).

Mercury – from gold "mining"



Use of mercury to capture gold from deposits in streambeds of Amazon tributaries = a major regional environmental source.

Mercury: Exposure Via Foods & Via Mothers

- Like any elemental poison, mercury may form compounds, but the element does not turn into something else.
- Metallic & inorganic mercury tend to have severe effects on GI tract & kidneys.
- In anaerobic sediments, mercury is methylated & the resultant methyl mercury:
 - is resistant to further biodegradation.
 - is lipid soluble.
 - concentrates in animals that feed in sediments.
- It is biomagnified via food chains, resulting in top predator (including human) exposures, especially via ingestion of *the muscle tissue* of predatory fishes.
- Infants of highly exposed mothers are especially at risk.
- Methyl mercury crosses lipid membranes (including blood-brain barrier) & damages nervous system, especially during development.
 - Developmental neurologic defects, with potential for life-long or lethal effects.
- Example: Humans experienced mercury toxicosis due to contamination of Minamata Bay, Japan.

Mercury: Exposure Via Foods & Via Mothers



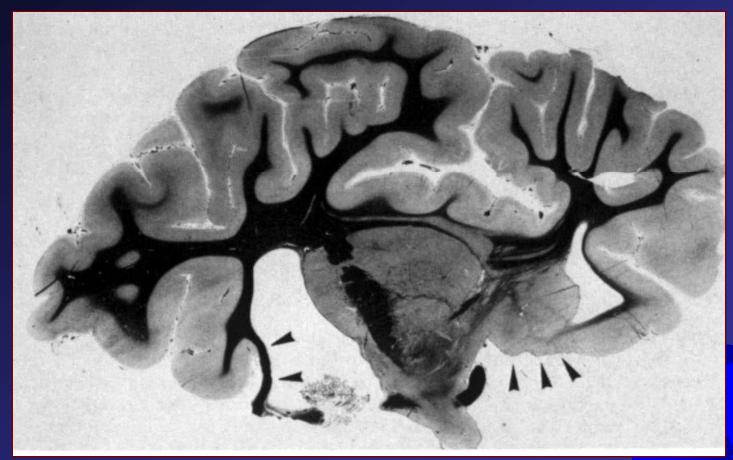
Domestic cats feeding on seafood from area were affected

- "Dancing cats" often fell in water & drowned.

- Unfortunately, the problem in cats was diagnosed only AFTER the problems in humans were recognized.
- Determined energetic diagnostic work earlier on could have reduced suffering of cats, humans, & other species in environment.

Mercury Toxicosis: Exposure in Utero

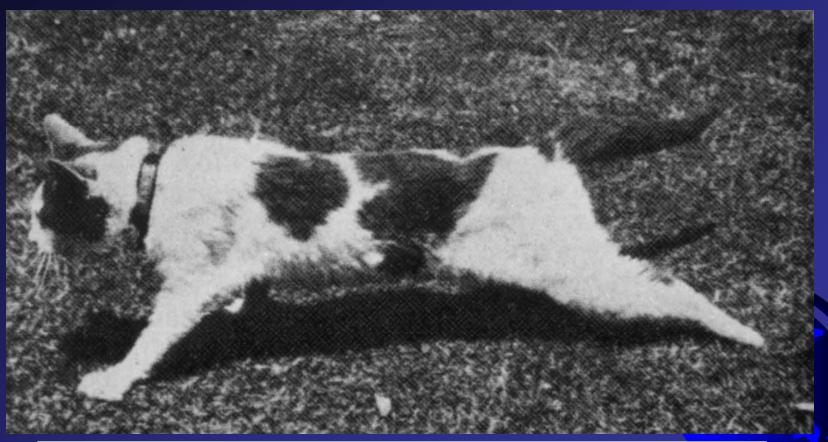
Teratogenesis: Major cerebellar/motor lesions & functional deficits that resulted from methyl mercury toxicosis.



Hypoplasia in human infant brain (fetal Minamata Bay disease): Reduced size of corpus callosum, stratus marmoratus, & hypomyelination (celloidin section, Heidenhein-Woelke stain).



Methylmercury Biomagnification \rightarrow Toxicosis



Ataxic stance in methylmercury poisoning. The cat's forelegs are widely spaced & it has knuckled over its rear paws.



People of the Faroe Islands (near Iceland) hunt pilot whales for human consumption.

