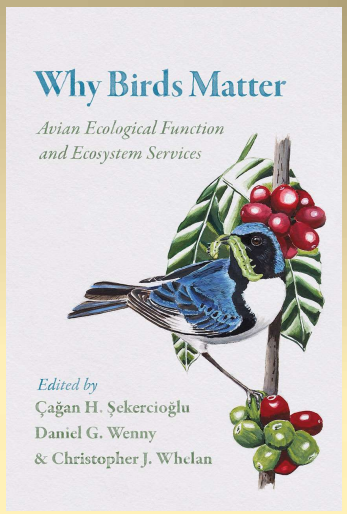
SAN FRANCISCO BAY BIRD OBSERVATORY

Why Birds Matter

A Brief Introduction to Ecosystem Services

SFBBO Birdy hour
30 April 2020



Acknowledgements

- Chris Whelan – Moffitt Cancer Center
- Çağan Şekercioğlu - University of Utah
- Megan Garfinkel – University of Illinois at Chicago
- Ron Davis – He actually read the book!
- Jo Ann Baumgartner – Wild Farm Alliance
- University of Chicago Press and all the coauthors of Why Birds Matter

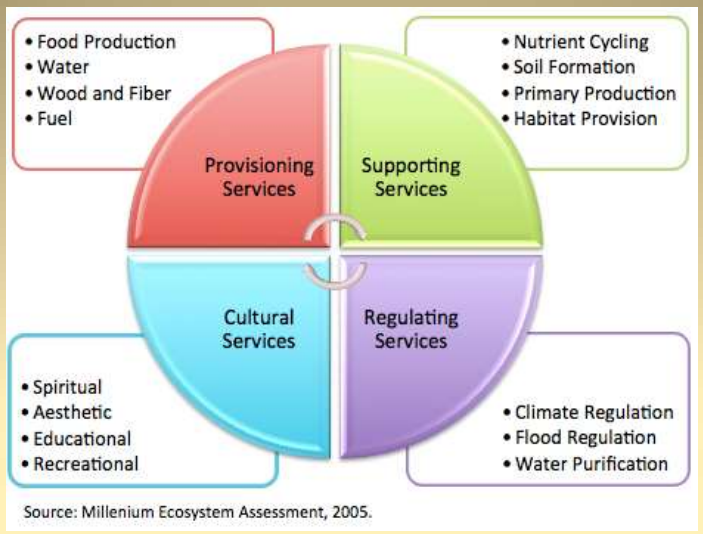
- This presentation summarizes the work of many researchers. While I can't list them all here please see the notes section for citations to some of the key papers

Goals for today

- Define/describe ecosystem services (ES101)
  - Be ready for the quiz
- Overview of ecosystem services provided by birds
  - Pest control
  - Seed dispersal
  - Scavenging
  - Maybe some bonus content if we have time
- Some things you can do

Ecosystem Services

- Natural processes and products that benefit human society



Human economy based on natural resources

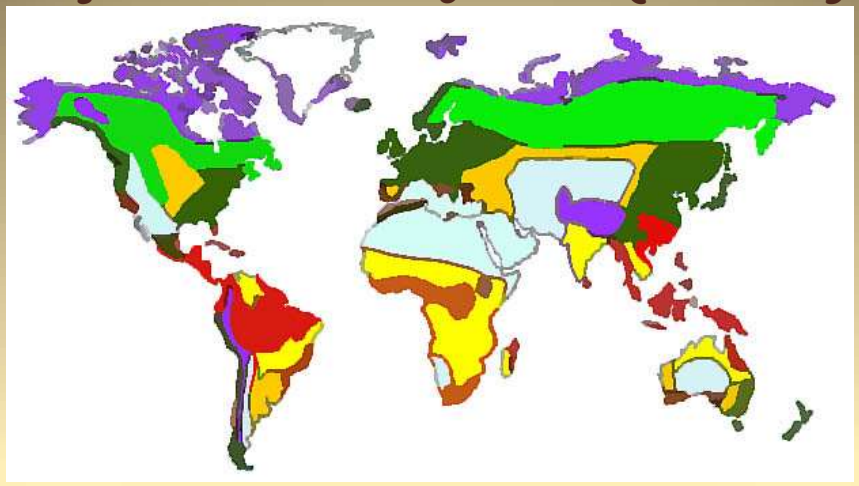
Birds provide all types of ecosystem services

- Provisioning
  - Food, clothing, fertilizer, insulation
- Cultural
  - Decoration, art & literature, spiritual, tourism
- Supporting and regulating
  - pest control, pollination, seed dispersal, nutrient cycling, ecosystem engineers, scavengers, environmental indicators

What is an ecosystem?

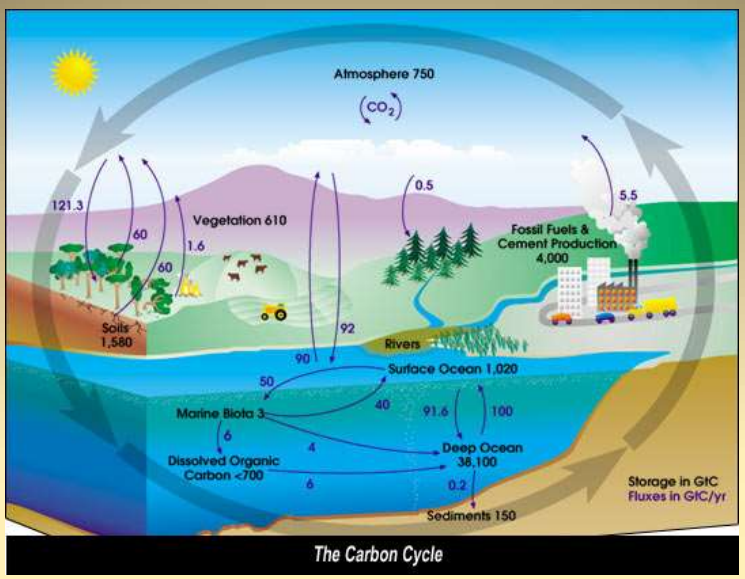
Major <u>interacting</u> system of organisms (animals, plants, fungi, bacteria) and the physical environment

Major World Ecosystems (Biomes)



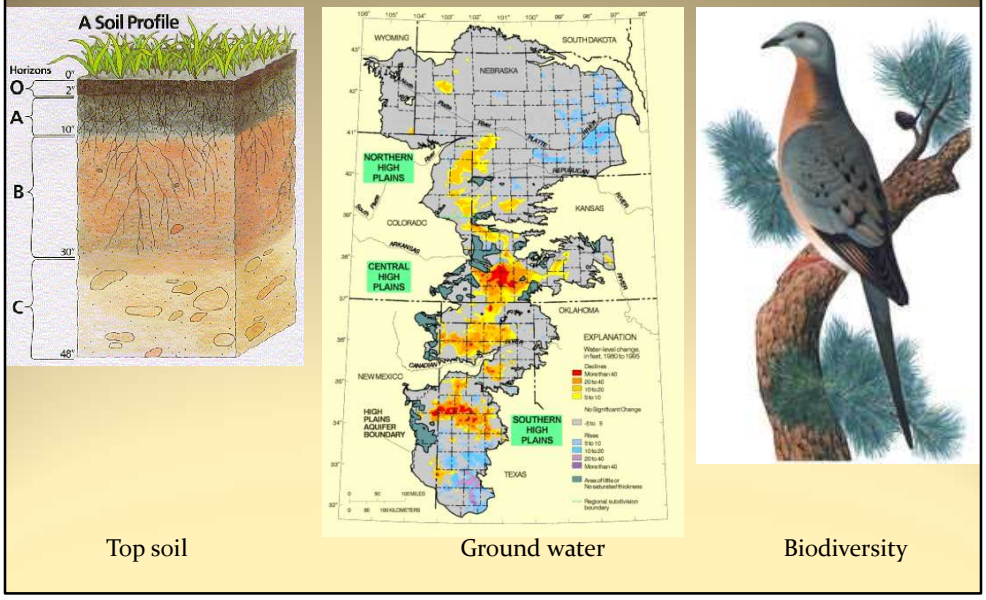
Biomes characterized by climate, soil, and vegetation

