Wildlife Issues Lecture Guide

by

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Chapter 1: Six Important Points Regarding Wildlife Issues

1. Wildlife issues are really human issues.
- because of this, they are never completely independent issues.

2. People love to get their way. They will do almost anything to get their way. One thing people often do is join an organization in the hope that they will "fight" for their position. Of course, the danger here is that organizations have agendas (lists of issues and positions), and people are more complex than agendas. So as an organization's agenda grows, fewer people are likely to support every position of the organization.

3. Wildlife issues mostly arise from wildlife management practices (WMPs)

WMPs refer to anything humans do (or don't do) that impacts wildlife. – Note: in this class I will focus on population level practices, not individual level.

4. There are actually only 2 main categories of wildlife issues:

- Species become abundant and are pests (handled by the USDA - Department of Agriculture)
- Species become rare and need protection (handled by the USDI - Department of Interior)

US Department of Interior agencies:

US Fish and Wildlife Service (USFWS) -- <www.fws.gov>

US Geological Survey -- Biological Resources Division (BRD) <www.biology.usgs.gov>

Bureau of Land Management (BLM) - <www.blm.gov>

National Park Service (NPS) - <www.nps.gov>

Department of Agriculture (USDA) agencies:

APHIS - Animal and Plant Health Inspection Service - <www.aphis.usda.gov>

Wildlife Services (once called Animal Damage Control and were in FWS) – <www.aphis.usda.gov/wildlife_damage/>

US Forest Service - <www.fs.fed.us>

5. Individuals don't get to make policy-unless the public lets them. "Policy" is often used in natural resources management and here I follow the definition in Webster's New Collegiate Dictionary (G.C. Merriam; Springfield, Mass. 1980). A policy, "Is a course of action selected from among alternatives, and in light of conditions, to guide present and future decisions."

6. No matter how good something sounds (in an article or on a blog or on TV, etc.) it could still be wrong...Trust no one!!!

Chapter 2: Issues, Policies and Beliefs

As we have already seen wildlife issues are human constructs. Unfortunately they are often weighed down by human beliefs, reinforced by passion and generally resolved using some form of brute force such as economics, politics, possibly religion or some other philosophical process.

According to Webster's New Collegiate dictionary, Issues are, "…matters of dispute between 2 or more parties, a point of debate or controversy."
We will commonly see situations where a policy of some sort is employed. Policies are widespread in the field and generally are cooked up when planning fails.

Consider the current *controversy* regarding human impacts on climate change. Notice that not too long ago the controversy was whether or not climate change was occurring, but now even the staunchest climate change deniers realize that the climate is changing so they have had to shift their strategy. The issue has shifted to whether or not *humans* are actually the main cause of climate change versus some variation in natural forces.

The point here is that controversies, and indeed all issues, are generally rather dynamic, which makes absolute resolution difficult, if the hallmark of resolution means both sides ultimately agree. Unfortunately, issues are generally based on *beliefs*. Simply, people on one side do not *believe* the other side. Thus, climate change deniers do not *believe* that climate change is the result of human activities. Clearly we want to resolve issues based on scientifically acquired knowledge.

And as noted by Albert Camus, in his novel, "The Plague", in the city of Oran numerous issues arose involving the progression of the epidemic (and hence a wildlife issue) through the city of Oran. As it became inescapably clear that the opinion (=belief) that the plague was, "… [just} something in the rats," was false, the storyteller notes:

"…ignorance nullifies opinion."

An appropriate quotation for many aspects in our everyday lives these days, not just in wildlife issues.

A central premise in this course is that in the best of all possible worlds, the best method for resolving issues is by means of the scientific method. However, when humans are involved, the scientific method is seldom used for resolving the kinds of issues that we will address.

Anatomy of a wildlife issue and its resolution

Consider the commercial net ban of the 1990s. Actually, this refers to the ban specifically on commercial use of gill nets within 3 miles of the Atlantic coast, and within 9 miles of the Gulf Coast. It became law July 1, 1995.

1. The idea of banning commercial netting started when someone (likely from the recreational fisher community) "believed" that there were fewer fish in the 1990s than in some unspecified early times.

2. Of course, one can imagine several possible causes for such a 'pattern' of fewer fish: (a) pollution; (b) commercial netting; (c) coastal development; (d) unknown factors.

    a. (Note: However, the idea that there might be fewer fish *because* there were more recreational fishers was not considered!)

3. Recreational fishers (who else would have minded, really) quickly identified the likely *cause*: (b) commercial netting

4. Identification of a *possible solution*: outlaw commercial netting within some arbitrarily defined zone (see above).

a) Persuade voters to sign a petition to place a proposed amendment on the ballot for the general election. This was not difficult to do as most voters likely did not really care strongly either way, and hence were particularly swayed by an intensive campaign to demonize the practice of commercial netting.

b) Once on the ballot, persuade voters to vote for the ban

c) Once the law is passed, enforce it with extreme severity. In fact, the law was passed and went into effect on July 1, 1995. In June 1995, Governor Lawton Chiles threatened to call out the National Guard to enforce the ban!

It takes two to make an issue

Pro-commercial netting supporters were outgunned from the start by net ban proponents. Net ban supporters had a vehicle ("The Florida Sportsman" magazine), that on a monthly basis published photographs of dead sea turtles, and various species of birds entangled in the nets of commercial fishers. Of course, the commercial fishers did not give up without a fight—they lodged their own arguments. Some pro-commercial fisher counter arguments and tactics are listed below (Note that in the end they did not work):

1. Denial – This is the first step – Commercial netting supporters denied that there were fewer fish than previously -- denial is always the first counterargument. (Take out commercial fishing and put in Global Climate change). Thus initially the anti-ban crowd simply denied that there were fewer fish than before – and besides (1) there are no ***data*** other than pro-ban group's ***beliefs***. When simple denial fails, then move to the next step…
2. Acceptance/ Deflection (of blame) – Okay, there *are* fewer fish but it is not due to the activities of commercial fishers.

3. Confusion/Migration -- But if -netting is banned how will commercial fishers make a living? (Note that this is no longer a wildlife issue).

In a nutshell, a trend or pattern might exist even if nobody believes it, and it might not exist even if everybody believes it. This is the basic problem with beliefs. As noted by philosopher of science, Imre Lakatos, in his book [*The Methodology of Scientific Research Programmes: Volume 1: Philosophical Papers (Cambridge*)] (1978):

"…no degree of commitment to beliefs makes them knowledge."

So, what can we do? Fortunately, we can recognize the role of beliefs in analyzing issues and we can try to employ the Scientific Method whenever possible.

The Scientific Method

Science (From the Latin *Scientia*, which means knowledge) is defined by Webster's Ninth New Collegiate Dictionary as, "...the state of knowing, knowledge versus ignorance or misunderstanding". The idea behind the scientific method is that it is a systematic mechanism for obtaining knowledge. It works as a series of steps.

1. Observation – a pattern or trend (At this point the observation corresponds to a belief). For example, someone advances the belief that there were fewer fish than back in the old days. in areas where there commercial netting has occurred.

2. Hypothesis – The hypothesis is basically a statement as to whether or not our pattern or trend is actually different from chance expectation. Obviously we cannot go back in time to evaluate the size of fish stocks, but we can make a comparison in present day. Thus we can hypothesize, "There are fewer game fish in areas where commercial netters operate, than in areas where they do not fish commercially." As opposed to the statement that, "The differences in fish population abundances in different areas is due to chance variation alone (the natural variability in nature)".

Note: we have to be careful here as the areas where there is no commercial netting might simply be areas with fewer fish for some other reason (e.g., pollution), commercial fishers are successful in part because they are adept at locating areas with more fish to begin with. So we want to make sure we are comparing similar areas.

3. Predictions of the Hypothesis – This is often referred to as the "if…then" phase. If we ban commercial netting in some areas (but not others), we predict that there will be more fish in areas where commercial netting was banned.

4. Testing the Hypothesis – Here we would specify some test, for our purposes this would typically involve a statistical test, but in the best of all possible worlds we would use a tightly controlled experiment. But often all that is available is a comparison. We then collect some data and conduct our test.

    a) If the test fails, (i.e. does not show a difference greater than chance expectation), we return to step 2 and formulate another hypothesis.

    b) If the test passes, then we make the indicated conclusion.

Chapter 3: Wildlife Issues and the Scientific Method

Wildlife issues are mostly driven by emotions or philosophy, and so generally do not lend themselves to resolution via the scientific method. Consider the case of Black Bear hunting in Fl. The issue is, "Should hunting bears be allowed or not?" This *is* an issue, but not one that can be resolved, as stated, by the scientific method. In fact, there is *no method* that can ever resolve this issue until perhaps every black bear in the state is dead. Then of course there could be no hunting. However, there are aspects of the issue that can be resolved using the scientific method.

Background:

Black bear hunting was banned in mid 1990s by the Florida GFC (Game and Fish Commission – now called the FWC) because of the perception of low and hence threatened population sizes. Since the 1990s numerous bear issues have emerged; for example, trash scavenging bears in back yards, and increased bear mortalities on highways. These points could imply that the Black Bear population has rebounded and is increasing. But they could also just mean that there are more backyards now and more traffic on highways due to more humans in Florida in the 2010s versus the 1990s.

Two sides:

1. Pro-hunting side. The bear population has increased -- home owners have bears in their yards, many more bears are dying in vehicle collisions on highways and hunting would reduce the population size and thus reduce bear conflicts in the suburbs. (Note: that this latter argument might or might not be true.)

2. Anti-hunting side. No bear population size is large enough to permit hunting. There should simply not be any bear hunting.

As stated, the issue "to hunt or not hunt black bears in Florida" is not one that can be resolved using the scientific method. However, certain aspects can be tested using the scientific method.

(Side note: Managed hunting can generate large amounts of money that can be used for bear management)

Without understanding completely why the black bear population was so small as to warrant a ban on hunting them, scientists can study population trends.

1) Observation – The bear population appears to be increasing,

    a) (e.g. evidence includes more mortalities of bears on highways; more observations in suburbia)

2) Hypothesis – The bear population is increasing versus it is not increasing (note that these alternatives are mutually exclusive)

3) Test – Divide the state into bear management units. Then use count data in the different management units over a period of years

    (Note: Actually, one thing agencies like the FWC (successor to the GFC) do for threatened populations is conduct annual censuses – so the data have been collected). Also increased incidents on highways and in suburbs could simply be due to more humans not more bears. So, we would need to control for increased highway traffic and increased suburban sprawl, before we run our test.

4) Conclusion – The bear population is, or is not, increasing.

Of course, simply knowing something about the population dynamics of the black bear in Florida means nothing to one side (the no-hunt side) in the initial issue of 'to hunt versus not to hunt'. Whenever one side is unwilling to compromise, nothing will change their perspective. Those who want to hunt bears would be bolstered by the confirmation of their belief that the bear population had increased and could likely be hunted without eradicating them.

What ultimately happened was that the FWC, in addition to monitoring population growth in bears, conducted a series of public forums where people could voice their opinions about hunting black bears. The Commissioners of the FWC (these are typically non-scientists, real estate developers and businesspeople and agriculturalists) agreed to a tightly controlled hunt in 2015.

The conditions were set – areas (bear management units) open to hunting, the prices of a permit, a limit on the harvest per management area (note that 'the harvest' is a euphemism for 'the kill') and some size limitations (no bears less than 100 lbs. were to be taken), nor were any bears with cubs to be killed. It is unclear how hunters were supposed to determine body size in the field, beyond using the old "eye-ball" technique. In the end there were some illegal kills (bears that were too small) and 21% (about 64) of the bears taken were lactating - this means they may have had cubs somewhere.

Florida residents paid $100 for a permit, whereas non-residents paid $300. In the end 3776 permits were sold (3742 to Florida residents + 52 to non-residents). This translates to $388,000 for bear management. Initially the statewide harvest was set at 320, and the hunt was closed after just two days when the total kill reached 304.

2015 FWC Bear Hunt Report

The commissioners voted to delay the 2016 hunt, and recently voted to delay the hunt for 2 years.

From an article in the Orlando Weekly by Jim Turner (April 20, 2017).
Bear hunt delay

"The agency received $825,000 for the current fiscal year to help residents in 11 counties get bear-resistant trash cans. The money was raised through licenses issued for the 2015 hunt and from proceeds of the Conserve Wildlife license plate."

If these figures are accurate ,it means that the money generated by the hunt did not even make up half the amount spent on bear-resistant trash cans.

Scientists at the FWC claim that the "science" comes down on the side of having a bear hunt, but public opinion argues against this. No doubt when the FWC says, "science", they mean the population increases.

Note that the US Fish and Wildlife Service (USFWS) declined to list the Florida Black Bear as Threatened under the Endangered Species Act– as noted in the Federal Register on April 19, 2017.

Chapter 4: Hypotheses and the Scientific Method

When there is natural variation in studies of natural systems people rely on statistical analyses.

1. For instance below, we will look at an experiment on the effects of bed fishing. In the end, it must be true that either bed fishing reduces the number of recruits to the population or it does not. Note that these are *mutually exclusive* outcomes.

2. Now the experiment used statistical comparison of recruits in bed-fished ponds versus control (i.e. non-fished) ponds. Statistics are based on probability – How unlikely is an outcome? Is an outcome less likely than expected by chance?

Hypotheses: We need a Null Hypothesis (sometimes called a "no difference" hypothesis), and a mutually exclusive alternative hypothesis: These are called H_0 and H_A

H_0 : There is no difference in number of recruits produced in control ponds (those not bed-fished) versus bed-fished ponds (we call these "treatment" ponds).

H_A : There is a difference in the number of recruits produced in control versus bed-fished ponds.