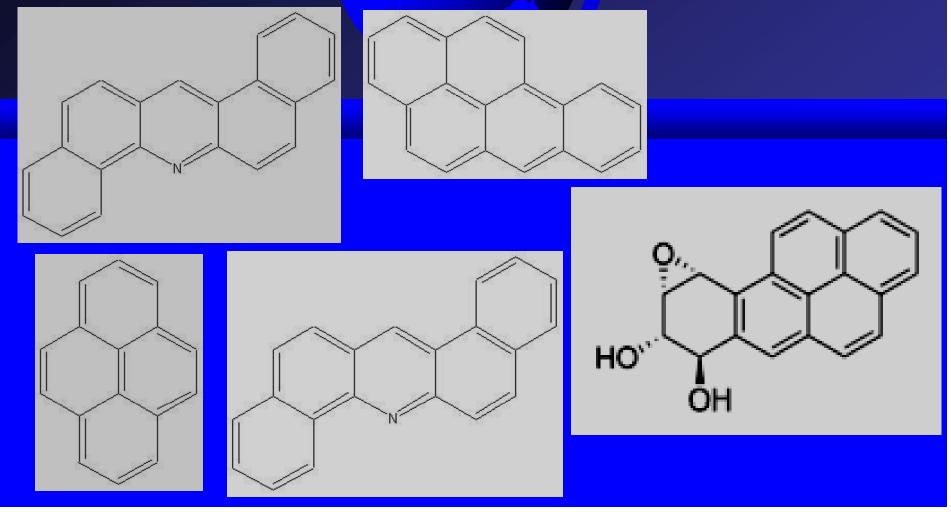
- The pilot whale tissues contain PCBs & methyl Hg.
- PCBs & Hg impair hearing & vision.
- When tested when 7-years-old, children with high PCB & methyl Hg exposures in utero had deficits in memory, language & attention.

Acid Rain & Methyl Mercury Release

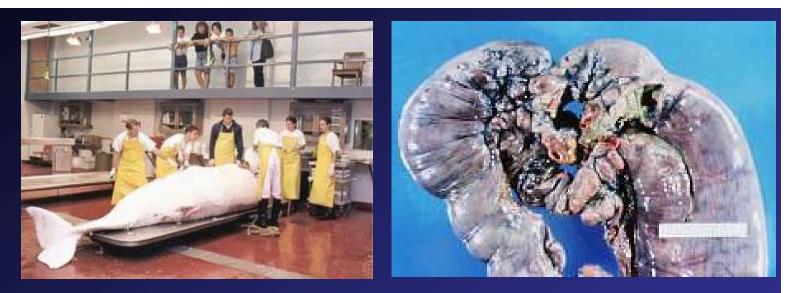
- Science News May 10, 2006
- Methylmercury concentrations rapidly increase in aquatic ecosystems after acid rain.
- An ecosystem-scale experiment confirmed that sulfate in acid rain speeds up methylmercury production.
- Coal burning typically releases sulfates that react to form sulfuric acid.

Products of Combustion Polyaromatic Hydrocarbons (PAHs)

Compounds from Smokes & Fossil Fuels that are Often Metabolized to Epoxides (Strained & Reactive) that form Adducts to DNA → Mutagenesis



PAHs



- Source: Aluminum smelter (super hot electrode). Contamination of local water bodies.
- Major cause of cancer in GI tract belugas of St. Lawrence River estuary.
- Whitefish (also bottom feeders) had liver cancers.
- Dr. Daniel Martineau veterinary pathologist, University of Montreal, St. Hyacinth
- Largely because of his research, the obsolete plant was slated to be replaced by a modern, clean plant ten years ahead of the original schedule.

Fundamental Mechanism of Ecosystem Disease: Industrial & Municipal & Mining-related Releases of Elemental, Inorganic, & Organic Contaminants



- Interactions between acid mine drainage or acid precipitation & metals → direct effects of acid + increased impacts of metals, e.g. aluminum (precipitates on gills of fishes, crayfish, other species).
- In much of West Virginia, the "spoils" have filled in headwaters of multiple small streams.
 - Tributary streams are the "usual" refugia of genetic diversity from pollution.
 - Destruction of locally-adapted biodiversity even in these refugia.
- Local flooding, mudslides, & water pollution impact human health & economies.

pH 2.6 – 2.9 Incompatible with most forms of Aquatic Animal Life. **Cannot absorb** enough calcium.

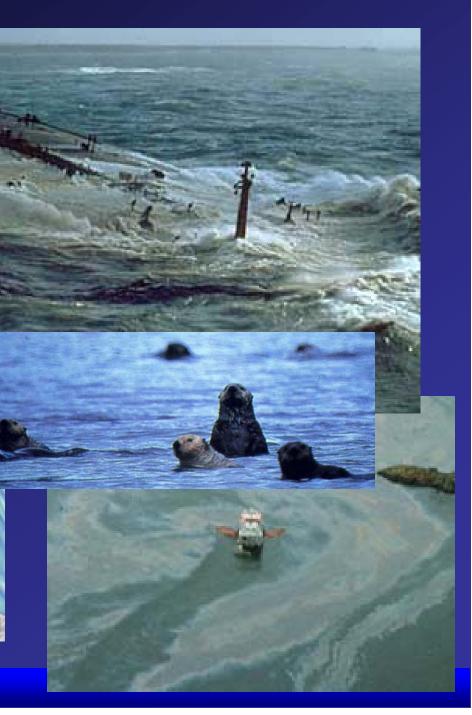


Major... Oil Spills





UC Davis – SVM – Wildlife Health Center, Oiled Wildlife Care Network.



