What Every Engineer Should Know About Endangered Species

by

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Course 321

4 PDH (4 Hours)

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Introduction:
This course presents an overview the Endangered Species Act and how it relates to land development projects. A basic knowledge of endangered species is crucial for anyone planning a land use development. While detailed knowledge of specific endangered species (their identification, habitat requirements, life history, etc.) is beyond what must be known by an engineer, an overall understanding of the concepts is very helpful.

The concept of endangered species can be a very controversial one. On one hand, many people complain about the effects of the Endangered Species Act on the economy and, particularly, on jobs. On the other hand, some people complain that too little protection is afforded endangered species or that not enough species are protected. This controversy is probably not surprising, considering that endangered species and their protection straddle the line between science and politics. However, this course will attempt to separate out the science and provide engineers with the tools they need to obtain answers to questions regarding endangered species. It will also attempt to point out some ambiguities associated with the protection of endangered species. Finally, some examples are given to show how an engineer working in an area that potentially harbors these species can obtain more information on a particular property.

Overview of the Endangered Species Act:
Until the very early part of the 20th century there were virtually no laws in place to protect the environment. However, as part of a growing environmental awareness on the part of the American people a number of initiatives were taken to try to provide some measure of protection for animals, plants and wild places. The timeline below highlights some of these measures, which taken together, form something of a background for the Endangered Species Act:

- In 1901 the Audubon Model Law was passed, protecting water birds from hunting for the plume trade.
- In 1903 President Theodore Roosevelt created the first National Wildlife Refuge at Pelican Island, Florida. (Today there are over 550 such refuges scattered around the United States).
- In 1905 the National Audubon Society was formed.
- In 1918 the United States signed the Migratory Bird Treaty with Canada.

Then, in 1966 Congress passed the Endangered Species Preservation Act, providing a means for listing native animal species as endangered and giving them limited protection. Following this, a conference in 1973 held in Washington, DC, led eighty nations to sign the "Convention on International Trade in Endangered Species of Wild Fauna and Flora" (CITES). CITES is an

international agreement to which nations and regional economic integration organizations can adhere. It has published three appendices (Appendix 1, II, and III) which lists species for which international protection is afforded.
Also in 1973 the US government passed the Endangered Species Act, which provided for the following:

1. It defined the concepts "endangered" and "threatened".
2. It made plants and invertebrate animals eligible for federal protection.
3. It applied broad "take" prohibitions to all endangered animal species and allowed the prohibitions to apply to threatened animal species by special regulation.
4. It required federal agencies to use their authorities to conserve listed species and consult "may affect" actions.
5. It prohibited federal agencies from authorizing, funding, or carrying out any action that would jeopardize a listed species or destroy its critical habitat.
6. It made matching funds available to states with cooperative agreements.
7. It provided funding authority for land acquisition for foreign species.
8. It implemented CITES protection in the United States.

The Endangered Species Act is administered jointly by the US Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS).

There are several sections to the endangered species act. Some of the more important sections are discussed briefly below:

- Section 4: This is the portion of the act that addresses the listing and recovery of species. It also deals with the designation of critical habitat for particular species.
- Section 6: This section focuses on cooperation between the federal government and individual states and authorizes both the USFWS and the NMFS to provide financial assistance to states that have entered into cooperative agreements supporting the conservation of endangered and threatened species.
- Section 7: This part requires that all federal agencies (in consultation with the USFWS and the NMFS) use their authority to further the purpose of the Endangered Species Act. They must also ensure that their actions are not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.
- Section 8: This section outlines the specific procedures for international cooperation.

- Section 9: This part of the act defines specific prohibited actions including the import and export, take, illegally taken possession of illegally taken species, and the transport or sale of endangered and threatened species. (These terms are discussed in some detail later in this course).
- Section 10: This section spells out the guidelines under which a permit may be issued to authorize otherwise prohibited activities.

What is an Endangered Species?

This is a seemingly very simple question that has a complex, multi-layered answer. An endangered species can be as large, easily-recognized and charismatic as a Bald Eagle, *Haliaeetus leucocephalus*, our national symbol. On the other hand it can be as small and unknown as a Bliss Rapids Snail, *Taylorconcha serpenticola*, which, with a total length of one tenth of an inch, would not be recognized or even noticed except by an expert.