Now we can conduct the experiment. We collect the data (i.e. count the recruits in both control and treatment ponds); and then we use a statistical test to see if the difference we observe is greater than expected by chance.

Statistical Pitfalls

Of course, when relying on statistical tests we are putting our faith in probability theory, and our final conclusion can be right in either or two ways or wrong in either of two ways. Consider the table below:

Statisticians view the possible outcomes like this:

		No difference	Is a difference
Our test says there is no difference		Ok (a)	Type II error (b)
Our test says there is a difference		Type I error (c)	Ok (d)

Here the columns reflect reality – there truly is a difference (Cells b and d) or there isn't (Cells a and c). The rows reflect the outcome of our test which says either there is no difference (Cells a and b) or that is there is a difference (Cells c and d)

A type II statistical error (Cell b) occurs when our statistical test says there is no difference due to an effect when in reality there is.

A type I error occurs when our statistical test says there is an effect when in reality there isn't an effect.

If your result leads you to either cell 'a' or 'd' then we are correct. Also note that for natural resource and environmental issues it is much more serious to commit a type II error, this is when you say there is no effect when there really is one.

Chapter 5. Experimental Studies in Wildlife Ecology and Conservation

Not only do wildlife issues not lend themselves to the scientific method, they also do not lend themselves to experimental studies. The reasons for this will become clear in the following example.

Recently one of our Ph.D. students (now Dr. John Hargrove) conducted an elegant experiment as part of a larger study on genetics of black bass. A side study allows for a test of the impact of a specific type of recreational fishing (bed fishing) on black bass population dynamics, specifically on the number of recruits or young produced. John set up 9 experimental ponds, each 0.4 ha (roughly 1 acre) in surface area. He stocked each pond with 20 bass (10 males + 10 females) as well as equal numbers of nest predatory fishes and food fishes (for the bass). As aquatic vegetation began to cover parts the ponds he added grass carp (2 per pond) to graze it down. Every effort was made to homogenize the structure in the pond (bass like to nest near structure, rocks or piles of vegetation), and the presence of predatory fish that would feed on unguarded eggs as well as prey fish the bass could eat.

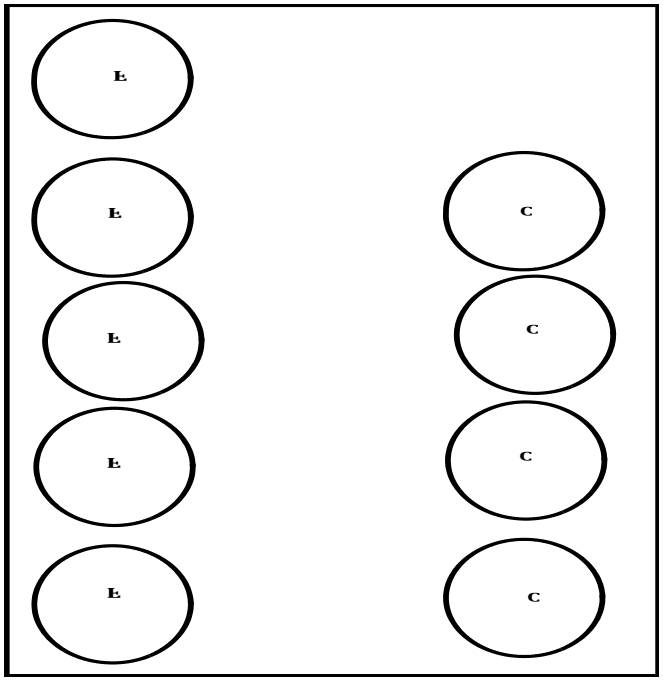
One of his goals was to see if bed fishing (sight fishing where the angler spots a fish on a bed or nest and targets that specific fish) impacted the number of recruits.

H0: There is no difference in number of recruits in bed-fished versus control (not bed-fished) ponds.

HA: Bed fished ponds have significantly fewer recruits (babies)

The results were very interesting as they show that when it comes to natural resources there is generally a large amount of variation. This is visible in the two bar charts below the table of the raw data.

Here is a hypothetical arrangement of the 9 ponds for the in the study; In both year 1 (2013) and year 2 (2014), 5 ponds were fished (F) and 4 were controls (C = not fished). Below the figure is a table with the raw data.



Experimental set-up. F= fished, and C=control (not fished

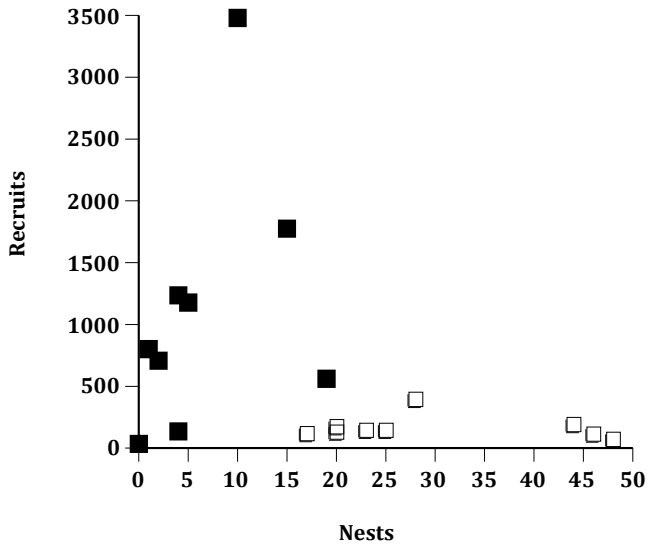
The raw data from the study. Legend: Yr = year; Trt = treatment, F = fished, C = control (unfished);

Yr	Trt	Pond id	Nests	Recruits
1	F	27	4	135
1	F	29	0	34
1	F	56	2	707
1	F	58	4	1236

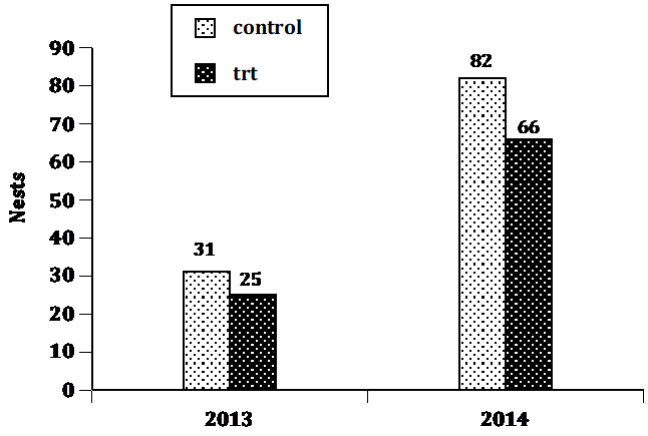
1	F	60	15	1775
1	C	23	5	1177
1	C	28	19	561
1	C	57	1	801
1	C	61	10	3479
2	F	23	23	140
2	F	28	28	390
2	F	44	44	186
2	F	46	46	109
2	F	48	48	66
2	C	27	25	140
2	C	29	17	113
2	C	45	20	125
2	C	47	20	169

Notice that in pond 29, in the first year 34 recruits were produced but no nests were found. This is interesting because the ponds were examined by snorkelers, and every effort was made to make the structure in the ponds (brush piles and cement blocks) identical. However, even though they were artificially constructed the ponds were variable in turbidity and aquatic vegetation growth so some nests could be overlooked.

A plot of recruits versus nests: solid squares = years 1; open squares = year 2.

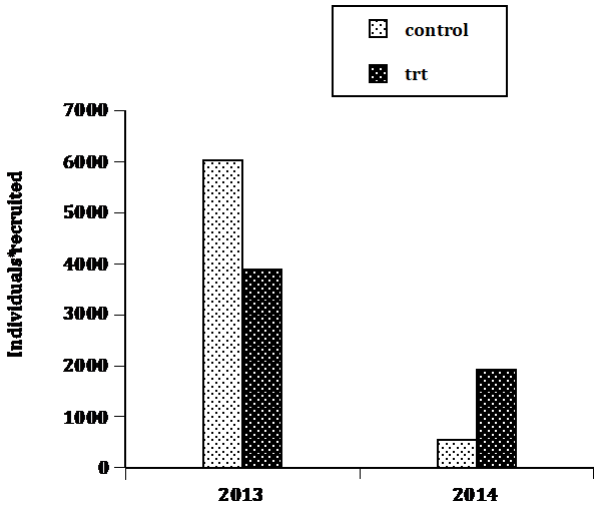


The frequency diagram below shows the year to year variation in number of nests in experimental ponds. The number of nests did not differ significantly.



So even though the ponds were experimentally manipulated to be as homogeneous as possible we see large variation between years on number of nests.

There were also no significant differences in number of recruits (young fish added to the population through reproduction), although it looks like there should have been, but of course appearances often fail to reflect reality.



Curiously, there were fewer recruits in year 2 when there were also more nests.

The bottom line here is that even in a tightly controlled experiment where size, shape and range of depths were identical across human-constructed ponds, there was a good deal of variation among the ponds.

And these were nine small ponds on a tract of land. Imagine the potential sources of variation when you consider statewide or regional effects.

Chapter 6: Resolving Issues: Propaganda: Sample Issues

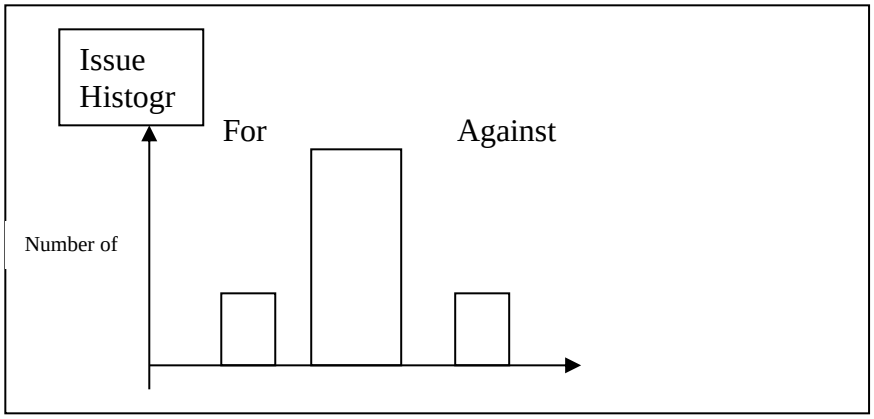
A note about resolving issues

As I stated previously the best way to resolve issues is the scientific method but it is seldom used in wildlife issues as they are often very emotionally charged and because it is not possible to couch them in the form of mutually exclusive and testable hypotheses.

Propaganda

In place of the scientific method people employ whatever they can to get their way, (Recall that individuals do not get to make policy when it comes to wildlife.) And two observations I have made over the past 50 years or so are that: (1) people like to have their way and will say or do anything to get their way, and (2) people are generally downhill thinkers and will tend to believe what is easy to believe.

In all issues we see this problem:



Both sides in an issue try to gain support from the middle

On effective tool in this situation (downhill thinking and the individuals can't make policy thing) is propaganda. According to Webster's New Collegiate Dictionary (G.C. Merriam; Springfield, Mass. 1980) *Propaganda* refers to (1) "the spreading of ideas, information, or rumor for the purpose of helping or injuring an institution, a cause, or a person"; or (2)

"ideas, facts , or allegations spread deliberately to further one's cause or to damage an opposing cause: also a public action having such an effect."

Propaganda can also involve associations with celebrities like Jackie Chan, as an example; he lent his name in a campaign against "bear parks" in Japan. The main group fighting these bear parks is the World Society for the Protection of Animals:

<http://www.wspa-usa.org/>

Wildlife laws - When someone has a position on an issue (for or against) the best outcome one can hope for is the enactment of a law, supporting their position. However, it turns out that people break laws all the time. So laws can really only shape human behavior they can't completely control it. Plus, sometimes, laws have loopholes and we will see this for example under our discussion of Shark conservation.

Some Sample Wildlife Issues

Saving the Black-footed Ferret <http://www.blackfootedferret.org/>

The black-footed ferret (BFF) is small (less than 1 kg), member of the weasel family (Mustelidae). They feed almost exclusively on prairie dogs (*Jones, J.K., jr,. David M. Armstrong, and Jerry R. Choate. 1985. Guide to the Mammals of the Plains States: University of Nebraska Press*) reported that more than 90% of ferret scats contained the remains of prairie dogs.

The presumed last wild ferrets were captured in Wyoming (in White-tailed Prairie Dog colonies) in 1985, when 17 were taken in for captive breeding.

1998 – After a successful captive breeding program there were, at last, more ferrets in the wild than in captivity (http://www.blackfootedferret.org/).

More than 8000 ferret kits have been produced in captivity; and 3500 have been reintroduced to 21 sites in (http://www.blackfootedferret.org/).

Listing the Black-tailed Prairie Dog

Of the four species of Prairie dogs in North America, only the Black-tailed Prairie Dog (BTPD) does not hibernate (*Kays, Roland and Don E. Wilson. 2002. Mammals of North America; Princeton University Press; Princeton, NJ*) There are may have been as many as 5 billion BTPDs at one time. They are listed as a "varmint" in Great Plains states, where they are considered a nuisance for agriculture. Cattle can step in prairie dog burrows and break a leg.

Why list the BTPD?

Petitioners to have the species listed argued that BTPDs suffered from three threats:

1. Sylvatic Plague.
2. Habitat loss – When the prairie is converted to farmland prairie dogs didn't persist, and most of the prairie has been converted.
3. Recreational shooting - One example of this is VHA (Varmint Hunters Association) another is the Red Mist Society – a group of people who like to shoot prairie dogs (see *Please Don't Shoot the Prairie Dogs*; *Kevin Fedarko; Time Magazine July 7, 1997*). They are basically thrill killers

    Note: There is a whole industry in "varmint" shooting.