Ecosystems driven by biogeochemical cycles



The Carbon Cycle

Non-replaceable resources

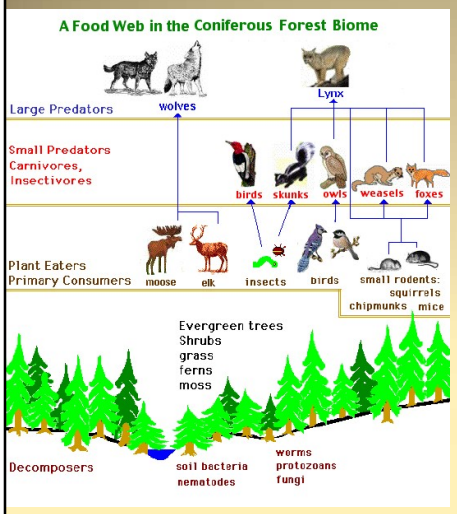


Top soil | Ground water | Biodiversity

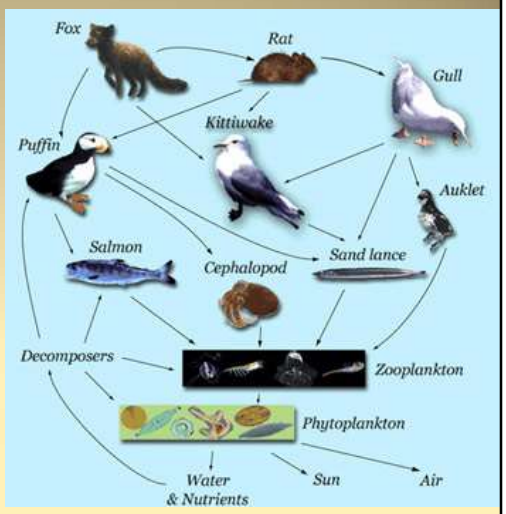
nonrenewable on human timescale; perhaps renewable on geologic/evolutionary timescale

Biotic control of ecosystem function

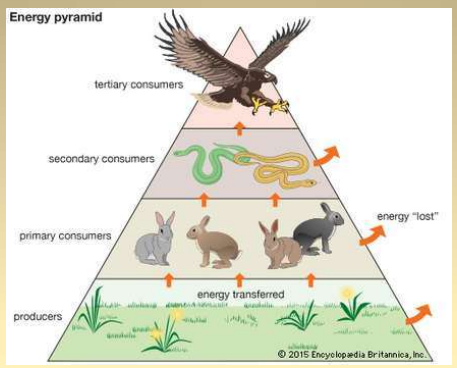
Food Chain



Food Web



Trophic structure within ecosystems

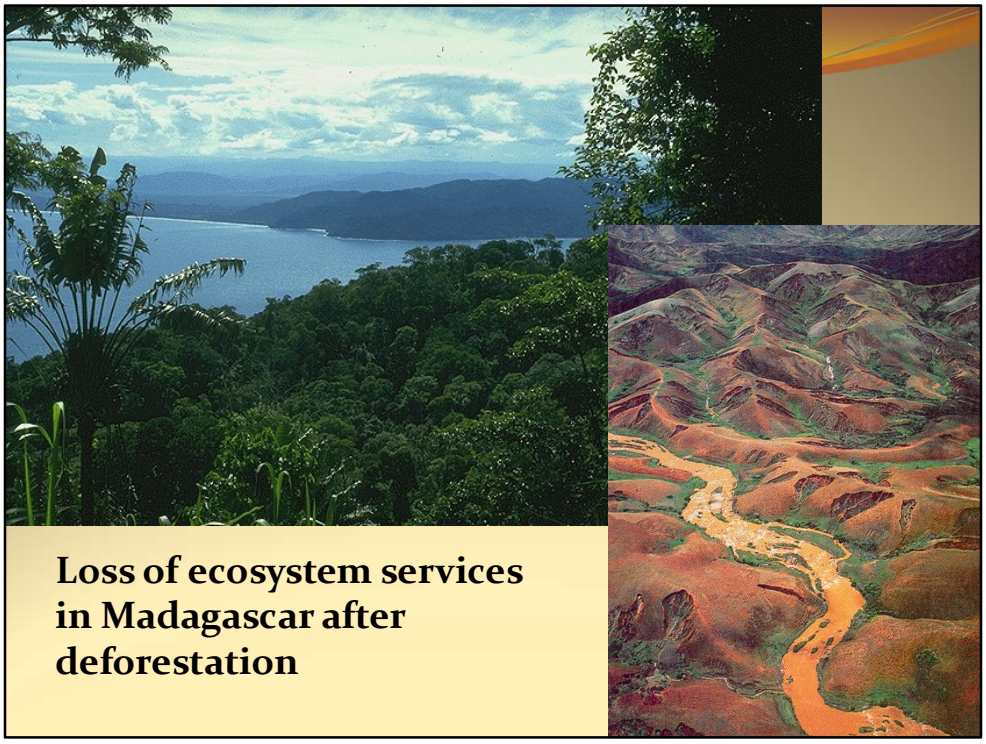


Top-down versus bottom-up

Energy from sun flows up the pyramid to the apex predator
Each level about 10% of the next lower level (you can feed many more vegetarians than carnivores)
Decomposers off to the side

Conceptual framework

- Biodiversity is a non-renewable resource
- Ecosystem services depend on biodiversity
- Higher levels of biodiversity promote:
  - more efficient delivery
  - potentially higher levels of ecosystem services
- Human land use patterns can greatly affect ecosystem services
  - "conventional" agriculture vs ecological farming



example of the value of biodiversity for ES – question is how to quantify the value

why birds?

- most birds fly
- respond to environmental changes
- occur in virtually all habitats
- very well known (compared to other animal groups)
- most diurnal and convenient to observe & study
- public connects with birds (unlike snakes, most insects, etc)

Ecological Roles of Birds

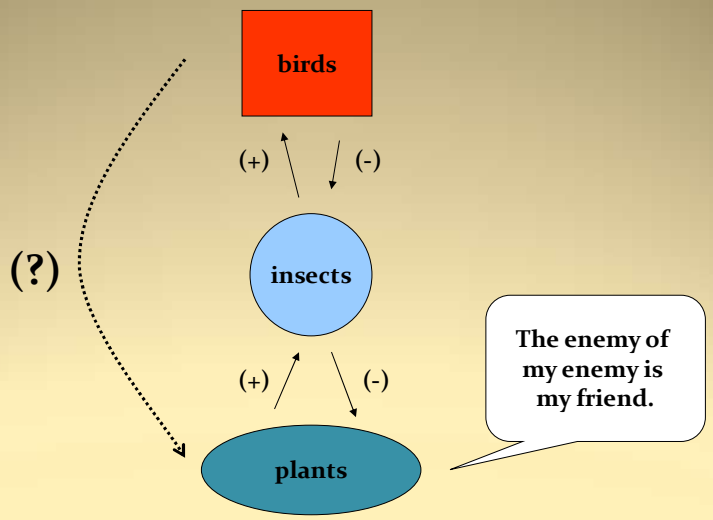
- Most bird services arise from foraging behavior:

- predation (invertebrates, fish, birds, mammals, seeds…)
- pollination
- seed dispersal
- scavenging
- nutrient cycling
- ecosystem engineers (usually nesting not foraging)

Most important Bird ES by # species
about 75% of all bird spp eat some inverts
huge diversity of morphologies & foraging behaviors

Herbivores like caterpillars can do tremendous damage to native and cultivated plants.

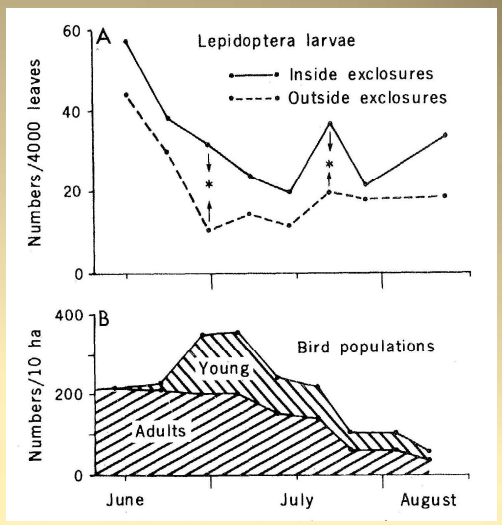
A simple food web



New Hampshire exclosure experiment

Experimental treatments

- **Cage (insects but no birds)**
- **Control (insects and birds)**



Bird Predation on Forest Insects: An Exclosure Experiment
RICHARD T. HOLMES[1],
JOHN C. SCHULTZ[1],
PHILIP NOTHNAGLE[1]
Science 26 Oct 1979:
Vol. 206, Issue 4417, pp. 462-463
DOI: 10.1126/science.206.4417.462

Missouri white oaks

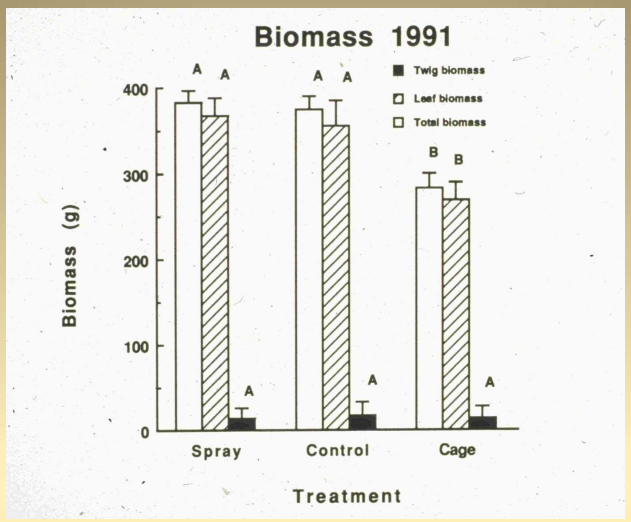
Experimental treatments

- **Cage (insects but no birds)**
- **Control (insects and birds)**
- **Insecticide (no insects)**

•Measured plant growth

…an experiment on cascading effects.