However, the term "endangered" has a specific meaning, as does the term "threatened" and other related terms. (Actually, as will be discussed in the course, these terms really have several different meanings and their meaning can change with time or from jurisdiction to jurisdiction. This makes a somewhat complicated issue still more cloudy). The US Fish & Wildlife Service uses the following designations to list plants or animals relative to their danger of extinction:

- Endangered: An animal or plant species in danger of extinction throughout all or a significant portion of its range.
- Threatened: An animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
- Species of Concern: This is an informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat, to the necessity for listing as threatened or endangered. Such species receive no legal protection and the use of this term does not imply that the species will eventually be proposed for listing. "Species at Risk" and "Imperiled Species" are terms with similar meanings.

The photograph below shows a silvery minnow, *hybognathus amarus*, an endangered species found in Big Bend Park in Texas.

As mentioned above, other jurisdictions have their own definitions regarding endangered species. For example, the New Jersey Department of Fish & Wildlife (NJDFWS) has a slightly different set of terms as explained below:

- Endangered: Refers to a species whose prospects for survival within the state are in immediate danger due to one or several factors, such as loss or degradation of habitat, over-exploitation, predation, competition, disease or environmental pollution, etc. An endangered species likely requires immediate action to avoid extinction within New Jersey.
- Threatened: The NJDFWS definition of "Threatened" has changed been recently changed. The old definition was: "a species that may become endangered if conditions surrounding it begin to or continue to deteriorate". The new definition is:

"a species likely to become endangered in the foreseeable future if conditions surrounding it begin to or continue to deteriorate". Note that the new definition adds a probability dimension and also a time dimension to the term. This is a case of the science becoming refined to better delineate which species are at risk. In both the new and old definition is assumed that a threatened species is one that is already vulnerable as result of small population size, narrow habitat requirements, significant population decline, or other factors.

- Special Concern: Applies to a species that warrants special attention because of inherent vulnerability to environmental deterioration or habitat modification that would result in its becoming threatened or endangered. Note that this category serves as an "early warning" device to alert biologists and the public at large that the species needs monitoring. However, species in this category do not receive legal protection, whereas "endangered" and "threatened" species do.
- Stable: A species that appears to be secure in New Jersey and is not in danger of falling into the endangered, threatened, or special concern category in the near future.
- Unknown: A species about which there is not enough information available to determine its status. Many of these species are cryptic or hard to detect in the field.

It should also be noted that a species can be "endangered" in one jurisdiction and "stable" in another or vice versa.

New York State maintains a list of Species of Greatest Conservation Need (SGCN), which is part of the state's current Comprehensive Wildlife Conservation Strategy (CWCS). New York has developed a State Wildlife Action Plan (SWAP) which is based, in part, on analyzing the current status of SGCN and additional species using factors such as abundance and conservation trends. These plans are administered by the New York Department of Environmental Conservation.

The Brown Thrasher, pictured below, is considered a SGCN in New York State.

A question related to "What is an endangered species" is "How does a species become listed as endangered"? The answer to this question depends on the agency listing the species. Generally it is political decision makers that list a species. However, this is based on significant input from the scientific community and interested parties.

The US Fish & Wildlife Service has a formal process for listing a species as endangered or threatened. Basically, a species is a candidate for listing if one of the five factors is true:

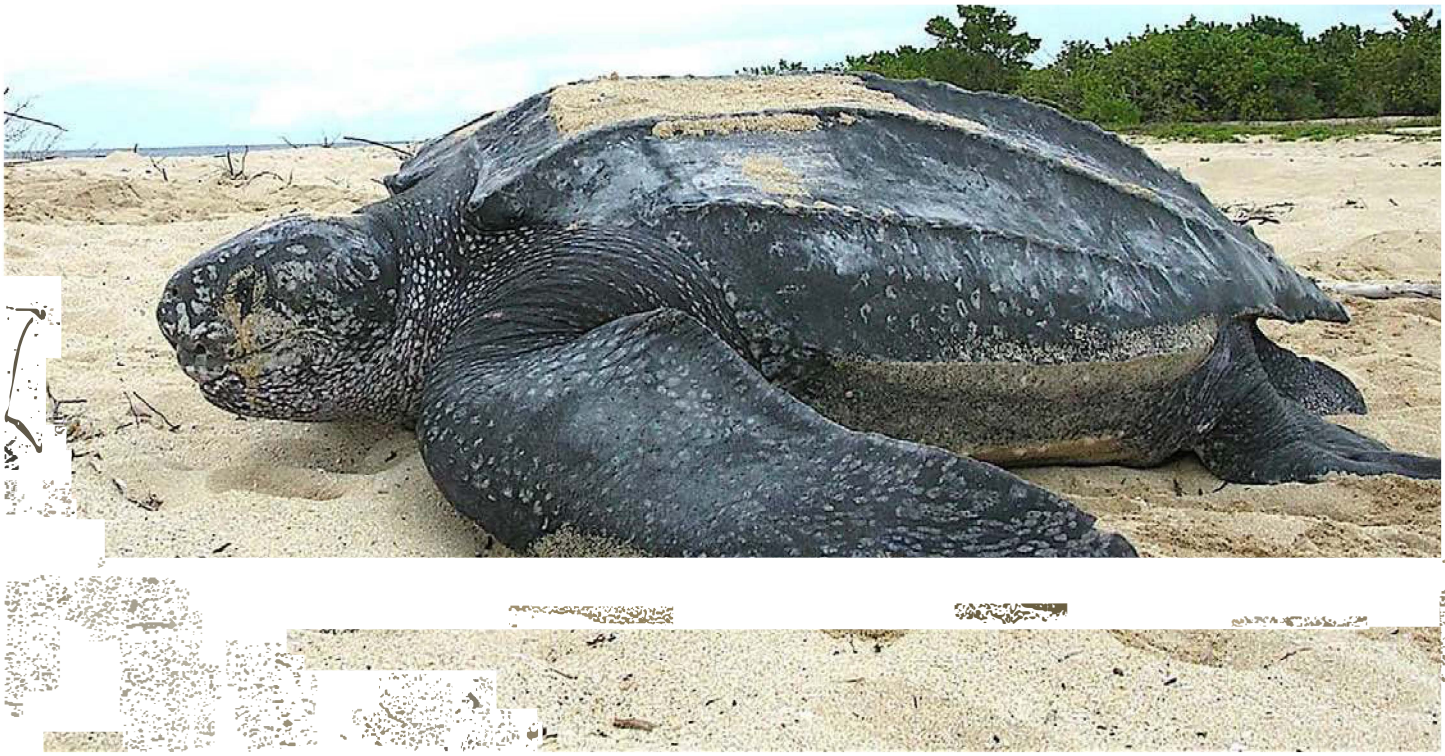
1. It is facing present or threatened destruction, curtailment, or modification of its habitat or range.
2. There has been over-utilization of the species for commercial, recreational, scientific, or educational purposes.
3. The species has been significantly affected by disease or predation.
4. The species is not currently being protected due to the inadequacy of existing regulatory mechanisms.
5. There are other natural or manmade factors affecting its continued existence.

The process of listing may be initiated by the federal government or any interested party. The following steps occur:

1. 90 day finding: At this point the species is considered a candidate for listing. During this period the petition to list the species may provide information regarding the status of the species. If the information provided is substantial, the US Fish & Wildlife Service will publish a positive 90 day finding in the *Federal Register* and will conduct a status review of the species. At this point the species is considered a candidate for listing.
2. 12 month finding: At this point the species is formally proposed for listing. After reviewing the available scientific evidence the US Fish & Wildlife Service will determine if listing is warranted. If it is warranted, then a positive 12 month finding will be published in the *Federal Register* stating that the species is proposed to be listed as endangered or threatened. At this point public comment is solicited regarding the proposed listing and one or more public hearings may be held to discuss the matter.
3. Final listing. After public comments are received a final determination is made as to whether or not to list the species. This final ruling is also published in the *Federal Register*.