    - specialized rifles (heavy barrels, longer barrels)
    - high magnification scopes

One prairie dog shooter (see *Reducing Varmints to "Mist"; Walter Kirn; Time Magazine, August 7, 2000*) claimed that, "…no amount of shooting can wipe out a thriving prairie dog colony." Question: Does this mean that if a population does get wiped out by recreational shooters that it wasn't thriving? Of course, if prairie dogs aren't shot on private property, ranchers may poison them.

In 2004, US Fish and Wildlife Service decided not to list the list the Black-tailed Prairie Dog as endangered or threatened (see 1: *USFWS; The Mountain-Prairie Region.; News Release August 12, 2004; 2: Federal Register, Vol 69, No. 158; August 18, 2004; pp 51217-51226.*) They had new information, so they decided 2 things:

1. There was more habitat (acreage) than previously thought – so they increased their estimate of total occupied habitat by a factor of 10.
2. They also discovered that colonies of the BTPDs could bounce back from sylvatic plague outbreaks

Snow Geese (and Ross' Geese) – Dealing with a population explosion

The Snow Goose population has exploded recently and they are now destroying the vegetation in their nesting grounds.

Note: The Snow Goose (*Chen caerulescens*) has two color morphs: a Blue morph (once considered a distinct species) and a White morph (*Johnsgard, P.A. 1987. Ducks, geese, and swans of the world, University of Nebraska Press, Lincoln, NE*). We now know that these are the same species, as people found nests with both color morphs in the young.

The short film entitled, *Storm Warning* was produced by the NGO (= non-governmental organization) Ducks Unlimited (<http://www.ducks.org/>). This organization is interested in conservation of wetland, but most members are hunters.

Chapter 7: Wolf Re-introduction – Another conservation success story

The species here is commonly known as the Gray or Timber Wolf (*Canis lupus*). Wolves were once found across North America and into Mexico (Mexican Wolf). Humans persecuted them and wiped them out in many places to the extent that by the last part of the twentieth century, the only surviving population in the lower 48 states was in Minnesota. Across the lower 48 states of the US the Gray Wolf was listed as Endangered, except in Minnesota where it was listed as Threatened. In the last several years, wolves have been reintroduced to the Yellowstone Area in Wyoming. The Mexican Wolf (a subspecies) has been reintroduced to Arizona and New Mexico. Not everyone approved of the re-introductions of the Mexican Gray Wolf. Of 11 individuals released in the winter of 1997, 4 were shot (*Deadly Days for Wolves: Andrew Murr; Newsweek 30, 1998*).

Gray Wolves have returned naturally to Michigan (in the Upper Peninsula – aka the U.P.), presumably through Wisconsin. In January 2007 the U.S. Department of the Interior de-listed the Gray Wolf in the DPS ('Distinct Population Segment'). in the western Great Lakes region (www.doi.gov October 24 2008).

Part of the de-listing process involves individual states drafting a management plan. In Michigan <http://www.michigan.gov/dnr/0,1607,7-153-39002_41978---,00.html>, they invited several groups to participate in this planning process. These included: Animal Rights Groups; NGO conservation groups; State agencies such as the Department of Natural Resources; the Michigan Sheriff's Association; and University Scientists.

According to the Midwest Region of the FWS (<http://www.fws.gov/> In 1992, there were 21 wolves in Michigan. In 2006, there were 434 wolves in Michigan. All wolves are in the Upper Peninsula. This is a strange place. It has 1/3 of the area in Michigan and 3% of the population.

Note: A really good management tool for managing populations that are small but are increasing rapidly is a limited, very experimental hunt.

Managing Michigan Black Bears – A model for the future of the Gray Wolf in Michigan

Black Bears, like wolves, are chiefly an Upper Peninsula species in Michigan. Black Bears were once considered pests in Michigan but now they are treated as a highly esteemed big game animal.

There are as many as 19,000 bears in Michigan, with 90% occurring in the Upper Peninsula. In 2006, hunters harvested 2641 black bears. The state says they have had record harvests in 5 of the last 6 years. There are 9 management units in Michigan (3 Lower Peninsula, and 6 Upper Peninsula).

Chronic Wasting Disease (CWD)

CWD is a type of Transmissible Spongiform Encephalopathy or TSE. Other TSEs include Mad Cow Disease (in cattle), Creutzfeldt-Jakob Disease (in humans), and scrapie (in sheep). It first appeared in Colorado in captive mule deer in the 1960s and later was detected in elk, white-tailed deer and moose. Recently it was found in reindeer in Norway. The origin of CWD is unknown but one idea is that it derived from scrapie infected sheep.

Since its discovery CWD has been observed in numerous states, as well as Canada and recently also in a free ranging reindeer and moose in Norway, the first detections in Europe.

Here is information regarding the recent report of CWD in the state of New York.

<http://www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_05_01.jsp>

New York State has several hundred establishments raising several thousand deer and elk in captivity. In the wild, DEC (Department of Environment and Conservation) estimates there are approximately one million deer statewide."

CWD as of August 31, 2019:

According to the map on the website:

<http://www.cwd-info.org/>

Wild Cervids (= species in the family Cervidae; White-tailed Deer, Mule Deer, Elk, or Moose) infected with CWD as of March 2013, have been found in Saskatchewan, Alberta, Colorado, Wyoming, Utah, New Mexico, Kansas, Nebraska, Illinois, South Dakota, Missouri, Wisconsin, New York, Pennsylvania, West Virginia, Virginia, and also in captive herds in all these states and provinces plus Michigan, Montana, Iowa and Oklahoma. Just recently (2016) it was discovered in a free ranging reindeer and moose in Norway.

Now recall that not all issues are independent. Different issues often have other ramifications. So, if deer (for example) have chronic wasting disease, many people would leave those deer alone (i.e. not hunt them), but this has economic impacts. Thus, the discovery of CWD in the state of Wisconsin figured to cost the state DNR a good deal of money in lost licenses and fees.

Until very recently (2017) there was no live test for chronic wasting disease. (https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/nvap/NVAP-Reference-Guide/Control-and-Eradication/Chronic-Wasting-Disease

The live test reported here specifically states that the test (involving a biopsy of rectal tissue). Back when the disease broke out in Wisconsin in 2001 it was only possible to test tissue of dead animals (white-tailed deer). So, when the disease broke out in Wisconsin there was panic. So, the state decided to establish a Herd Reduction Zone (HRZ) that covered several counties in southern Wisconsin and within the HRZ, they established two Deer Eradication Zones (DEZs), in which they killed as many deer as they could, then tested them for chronic wasting disease.
(<http://dnr.wi.gov/topic/wildlifehabitat/documents/surveillanceplan.pdf>).

https://dnr.wi.gov/topic/wildlifehabitat/regulations.html

This map shows positive detections of chronic wasting disease in Wisconsin as of 2019. It is likely that the eradication zone boundaries were set after much public comment (compromise financial interests versus deer management), and will have to be reset in the future as more data are collected, meaning for example in Illinois where CWD has now been found.

Note: Any management plan for chronic wasting disease in Wisconsin ends at the state line but, deer don't know any better and chronic wasting disease goes with the deer.

Some people think escapees from captive deer herds spread CWD. According to the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), Wisconsin had more than 820 captive deer farms as of 2003! And the April 2003 report by The Southeastern Cooperative Wildlife Disease Study stated that Wisconsin deer farms held more than 16,000 deer, 24 farms were unlicensed, and 436 individuals had escaped and not been recovered.

In Colorado, where chronic wasting disease first appeared, the Colorado Division of Wildlife (CDOW) set up zones wherein hunters were required to submit the heads of any deer or elk they killed for chronic wasting disease testing. The state refunded the license fee if the animal tested positive. Click here to see the maps for Mule Deer and Elk.

A recent study (*Rachel C. Angers, Shawn R. Browning, Tanya S. Seward, Christina J. Sigurdson, Michael W. Miller, Edward A. Hoover,4 Glenn C. Telling 2006. Prions in skeletal muscle of deer with Chronic Wasting Disease. Science 311: 1117*) found prions (small, proteinaceous particles that cause chronic wasting disease) in skeletal muscle of deer. This suggests that the meat could be tainted.

Devil Facial Tumor Disease

Tasmanian Devils – In 1996 people stated noticing Tasmanian Devils with facial tumors called Devil Facial Tumor Disease) (DFTD). Scientists were stumped initially, as it appeared to be a transmissible form of cancer. However, it has since been learned that (1) the devils went through a severe genetic bottleneck following intensive killing to protect agriculture. But once the killing was halted the population re-bounded but the individuals are apparently very closely related. (2) the devils tend to have the tumors on the face around the mouth and this is where they bite each other at carcasses they are scavenging and in fight for mates. Recently scientists at Cold Spring Harbor Lab found a genetic marker for the disease. Hopefully this will lead to finding a vaccine.

Kangaroos

The quota is the maximum number allowed (targeted) for harvest
According to statistics posted on the worldwide web by Australian governmental agency – The Department of Sustainability, Environment, Water, Population and Communities, four species are commonly harvested commercially: Red Kangaroo; Eastern Grey Kangaroo: Western Grey Kangaroo: Euro or Walleroo.

Australians have studied the whole phenomenon of the kangaroo harvest ecologically. So, the Wildlife Conservation Society (in the U.S.) asked some Australian ecologists (*this link is for an article on The University of Queensland News On Line web page for March 3, 2004*) to help design a harvest program for Mongolian Gazelles in Mongolia.

Cats in Australia – A problem of introduced species harming the natives

A New York Times article from 1997 (Seth Mydans, 1997. The Stray Cats of Australia: 9 lives seen as 9 too many; January 23, 1997) stated that there were as many as 12 million cats in Australia.

Cats were introduced to Macquarie Island, Australia, in 1820 by whalers to control rats and mice in their grain stores. In 1878 sealers introduced rabbits to the island as a food supply for humans. Cats ate rabbits as well as sea birds and so the cats were reduced. Rabbits, once held in check by the cats, increased and devastated the vegetation. Rabbits had a devastating effect on the island's vegetation. So managers introduced Myxomatosis, a lethal disease in rabbits, in 1968. Rabbits declined from 130,000 in 1978 to 20,000 ten years later. For a complete analysis see:

(Selkirk, P.M., R.D. Seppelt, and D.R. Selkirk. 1990. Sub Antarctic Macquarie Island: Environment and Biology. Studies in Polar Research, Cambridge University Press, Cambridge.)

Ideas on how to control Rabbits:

1. Drop poison bait when the birds are absent (i.e. outside the nesting season)
2. Re-introduce dingoes. These are basically wolves that the aboriginal humans brought to Australia.
3. Introduce a rabbit-killing disease (like Myxomatosis)

Section 3 - What is Wildlife? CITES; Five Kingdom System

What is wildlife?

For the purposes of this class we will define the term "wildlife" to refer to all living species. It can include even domestic livestock. Now some say livestock do not qualify as wildlife but there are two reasons for including them:

1. all livestock species descended from a wild species via artificial selection.
2. in some populations, the line between domestic and wild is blurry. *These days people are now farming various wild species – Ostriches, Turkeys, Rheas Emus, Crocodilians etc. It is hard to draw the line here between wild and domestic.]*

Another commonly used term is "Feral". A feral population is one that is made up of individuals that have escaped domestication (e.g., horses, dogs, cats)

There are two basic schemes for classifying wildlife:

1. Non-phylogenetic – can be science based but not on shared evolutionary history. Instead these schemes might be based on geographic distribution and/or abundance and could be imposed at the local, state, national or international levels: CITES (Convention on International Trade in Endangered Species) is an example of an international agreement and ESA (Endangered Species Act) is an example of a national scheme. Other schemes are the IATTC (Inter-American Tropical Tuna Commission; ICCAT (International Commission on the Conservation of Atlantic Tunas); and the CCAMLR (Convention on the Conservation of Antarctic Marine Living Resources).

2. Phylogenetic – based on a presumably shared evolutionary history as evidenced by shared characteristics – kingdoms, phyla, classes, orders, families, genera, species.

CITES: What is it and how does it work?

CITES deals with monitoring trade across international boundaries. It is driven by a listing system that is similar to the one in our ESA. Currently (Spring 2017) 183 nations have signed the convention. Basically, CITES has 3 appendices:

Appendix I – most endangered species, species in this group are the most endangered and face extinction. International trade involving species in this group is only allowed under special circumstances (i.e. non-commercial)

Appendix II – species that could become endangered if trade is not regulated

Appendix III – species that some "party" (i.e. some country) already regulates trade in the species and needs other nations to help. Specimens of species on this list can only be traded with proper CITES permits.

Now looking at the appendices you might notices that all but one primate species are listed in Appendix 1 (only exception is on Appendix II)

As of Spring 2017 only 6 nations had not signed onto CITES. These are: Western Sahara; South Sudan; Turkmenistan; North Korea; Timor-Leste; and Haiti.

Two holdouts recently signed: Lebanon signed in February of 2013; Tajikistan signed in March of 2016)

The Endangered Species Act (ESA)
This is US law, passed in 1973 and attacked repeatedly since….

According to ESA species are considered "listed" only if they are classified as "Endangered" or "Threatened".

ESA Definitions:

Endangered – species (or populations or subspecies) in danger of extinction over all or a significant portion of its range.

Threatened – species that could become endangered in the foreseeable future.
Candidate species – species that stand to be listed once more data are received or if their priority number drops.

Priority numbers are based on:

1. Magnitude of the threats – 2 levels; High or Moderate to Low (i.e. not high)
2. Immediacy of the threats – 2 levels; Imminent or Not Imminent
3. Taxonomic uniqueness (species>subspecies) – 3 levels, the highest is for monotypic genera (1 species in the genus); lowest level is for subspecies; and species in multi-species genera are in the middle

So theoretically a species could have a priority number anywhere from 1 to 12.