Missouri white oaks - Results



Lower plant biomass when birds excluded

An example of top-down effects

Insectivorous Birds Increase Growth of White Oak through Consumption of Leaf-Chewing Insects
September 1994
Ecology 75(7):2007-2014
DOI:
10.2307/1941605
Robert J Marquis
Christopher J Whelan

Numerous other examples

apple orchards

coffee plantations

broccoli

Birds can control insect pests in agricultural ecosystems, precluding the use of harmful pesticides!

Summarized in:
Ecosystem Services Provided by Birds
June 2008
Annals of the New York Academy of Sciences 1134(1):25-60
DOI:
10.1196/annals.1439.003
Christopher J Whelan
Dan Wenny
Robert J Marquis

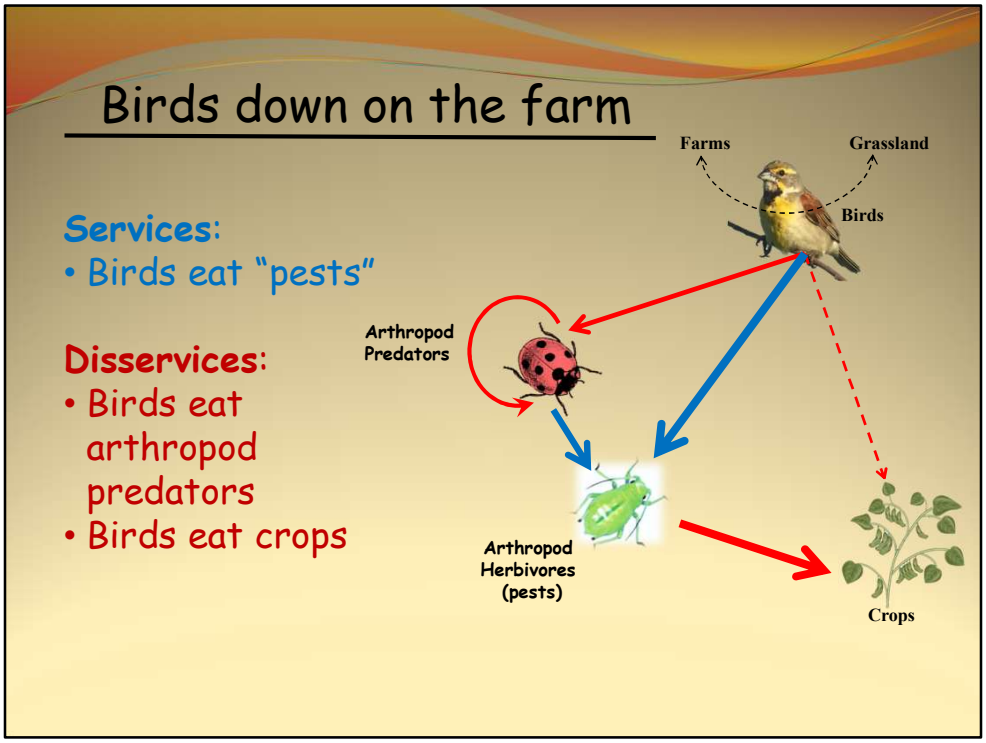
Birds as Insecticide

Birds as biological insecticide: why bird insectivores are not DDT

- Each bird species has its own fundamental niche – its own unique way of making its living
- Each species hunts in a unique way, dependent upon its unique adaptations of wings and tail, legs, bill, sight – each has a unique foraging strategy
- This means it is difficult for an insect herbivore to develop a "one size fits all" defense against bird insectivores.

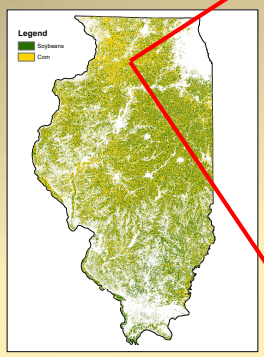
Also, pesticides and herbicides quickly lead to resistant pests

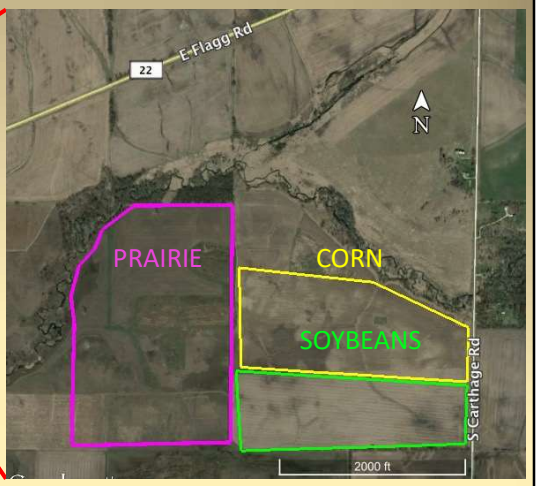

Do prairie birds provide services or disservices on adjacent conventional farms?
Megan Garfinkel
University of Illinois at Chicago



- Birds can affect crops in a number of ways through trophic interactions
- No obvious signs of direct songbird damage to established corn or soy.
- A purdue study found little to no damage to established field corn or soy by birds. Birds like turkeys may damage newly emerged crops, but not when they are established
- Birds can also do a combination of service/disservice

Year 1: Study sites at Nachusa Grasslands





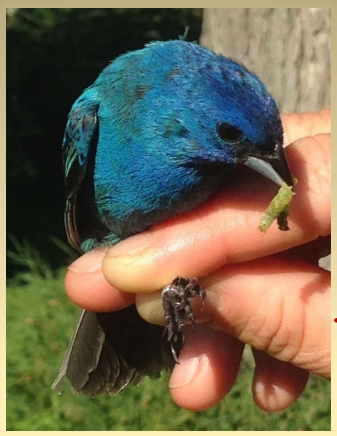
- harvested and dried crops from exclosures and control plots to compare yield
- Dried them to constant weight

Year 1: Economic Effects of birds

CORN:

Service

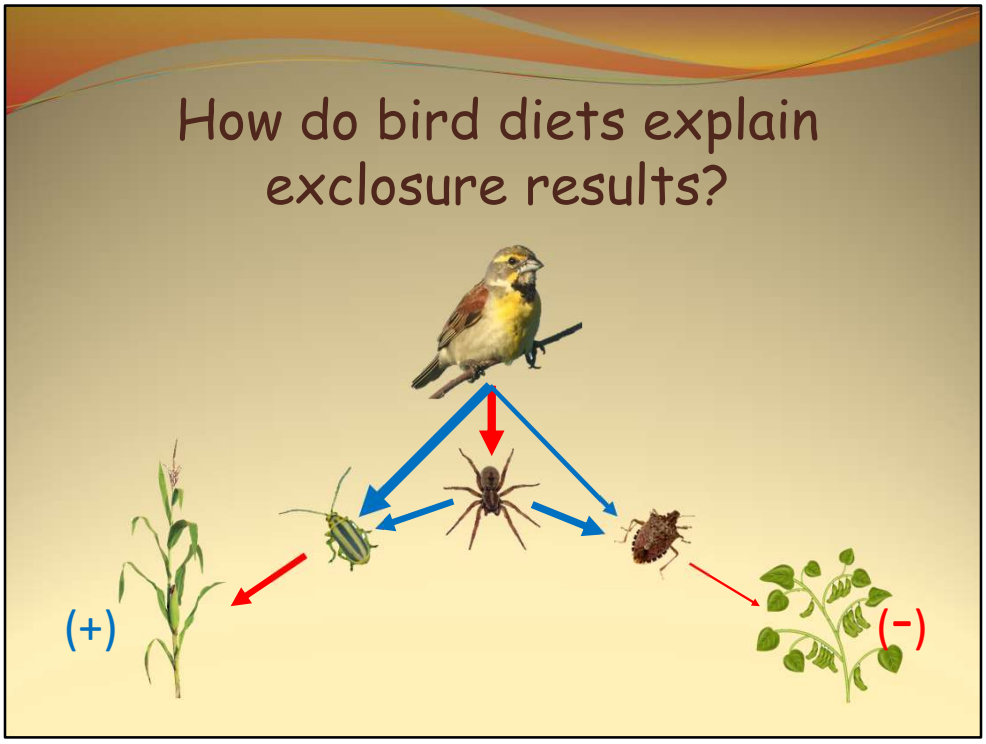
$115.28/acre



SOY:

Disservice

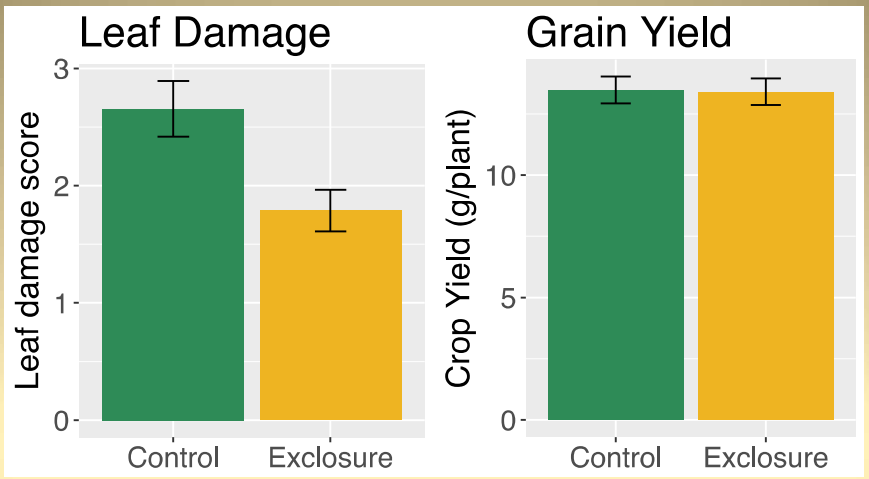
- $145.54/acre



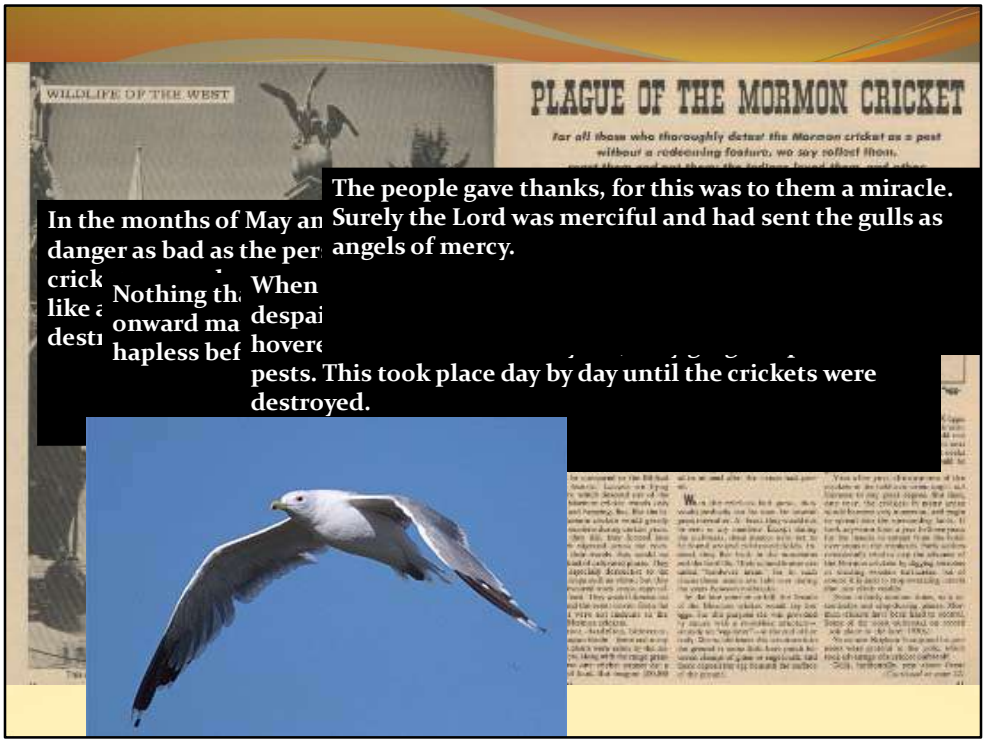
None of the soybean pests detected generally cause extreme economic damage at normal densities

ADD IN BLUE AND RED, ADD IN PARENTHASES AROUND + AND -
How do we explain the fact that birds seem to be providing a service in corn, and a disservice in the adjacent soy field?
The main difference here is that northern corn rootworms are known for causing real economic damage in corn, whereas all of the soy pests that I detected, such as the one-spotted stink bug, generally don't cause high levels of damage in soy at normal densities. So although lots of birds are eating beneficial arthropod predators, this isn't enough to disrupt the biological control by arthropods in corn, but it may be in soy, leading to increased crop yield when birds are excluded from the crops

Year 2 Results: Birds did not affect soybean grain yield



By David McConeghy from Oxford, OH, USA - Flickr, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=1814827


WILDLIFE OF THE WEST
PLAGUE OF THE MORMON CRICKET
For all those who thoroughly detest the Mormon cricket as a pest without a redeeming feature, we say rollout thou,
In the months of May an
danger as bad as the per
crick
like
desti
Nothing th
onward ma
hapless bef
When
despai
hovere
pests. This took place day by day until the crickets were destroyed.
The people gave thanks, for this was to them a miracle. Surely the Lord was merciful and had sent the gulls as angels of mercy.

Pest Control - rodents

300 + 1100 species

- Raptors track changes in rodent abundance
- Evidence suggests raptors can control rodents but few experiments demonstrating top-down effects

Kross, S.M., Bourbour, R.P+., & Martinico, B.+ 2016. Agricultural land use, barn owl diet, and vertebrate pest control implications. *Agriculture, Ecosystems and Environment*. 223: 167-174

Seed-eating birds

1100 + 1000 species

- Crop pests or weed seed control?
- Few experimental studies in agroecosystems

Red-billed quelea

- Most abundant wild bird species (1.5 billion)
- Specialized on annual grasses (including crops)
- Significant pest locally

- Also eats insects
- Guano
- Eaten by people

- Pest control "cure" may be worse than the disease

Red-winged blackbird

- Crop pest in corn
- official crop damage 20%
- Actual damage <1%

- Now less palatable varieties
- Eat insects, including more significant crop pests

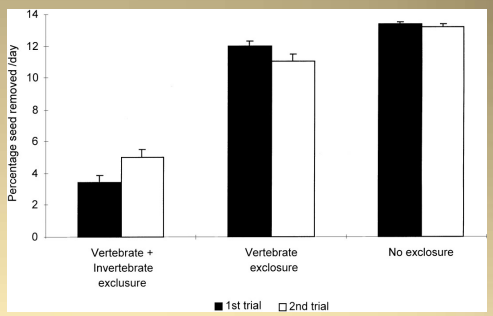
- Similar situation in rice fields


Alan Brock


Phil Kahler

Results from exclosures

- Small mammals and invertebrates eat most seeds in agroecosystems
- Seed predation by birds adds to that total
- Seed removal often 90%
- Bottom up > Top down
- Definitely need more research in this area



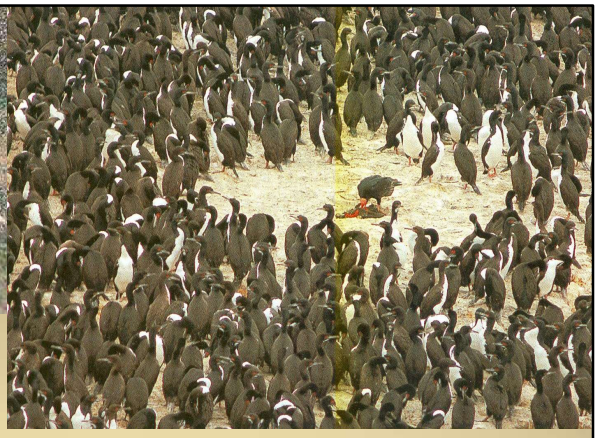
Post-dispersal weed seed predation in Michigan crop fields as a function of agricultural landscape structure.
Menalled et al. 2000 Agriculture, Ecosystems and Environment 77 (2000) 193–202

Scavengers

40 + 300 species

New World – 7 spp

Old World – 15 spp.