Petroleum

Oil spills (transport of crude oil or refined products). Losses from pipelines or vessels – e.g. tankers.

- The set of the set of
 - Rapid loss of body condition, weakness.
- Peurotoxicity.
- Respiratory toxicity.
- \sim Immunotoxicity \rightarrow increased infections.
- Any of the above can be lethal.

Fundamental Mechanism of Ecosystem Disease:Chemical ContaminationPersistent Halogenated Organic Chemicals



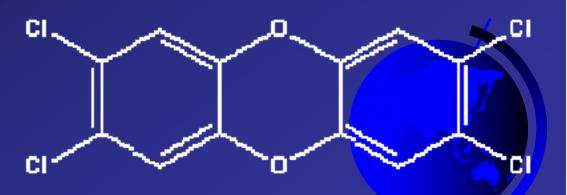
- Pesticides: agricultural, mosquito control, termiticides (DDT, endrin, heptachlor, chlordane).
- Industrial organochlorines (PCBs)
- Accidental by-products of chemical synthesis (polychlorinated dibenzodioxins, polychlorinated dibenzofurans, many others).
- Many OCs (& other classes of compounds) are endocrine disruptors that act as agonists at Aryl hydrocarbon (= Ah) receptors, are either agonists or antagonists at sex steroid receptors), or are anti-thyroid compounds (by several mechanisms).

Persistent Organochlorine Contaminants

Insecticides:

- Dichlorodiphenyl trichloroethane (DDT)
- Cyclodienes
 - Endrin
 - Aldrin & dieldrin
 - Chlordane, cis & transnonachlor
 - Heptachlor, heptachlor epoxide
 - Toxaphene
- Mirex
- Kepone
- Hexachlorohexane
 - Lindane
- Fungicide:
- Hexachlorobenzene

- Industrial Chemicals:
- Polychlorinated biphenyls (PCBs)
- Polychlorinated
 dibenzofurans (PCDFs)
- Polychlorinated dibenzo-pdioxins (PCDDs)



2,3,7,8-Tetrachlorodibenzodioxin (TCDD)

Dioxins (polychlorinated dibenzodioxins)

Accidentally produced industrial byproducts.

Seveso, Italy



Chlorinated dioxins, dibenzofurans, & related molecules also made in fires where chlorine-containing plastics or paper are burned. • 2,3,7,8-TCDD accidentally produced in overheated reaction vessel used to make 2,4,5-T herbicide.

- Pressure triggered relief valve to open.
- Local community exposed.
- 187 cases of chloracne.
- Reduced boy/girl ratio.
 - Reduced survival boys.
- Rabbits died.

• 80,000 domestic animals slaughtered to protect human food chain.

• Agent Orange – ½ 2,4-D & ½ 2,4,5,-T,Vietnam War (American War) herbicide. Protected American Soldiers from bullets, but soldiers had 2,3,7,8 TCDD exposures & toxic impacts.

Releases of Complex Chemical Mixtures

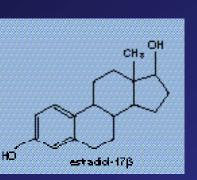
Refuse fires" in developing countries that lack adequate waste disposal systems. – especially of concern are chlorinated plastics due to formation of dioxins & dibenzofurans.

Landfills – Municipal or Chemical (or older combined landfills & dump sites)

 Myriad Chemical Products of Spontaneous Oxidative, Reductive, & Hydrolytic Reactions

Multiple Organ Systems Effects of Persistent Organochlorine Contaminants

- Endocrine disruption
 - Hypophysis
 - Pituitary
 - Gonads
 - Thyroid
 - Retinol



- Adrenal
- Neuro-immune axis

- Immunosuppressive
- Teratogenic
- Carcinogenic
- Peurotoxic
 - Neurobehavioral
 - Neuropathology
 - Neuroendocrine
- HepatotoxicDermatotoxic

Ecotoxicology: Endocrine Disruptors

Effects at Estrogen Receptors:

- Agonists.
- Antagonists.
- Agents that are antagonists & agonists
 - e.g. Tamoxifen.
 - Weak agonists that:
 - stimulate juvenile endocrine receptors.
 - competitively inhibit adult endocrine receptors.
- Effects at Androgen Receptors:
 - Agonists.
 - Antagonists.
- Agents that inhibit synthesis of natural hormones.
- Agents that compete with natural hormones bound to albumin in blood so that more is displaced, enters liver, metabolized.
- Agents that induce enzymes to accelerate metabolism, conjugation, and/or excretion of natural hormones.