So a *species* in a monotypic genus, facing a Severe and Imminent threat would be given a priority number of 1; and a *subspecies* that faces a Moderate to Low, and Non-imminent threat would get a priority number of 12.

How to list a species under ESA:

1. Petition – proposal sent to the Department of the Interior
2. Review – by USFWS
3. Decision -- by USFWS
4. Rule –Signed off on by Secretary of the Interior

Petitions and review results are published in the Federal Register. This is a thick publication in very small type.

A Phylogenetic Scheme – The Five Kingdom System

More recent treatments of life on Earth such as Campbell 10th Ed, list more than 5 kingdoms but this increase is due to a newer view of prokaryotic species.

Prokaryotes have cells without organized nuclei or membrane bound organelles like chloroplasts or mitochondria.

Eukaryotic cells have organized nuclei, and membrane bound organelles. Given this form of division of labor, eukaryotic cells are larger than prokaryotic cells.

Based on Weighted as opposed to Unweighted characteristics

Five Kingdom System (*Curtis, H. 1983. Biology; 4th edition. Worth Publishers, New York)*

1. Monera – prokaryotes, bacteria (Campbell splits these into 2 kingdoms)

2. Protista – eukaryote, sort of a catchall group for single celled eukaryotic species

3. Fungi – eukaryotes, has a cell wall (chitin)

4. Plantae – eukaryotes, has a cell wall (cellulose)

5. Animalia – eukaryotes, no cell wall

We will focus on Kingdom Animalia in this class and just mention the others in passing. This is not to say they are lacking in importance, but rather because there are other courses that give them more attention.

Fungi – Multicellular Eukaryotes. This Kingdom includes the mushrooms, rusts, molds, and the smuts.

A Fungal Issue – The Salem Witchcraft Affair -- In 1982, Mary K. Matossian (University of Maryland) – published an article in (*Ergot and the Salem Witchcraft Affair, American*

Scientist, 70: 355-357) on Ergot and Salem. She argued that the symptoms of the "bewitchment" mirrored the symptoms of ergot *Claviceps purpurea* poisoning.

She noted that 50,000 people died in France in the middle ages of Ergotism (called St. Anthony's Fire). It causes gangrenous extremities and hallucinations.

Symptoms of Ergotism – St Anthony's Fire

Gangrenous; convulsions; madness; RBD (really bad diarrhea)

During the Salem witchcraft affair (1690s) an approach to determining if one was bewitched was through the use of a *witch cake*. A "witch cake" was made and fed to a dog. If the dog showed any symptoms, then they would say the afflicted person was indeed "bewitched." The puritans had lots of rye (cold weather, damp environment during the years around 1692.

Key Point!! *When faced with unexplainable phenomenon, people generally cook up explanations that fit the facts. And we are good at this, even though any specific explanation can be completely wrong!!!*

Also note: plants and fungi produce lots of secondary compounds that have impacts on humans.

Section 4: Lower Invertebrates: Sponges; Cnidaria; Geological Time Scale

In order to appreciate the evolution of wildlife in general it is important to have some notion of the Geological Time Scale re-drawn from USGS. Note that different treatments of the time scale use different numbers, so assume that these dates are just estimates, and focus on the relative length and sequence of each Era, Period, and in the case of the Cenozoic, Epoch (see Section 17).

ERA	PERIOD	MILLIONS OF YEARS AGO (mya)
Cenozoic	Quaternary	1.6
	Tertiary	66
Mesozoic	Cretaceous	138
	Jurassic	205
	Triassic	240
Paleozoic	Permian	290
	Pennsylvanian	330
	Mississippian	360
	Devonian	410
	Silurian	435
	Ordovician	500
	Cambrian	570

Kingdom Animalia* (number of invertebrate species per phylum taken from Ruppert, E.E., R.S. Fox, and R.D. Barnes. 2004. Invertebrate Zoology, 7th edition. Brooks/Cole – Thomson Learning, Belmont, CA.)

Phylum Porifera – (approximately 8,000 species*). These are the sponges; the most primitive animals we will look at. In fact, at least one author (Paul Meglitsch) referred to the sponges as belonging to a group called the Parazoa, owing to the fact that they seemed to have evolved along a different path from the other animal groups. (*Meglitsch, PA. 1967. Invertebrate Zoology. Oxford University Press, London*.) Species in this group are not much more than simple amalgamations of cells.

The basic body plan includes a central cavity called the *Spongocoel* and out a central opening called the *Osculum* – Water flows into a sponge through the porous body into the spongocoel and out the osculum.

Sponges are characterized by having Intracellular digestion – As water flows in through the body wall, tiny food particles are trapped by specialized cells called choanocytes or collar cells, and transferred to other cells called amoebocytes. Amoebocytes engulf and digest the food. Sponges are the only animals to use *intracellular* digestion. Other species use *intercellular* digestion generally in the gut.

Sponges were once harvested in the Keys, but now they are just harvested out of Tarpon Springs, where they are vulnerable to red tides. In fact, a massive die off in 1995 was thought to have been caused by red tide toxins.

Recently, people discovered that some sponges produce a Taxol-like substance called discodermolide – a compound noted for fighting cancer (see *Gunasekera, S.P., M. Gunasekera, R.E. Langley, and G.K. Schulte. 1990. Discodermolide: A new bioactive polyhydroxylated lactone from the marine sponge Discodermia dissolute. J. Organic Chemistry 55:4912-4915.)*

Phylum Cnidaria (approximately 10,000 species*)

Species in this phylum have one or two body forms:

1. medusa, or bell
2. polyp

Three subgroups (Classes) groups in the phylum:

1. Hydrozoans – In these species the polyp phase dominates, but there are reduced medusae. Note that the medusae of Hydrozoans have a lip around the inside of the bell called the velum.

2. Scyphozoans – These are the jellyfish; in these species the medusa phase dominates. I include the box jellyfish here, some authors call this a fourth subgroup, but I follow Ruppert et al. 2004. I include the box jellyfish here as well – some call them the Cubozoa, which include some highly venomous jellyfish species such as the Irukandji of Australia.

3. Anthrozoans – These are the corals and sea anemones and these species have just the polyp phase.

All Cnidarians have nematocysts and are diploblastic.

Diploblastic means 2 tissue layers:

1. Epidermis
2. Gastrodermis

All are characterized by having an acellular gelatinous layer called the Mesoglea between epidermis and gastrodermis.

All species have nematocysts (specialized stinging cells). In some species, the toxin produced by these can be deadly – as in Box Jellyfish of the Indo-Pacific region.

Section 5: Flatworms and Roundworms

Phylum Platyhelminthes – (approximately 20,000 species*) These are the flatworms, flukes, and tapeworms. No secondary body cavity (they are acoelomates = no coelom – this is the technical name for the true secondary body cavity), but they have bilateral symmetry -- an adaptation for directional movement. This led invertebrate zoologists to call them members of the *Acoelomate Bilateria*.

Three Subgroups (some say four)

1. Turbellaria (mostly free-living flatworms)

A typical free-living species is *Planaria*. These are slow moving (unsegmented bilateral symmetry) worms.

2. Trematoda (flukes) – These are parasites, many are characterized by having a complex (or indirect) life cycle. Here we will look at the life cycle of the liver fluke of humans. The adult flukes produce eggs, which are shed in the infected human's feces. Snails can eat the eggs, which mature and hatch the Miracidium. The miracidium is a larval form that actively penetrates the wall of the snail's gut. Here the miracidium develops into a Sporocyst, which produces Redia, that, in turn mature and release the next larval form, the Cercariae. The Cercariae are shed by the snail and these actively penetrate the body of a fish, and form cysts in fish muscle. Humans eat the fish and the cycle continues.

3. Cestoda (the Tapeworms) -- Tapeworms have a simpler more direct life cycle than the flukes. The head is called the scolex. Body segments are called proglottids. The adult Beef Tapeworm lives in intestine of a human. Gravid (egg-bearing) proglottids are shed in the

feces and a cow may eat those that are dropped in wet grassy areas. In the cow they form cysts in the muscle, which humans may then ingest.

Phylum Nematoda: The Nematodes -- These are round worms, many are parasitic.

In this group are the parasites that cause elephantiasis, hookworm and ringworm. Some are free living in the soil and people in some places spend a good deal of money to control them.

Section 6: Higher Invertebrates: Protostomes and Deuterostomes

The Protostomes

Phylum Mollusca (approximately 100,000 species*).

These are broken down into several subgroups we will look at just 3 of these:

- Gastropoda -- the snails and slugs (approximately 60,000 species) marine, freshwater and terrestrial species.

- Bivalvia – the clams, oysters, scallops and shipworms (about 8000 species) mostly marine but about 1300 species live in freshwater. Many of these are involved in wildlife issues such as scalloping in Florida.

- Cephalopoda -- these are the squids, octopods, cuttlefish, and nautilus (about 700 extant species)

Phylum Arthropoda -- (approximately 1,113,000 species* are known but some say there could be 30 million species). A very diverse group that includes:

Class Insecta – More than 1,000,000[a]. The insects are highly diverse and in fact Ruppert et al. (2004) now list these as belonging to several phyla.

Class Arachnida – 50,000 species [a.] These are the spiders, ticks and mites.

Class Crustacea – about 30,000 species

References

Ruppert, E.E., R.S. Fox, and R.D. Barnes. 2004. Invertebrate Zoology, 7th edition. Brooks/Cole – Thomson Learning, Belmont, CA.)

[a]Hickman, C.P., L.S. Roberts, and F.M. Hickman. 1990. Biology of Animals, 5th edition. Times Mirror / Mosby College Publishing. St. Louis, MO.

The Deuterostomes

Phylum Echinodermata (6000 species) Sea urchins, Sea Stars, Brittle stars Sea Lilies and sea Cucumbers.

Phylum Hemichordata (62 species)

People once thought the hemichordates were chordates, but they lack some of the four main chordate characteristics (see below). There are two subgroups here: The Pterobranchs, which are sessile (def.: attached at the base to a substrate and not free-moving) filter feeders; and the Acorn Worms. The Acorn Worms live in tubes and are sediment feeders.

Phylum Chordata (52,000 species) Chordates all share the following four characteristics that are visible at some time in their life cycles:

1. dorsal hollow nerve cord
2. notochord
3. pharyngeal gill slits
4. post anal tail

Invertebrate Chordates

1. Urochordates -- aka sea squirts or tunicates. These are sessile as adults, small and translucent. They live their lives attached to sea grass or other structures.
2. Cephalochordates -- like the famous *Amphioxus*

Garstang's Hypothesis - This is the idea that the first vertebrates evolved from a sessile chordate ancestor with a mobile larval form (like modern urochordates) via the process of paedomorphosis (sexual maturity in juvenile form)

Section 7: The Jawless Fishes: The Ostracoderms and Class Agnatha

Ostracoderms – These were perhaps the earliest vertebrates, they appeared at least by the Ordovician and possibly earlier, but Cambrian Period fossils are not identifiable beyond microstructure of hard tissues.

Class Agnatha – This is the first modern vertebrate class. This group includes the so-called jawless fishes, the Hagfish and Lampreys. These two groups bear a superficial resemblance to each other but they are very different evolutionarily, both groups having split off from the Ostracoderms line in the Ordovician period, and hagfish and lampreys diverged in the Devonian.

Lampreys -- Some species of lamprey have caused serious problems for commercial and recreational fishers. The problems arise from the parasitic habit of some species, especially the Sea Lamprey (*Petromyzon marinus*). But note: not all lampreys are parasitic.

Sea lampreys in the Great Lakes

Before we explore the invasion of the Great Lakes by the sea lamprey it is worth noting that there are some native species in the Great Lakes, but they are smaller than the Sea Lampreys. These are the Silver Lamprey, Chestnut Lamprey, Northern Brook Lamprey, and the American Brook Lamprey. The Silver and Chestnut are both parasitic, the two Brook lampreys are not (*Hubbs, C.L. and K.F. Lagler. 2004. Fishes of the Great Lakes Region, Revised Edition, (Revised by Gerald R. Smith) The University of Michigan Press, Ann Arbor, MI*.)

How did sea lampreys get to the Great Lakes?

Lampreys may have benefited from a human-assisted introduction to the upper Great Lakes. Possibly through the construction of the Erie, Oswego, and Welland canals. They might well have been able to invade the lower Great Lake (Ontario) thanks to canals that were constructed around Montreal. However, a recent paper suggests that the sea lamprey

could have been stocked in the Great Lakes by humans *(Daniels, R.A. 2001. Untested assumptions: the role of canals in the dispersal of sea lamprey, alewife, and other fishes in the eastern United States. Environmental Biology of Fishes 60: 309-329*). It turns out that, according to this paper, lamprey larvae (ammocoetes) were common as a fish bait and so people might have just dumped out what they did not use on a given fishing trip. Also Daniels argued that the canals are too long for Lampreys to swim their entire length in a single season. This is not proof that the canals played no role, but it does support the stocking notion.

How to manage Sea Lampreys?

Sea Lampreys are *anadromous*, meaning they spawn in creeks and then return to open water at maturity. So their life cycle involves adults swimming up streams to spawn. The eggs hatch and the ammocoetes live in burrows in the streambeds. They filter feed and grow and then at some point they mature and they migrate to open water.

Management involves killing the ammocoetes in streambeds with Bayluscide or other lampricide such as TFM (3-trifluromethyl-4-nitrophenol) According to an A.P. article in the Traverse City Record-Eagle (*September 9, 2006*), some salmon were inadvertently killed by TFM in the Betsie River in Michigan. The USFWS applied the TFM and it caused the pH of the water to drop (this means it became more acidic). Although there was a salmon kill, as noted by one state fisheries biologist, without the TFM every 4 years, there may not be any salmon at all.