East Africa:

64% of ungulate deaths "non-predatory"

26 million kg annually

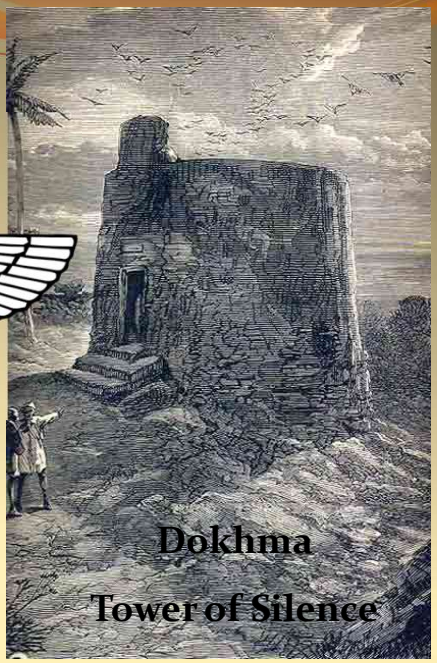
Translation: lots of dead stuff out there

Vulture declines in India

- Declines up to 95% in past 25 yrs
- Diclofenac residue in cattle
- Increase in disease
- Increase in rats, feral dogs
- $34 billion in increased health costs 1993-2006

Counting the cost of vulture decline-An appraisal of the human health and other benefits of vultures inIndia
Markandya, A; Taylor, T; Longo, A; et al.
Ecological Economics 2008

Zoroastrians



Dokhma

Tower of Silence

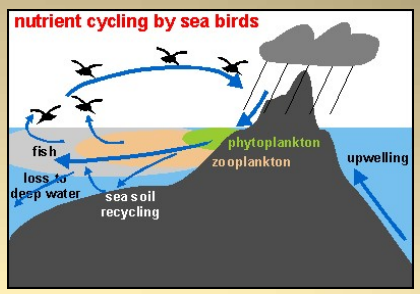
Man missing in Grand Canyon

Tuesday, April 08, 2008

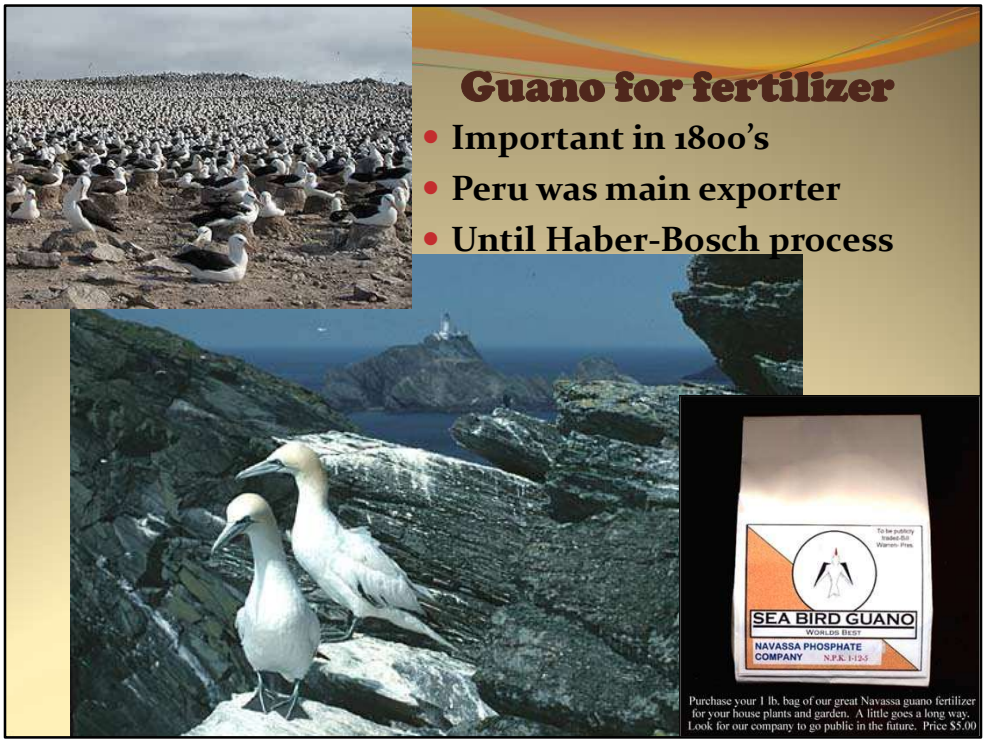
A Grand Canyon resident reported missing has been found dead 300 feet below a popular point looking out onto the Bright Angel Trail, the National Park Service said Monday.

The man was reported missing March 14, prompting a search in the Grand Canyon. His body was found Friday, when a wildlife biologist noted intense condor activity in one area and then hiked to a vantage point to spot the body.

Nutrient Cycling



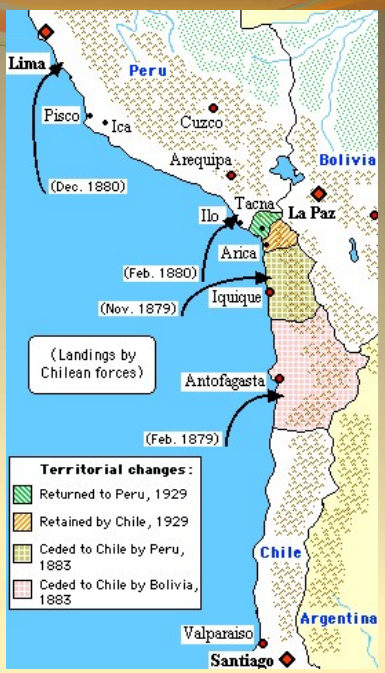
950 species of seabirds


Guano for fertilizer
Important in 1800's
Peru was main exporter
Until Haber-Bosch process
SEA BIRD GUANO
NAVASSA PHOSPHATE COMPANY
Purchase your 1 lb. bag of our great Navassa guano fertilizer for your house plants and garden. A little goes a long way. Look for our company to go public in the future. Price $5.00


South America
80°
60°
40°
Caracas
Venezuela
Georgetown
Paramaribo
Magdalena R.
Orinoco R.
Guyana
French Guiana
(France)
Cayenne
Atlantic
Ocean
Bogotá
Colombia
Negro R.
Suriname
Quito
Ecuador
Amazon R.
0°
Amazon R.
Maranon R.
Xingu R.
Tocantins R.
Ucayali R.
Brazil
Peru
São Francisco R.
Lima
Bolivia
South
Pacific
Ocean
Lago
Titicaca
La Paz
Brasilia
Tropic of Capricorn
Paraguay
Paraná R.
20°
Asunción
Chile
Paraná R.
South
Atlantic
Ocean
Uruguay
Santiago
Montevideo
Buenos Aires
Argentina
40°
N
0 500 km
0 500
nautical miles
Strait of
Magellan
Falkland Is. (UK)
Stanley
20°
Cape Horn
©1997 MAGELLAN Geographix℠
(805) 685-3100 www.maps.com

The Guano Wars

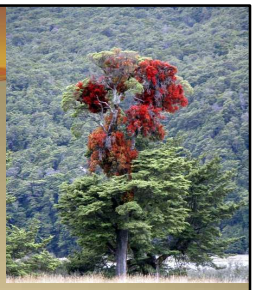
- Guano Island Act 1856
  - US vs UK vs Venezuela
- 1864-1866
  - Spain vs Peru
  - Spain vs Chile
- 1879-83
  - Chile vs Peru + Bolivia



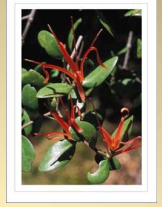
Pollination

- 600 + 350 species
- All continents except Europe, Antarctica
- 5-10% of plant species
- 5.4% of 960 ag crops
  - Most are bee-pollinated

Loss of pollinators



- New Zealand mistletoes
  - Plant population declines after bird extirpation
- Bahamas post-hurricane
  - Fruit set declined 74%
- Competition from introduced honeybees
- Forest fragmentation in Australia
  - Reduced gene flow



Cascading Effects of Bird Functional Extinction Reduce Pollination and Plant Density
January 2011
Science 331(6020):1068-71
DOI: 10.1126/science.1199092
Sandra Helen Anderson
Dave Kelly
Jenny J. Ladley
Jon Terry

Rathcke, B. J. 2000. Hurricane causes resource and pollination limitation of fruit set in a bird-pollinated shrub. *Ecology* ***81: 1951–1958.***

Frugivores and Seed Dispersal

- 1400 +2600 bird species
- 50,000 – 80,000 plant species

40% of bird species eat at least some fruit
20-25% of seed plant species potentially dispersed by birds

Advantages of Seed Dispersal

- Escape from predation and competition
- Colonization of open sites
- Directed dispersal to the best sites
- Gene flow

- Enhanced germination

compared to no dispersal (falling under parent plant)