Ecotoxicology: Endocrine Disruptorsthe influence of age.

- Period of brain development.
 - Intelligence Impaired cognitive ability children, rats (PCBs).
 - Sexual identity?
 - Emotions?
- Period of reproductive tract development.
 - Intersex.
 - Reproductive performance.
- Period of immune system development.
 - Phytoestrogens have been shown to be immunosuppressants.
- Period of mammary gland development?
 - Phytoestrogens early in life may be protective against mammary gland cancer – accelerate differentiation/proliferation of tissue.
- Period of old age?
 - Impaired cognitive ability (PCBs).
 - Promotion of estrogen-responsive breast tumors (phytoestrogens, other xeno-estrogens as tumor promoters stimulate proliferation of estrogen-responsive cells).

Relay Toxicosis from a Veterinary Drug Diclofenac & Massive Declines in Vultures of the Indian Sub-continent



Asian & African Vultures

Eight species of *Gyps* vultures worldwide (Birdlife International, 2004):

- Four species found only in Asia.
 - ◆ Oriental White-Backed Vulture G. bengalensis [OWBV].
 - ◆ Long-Billed Vulture *G. indicus* [LBV].
 - ◆ Himalayan Griffon G. himalayensis [HG].
 - ◆ Slender-Billed Vulture G. tenuirostris [SBV].
- Three species found exclusively in Africa.
- One species in Eurasia but migrates into Africa & South Asia.
- High annual survival rate.
- 0.5 to 1.0 fledglings/pair/year.







Massive Vulture Declines

- Problems first documented in a breeding colony of OWBV in Keoladeo National Park, eastern Rajasthan, India (Prakash, 2003).
- Population declines.
 - India (over a 12 year period):
 OWBV 99.7%
 LBV & SBV 97.4%
 - Pakistan (over a 5 year period):
 OWBV 92%
 - A rapid decline in progress in Nepal.
 - High adult & juvenile mortality.
- IUCN The World Conservation Union:
 - Lower Risk/Least Concern, 1988.
 - Lower Risk/Near Threatened, 1994.
 - Critically Endangered, 2004.
 - ◆ Highest category of endangerment.
 - High risk of global extinction in wild in near future.





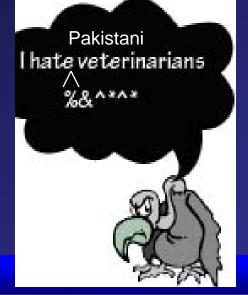
Relay Toxicosis Vultures in Pakistan, India

Diclofenac

Dr. Lindsay Oaks Washington State University Dr. Gerry Swan University of Pretoria



- Meloxicam (safe for birds) now on market.
- Diclofenac banned in India in 2006.
- Diclofenac still not banned in Pakistan.





Human & Ecosystem Health Roles of Vultures

Scavengers – extremely effective & efficient.

- 60 70 birds sloth bear carcass 40 minutes (Ali & Ripley, 1968).
- 20 30 birds human body 30 minutes.
- Mature's sanitary corps:
 - In India, traditional disposal of livestock carcasses in cities, villages & countrysides.
 - Help prevent outbreaks, epidemics.
 - Clean up after famines.
 - Clean up after floods.
- Rotting carcasses unaesthetic.
- Vultures reduce risks of infectious diseases:
 - Acid environment in stomach kills most pathogens.

Ecosystem Health Impacts of Vulture Die-Off



- With more carcasses left behind to rot, populations of feral dogs, (& probably rats) are increasing.
 - 3.5 million dog bites are registered every year in India.
 - Potential increase risks of rabies, distemper, parvovirus, leptospirosis, & more.
 - Rabies is India's bane.
 - 81% of reported global human deaths of rabies occur in India (WHO Report, 1997).

Higher predation on other species from excess dogs.

- Rotting carcasses breeding ground for pathogens?
 - Livestock-borne diseases, such as tuberculosis & anthrax.
- Contamination of soil & groundwater sources.

In an edition of Scientific American entitled "Managing the Earth," William Ruckelshaus, the first EPA secretary (under President Nixon), stated:

- ☞ "If 80% of (people) are poor, we cannot hope to live.. at peace.
- If the poor nations attempt to improve their lot by the methods we have employed, the result will be world ecological damage.
- Can we move nations & people in the direction of sustainability?
- Such a move would be a modification of society in scale to only two other changes: the Agricultural Revolution of the late Neolithic [Period] and the Industrial Revolution of the past two centuries. Those revolutions were gradual, spontaneous, & largely unconscious.
- This one will have to be a fully conscious operation, guided by the best foresight that science can provide—foresight pushed to the limit.
- If we actually do it, the undertaking will be absolutely unique in humanity's stay on Earth."