Bayluscide is also used to kill snail hosts of some dangerous trematodes and as it kills lampreys it might be a problem for native lampreys (even the non-parasitic species), and native mollusks.

Hagfishes

Hagfishes are all marine dwellers (*Moyle, P.B. and J.J. Cech, Jr. 2004. Fishes: and introduction to Ichthyology. Fifth Edition. Pearson Benjamin Cummings, San Francisco, CA.*) They are scavengers and not parasitic like some lampreys.

As a defense mechanism, hagfish secrete slime. A single hagfish can produce 25 liters of slime for protection. The slime filaments are reportedly 60 times thinner than a human hair (*Munro, M., Can west News Service, article in the Niagara Falls Review, December 10, 2005*). The slime coats a fish predator's gills and suffocates it.

Section 8: Evolution of jaws; Placoderms; Class Chondrichthyes; Osteichthyes; Shark Finning and Asian Carp

The Placoderms – These were the first jawed fish appear in the Lower (=older part) of the Silurian Period of the Paleozoic Era. Two early groups of jawed fishes were the Placodermi and the Acanthodii. The Placoderms appear in the fossil record as early as the lower Silurian (*Carroll, R.L. 1988. Vertebrate Paleontology and Evolution. W.H. Freeman and Company, New York*.) and were long thought to have been similar to the ancestor of the modern jawed fishes. Robert Carroll, argues in this book that the modern fishes are perhaps more akin to the Acanthodians known as the 'spiny sharks'.

The modern jawed fishes include the Class Chondrichthyes and the Class Osteichthyes.

The name 'Chondrichthyes' can be broken down into:
Chondr = cartilage, ichthyes = fish, so these are the Cartilaginous Fishes.

As a generality, vertebrates use gills for breathing. Recall that invertebrates use their gills for feeding. As the O_2 in H_2O is not abundant, they need to pump a lot of water over the gills. They must do this to maintain their active life style.

The general idea is that jaws:

- evolved from gill arches
- also, for the jaws to work properly, they need to have some mechanism to stabilize the body movement (control over yaw, pitch, and roll) paired fins represent this mechanism as they stabilize the body. There are 2 groups of modern Chondrichthyes:

1. Elasmobranchii – the sharks, skates, rays
2. Holocephali – the ratfish

Sharks are mostly live-bearing (*viviparous*) and so have low reproductive rates, although certain skates and rays may lay eggs (*oviparous*) or retain the fertilized eggs in the reproductive tract (*ovoviviparous*).

Sharks are harvested for:

1. Cartilage – as an alleged cancer preventative (This has been shown not to work, but some people still buy it)
2. Food – Mostly the fins, for shark fin soup, which is considered a delicacy in Asia.

Shark Conservation

In the 1990s, shark populations were being devastated to supply the demand for shark fin soup. A typical routine involves catching sharks, cutting off their fins while they were alive and throwing the sharks' bodies overboard. Needless to say that as this became more widespread people became dismayed.

Shark finning was banned in US waters of the Atlantic, Caribbean, and Gulf of Mexico but not those in the Pacific. In Hawaii alone long-line fishers harvested 2289 sharks in 1991 and 60,857 in 1998. In 2014, Oceana, a non-governmental organization, reported that 73 million sharks a year are killed mostly for their fins.

On December 21, 2000 then President Clinton signed the Shark Finning Prohibition Act (SFPA). But there turned out to be a loophole. In August of 2002, the US Coast Guard boarded the King Diamond II (KD II) ship out of Honolulu. It contained 32 tons of shark fins most of which were rotting as the ship's refrigeration system had conked out.

Later a judge ruled that the KDII was not actually a fishing boat as presumably laid out in the SFPA so the owner won the case, due to that legal loophole….

Later congress passed the Shark Conservation Act (Signed by President Obama on January 4, 2011) prohibiting the landing of shark fins not attached to a shark body and clarifying that this restriction is for *all* boats not just those decked out for commercial fishing (this was the loophole in the SFPA= the KDII was deemed as not a fishing vessel).

Class Osteichthyes – the Bony Fish

In terms of number of species, this is the most successful group of vertebrates with more than 23,000 species. Two main groups of bony fish emerged: These were the Sarcopterygii (the fleshy-finned fish) and the Actinopterygii (the ray-finned fish).

The Fleshy-finned group includes the Coelacanth and the Lungfishes. We will come back to the Coelacanth when we get to the Amphibians. The Lungfishes are exclusively found in the southern hemisphere. A single species each occurs in Australia, South America and Africa. The African species is the only one known to Aestivate. Aestivation refers to a condition of dormancy during the dry season.

The Ray-finned group has three additional subgroups:

- Teleostei – your basic fish
- Holostei – gars/bowfin
- Chondrostei – sturgeons/paddle fish *Polypterus*

A. Chondrostei – This group includes two orders: Acipinseriformes, the Sturgeons (Family Acipenseridae and the Paddlefish (Family Polyodontidae); and Polypteriformes, the Bichirs (Family Polypteridae)

Sturgeons are long-lived, northern hemisphere species. They have a sub-terminal mouth and a heterocercal tail.

Paddlefish occur in the Mississippi River drainage and also in China. These feed on zooplankton

Bichirs are exclusively found in Africa in freshwater. These are predatory fish with a strange arrangement of dorsal finlets.

Sturgeon Issues

Sturgeon eggs are edible and considered a delicacy in some gastronomic circles. The most extreme case is Beluga Caviar.

Beluga Caviar was banned from import to the US since 2005 by the USFWS. We saw prices online for $150 per ounce.

The Beluga sturgeon is in the five Caspian Sea countries: Iran; Kazakhstan; Turkmenistan; Azerbaijan; Russia.

Sturgeons are also making a comeback in the Great Lakes and they are jumping into boats in Florida, perhaps being frightened by the sound of the motors. Sometimes people have been seriously injured by jumping sturgeon.

B. Holostei – This group includes the bowfin and the gars, like the Alligator Gar

Holostei have a false heterocercal tail.

C. Teleostei – This is the most successful vertebrate group in terms of number of species. These live in marine as well as fresh water environments and include a diversity of diets and foraging strategies, as well as reproductive modes.

You can tell a lot about where a fish lives and its natural history by looking at its body shape and fin pattern.

some are high speed cruisers (such as mackerel and tuna)

some are designed for burst of speed (barracuda, pikes)

some are designed for picking food items from the water column (sunfish)

Some Bony Fish Conservation Issues

There are lots of fish issues involving marine species. Some nations use embargos to alter other nations habits; some use military.

1. Patagonian Tooth fish

The Convention on Conservation of Antarctic Marine Living Resources (CCAMLR) sets up zones and monitors fishing there. They mainly monitor the Patagonian Tooth fish (aka Chilean Sea Bass). Australia enforces the CCAMLR with gunboats.

2. Swordfish and Atlantic tuna – the ICCAT – International Commission on Conservation of Atlantic Tuna (and Swordfish)

3. The Embargo of Mexican Tuna: Here we are talking chiefly about Pacific Ocean fishing and the management group known as the IATTC – Inter-American Tropical Tuna Commission

In the early 1990's Congress established an embargo on Mexican Tuna because of dolphin mortality (dolphins are protected by the 1972 Marine Mammal Protection Act). By the end of the 1990's, Mexican Tuna fishers had drastically reduced dolphin mortality. The US Senate voted 99-0 to lift the ban.

4. Asian Carp (from the Michigan Department of Natural Resources): Asian Carp is a term for several species that have invaded the Mississippi River drainage. They have been shown to destroy food chains by consuming the organisms at the bottom of the chain that support many native species.

1. There are actually 7 species of "Asian Carp": Bighead; Black; Silver; Grass; Common; Goldfish; and Crucian. Of these, Bighead, Black and Silver Carp are considered the most recently introduced and thought to represent the greatest environmental threat.

2. These are filter feeders that consume the base of aquatic food chains ultimately eliminating food for native species.

3. Catfish farmers brought the carp the US to clean ponds in the 1970s, but they were introduced inadvertently when ponds overflowed in the floods of the1990s.

4. Silver Carp jump high out of the water at the sound of watercraft and may injure humans,

5. These species are not yet (as of 2017) established in the Great Lakes.

Section 9: Evolution of the Tetrapods: Amphibians and Reptiles; Deformities and population declines:

The Amphibians were the first tetrapods. They evolved in the mid-Paleozoic (Devonian) and were able to exploit life on land, but they never (as a group) quite made the separation from water completely. Many species (especially frogs and toads and many salamanders) live their lives on land or at the water's edge, but must to return to water for reproduction.

Amphibians descended from the same lineage (Fleshy-finned fishes – Sarcopterygii) that produced the coelacanth (a Lobed-finned fish). The Coelacanth survives today in the Indian Ocean.

The fossil Lobed-finned fishes share 2 important characteristics with the early amphibians:

1. labyrinthine in-folding in tooth enamel
2. fore and hind limbs both have a bone pattern of one upper and two lower bones.

These are two characters not found in any other groups. So either these traits evolved independently or the two groups share a common ancestor.

Fossil Amphibians produced at least 3 lineages:

Lisssamphibia: Labyrinthodontia; Lepospondyli

A. Lepospondyli -- Species in this group have vertebrae with spool-shaped centra (this is the lower part of the vertebra) fused to the neural arch (the upper part of the vertebra).

This is an extinct group. There are several (maybe six) subgroups, we will look at just three:

1. Aistopoda – These are limbless snake-like species. They apparently "lost" their limbs, as an adaptation for a burrowing life style. Note that this is not an uncommon

phenomenon – evolving to some adaptive plateau and then "back-sliding" in a sense/

2. Microsauria – Named by people who thought these were reptiles. I mention this group to emphasize that there was, and is, some surrounding this group. This is not surprising as the differences between amphibians and reptiles are subtle.

3. Nectridea – These were aquatic tetrapods with a large "horns" on the skull, the functions of which are uncertain.

B. Labyrinthodontia - In this group the centrum consists of two separate bones: the pleurocentrum and the intercentrum. In the some of these groups the intercentrum enlarges, evolutionarily, and the pleurocentrum vanishes. In other groups the pleurocentrum enlarges and the intercentrum dominates.

C. Lissamphibia - Some argue that this is the subgroup of all the modern amphibians. But not everyone accepts this idea. Some say the various modern groups share characters with different fossil groups. A few observations make this a more complex case. First, all the fossil frogs are from the Southern Hemisphere, but all the fossil salamanders are from the Northern Hemisphere. Today, there are no native salamanders in Australia and only a handful in Africa.

Modern Amphibian Groups

There are three main groups of modern amphibians: (Note: the different orders of the modern Amphibians have had several names -- here I follow the terminology used by Duellman and Trueb in their gigantic book entitled *Biology of the Amphibia*, Johns Hopkins paperback edition 1996.) Also check out the fantastic book by Stebbins and Cohen entitled *A Natural History of Amphibians*, Princeton Press, 1995).

1. Frogs and Toads (Order Anura)
2. Salamanders (Order Caudata)
3. Caecilians (Order Gymnophiona)

The main differences among these groups are that in body form and in reproductive mode.

Body Form: Salamanders have the basic form: four limbs (typically) and a tail. There are many *paedomorphic* salamanders. Many retain juvenile characteristics at sexual maturity. Some juvenile characteristics include: small or reduced limbs: external gills; no eyelids; a paddle-like tail.

Frogs and toads (Order Anura) have four limbs and no tail.

Salamanders (Order Caudata) mostly our limbs and a tail -- some like Sirens have just 2 front limbs, some like the Amphiumas have greatly reduced limbs

Caecilians (Order Gymnophiona) have a tail (in some specie) and lack limbs.

Reproductive Mode: Salamanders use internal fertilization via spermatophores. Frogs and toads use external fertilization. Caecilians use internal fertilization and the males have a copulatory organ.

Frog Reproduction:

In frogs, typically, the males set up a “chorus” in a pond, and the females come to the pond. The males clasp the females (amplexus), and the female sheds the eggs. As the eggs are shed, the male fertilizes them.

Frogs have evolved different types of amplexus (these are species specific).

Frogs and toads thus rely on vocal stimuli, but tactile information (touch) is also involved.

Salamander Reproduction:
Salamanders use internal fertilization (spermatophores). Salamanders use no vocalization. They rely instead on visual and olfactory (smell) cues. They are also tactile. Basically the males produce structures called spermatophores. Then, by hook or crook (see below), the males entice or coerce the females to take up the spermatophores. The spermatophores are stored in sac-like structures off the cloaca called spermatheca.

Salamanders may use any of the following methods to transfer the spermatophores to the female:

1. Physical force – males use physical force to get the females to take up the spermatophore. *Euproctus*, the European Mountain Salamander uses his tail to trap the female so the spermatophores can be transferred directly.
2. *Eurycea* – male uses teeth to abrade females back secretions from mental or Hedonic glands to inoculate her. This influences receptivity.
3. Some sort of "dance" featuring nudges, waltz, head slaps, etc.
   Ambystoma – fairly simple "dance"
   Plethodon – more complex "dance"

Class Reptilia Fossil Groups & Characteristics

The Reptiles

Note: the difference between the amphibians and reptiles, at least superficially, is quite subtle when compared to the transition from fish to amphibian.

Amphibians vs. Reptiles

There are many advances seen in Reptiles over the Amphibians. We'll just focus on two:

1. Reptiles have epidermal scales -- amphibians don't. This gives reptiles a tougher skin and one that protects against desiccation
2. Reptiles have an amniote egg. The amniote egg internalizes the fluid bath needed to protect the embryo from drying out. Amphibians have an anamniote egg and hence they typically require an aquatic or at least very moist environment.