The following simple example will illustrate the beginning of the process of listing a species. The Leatherback Turtle, *Dermochelys coriacea*, pictured below, is presently listed as endangered by the federal government. However, despite this listing, an organization known as Blue Water Fisherman's Association filed a petition in 2017 to have the Northwest Atlantic population of this species designated as a distinct population segment (DPS) and to be listed

separately. This is largest turtle in the world.



An excerpt of a portion of the announcement of the petition filed, taken from the *Federal Register*, is shown below. The announcement shows that the preliminary finding is that there is sufficient evidence to consider this population for listing and it includes a request for further information.

SUMMARY:

We, NMFS, announce a 90-day finding on a petition to identify the Northwest Atlantic subpopulation of the leatherback turtle (*Dermochelys coriacea*) as a Distinct Population Segment (DPS) and list it as threatened under the Endangered Species Act (ESA). We find that the petition and information readily available in our files present substantial scientific and commercial information indicating that the petitioned action may be warranted. We are hereby initiating a status review of the leatherback turtle to determine whether the petitioned action is warranted and

to examine the species globally with regard to application of the DPS Policy in light of significant new information since the original listing. To ensure that the status review is comprehensive, we are soliciting scientific and commercial information pertaining to the leatherback turtle from any interested party.

On the other hand, when considering species for listing some states employ an interesting technique called the Delphi Technique. The Delphi Technique is an iterative, systematic methodology that allows researchers to reach a consensus as to which species should be listed as endangered or threatened. Recently, New Jersey re-evaluated all of the bird species found in the state to determine their status. A panel of approximately 20 experts was chosen and each one was given a listing of the species along with a survey asking what status they would assign each species and how confident they were in their decision (based on a numerical system from 1 "very unreliable" to 8 "certain"). The panelists were anonymous (which controlled for the possible confounding effects of personality or reputation) and the results were then tabulated. This process was repeated until a consensus was reached for virtually all of the species. Of course, the final results still have to be sent to the state's decision makers, because, as stated before, the endangered species question does straddle science and politics.

Another question that sometimes arises in the endangered species debate is: what exactly is a species? The answer to this simple question is also not always as straight-forward as it might seem. A case in point involves the Red Wolf *Canis rufus*, an endangered "species" found in North Carolina and some other southern states. Taxonomists still dispute the exact nature of a Red Wolf. Many scientists believe that is a valid species that became endangered partly as a result of the Coyote's eastward expansion in the last several decades. Other scientists believe that the Red Wolf is actually a hybrid between the Gray Wolf *Canis lupus* and the Coyote *Canis latrans*. (Hybrids are not true species and do not warrant protection under current regulations). Presently those that consider the Red Wolf a separate species have the upper hand, but the debate continues.

The photograph below shows a Red Wolf in a fenced enclosure:

How can a debate like this be decided? It depends on the definition of a species. The most commonly accepted definition is the Biological Species Concept (BCS) which states: "A species can be defined as a population, or group of populations, of actually or potentially interbreeding individuals, reproductively isolated from all other such populations. The members of a species should be able to interbreed freely and produce fertile offspring." This definition is fairly straight-forward but it is sometimes difficult to apply it, especially in wide-ranging species that have a far-flung and patchy distribution. For this reason, alternate definitions of species have arisen. One of this is Phylogenetic Species Concept (PSC) which defines a species as "The smallest diagnosable cluster of organisms in which there is a parental pattern of ancestry and descent". This definition has not received widespread approval because it appears to minimize the biological concept of the animals. However, it does illustrate, in part, why debates such as the one regarding the Red Wolf are hard to resolve.

The Red Wolf debate has yet another dimension to it. As an endangered species, it enjoys federal protection. However, many of these animals (including the one pictured above) are part of what is termed an "experimental population" and are not considered essential. Individuals that are part of an experimental population are not protected by federal law. (The US Fish & Wildlife Service defines an "experimental population" as a population (including its offspring) of a listed species that is wholly separate geographically from other populations of the same species).

Another controversy that can arise is when restoring a population of one endangered species puts another endangered species at risk. This is the case with the Peregrine Falcon, *Falco peregrinus*. A population of Peregrine Falcons has been artificially established at the New Jersey shore. However, in this location they often prey on Least Terns, *Sternula antillarum*, another species designated by both the federal and the New Jersey state governments as endangered. (It should be noted that this is not a unique situation and it is not confined to the United States. Researchers in India found that when the endangered Tiger, *Panthera tigris*, was re-introduced into some forests in that country it forced Leopards, *Panthera pardus*, into agricultural lands where they came into conflict with humans and their livestock.)