Envirovet Summer Institutes & Envirovet Baltic About 400 individuals trained from 40 nations to date



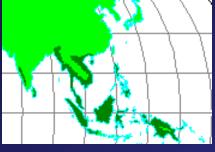
Directions (2007): Envirovet Arctic



Envirovet Programs for Regional Stewardship, Responsibility, Accountability

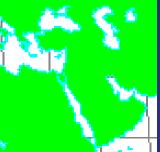
~ 2008

Envirovet Asia

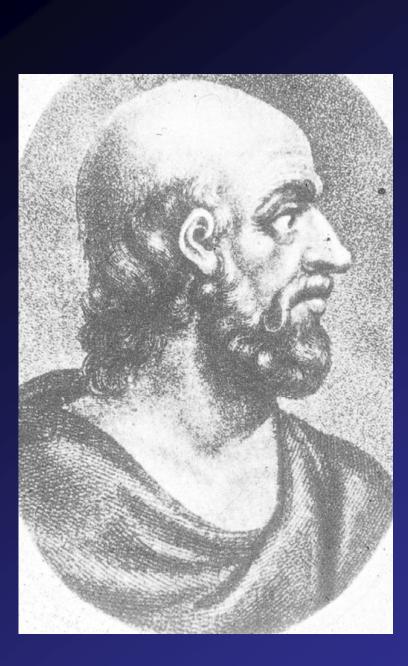


~ 2009

Envirovet Mediterranean Envirovet Africa Envirovet Latin America Envirovet Caribbean







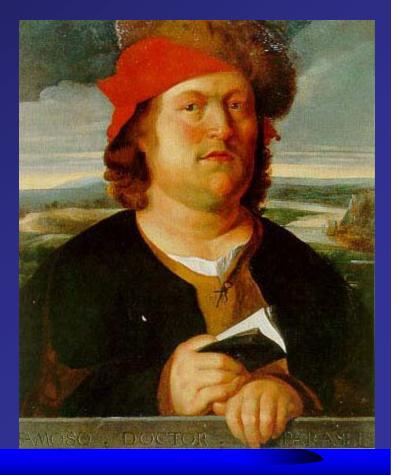
Hippocrates

"If you want to learn about the health of a population, look at the air they breath, the water they drink, and the place that they live."

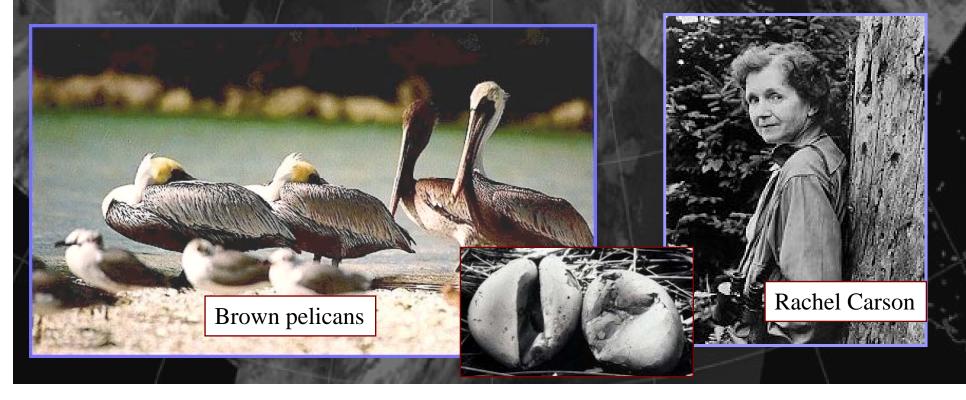
Airs, Waters, Places

Paracelsus

All things are toxic to all organisms.



Since Publication of "Silent Spring" <u>We Have Witnessed 40 Additional Years of</u> **Contamination of Ecological Resources** Major Adverse Effects on Wildlife Populations! Where Were/Are the Veterinarians, Toxicologists, Government Regulators, Legislators, Informed Citizens?