These two characteristics are both adaptations for protection from drying conditions. Reptiles appeared in the Carboniferous Period of the Paleozoic Era. The environment in the Carboniferous cooled and dried out. At the same time the reptiles were evolving (amniote egg and epidermal scales) plants were evolving (seeds), in the form of the seed ferns. Seeds are also an adaptation for cooling and drying.

Fossil Reptiles – Groups

There were six subclasses of fossil reptiles:
Epidermal Scales

Amniotic Egg
The amniotic egg enabled reptiles to separate their reproductive efforts from water.

The Modern Reptiles

There are four orders of modern reptiles:

Order Testudines– The Turtles (341 species): No teeth, Side-necked Turtles (Pleurodira) are not able to retract the head into the shell. They are all southern hemisphere species, and all are aquatic. There are no land dwellers. Hidden-necked Turtles (Cryptodira) are found on Northern continents, as well as South America and Africa. There are no cryptodires in Australia, and in fact Australia has no land turtles.

Order Squamata – The Snakes, Lizards and Amphisbaenians (3567 snake species + 6145 Lizard species + 191 Amphisbaenians)

Order Crocodylia -- The Crocodiles and Alligators (20-25 species)

Order Rhynchocephalia -- The Tuatara (1 species) native to New Zealand

A Reptilian Issue:

Brown Tree Snakes in Guam have devastated the native fauna of Guam, first the birds, and then the smaller vertebrates. Recently people have discovered that Brown Tree Snakes can be killed using low doses of acetaminophen (80 mg.) A single extra strength Tylenol (Acetaminophen) is 500 mgs. People put the 80 mg tablets in the guts of dead mice and drop them over Guam in the hope that the snakes will eat the mice and be killed by the acetaminophen.

Section 10: Origin of the Birds: Issues involving birds; Mammals and Mammal diversity

Class Aves – The Birds

Two important references for fossil Birds: *The Origin and Evolution of Birds*, by Alan Feduccia, Yale University Press, 1996; *Prodigious Birds: Moas and moa-hunting in prehistoric New Zealand*, by Atholl Anderson, Cambridge University Press, 1989.

Fossil Groups – Birds emerged in the Mesozoic Era. The Mesozoic is broken down into three periods. From oldest to youngest, with the beginning dates in mya (= millions of years ago) in parentheses, these were the: Triassic (245 mya); Jurassic (208 mya); and Cretaceous (146 mya).

First Bird – *Archaeopteryx lithographica*, known from deposits dating back to the Jurassic Period of the Mesozoic Era, Germany. *Archaeopteryx* was likely capable of sustained flight, and the evidence supports the idea that flight evolved in arboreal species not in strictly terrestrial species

This strongly suggests that flightless species today, meaning the ratites (see below) descended from flying ancestors.

Cretaceous Period of the Mesozoic Era -- *Hesperornis* – This was a loon-like diving bird.

Birds really began to diversify in the Cenozoic Era, which is broken down into Epochs as well as Periods.

Tertiary Period of the Cenozoic

Tertiary is broken down into Epochs – beginning dates in parentheses (mya = millions of years ago). These approximations came from *Biological Science*, by William T. Keeton and James L. Gould, W.W. Norton, 1993).

- Paleocene (65 mya)
- Eocene (54 mya)
- Oligocene (38 mya)
- Miocene (26 mya)
- Pliocene (7 mya)

Quaternary Period of the Cenozoic

- Pleistocene (2.5 mya)
- Holocene (0.01 mya)

Ratites versus Carinates

Ratites are ***flightless*** birds of the southern hemisphere (see below). They are characterized by having (1) a paleognathous palate and (2) an unkeeled sternum.

Carinate birds are all the other species. They are characterized by having a neognathous palate and a keeled sternum (for attachment of flight muscles).

The difference in the palatal structure between paleognathous and neognathous comes down to mobility. The paleognathous palate is not as mobile as the neognathous palate.

The Ratites and where they live

1. Rhea, and Lesser Rhea – South America
2. Emu – Australia
3. Cassowary – New Guinea, Australia
4. Kiwi & Moas (Extinct) – New Zealand (One species of Moa is the tallest bird known)
5. Elephant Birds (Extinct) – Madagascar – Heaviest bird known
6. Ostrich – 2 toes – African Only (introduced to Australia to start a feather industry)

Moas – oldest fossils found so far according to Atholl Anderson who wrote a book called "Prodigious Birds: Moas and moa-hunting in prehistoric New Zealand" (1989 – Cambridge University Press) – There were maybe 13 species, are just a little more than one million years old. But the problem is that New Zealand split from the other southern landmasses starting about 80 million years ago. So by Anderson's argument, it is possible that the ancestor to the Moas could have flown to New Zealand and then lost the power of flight. Why would this happen? Well, to reduce energy expenditures in resource poor environments. See below the work by U.F.'s own Professor Brian McNab (Department of Zoology).

An Interesting Observation

Many Carinate birds *on islands* have also lost the power of flight. These include several species of rails, geese, cormorants and parrots. Still other species have reduced flying ability.

Professor McNab – Wrote papers in the early 1990s arguing that loss of flight muscle in island birds is an adaptation to reduce energy expenditures. As ecologists have learned, life on islands can he difficult in terms of finding adequate resources. A reduction in the mass

of muscles needed for flight could reduce energy needs substantially and provide a huge selective advantage.

Modern bird groups:

Non-passeriform Groups -- (Orders): Waterfowl - Anseriformes: (Ducks, Geese and Swans); Game birds - Galliformes (Quail, Grouse, Pheasants, Partridges); Diurnal birds of prey -- Accipitriformes - (Hawks, Eagles, New World Vultures, Kites); Owls -- Strigiformes.

Passeriform Groups -- (Families) Finches (Fringillidae, Emberizidae, Cardinalidae); Jays and Crows (Corvidae); Flycatchers (Tyrannidae).

Some Sample Avian Issues

1. Snow Geese – Population explosion, and increased efforts to convince hunters to harvest them.

2. Mute Swans – These are an aggressive non-indigenous species. They chase other swans away. They don't migrate, they eat tons of sub-aquatic vegetation. State agencies won't "manage" mute swans, but NGO's often fight them.

3. Listing the Cerulean Warbler – In 2000, Audubon, Defenders of Wildlife, and regional conservation organizations petitioned the USFWS to list the Cerulean Warbler.

   Audubon claims that the Cerulean Warbler population has declined by 82% in last 40 years. Much of the decline is due to mountain-top removal for mining and the resulting loss of forests.

   Budget cuts lead to fewer people and slower action. When agencies fail to meet deadlines people who oppose ESA can claim the agency is a bunch of slackers.

The USFWS says there are too many Cerulean Warblers to warrant listing as "Threatened".

In fact, this is the new policy with respect to ESA – wait until populations are in trouble before taking any action. This is a dangerous strategy.

4. Listing the Sage Grouse and Lesser Prairie Chicken. Scientists now recognize two species of Sage Grouse: The Greater Sage Grouse; and the Gunnison Sage Grouse. The Greater Sage Grouse occurs mostly in the Great Basin from Northwestern Colorado to eastern California and Washington state. The current distribution is somewhat fragmented.

Class Mammalia: The Mammals

Class Mammalia* Much of what follows is based on the book *Mammalogy: Adaptation, Diversity and Ecology*, by G.A. Feldhmer, L.C. Drickamer, S.H. Vessey, and J.F. Merritt, McGraw-Hill Second edition, 2004.

The Mammals first appeared in Triassic Period of the Mesozoic Era. But they were generally small and they stayed small pretty much throughout the Mesozoic. There were loads of larger and fiercer animals (mostly reptiles) to prey on them.

At the end of the Mesozoic on the boundary between the Cretaceous (Mesozoic) and Paleogene (= Tertiary) Periods, about 65 mya, came the so-called K-Pg boundary, birds and mammals diversified. The K stands for "Kreide" (German for chalk) and Pg stands for Paleogene the first part of the Cenozoic era; followed by the Neogene (Miocene and Pliocene Epochs).

During the early Paleogene (Paleocene, Eocene and Oligocene Epochs) the continents drifted and flowering plants evolved. There was also a new wave of diversification of the insects. Continental Drift isolated species so that they could evolve down different

pathways. And as insects diversified, flowering plants evolved – fruit, seeds and flowers, nectar, and pollen arose and provided new resource opportunities for birds and mammals to exploit. There was also a mass extinction of the dinosaurs, the exact cause of which is still uncertain.

The first mammals derived from the Reptilian Subclass Synapsida. There were two subgroups in this subclass:

1. Pelycosaurs – these were the sail back reptiles like *Dimetrodon*

2. Therapsids (mammals derived from Therapsids)

Mammal characteristics:

Mammals have at least 20 defining characters. Here are 10 of them: hair; mammae; facial muscles; 7 cervical vertebrae; muscular diaphragm; secondary palate; two occipital condyles; dentary-squamosal jaw articulation; the lower jaw is made of a single bone -- the dentary; and three middle ear ossicles.

In contrast to mammals, reptiles have quadrate-articular jaw articulation and a single middle ear ossicle – the columella. Over the course of evolution into mammals, the columella of reptiles morphed into the stapes in mammals, and the quadrate and articular became the incus and the malleus of the mammal middle ear.

Three modern mammal groups:

1. Prototheria – 1 order (Monotremata), 2 families
   3 species, 2 in Australia; 1 in New Guinea. These species are all oviparous.
   Platypus – only on the east coast or Australia and in Tasmania
   Short-beaked Echidna - all over Australia, eats ants.
   Long-beaked Echidna – in New Guinea – adapted for feeding on worms.

2. Placentals (Eutheria) – There 18 orders, 113 families, and nearly 4400 species. Young are better developed at birth than marsupials.

3. "Marsupials" (Metatheria) – 262 species, in 7 orders, 18 families. South America has 3 families, and North America has 1 species. Australia has 15 families. There is one weird species in Chile. The so-called marsupials once were treated as a single order, but based on morphology of the foot (do the feet have fused digits = syndactylous or not = didactylous?) and dentition (four or more upper incisors on each side of the jaw = polyprotodont or fewer than three upper incisors on each side of the jaw = diprotodont) people have split them into the current 7 orders.

There are many morphological and ecological marsupial equivalents to placentals. Here are just a few examples:

Marsupials	Placentals
Kangaroos	Deer
Mole	Moles and Golden moles
Antechinus	Mice
Thylacines	Wolf
Numbat	Anteater
Gliders	Squirrels
Wombats	Ground Hog
Koala	Sloths
-	Primates
-	Whales
-	Bats

Section 11: Wildlife Management

I define wildlife management practices here to include all human actions (or inactions) that affect wildlife.

Management is basically a combination of *decisions* and *actions* (hopefully based on science).

Historically, management dealt with game (edible) species, which includes all species hunted for sport and food, predators (species that kill game animals), and varmints (a combination of predatory and nuisance species that may be hunted for "sport" but not necessarily food (such as prairie dogs or coyotes).

Regardless of which species are included, all management boils down to a neat little concept, and highly useful concept, I call the ***Ideal Number*** (Note: I made up this term and my old advisor cautioned me to avoid this as he always said, "New terms are the hallmark of pseudo-science."

The Ideal Number is based solely on human perceptions regarding population sizes or growth rates. For any population, we must ask are there:

1. Too many? (i.e. Is the population size > ideal number?)
2. Too few? (i.e. Is the population size < ideal number?)
3. Or is there just the right number? (not too many or too few) Note: In reality people hardly give a second though to populations or growth rates they do not consider as being too large or too small.

Trouble is that people do not necessarily agree on things. Consider the *Cerulean Warbler* – some (like the Audubon Society) say it should be listed as Threatened (i.e. because there

are too few, and the population appears to be declining precipitously), but the FWS said there were not too few, and so declined to list them. So the Audubon society focused on the *population growth rate* as it is impacted due to changing land-use patterns (The chief threat is loss of nesting habitat due to mountaintop removal for mining operations) whereas the FWS looked at *absolute numbers* and said there were not too few individuals.

Management and the Ideal Number

Assume we can discern an ideal number for a species. Then there are basically two decisions and several actions that can be followed.

Case 1: Decision: Too many individuals (population > ideal number)

a. increase mortality (kill them)
b. decrease natality (birth rate)

Possible Actions:

A. Decreasing Natality – basically this involves reducing the birth rate generally using some sort of contraception

1. African Elephants

Kruger National Park in South Africa – Too many elephants. Kruger is an area equal in size to Israel. They were killing 600 elephants a year to keep the herd at 7500. They also tried contraception to reduce natality, but it didn't really work.

2. White-tailed Deer.

On Hilton Head Island an effort was made to use immuno-contraception on white-tailed deer – Some (in the insurance industry (fide Bob Warren of the University of Georgia) wanted to reduce the herd, as there were numerous vehicle / deer collisions on the island, but others wanted to keep the deer protected. The effort failed in the end as once the deer

were darted (inoculated once) they would never return to the baiting station for a necessary second inoculation. Also people on the island would chase the deer away from the baiting station thinking (incorrectly) that the people were baiting them in to kill them.

B. Increasing Mortality

1. At Gettysburg National Battlefield 900 white-tailed deer were killed over a 2-year period to reduce consumption of park vegetation. This sparked an uproar from neighbors.

Reducing the camel population in Australia. One website <Camel Cull> reported that between 2009 and 2013 as many as 160,000 camels had been shot from helicopters. The remaining population was estimated to be 300,000. The reason for the cull was that the cattle growers were complaining about camels reducing forage and water.