Not only can plant and animal species be classified as endangered, but entire ecosystems can be classified as threatened or endangered due to their inherent rarity or vulnerability. Coral reefs, for example, are endangered by many hazards.

The photograph below shows a portion of the New Jersey Pine Barrens. A part of this area is made up of a stunted forest which has been classified as a "globally rare ecosystem".

Many other ecosystems in the United States have also received the classification of globally rare. Some of these include the following:

1. Cottonwood dune savannah (present in the southeastern United States).
2. Old growth forests in the Pacific northwest.
3. Tall grass prairie in the northern Great Plains.

Why Should Endangered Species be Protected:

Many people wonder why it is important to protect endangered species. The US Fish & Wildlife Service lists the following seven different types of benefits:

1. Benefits of natural diversity: Because species evolve and live together in ecosystems the extinction of one species can have a detrimental impact on many

other species. Therefore, the loss of one species can have a deleterious cascading effect on a host of other species.

2. Contributions to medicine: Many relatively unknown plans (and animal) species provide the ingredients in common medicines. Penicillin comes from a fungus and more than a quarter of all prescriptions written in the United States contain some product from wild species. For one example out of thousands, consider the anti-cancer compound taxol, which was originally extracted from the bark of the Pacific Yew Tree, *Taxus brevifolia*.
3. Biodiversity and agriculture: Many species are used as "biological controls" in agriculture. These species prey on certain crop pests and reduce or eliminate the need of pesticides.
4. Environmental monitors: Some species (notably birds of prey and freshwater mussels) can act as biological monitors. Toxins in the environment tend to build up in these species. Therefore, the health of these "indicator" species is a guide to the health of the environment.
5. Ecosystem services: Some species have the ability to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The alpine pennycress, *Thlaspi caerulescens* for example, cleans soils contaminated with zinc and cadmium by removing these metals from the soil. In a similar way, some houseplants have the ability to remove benzene and other harmful chemicals from the air. Freshwater mussels obtain food by filtering suspended particles, leaving the stream water clear.
6. Other economic values: Wild species provide tangible economic benefits in many ways. As an example, in 2008 a total of 13 million whale watchers from around the world poured an estimated two billion dollars into the global economy. In the United States alone it was estimated that wildlife watching added 55 billion to the country's economy.
7. Intangible values: The loss of species through extinction is, by definition, irreplaceable and it a reduction of the heritage that we pass on to future generations. This alone should be adequate reason to try to protect endangered species.

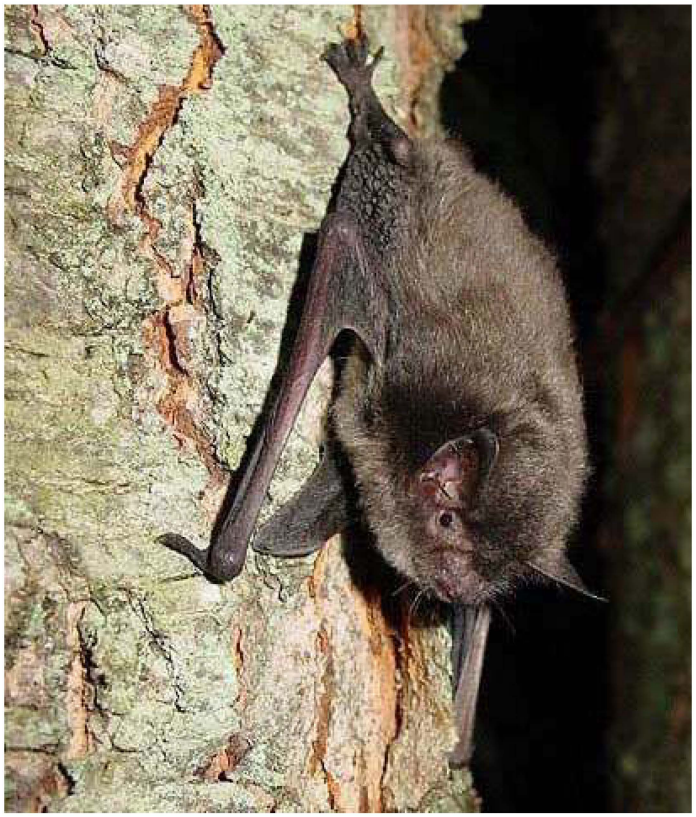
How Can the Presence of Endangered Species Affect Engineering Projects?