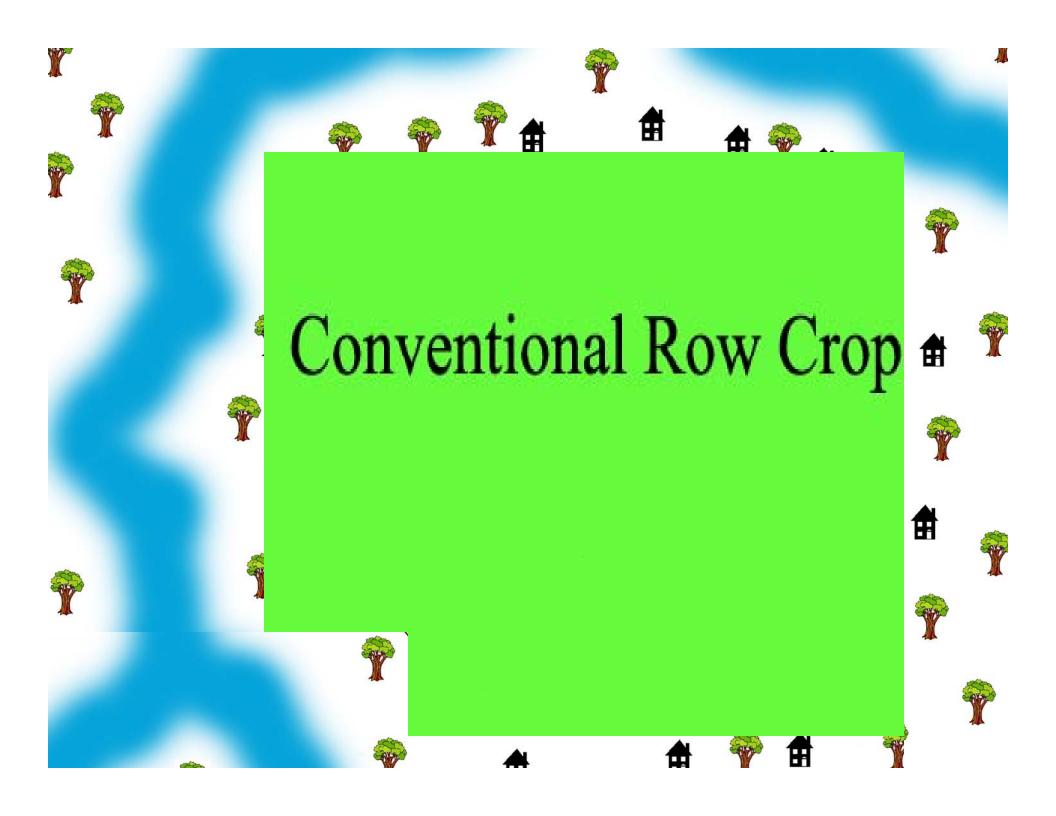


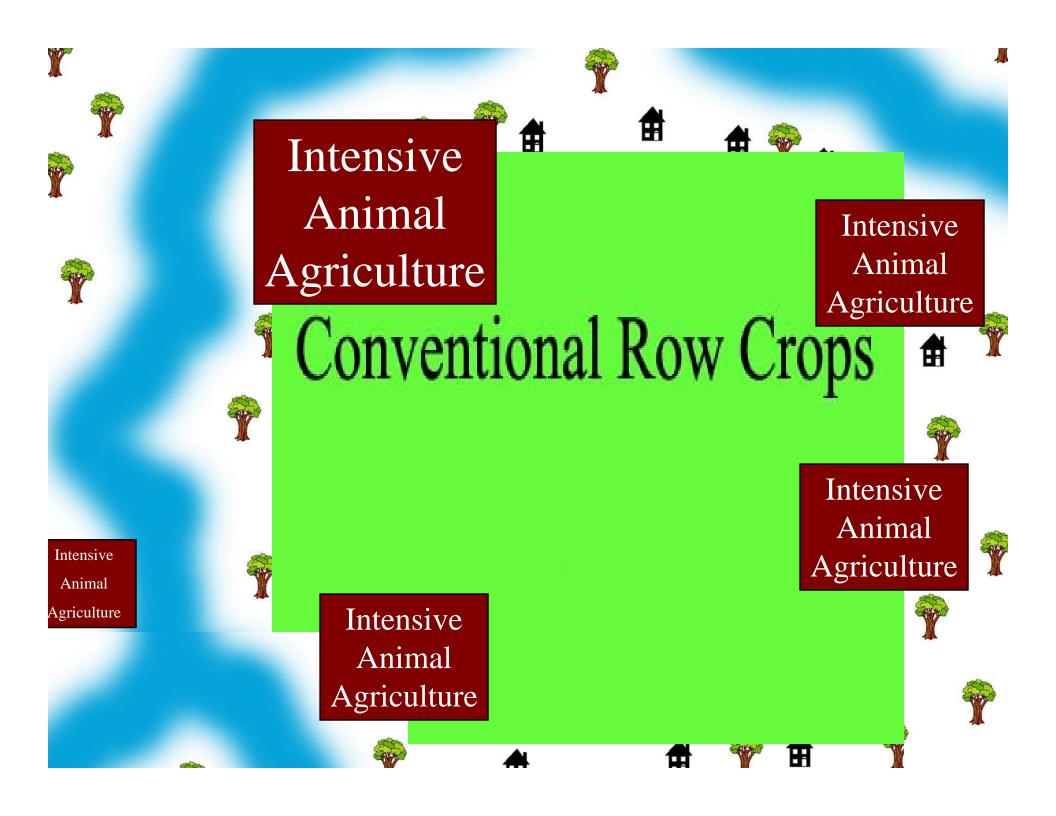
Economic Impacts

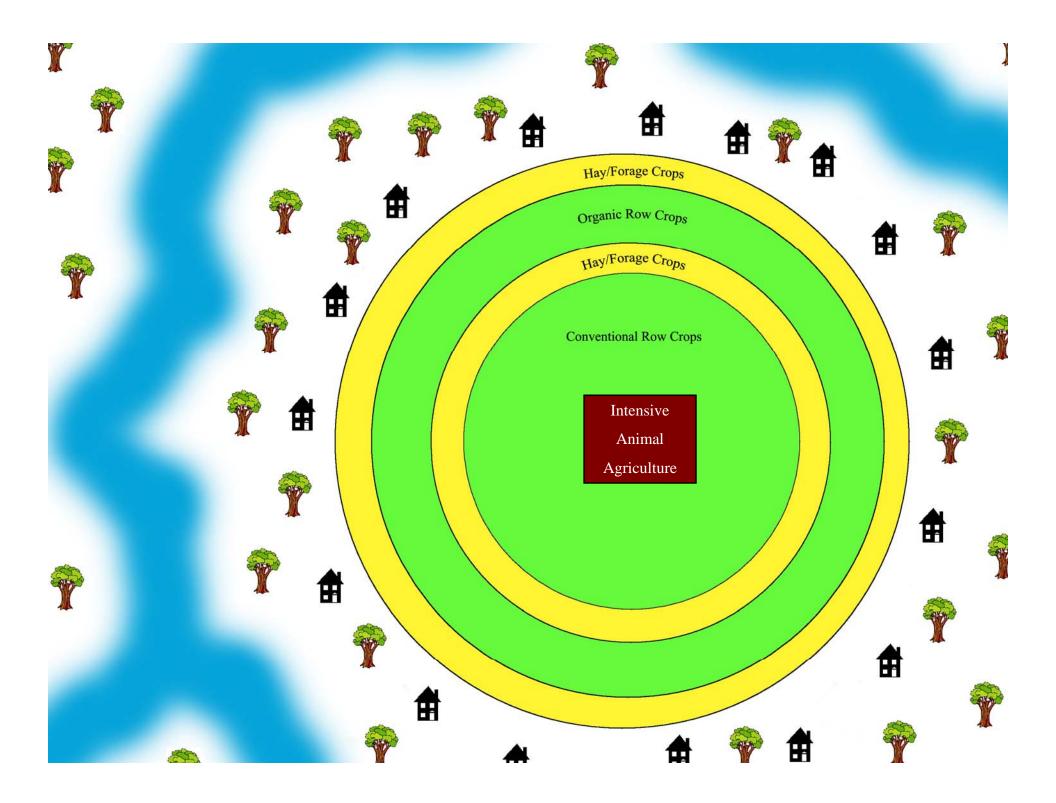
- Costs to villagers of disposing carcasses.
- Costs of increased dog bites.
- Costs for human patients & livestock owners from dog- and rat-borne diseases.
- Vaccinations of livestock & humans.
- Costs to control stray dog population.
- Mew drug discovery costs.
- Purchase of the new alternative drug to replace cheap, effective diclofenac.

Management Priorities

- Outright ban on veterinary use of diclofenac.
- Support for ban through increased awareness of problem of diclofenac poisoning of vultures by:
 - ◆General public.
 - Private farmers, veterinarians, pharmacists.
 - Government wildlife & agricultural personnel.
 - Religious & environmental groups that place a high value on vultures.
- International population monitoring programs for vultures:
 - Continue in India, Pakistan.
 - Initiate in Bangladesh, Bhutan, Cambodia, Myanmar, Laos & Nepal.
- Captive breeding of vultures for restocking.







Overfishing, lampreys, dioxins & related contaminants nearly eliminated lake trout – Great Lakes top predator.

Mobility and Exotic Species Introductions

- Accidental introductions of animals:
 - Sea lampreys Great Lakes.
 - Zebra mussels Great Lakes.
 - Brown tree snakes Guam.

Purposeful introductions of animals:

- Starlings.
- Toxic "cane toads."
- Asian carp escaped from catfish ponds to Mississippi & Illinois Rivers.
- Atlantic salmon.
- Domestic cats.