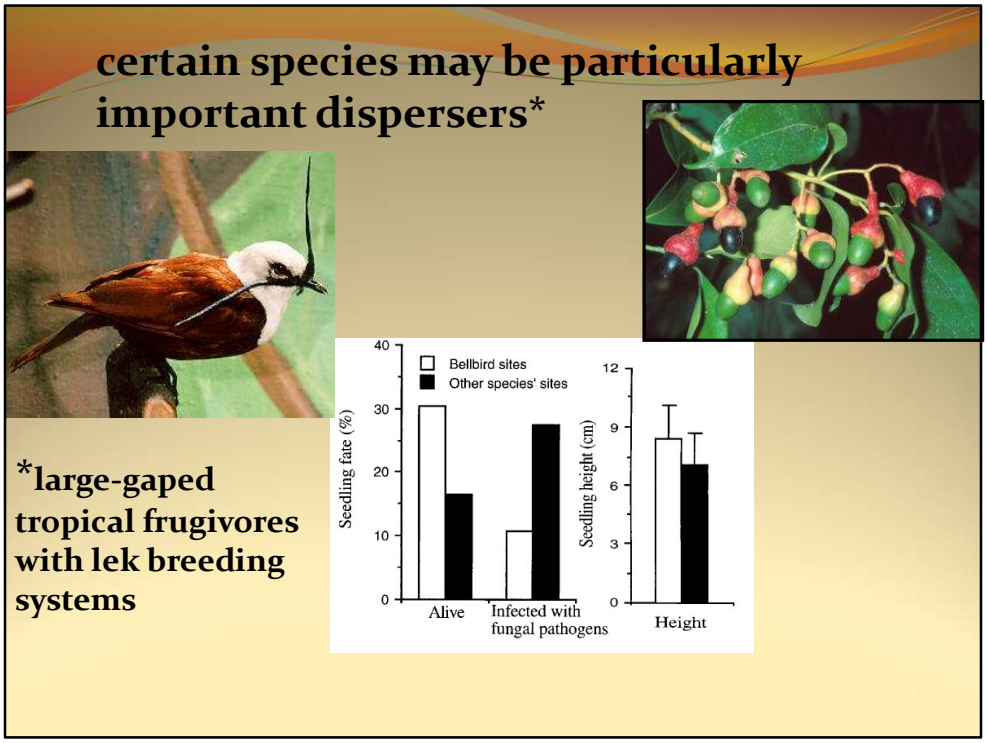


FIG. 3. One-year seedling survival, proportion of mortality caused by fungal pathogens, and seedling height (mean +/- SD) for seeds dispersed by bellbirds (open bars) and four other species (shaded). Seeds dispersed by bellbirds were more likely to survive to 1 year (X2 = 4.6, df = 1, *P* = 0.03), and the resulting seedlings (*n = 17) were taller (t test = 2.37, df = 36, P = 0.02) than were seedlings from seeds dispersed by the other four* species (*n = 21). Bellbird sites had a lower incidence of mortality by fungal pathogens than did the seedlings from seeds dispersed by the other*
four species (X2 = 4.28, df = 1, *P =0.03).*
Wenny, D.G. & D.J. Levey. 1998. Directed seed dispersal by bellbirds in a tropical cloud forest. *Proc. Natl. Acad. Sci. USA* ***95: 6204–6207.***

Nurse plants and treefall gaps

Seed dispersal by birds and mammals drives plant succession in many habitats

Mistletoes

Most species require seed dispersal by birds

Seed Dispersal - Waterbirds

ducks & geese, shorebirds, gulls, rails

Disperse seeds of aquatic plants and eggs of invertebrates

Green & Elmberg 2014 *Biol. Rev.* ***89, pp. 105–122.***

no systematic survey so # species involved not clear (birds, plants, or inverts)

Scatterhoarding by Corvids

Pines & Oaks

Long distances

Suitable sites

Loss of dispersers

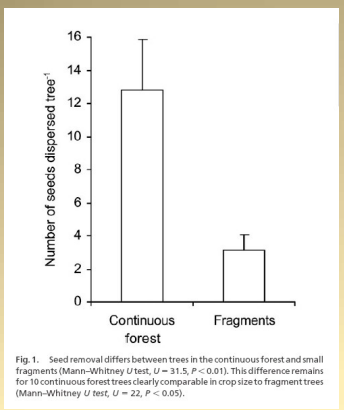
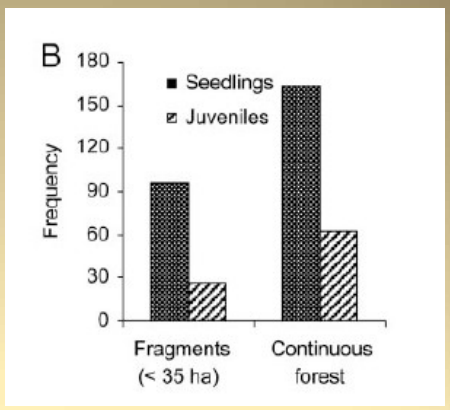


Fig. 1. Seed removal differs between trees in the continuous forest and small fragments (Mann–Whitney *U* test, $U = 31.5$, $P < 0.01$). This difference remains for 10 continuous forest trees clearly comparable in crop size to fragment trees (Mann–Whitney *U test*, $U = 22$, $P < 0.05$).



Cordeiro, N.J. & H.F. Howe. 2003. Forest fragmentation severs mutualism between seed dispersers and an endemic African tree. *Proc. Natl. Acad. Sci. USA* ***100:*** 14052–14056.

ultimately a shift in forest plant composition: large-seeded trees become less common, small-seeded and wind-dispersed species become more common

Frugivory & Seed dispersal Service or Disservice?

Costs

- fruit damage in orchards, vineyards, berries
  - Cost of deterrence
- Spread invasive species
- Species considered crop pests:
  - American robin
  - Cedar waxwing
  - European starling

Benefits

- May eat insect pests
- Help regenerate hedgerows and natural areas

A review and synthesis of bird and rodent damage estimates to select California crops

Crop Protection 30 (2011) 1109–1116

Karen Gebhardt [a,b], Aaron M. Anderson [a], Katy N. Kirkpatrick [a], Stephanie A. Shwiff [a,*]

Table 2
Expected yield loss per damaged acre, percent of total acreage that suffers damage, and percent of total yield that is lost to bird and rodent pests.

Crop	Expected Yield Loss Per Damaged Acre (%)	Acres Damaged (% of total)	Expected Damage (% yield loss)
Almond	5.1	50.8	2.6
Artichoke	11.8	70.0	8.3
Broccoli	9.5	42.1	4.0
Carrots	0.4	40.0	0.2
Cherries	11.1	34.0	3.8
Citrus, oranges	1.0	30.0	0.3
Citrus, lemons	3.5	30.0	1.1
Grapes, table	5.4	67.5	3.6
Grapes, wine	10.7	67.5	7.2
Hay, alfalfa	24.0	17.0	4.1
Lettuce	6.1	42.1	2.6
Melons	4.2	17.5	0.7
Nursery, flower	3.0	20.0	0.6
Nursery, container	5.0	100.0	5.0
Peaches	1.6	40.0	0.6
Pistachios	8.4	53.0	4.5
Rice	0.7	39.0	0.3
Rice, wild	5.4	93.0	5.0
Spinach	6.1	42.1	2.6
Strawberry	2.6	30.0	0.8
Tomato	0.8	30.0	0.2
Walnut	5.0	40.0	2.0

Apple orchards (Australia)

Peisley et al. (2016), Cost-benefit trade-offs of bird activity in apple orchards. PeerJ 4:e2179

- low fruit damage (1.9%)
- Birds ate codling moth larvae
- 12% more apple damage when birds excluded
- Net benefit of birds in apple orchards

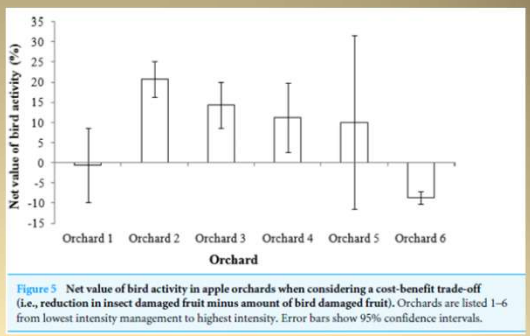


Figure 5 Net value of bird activity in apple orchards when considering a cost-benefit trade-off (i.e., reduction in insect damaged fruit minus amount of bird damaged fruit). Orchards are listed 1–6 from lowest intensity management to highest intensity. Error bars show 95% confidence intervals.