The presence of endangered species can have a significant effect on proposed land use projects. This is true of large-scale public projects including the construction of dams and highways and also of small scale single-lot developments. There are actually several ways that the presence of

these species can affect a project. In part, this depends on the jurisdiction listing the species as endangered or threatened.

At times, the development can be a high profile project that is abruptly halted (temporarily or permanently) by the finding of an endangered species on the site. Some recent examples include:

1. A 15 million dollar highway project in northwestern San Antonio, Texas was jolted to halt when the endangered Bracken Bat Cave Meshweaver Spider, *Circurina venii* (a species that had not been seen in over three decades) was discovered.
2. In the Crestview area of Florida, a 48 million dollar project was recently stopped (at least temporarily) because silt was causing a detrimental impact on a 3 inch long endangered species of fish known as the Okaloosa Darter, *Etheostoma okaloosae* .
3. In 2009 a federal court in Maryland halted construction of a three hundred million dollar wind turbine project because of its potential detrimental impact on an endangered species, the Indiana Bat, *Myotis sodalis* (pictured below). The project was to have included the installation of 122 wind turbines along 23 miles of the Appalachian Mountains and would have provided electricity for approximately 50,000 homes in West Virginia. Opponents of the project convinced the court that the project would pose a hazard to the endangered bat due to potential collisions with the wind turbines. In addition, it was argued that the changes in air pressure in the vicinity of the turbines would harm the bats lungs and eardrums. The court agreed that the project would constitute a "take" and that it would "harass, harm, and kill" an endangered species.



These examples show that it is imperative that the potential for endangered species on a site be evaluated before significant money is spent on a project.

The US Fish & Wildlife, for instance lists the following as potential prohibitions:

1. Destruction or adverse modification of critical habitat: A direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species.
2. Harass: To intentionally or negligently, through act or omission, create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns such as breeding, feeding, or sheltering (defined by FWS regulations; NOA Fisheries does not have a definition of "harass").
3. Harm: To perform an act that kills or injures wildlife; may include significant habitat modification or degradation when it kills or injures wildlife by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering.

4. Take: To harm, harass, pursue, hunt, shoot, kill, capture, trap, or collect, or attempt to engage in any such conduct; may include significant habitat modification or degradation if it kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding, and sheltering.
5. Incidental take: Take that results from, but is not the purpose of, carrying out an otherwise lawful activity.

Many seemingly harmless land-disturbing activities can negatively affect the habitat of one or more threatened and endangered species (T&E). It is obvious, then, that the presence of (T&E) species can significantly affect a land development's ability to proceed. The US Government uses the criteria above in judging land-disturbing activities. In other jurisdictions, there is also the potential for endangered and threatened species to negatively affect a land use project. In New Jersey, for example, the presence of these species can increase the required transition area from wetlands significantly.