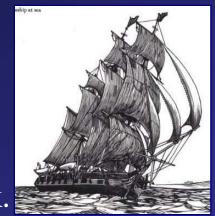


Dale Bast: Great Lakes, Successful Reintroduction of Lake Trout



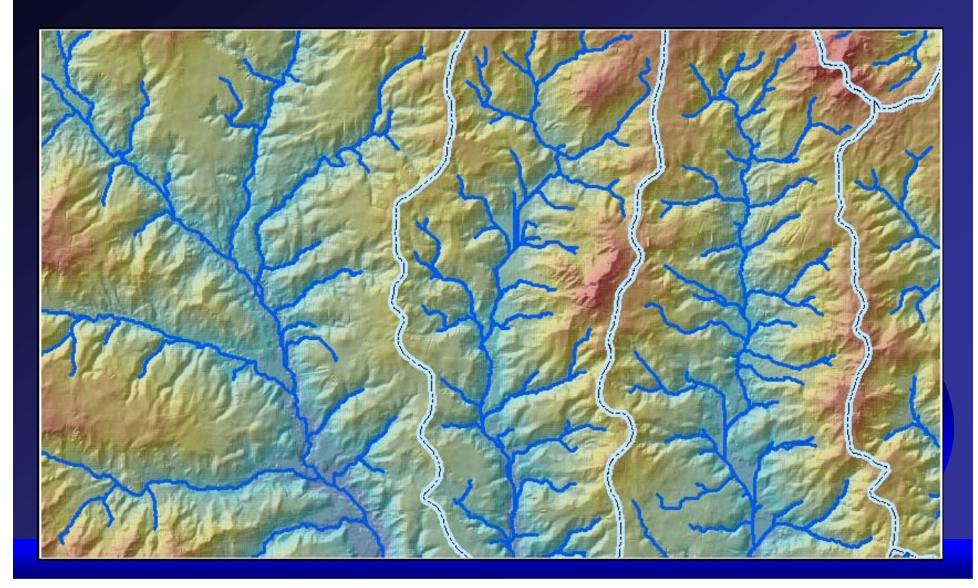
Whaling Ship Essex 1820

- In November 1820, the Essex rammed twice & sunk by a sperm whale.
- Twenty men salvaged food & equipment as ship sank.
- They set out in 3 whale boats to try to reach coast of S. America.
- They avoided then nearby Marquesas Islands, because of fear of cannibals.
- They reached Henderson Island a month later, but found too little water & food to sustain them all.
- Three men elected to remain there, the others sailed on.
- When the food ran out, they ate corpses of their dead shipmates.
- Then one man was chosen by lot to be shot & eaten.
- Pitcairn Island, with food, water, & friendly inhabitants, was a few days sail away, but whaling crew was unaware of its existence.
- February 1821, 2 of the whale boats were picked up near S. America.
- Those on Henderson Island were rescued in April 1821.
- Inspired the conclusion of Melville's "Moby Dick".

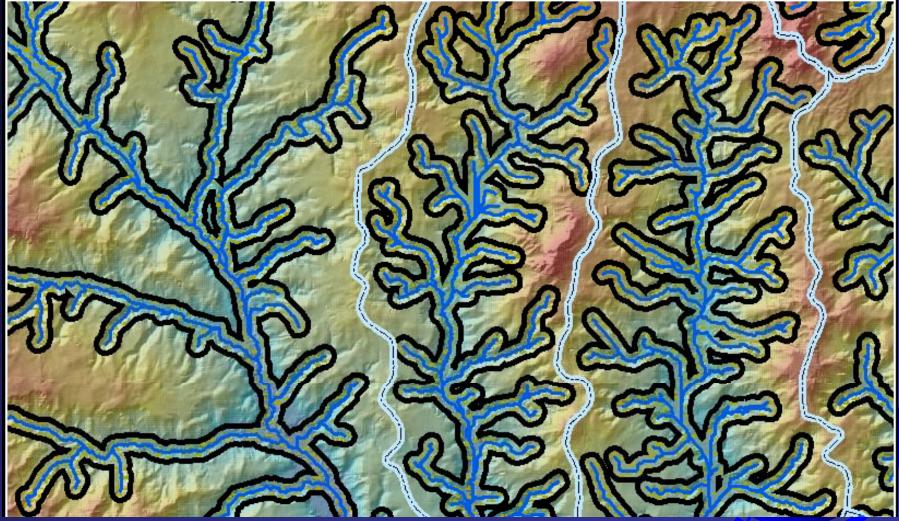


Stream network in central North Carolina.

Black dotted lines with white borders are watershed boundaries.



Map program to add 150 m buffer along streams in North Carolina.



Close up of buffer to link habitat across watersheds in central North Carolina.

White line with black dotted line is watershed boundary.