Case 2: Decision: Too few individuals (population size < ideal number)

Possible Actions:

a. Reduce mortality –That could mean more habitat, or more food
b. Increase natality – Reintroduce individuals from other populations

1. Since small populations are susceptible to inbreeding depression, one management tool involves reinforcing a population with individuals from other places (assuming they exist) so, in the early 1990s, FWC brought in Cougars from Texas in the hope that they would breed with the Florida panthers.

2. Kirtland's Warbler – Recall from the chapter, "Wildlife in America".

Managers used habitat management (we will explore this in more detail in section 22) the form of prescribed burns and replanting of pines to create more nesting habitat, and they

also made efforts to control the population of the number one enemy of the Kirtland's Warbler, the Brown-headed Cowbird.

People might not be able to decide about ideal numbers, but there are many techniques for counting wildlife.

The first step is to set up or delineate management units. For example:

1. Colorado has 200 Big Game Management units
2. Florida has 3 hunting “zones”

Section 12: Hunting

Who hunts? In more developed nations, trophy hunting has become largely a past time of the wealthy. And the money that hunters can inject into a local economy can be substantial.

Does hunting increase mortality?
Some people argue that hunting is a valuable mechanism for increasing mortality.

Of course hunting is just one way to increase mortality and individuals die from all sorts of causes. Note: dying of "natural causes" may be highly over-rated. Being torn apart by a pack of feral dogs or wolves may seem more natural than a gun shot, but which is more humane?

Theoretically there are 2 types of mortality:

1. Additive – this is what animal rights organizations claim
2. Compensatory – by reducing the population size though hunting, the chances for survival of all the other individuals go up.

The question is how are these types of mortality linked to population growth rates?

The importance of Money in Wildlife Management

In his 1933 book (Game Management) Aldo Leopold, arguably the father of wildlife (=game) management claimed that wildlife populations could be restored (after having been decimated by market hunters, forestry and farming, etc.) by the *'creative use'* of the very tools that caused their demise: the axe, the plow, the cow fire and the gun. We now know that he left out the most important contribution at least as far as hunters are concerned and that is the wallet. In 1934 the Migratory Bird Hunting Stamp Act (aka the

"Duck Stamp Act") required hunters of migratory birds like ducks, geese, and swans to purchase a federal Duck Stamp - the generated money was to be used for wetlands conservation. The act generated more than $500 million and more than $22.9 million per year as of 1997.

Since its passage in 1937 the Federal Aid in Wildlife Restoration Act (aka The Pittman-Robertson Act) has generated more than $3.8 billion for conservation.

Hunter's licenses and fees have contributed $10.2 billion to fund more than 90% if state wildlife agency budgets.

1. Florida Bear Hunt - The Florida Fish and Wildlife Conservation Commission reports that ion the 1970s there were as few as 300 black bears in all of Florida. The old GFC (Game and Freshwater Fish Commission) imposed a moratorium on Bear hunting in 1994. Fast forward to 2015 when the total population was estimated to be 4220.

After much debate the state allowed a restrictive hunt in 2015. They sold 3776 permits of which 99% (about 3738) were to Florida residents at $100 per permit. The remaining 38 permits were sold to non-residents at $300 per permit.

The allowable harvest was just 320 bears (320/4220 = 7.6%). Harvest quotas were set per Bear Management Unit and the hunt lasted for just one or two days depending on the management unit -- they ended the hunt when the total number killed approached their target of 320.

In the end 304 bears were killed and the hunt generated more than $370,000 for future bear management projects. It is unclear if the hunt will be re-instated sometime in the future but there was not hunt in 2016.

2. Elephant hunts in Africa - This is from an article called *The Tourist Safari Hunter's Role in Conservation*, by William I. Morrill, *in* Integrating People and Wildlife for a Sustainable Future, The Wildlife Society, 1995. Morrill is with the Safari Club International.

Based on 1992 data, Morrill reported that the Republic of South Africa was granted a CITES quota of 16 elephants. The government issued 10 permits. The average cost of a hunt was $41,128.00. Similarly, Zimbabwe was granted a CITES quota of 205 elephants. A total of 150 permits was issued, and 150 elephants were 'harvested'. The average cost of a hunt was $42,120.00.

Side note: The Safari Club International is always interested in gaining new members. This likely explains why they have a special women's group called the "Sables". And they give out awards for the best female hunter.

When you fly into Namibia you land several kilometers from the city. As you drive into town you pass a small shop that sells cold drinks, snacks and knickknacks. They also run a huge (difficult to appreciate from the road) taxidermy operation. I noticed that there were a lot of people employed in the various aspects of preparing trophies. I asked the owners there how many people they had working for them and was surprised when she told me they had more than 70 people working there. In fact, there was a village down the slope where the people and their families

2. The Foundation of North American Wild Sheep. Each year these guys auction off auctioned permits to shoot wild sheep (e.g. Dessert Bighorn in Mexico). The stipulation is that 90% of the funds generated must go to the local community. One example from Mother Jones magazine shows a hunter who won an auction with a bid of more than $50,000 for a single Desert Bighorn Sheep.

The Cost of Hunting

Hunters pay for wildlife management via the Pittman-Robertson Act (1937). (In 1937, most guns and ammunition were probably purchased by hunters.) Presently however, the US has 60-80 million gun owners, but only 15-20 million hunters – so most Pittman-Robertson money likely does not come just from hunters. But, hunters buy licenses, pay fines, etc.

Hunting Licenses in Florida 2018:

- Resident Hunting License: $17
- Nonresident Hunting License: $151

Generally, these fees are just for one year. States decide:

- how many individuals you can kill
- where you can kill them
- when you can hunt

Generally, these fees are just for one year. States decide how many individuals you can kill, where you can kill them, and when you can hunt.

Hunting and Wildlife Management

Recall, hunting is often pitched as an important management tool. For most hunted species this is likely untrue, because hunters (recreational or sport) do not want small "thinned out" populations.

One exception, sometimes agencies "ask" hunters to kill everything they see. In Michigan, recently the exception was wild hogs. In the west, the exception is coyotes and feral dogs.

Perhaps the most effective wildlife management in the US is basically habitat management.

We will see this in the next section when we talk about the Kirkland's Warbler and how it has rebounded following intensive habitat management (replanting of jack pines and red pines and cowbird control).

Section 13: The importance of Habitat and Habitat Management

Habitat is a very general term that refers to the place where a species occurs. The habitat of a species basically encompasses all the components a species requires in its environment. It can be defined in terms of the vegetation structure, soil type, as well as other ways. Of course it is easy to explain the absence of a species from some place as being due to, "A lack of suitable habitat."

As noted previously, a good deal of wildlife management is simply *habitat management*. This consists of two parts. First, people study the ecology of a species and determine what wildlifers call its "limiting factors". Second involves efforts to improve inadequate habitat or create more habitat. As an example recall the Kirtland's Warbler in Michigan. For Kirtland's Warblers, scientists analyzed habitats that the warblers used and discovered what constituted the best habitat and how much habitat a single pair of birds needed to successfully nest. Although the birds nested on the ground in jack pine forests of a specific age range, managers discovered that the could substitute red pines which grew faster and the warblers even nest in plantations of red pine that meet certain requirements (USFWS, downloaded November 12, 2012 <http://www.fs.fed.us/database/feis/animals/bird/deki/all.html#BIOLOGICAL%20DATA%20AND%20HABITAT%20REQUIREMENTS>

Keystone Species -- The concept of Keystone species refers to species that are tied to a specific habitat and that many other species depend on. Dr. Robert Paine first enunciated the concept in a classic study at Mukkaw Bay on the Washington coast in 1966. (Paine, R.T. 1966. Food Web Complexity and Species Diversity. American Naturalist 100:65-75).

Paine studied mostly sessile invertebrates (i.e. barnacles, bivalves and other molluscans) that colonize rock substrates in the intertidal marine environment of the Pacific at Mukkaw Bay on the Pacific side of the Olympic Peninsula. Paine set up a control plot and an experimental plot. In the experimental plot he removed the predatory starfish (*Pisaster*) and left the control plot alone. Over time the diversity of species in the control plot

remained the same as before the experiment, but in the plots where he removed *Pisaster*, the number of species declined from 15 to 8. He reckoned that Pisaster when present controlled a species that outcompeted (i.e. crowded out) many of the other species.

One of the largest problems for native habitats Fragmentation and habitat change can occur naturally or through human influence.

Natural Changes and the Process of Secondary Succession

Secondary Succession refers to a series of changes in plant communities following some sort of environmental disturbance like a fire or tornado.

Consider a large tract of eastern Deciduous Forest. Now say that there is a lightning strike and a fire ravages a large area of the tract. After the fire is out the process of succession begins. The area passes through a series of plant communities, as follows:

Fire → bare ground → annuals → perennials → shrubs → trees

Different species are adapted to the habitats provided by these different successional stages. We will look at two examples in Michigan:

1. Kirtland's Warblers – A naturally adapted successional species

2. Prairie Chickens and Sharp-tailed Grouse – beneficiaries of human impacts

Background Information

In the pre-Columbian times, Michigan was mostly forested. In fact, one botanist estimated that at most Michigan had 125 square miles of native prairie in pre-Columbian times. This prairie all developed via secondary succession following fires. As European settler moved in forests were cleared and artificial prairies were formed.

Let's look at the Kirtland's Warbler first.

A dentist named Lawrence Walkinshaw enjoyed studying birds. One species he found intriguing was the Kirtland's Warbler. He set out to study the species and he learned a great deal. For one thing he recognized the severe damage to the population caused by Brown-headed Cowbird nest parasitism. Basically, the cowbird female lays an egg (or two) in the nest of a Kirtland's Warbler. The cowbird chick hatches earlier and then knocks the other nestlings or eggs out of the nest. Walkinshaw eventually wrote a very interesting book entitled *Kirtland's Warbler: The Natural History of an Endangered Species*; Cranbrook Institute of Science, 1983. Harold Mayfield also wrote a book on Kirtland's Warbler called *The Kirtland's Warbler*; Cranbrook Institute of Science, 1960.

Research led managers to conclude that the Kirtland's Warblers needed two management actions:

1. Create more, young Jack Pine (*Pinus banksiana*) stands at least 80 hectares (200 acres) in area. They do better in larger blocks of preferred habitat. (note: they nest on the ground). So they require the habitat to be in a successional stage.

2. Control Brown-headed Cowbirds, which lay their eggs in nests of Kirtland's Warblers and when they hatch they simply knock the baby warblers out of the nest where they subsequently starve.

Kirkland's Warblers typically nest under Jack Pine trees. Not just any kind of tree will work, although scientists found that they will also nest under Red Pines (*Pinus resinos)*. They need stands of Jack Pines < 20 years old. They lay 4 or 5 eggs and both parents feed the young. They spend winter in the Bahamas.

Before Europeans came to the area there were frequent natural fires in the Jack Pine forests. Fires still pop up but nowadays people jump in and suppress them. This

eliminates the successional stage habitats that many species evolved to live in. Many species actually depend on fire, in Florida for example, Hairy Woodpeckers seem adapted for burned forests. Anyway the Jack Pine cones are closed and open only after a fire – fire clears a seedbed. We can't rely on natural fires; there is too much private property.

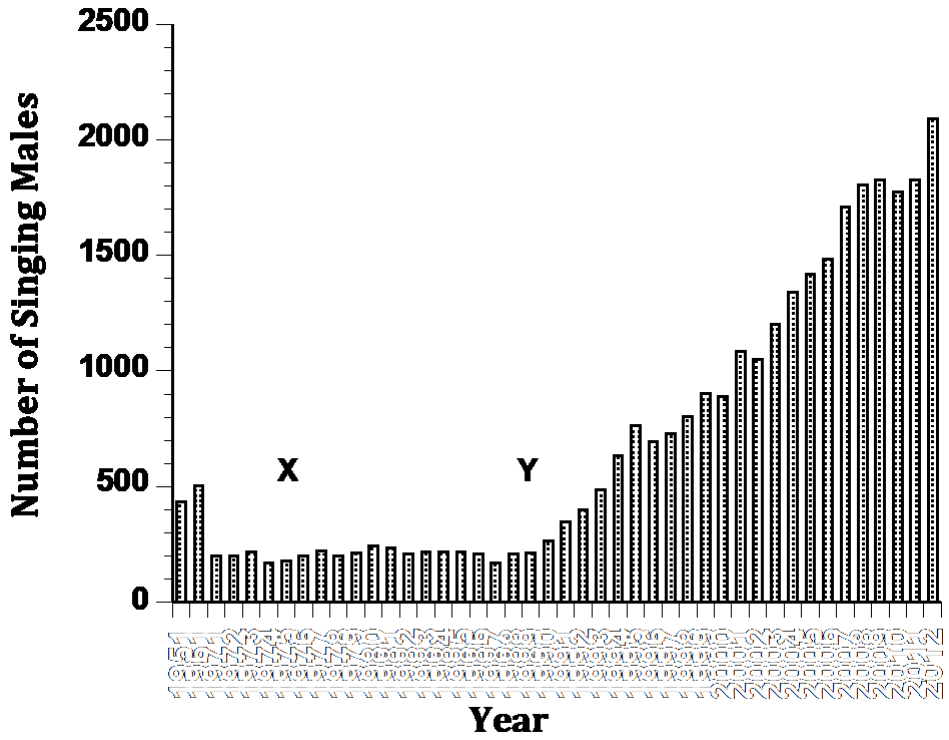
Every effort is made to guarantee that managed habitat is very similar to a natural habitat. Older trees are cut down and smaller trees are replanted. They leave strips of live trees to simulate results of wild fire. Cleared areas are large because natural fires burned a large amount of acres.