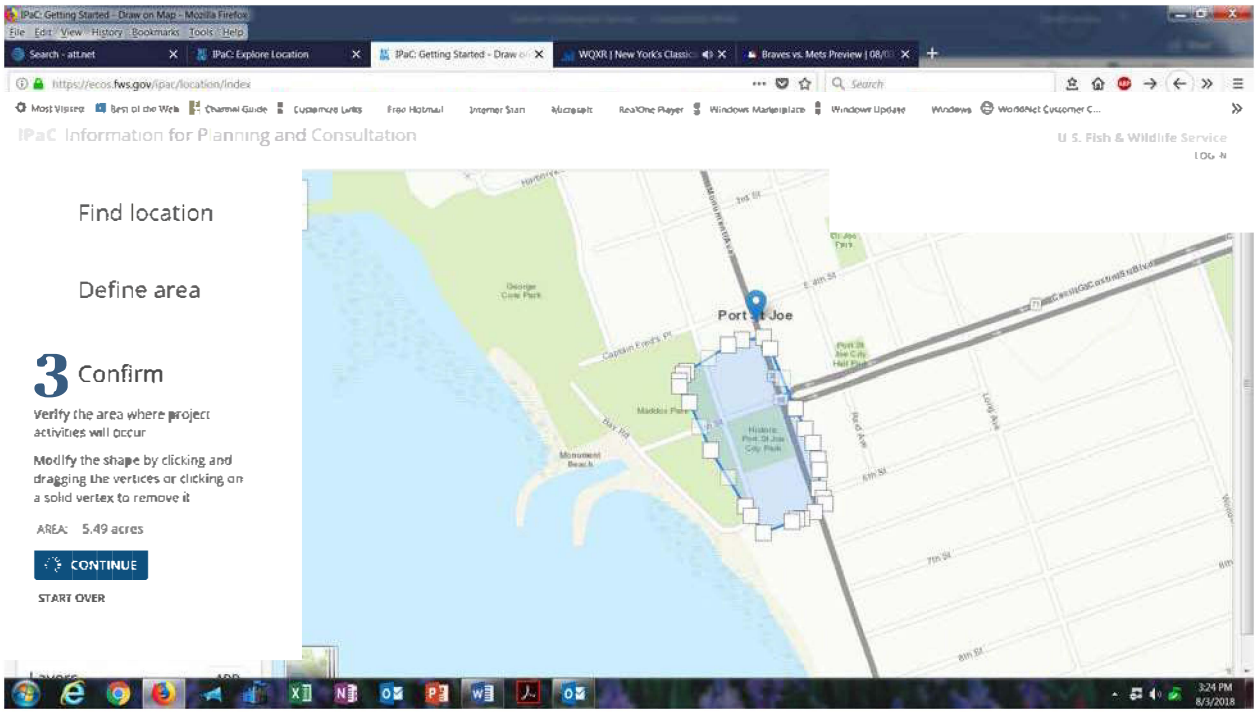
The photograph below shows a stream flowing through a rural backyard in Morris County New Jersey. There are wetlands associated with this stream and the associated transition area would be 50 feet if no T&E species are present and 150 feet if these species are present. There is a colony of Bog Turtles, *Clemmys Muhlengerii,* (a federally and state listed species) in the vicinity of this site and the NJDEP was asked to make a determination as to whether this property was suitable habitat for the turtles. Their answer affected the proposed re-development of this property greatly. If the wetlands were assigned a 150 foot buffer, the homeowners would have been unable to make needed additions to their dwelling. However, in this case the ruling was

that the property in question did not contain suitable habitat for these turtles, and the project was able to proceed.

Sometimes, if endangered species are present on a site, the engineer can design around these species by concentrating the development away from the most sensitive areas. In other cases, potential negative impacts on endangered species can be mitigated by timing the land-disturbance activities appropriately. Therefore, avoiding siltation in streams during fish spawning runs or delaying mowing of meadows until the nesting season of grassland bird species can be very beneficial.

So the question arises: How does an engineer go about determining if the presence of threatened or endangered species could potentially have an impact on a specific project. The USFWS has a very convenient website that is a good starting point, which can be accessed at https://ecos.fws.gov/ipac/

In order to get a preliminary listing of potential endangered species on a property, the engineer simply types in an address and can sketch an area on the resulting map. For example, suppose that the city of Port St. Joe in Florida hires an engineer to look into the feasibility of expanding its historic park with additional facilities and a parking area. The engineer can sketch this area on the map. (Note that a polygon or even a line can be chosen as opposed to sketching an area). A screen shot of the resulting polygon is shown below:



The engineer then clicks the "continue" button and a list of threatened and endangered species will appear. In this area, although the area chosen is only about five and one half acres an impressive total of 20 species occurs. These are listed below:

Mammals:

1. West Indian Manatee, *Trichecus mantus*

Birds:

1. Florida Scrub-jay, *Aphelocoma coerulescens*
2. Piping Plover, *Charadrius melodus*
3. Red Knot, *Calidris canutus rufa*
4. Red-cockaded Woodpecker, *Picoides borealis*
5. Wood Stork, *Mycteria americana*