Orchard 6 was most intensely managed so not much opportunity for birds to be beneficial

DOI: 10.1111/1365-2664.13172

RESEARCH ARTICLE

Journal of Applied Ecology

Falcons using orchard nest boxes reduce fruit-eating bird abundances and provide economic benefits for a fruit-growing region

Megan E. Shave[1,2] | Stephanie A. Shwiff[3] | Julie L. Elser[3] | Catherine A. Lindell[1,2,4]

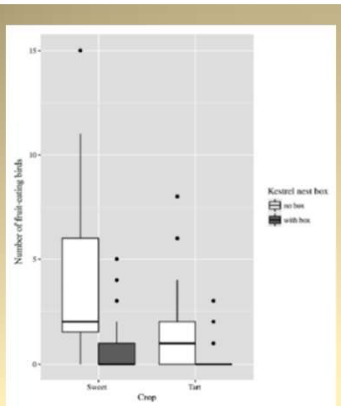


FIGURE 4 Numbers of fruit-eating birds (medians and interquartile ranges [IQRs]) observed per 10-min survey in fixed-width survey areas at sweet and tart orchard blocks with and without active nest boxes. Boxplot whiskers extend 1.5 IQRs

- Fewer fruit-eating birds in areas with kestrel boxes
- Every $1 spent on nest boxes saves $84 - $357 in sweet cherries
- Regional benefit of > $2 million

New Zealand vineyards

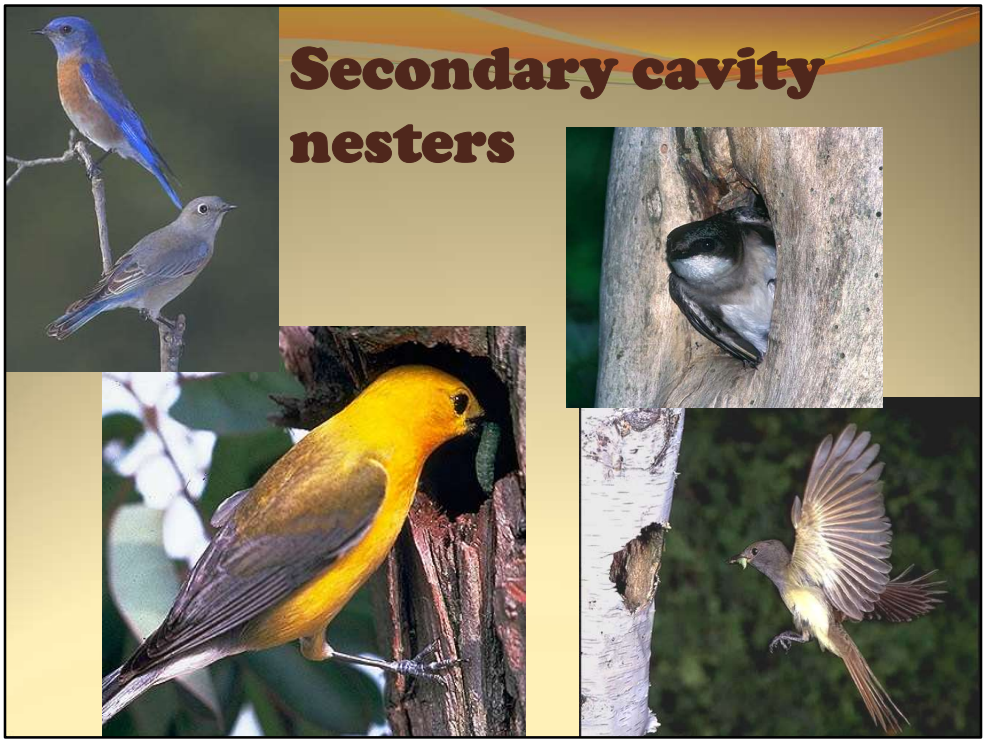
- Fewer birds in areas with falcons
- Less crop damage
- $200 - $300/ha benefit

Kross, S.M., J.M. Tylianakis & X.J. Nelson. 2012. Effects of introducing threatened falcons into vineyards on abundance of passeriformes and bird damage to grapes. *Conservation Biology*. DOI: 10.1111/j.1523-1739.2011.01756.x

Ecosystem Engineers

Woodpeckers - 180 species,

Burrows & cavity nesters - 1000 species


Secondary cavity nesters

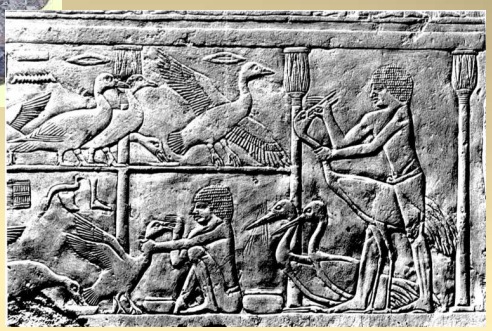
Hummingbirds regularly use sapsucker wells

Provisioning and Cultural Services

- Food
- Insulation
- Fertilizer
- Decoration

- Art & Literature
- Music & dance
- Myths & religions

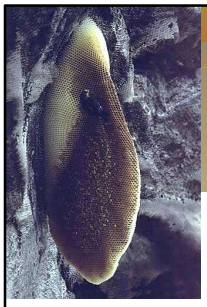
- Tourism
- Hunting
- Falconry
- Pets



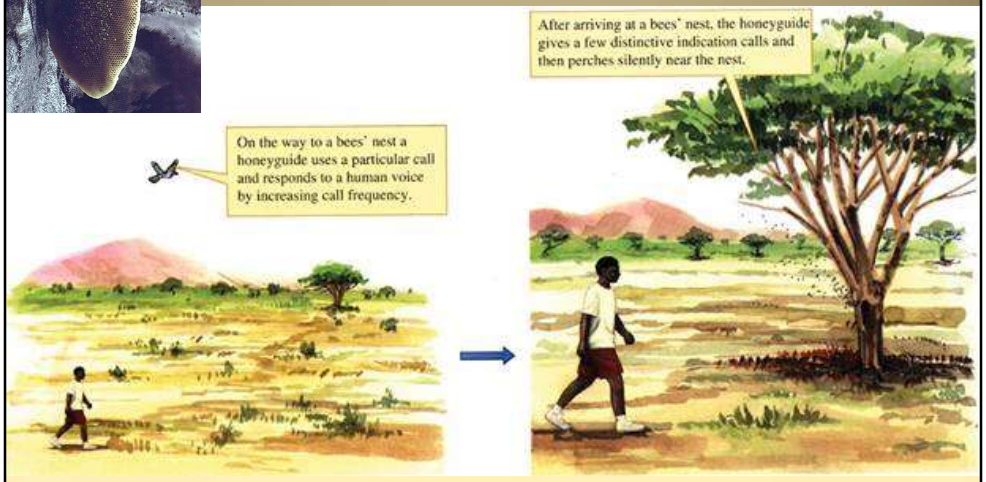
US - $12 billion (all hunting)

World - $25 billion


Nests
$1000/pound
Soup $60
in Hong Kong
BIRD'S NEST
DRINK



Honeyguides



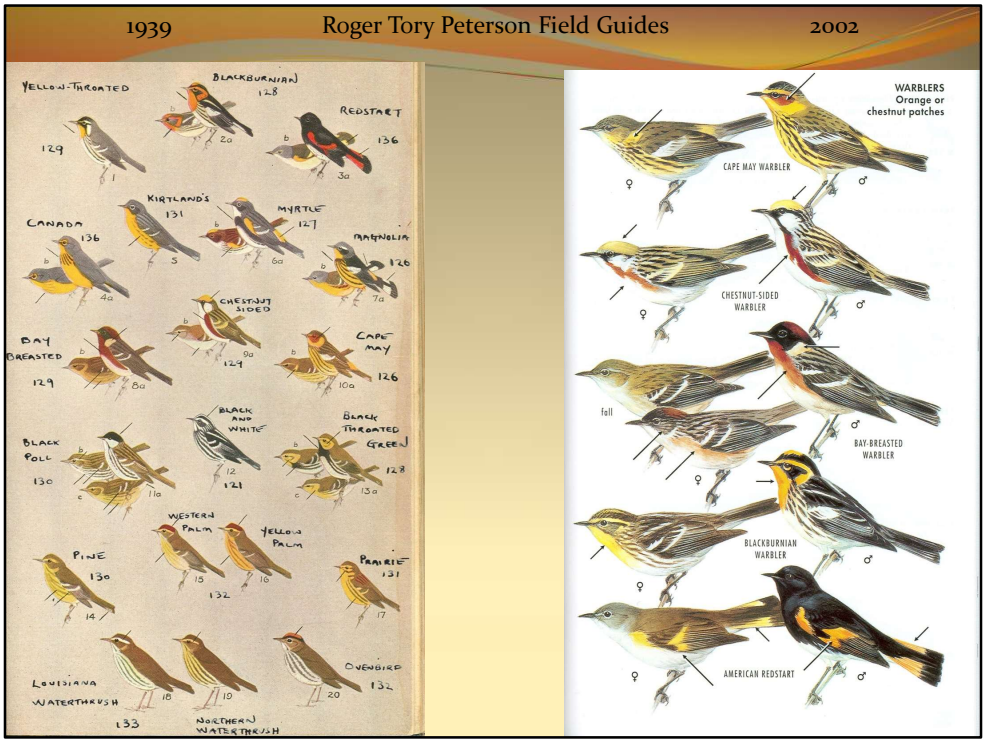

Oahu o'o
I'iwi


Photographed and Published by
J. GURNEY & SON,
9th Ave. cor. 16th St. New York.