1972 – USFWS began trapping cowbirds and removing them. 70% of Kirkland Warbler nests were parasitized. Each cowbird can lay 35 eggs per year. (So, if 70% of Kirkland Warbler nests are parasitized, why haven't they evolved a mechanism to avoid this?) A possible answer is that perhaps cowbirds have not been there that long. Only 6% of nests were parasitized in one year after cowbird trapping began.

Michigan Department of natural resources worked with USFWS and USFS on Kirkland Warbler management.

Motels and other local businesses benefited from bird watchers who came to see Kirkland Warblers.

The figure below shows the number of singing males over time from 1951 - 2012. X represents the year 1972 when Brown-headed Cowbird control began, and Y represents the year 1990 when additional habitat became available.



The Upland Sandpiper is one of several other species that benefits from the Kirtland's Warbler management scheme.

Prairie Chickens and Sharp-tailed Grouse.

In Pre-Colonial times, there were no Prairie chickens in Michigan (it was too heavily forested). As the habitat was altered, some things happened: As a result, prairie species including Prairie Chickens, Brown-head Cowbirds, and upland Sandpipers invaded. By 1930, there were Greater Prairie Chickens in every county of the lower-peninsula. Then as the habitat shifted from prairie to shrub lands in the Upper-Peninsula, Sharp-tailed Grouse moved in. In some places they actually hybridize with Greater-Prairie Chickens.

Other Successional Species:

1) Golden-winged Warbler (GWW) – a successional species. The GWW has a similar congener, the *Blue-winged Warbler* (BWW), that lives in mature forests (so it is *not* a

successional species). But where GWW and BWW come together they can form hybrids:

- *Brewster's Warbler* (hybrid – not a distinct species) – these hybrids are formed by a mating between a pure GWW and a pure BWW. Parents. This is the more common of the hybrids.

- *Lawrence's Warbler* (hybrid – not a distinct species) – these hybrids are much less common than Brewster's Warblers, and usually formed when F_1s (i.e. Brewster's back cross with either of the 2 parental types (but it can also occur in matings that involve 2 GWWs provided both parents carry a certain recessive trait).

2) Rufous-sided Towhees are another example of a species that does well in edge type (i.e. successional stage habitats). Interesting side note: the scientific name for the Rufous-sided Towhee is *Pipilo erythrophthalamus,* which means red-eyed. Indeed, the towhees from the northeastern states have red eyes. However here in Florida the native towhees have white-eyes, and they are scrub species.

Section 14: Agriculture and Wildlife

Agricultural effects are human effects. We have seen many cases already:
British breeding birds – Habitat loss and chemical use

Black-tailed Prairie dogs – Habitat loss

Asian Carp – Non-indigenous species

Agricultural effects are of 3 types:

1. Habitat destruction
2. Chemical use
3. Species' introductions

Chemical Use:
Includes both pesticides and fertilizers:
Examples:
1. Atrazine – a common weed killer that causes sex change in Amphibians.
2. Other chemicals may cause frog deformities (retinoids).

Water Use:

Aral Sea – water pumped out to grow cotton. The Soviets called it "white gold."

Dead Zones: *Check out the Science Museum of Minnesota's web site for this:* < http://www.smm.org/deadzone/ >

The Gulf of Mexico Dead Zones are the result of chemical run-off from farms hundreds of miles away (in the Upper Midwest). Note that the problems have not gone unappreciated

by farmers. In fact, some farmers in the upper reaches of the Mississippi have worked hard to develop alternative farming practices that would be environmentally more friendly (i.e. less run-off of chemicals and top soil).

How fertilizers can cause "Dead Zones"

1. Fertilizer runs off, leading to...
2. Algal blooms (i.e. huge increases in algal populations).
3. Algae unfortunately are very short-lived and when they die...
4. Bacteria consume the dead algae and by the process of aerobic respiration, use up much of the dissolved O_2 in the water

Also, increased corn planting for biofuel has caused larger dead zones. Now, there is a new dead zone off the Coast of Texas.

Other Dead Zones:

- Chesapeake Bay - this is also from run-off

- Lake Erie (made worse by Zebra and Quagga mussels - 2 introduced species from Eurasia)

- Off Oregon coast

Ranching and Wildlife

1. Managing Wild Horses and Burros.

In the western US there are roughly 260 million acres of rangeland that is managed by the Bureau of Land Management (BLM - Dept of Interior) and the US Forest Service (USFS - Dept of Agriculture). These lands are opened for grazing of private livestock herds,

and the BLM manages roughly 27 million acres in 179 are "Herd Management Areas" for Wild Horses and Burros.

The BLM was established in 1946 to manage rangelands. Now one of their charges is to manage wild horses and burros on those rangelands as per the 1971 Wild Free-Roaming Horses and Burros Act. The numbers in the table below are current as of 2014. Ten states have wild horses and five have burros. "AML" stands for Appropriate Management Level. Note that all ten states have more animals than they should have according to the Maximum AML. Also notice that only five states have any wild burros, and the state of Washington has none of either.

2017 data

State	Horses	Burros	Total	Max AML
Arizona	364	6241	6605	1676
California	5088	3657	8745	2200
Colorado	1693	0	1693	812
Idaho	563	0	563	617
Montana	166	0	166	120
Nevada	34780	2931	37711	12811
New Mexico	168	0	168	83
Oregon	4302	49	4351	2715
Utah	5215	313	5528	1956
Wyoming	7144	0	7144	3725
Total	59483	13191	72674	26715

2014 data

State	Horses	Burros	Total	Max. AML
Arizona	333	4411	4744	1676
California	4086	1922	6088	2,184
Colorado	1205	0	1205	812
Idaho	668	0	668	617
Montana	160	0	160	120
Nevada	23,347	1688	25035	12,796
New Mexico	146	0	146	83
Oregon	3120	60	3180	2715
Utah	3979	313	4292	1956
Wyoming	3771	0	3771	3725
Total	40815	8,394	49,209	26,684

So, what can be done about this apparent over-population? One effort involves rounding up animals for adoption by private citizens. The rules state that, "No more than four wild horses and / or burros may be bought by an individual or group within a six-month period from the BLM without prior approval of the Bureau's Assistant Director for Renewable Resources and Planning."

It seems likely that this rule is meant to make it difficult for those who would buy the animals for slaughter.

As for adoptions by private citizens, BLM claims that more than 230,000 animals have been adopted under their system since 1971, so over 43 years (to 2014) that averages out to roughly 5350 individuals per year. This will hardly take care of the excess animals. BLM has also tried to reduce the population growth rate using immuno-contraceptive methods, namely treatments of *porcine zona pellucida* (or PZP).

There are several other aspects to ranching and wildlife. One is managing private ranchlands for sport hunting. We will return to this idea in section 15 on nonindigenous species.

Section 15: Non-indigenous Species and Overkill

Two main questions:

1. Why do some species succeed when introduced and others fail?

2. Why are some places easier to invade (i.e. more vulnerable to species introductions) than other places?

Before we answer these questions one thing must be kept in mind:

Species often have different levels of success when introduced to different places. Examples: (1) Red-whiskered Bulbul had very limited success in south Florida, but it is the most common land birds in the Mascarene Islands, where it also was introduced (2) Melaleuca -- a problem in Florida, but it grows in neat groves on Oahu

Some possible explanations for the first two main questions:

4 categories of factors: Species-level factors; Site-level Factors; Human or Event-level factors and Individuals factors.

A. Human-level

Humans control every aspect of the introduction process which species, how many species and how many individuals of each species, how are they transported, where are they released and when are they released.

Example: Propagule pressure (PP) – How many individuals are released and how often?

PP is largely defined as introduction effort. It is true that small propagules have low chances for success, but it may not be true that above some number any additional

individuals will increase the chances for success.

Consider one counter example. In Florida, the old GFC released scores (maybe hundreds) of white-winged doves in south Florida for recreational hunting. Yet, these have not spread far from where they were released; they are still mostly south of Lake Okeechobee. On the other hand, the Eurasian Collared Dove came to Florida when a handful of individuals escaped from a pet store in the Bahamas. Eurasian Collared Doves have now spread all over the US.

B. Species-Level.

Species characters include response to evolutionary factors such as response to sexual selection, size of native range, place of origin, life-history variables (reproductive rates, longevity, diet, relative brain size – in birds).

Response to Sexual Selection – Among passerine birds, dichromatic species (those that have responded to sexual selection) tend to have lower introduction success rates. The idea is that species that respond to sexual selection, in doing so, might compromise adaptive gains made via natural selection. If so, and if characters are correlated, then dichromatic species should be less able to adapt to environmental changes. This idea holds for introduced passerines, but not Galliforms (game birds) or Columbiforms (pigeons and doves).

Range Size and Introduction Success – Species with larger ranges may be more ecologically generalized, and therefore have enhanced chances for becoming established.

Point of origin and Introduction Success – Species from some parts of the world (biomes or zoogeographic regions) might be pre-adapted to succeed as introduced species.

B. Site-level

Why do some places have more introduced species than others? For example: islands often have introduced species than continents. No one knows why this is so, but there are lots of possibilities. Islands might have more because they have fewer native species – meaning fewer enemies.
But this difference also exists among similar sized islands.
For example, New Zealand has many introduced species. England (an island of about the same size) has few. This might be because fewer species have been introduced to England than New Zealand. Oahu and Tahiti are similar in size and have had similar numbers of species introductions but Tahiti has only 7 successful introduced passerines whereas Oahu has more than 20.

D. Individual Level

This level refers to the physical condition of the individuals that are released. If individuals are in poor health when released they might be doomed regardless of how nice the introduction site is, how ecologically or evolutionarily predisposed they are. In the late 1800s lots of birds were taken from England to New Zealand. The death rate on the ships was astonishing for birds. Things go t better when they shifted transport from sailing ships to steamers and when the voyage was shortened by the completion of the Suez Canal.

Other factors at this level include the sex ratio of the introduced individuals – if it is highly skewed, or the age of the individuals – they might all be past their reproductive prime.

Why do some places have more introduced species than others?

For example: islands often have introduced species, than continents. New Zealand has many introduced species. England (an island of about the same size) has few. No one knows why this is so, but there are lots of possibilities. One idea is that perhaps not as

many species have been introduced to England. But there is more to this than meets the eye.

Tahiti and Oahu are roughly the same size and yet Oahu has more than 20 successfully introduced passerines whereas Tahiti has just 7. Both islands have had similar numbers of passerines introduced but the success rates are quite different.

Islands in general seem easier to invade than continents maybe because they have fewer native species, which could mean fewer enemies. This is the idea of Charles Elton.

NIS in Florida and Elsewhere

Some examples of introduced species in Florida and elsewhere:

Amphibians:

1. Cuban tree frog – from Cuba (1931 earliest record in Florida)
2. Greenhouse frog –from Cuba and the Bahamas (1875 earliest record in Florida)
3. Marine toad – from Texas and Central America (1936 introduced in Florida for pest control in sugar cane)

Reptiles:

- Several Species of family Iguanidae (15 species) and Gekkonidae (11 species) lizards
- Green Iguanas (Iguanidae)
- Nile Monitors (Varanidae)
- Mediterranean Gecko (Gekkonidae)
- Burmese Pythons (Boidae)

Birds:

Florida has just a few introduced passerines (song birds) but relatively speaking a lot of introduced parrots (Psittacidae). More than 65 species have been seen free-flying in

Florida and 18 introduced parrot species have been considered successfully introduced in Florida (e.g. Monk Parakeets). In pre-Columbian times there was a single native species – the Carolina Parakeet.

In contrast, Hawaii has very few parrot species, but many passerines.

Mammals:

- Nutria – from South America now widespread in the Southeastern US
- Ungulates – many species released in New Zealand and in Texas for recreational hunting

In New Zealand, several species became pests and the government moved in to thin them out. In fact Graeme Caughley wrote a book called The Deer Wars: The Story of Deer in New Zealand (1983, Heinemann Publishers, Auckland). New Zealand supports populations of Feral Goats, Feral Sheep, Feral Cattle, Chamois, Himalayan Tahr, Wild Pigs, Sika Deer, Red Deer, Elk, Moose, Sambar Deer, Rusa Deer, Mule Deer and White-tailed Deer.

In Texas, most (but not all) of the introduced species of ungulates are still confined. Yet Aoudad (aka Barbary Sheep); Mouflon, Blackbuck Antelope, Axis Deer and Wild Hogs have all escaped confinement. Most of these species were brought to ranches for sport hunting.

Management of Introduced Species

Perhaps the best approach is to eradicate introduced species as soon as detected

Successful eradications:

- Red-billed Blue Magpie in Oahu

- Red-vented Bulbul in New Zealand

Unsuccessful attempts at eradication:

- *Melaleuca* (from Australia) in Florida

Overkill and Wildlife Products

Wildlife Products

Wildlife products are used for:

1. Foods
2. Medicine
3. knickknacks
4. Clothing – (such as cowboy boots)

Knickknacks

- Cascade Beer (Australia) – uses a Thylacine image on the label
- Kangaroo Paw – used as a back scratcher and bottle opener
- Nutria foot
- Kangaroo scrotum pouch
- Emu Oil
- Deer (buck) attractant – Doe in heat urine
- Cover Scent – Red Fox Pee
- Cuttle Bone – it's not true bone, it's the 'pen' from a cephalopod

Medicine:

- Preparation H – Shark liver oil
- Traditional Chinese Medicine (TCM)
    - Tiger Penis Soup

- Tin Hee Tong Pills --
- Ying Chao Pills (Antelope)
- Hiya Kioga Silver (Bear Gall)

Food Items:

- Jerky: Crocodile (Australia); Kangaroo (Australia); Caribou/Muskox/Deer (Alaska)
- Snapper Turtle Soup
- Steamer Clams