Frank Chapman's 1886 Feathered Hat Census

7 Grebes
1 Green-backed Heron
1 Virginia Rail
1 Greater Yellowlegs
5 Sanderling
1 Laughing Gull
21 Common Tern
1 Black Tern
2 Ruffed Grouse
1 Greater Prairie Chicken
16 Northern Bobwhite
2 California Quail
1 Mourning Dove
1 Northern Saw-whet Owl
21 Northern Flicker
2 Red-headed Woodpecker
1 Pileated Woodpecker
1 Eastern Kingbird
1 Scissor-tailed Flycatcher
1 Tree Swallow
5 Blue Jay
3 Eastern Bluebird
4 American Robin
1 Northern Shrike
1 Brown Thrasher
1 Bohemian Waxwing
23 Cedar Waxwing
1 Blackburnian Warbler
3 Blackpoll Warbler
3 Wilson's Warbler
2 Tree Sparrow
1 White-throated Sparrow
15 Snow Bunting
1 Bobolink
2 Meadowlarks
5 Common Grackle
9 Northern Oriole
3 Scarlet Tanager
1 Pine Grosbeak


45 million bird enthusiasts in US
$32 million spent in 2001
$85 million in overall economic activity
860,000 jobs


1939
Roger Tory Peterson Field Guides
2002
YELLOW-THROATED
BLACKBURNIAN
128
REDSTART
136
129
KIRTLAND'S
131
CANADA
136
MYRTLE
127
MAGNOLIA
126
CHESTNUT SIDED
BAY BREASTED
129
CAPE MAY
126
BLACK AND WHITE
BLACK POLL
130
BLACK THROATED GREEN
128
121
WESTERN PALM
YELLOW PALM
PINE
130
PRAIRIE
131
132
LOUISIANA WATERTHRUSH
OVENBIRD
132
NORTHERN WATERTHRUSH
133
WARBLERS
Orange or chestnut patches
CAPE MAY WARBLER
CHESTNUT-SIDED WARBLER
fall
BAY-BREASTED WARBLER
BLACKBURNIAN WARBLER
AMERICAN REDSTART

Not the

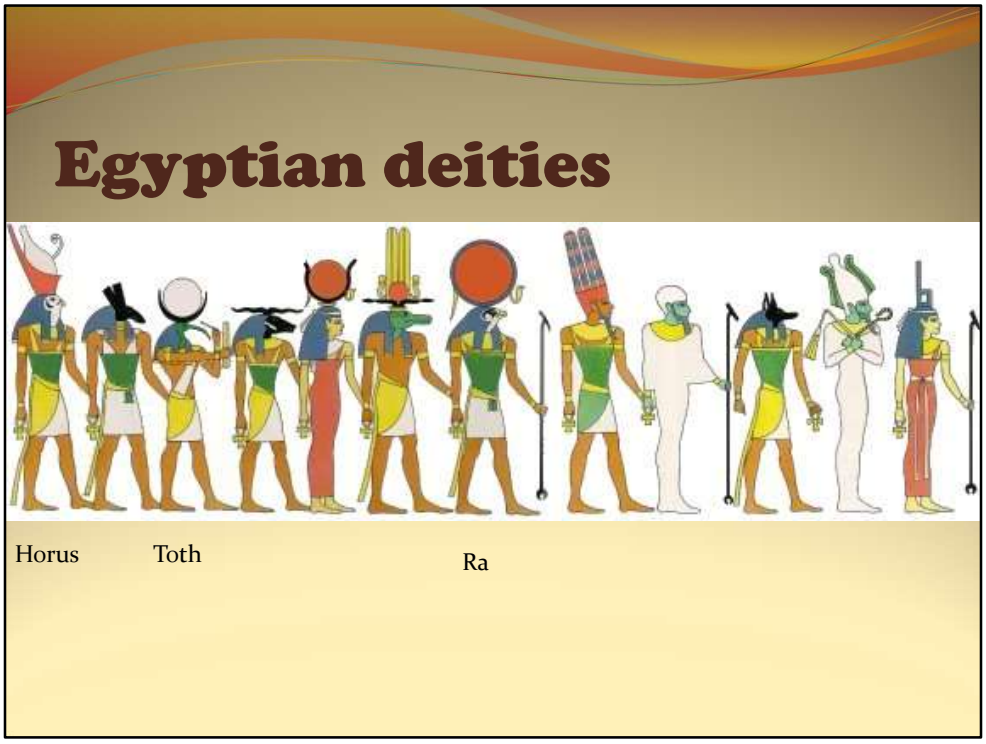
Bird-man of Lascaux, France

16,500 ybp

The Crane Wife – Japanese folk tale
Alfred Hitchcock's The Birds – (all fake, don't believe it)
Swan Lake
Aesop's Fables

Birds in music

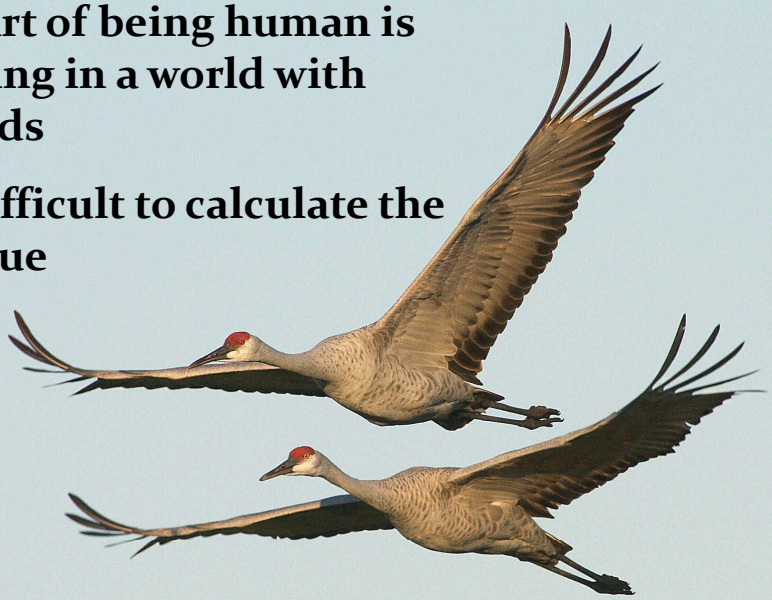
- Eurasian Common Cuckoo
  - Beethoven: 6th symphony
- Goldfinch
  - Vivaldi: Il Gardellino flute concerto
  - Mozart: Piano Concerto in G, No. 17
- Nightingale
  - Rameau: Air du Rossignol
- Scarlet Tanager
  - Dvorak: American String Quartet
- Vaughn Williams – The Lark Ascending



Horus = Barbary falcon?
Toth = sacred ibis
Ra = Lanner falcon

false idols

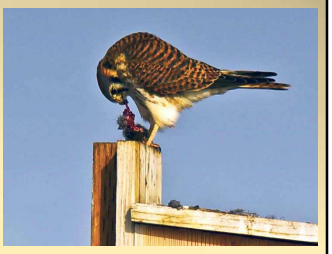
- **Part of being human is living in a world with birds**
- **Difficult to calculate the value**



Conclusions

Actions to help birds

- Manage the landscape to provide bird habitat
- Erect hunting perches for birds of prey
- Deploy nest boxes – bluebirds, swallows, kestrels, barn owls
- Intercrop bird habitat with agricultural crops
- Buy shade-grown coffee and other bird-friendly agricultural crops
- Keep cats indoors (and don't feed ferals)

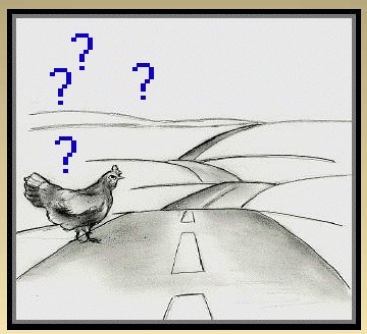


Photos from Utah State University Extension Services

Birds as Bio-indicators

- Citizen science programs
- 20% of bird species at risk
- 6% functionally extinct

- By 2100:
  - 6-14% of birds extinct
  - 7-25% functionally extinct



More study needed