Reptiles:

1. Eastern Indigo Snake, *Drymarchon corals couperi*
2. Hawksbill Sea Turtle, *Eretmochelys imbricata*
3. Leatherback Sea Turtle, *Dermochelys coriacea*
4. Loggerhead Sea Turtle, *Caretta caretta*

Fishes:

1. Atlantic Sturgeon (gulf subspecies), *Acipenser oxyrinchus desotoi*

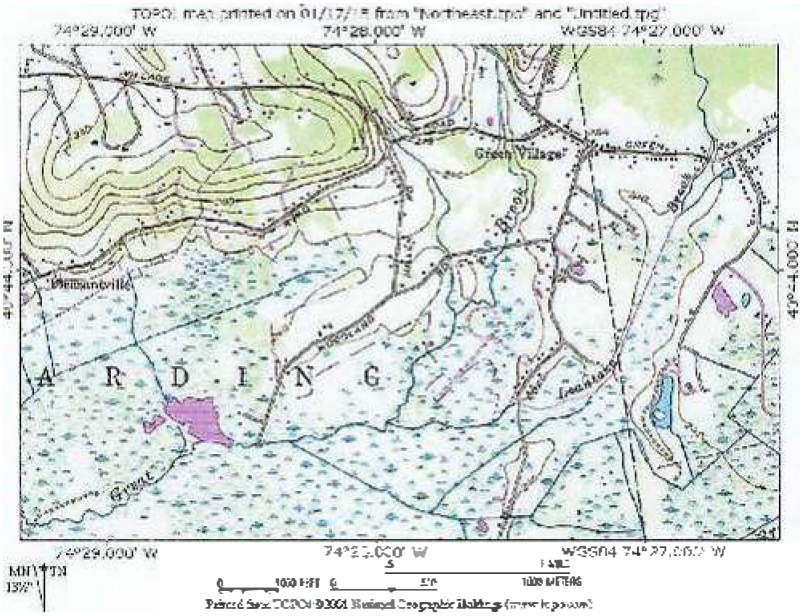
Flowering Plants:

1. Brooksville Bellflower, *Campanula robinsiae*
2. Florida Bonamia, *Bonamia grandiflora*
3. Florida Golden Aster, *Chrysopsis floridana*
4. Pygmy Fringe-tree, *Chionanthus pygmaeus*

Does this long list of species mean that the project is not feasible and must be abandoned? Not necessarily. Even a cursory examination of the species indicates that some of these species are aquatic and wouldn't necessarily be using the terrestrial habitat. What it does mean is that the engineer should now consult with a qualified wildlife biologist at this point before proceeding with any formal site plans. This expert might find that some of these species would not be present on the site. He or she might also recommend that certain features are included in the design that would allow the species that are present to continue to thrive. These recommendations might include replanting some of the endangered plants or leaving beach habitat untouched to accommodate nesting sea turtles. However, having this information at the beginning of a project is vital to the eventual success of the enterprise.

In some other jurisdictions also have an easy way to obtain a preliminary list of potential threatened and endangered species that might affect a particular project. In New Jersey, for example, an engineer can contact the NJ Natural Heritage Program (administered by the New Jersey Department of Environmental Protection Division of Parks and Forestry) to obtain a list of threatened and endangered species that may be associated with a particular property. The engineer simply sends a request form and a copy of the USGS quad sheet showing the property in question.

A copy of a portion of a USGS quad sheet is shown below. This sheet shows a portion of Harding Township in Morris County and covers a portion of the Great Swamp – an area known for the presence of several threatened and endangered species.



The NJ Natural Heritage Program will respond to the request with a listing of T&E species known to be utilizing the property. Actually, often they will respond with two sets of lists of species – one representing species that have been seen on the property and one showing species that have been sighted within one mile of the property in question. Typical lists of species within one mile of the site might look something like the following hypothetical list:

Animals:

Common Name	**Scientific Name**	**Federal Status**	**State Status**	**Global Rank**	**State Rank**
Barred owl	*Strix varia*		T/T	G5	S2B, S2N
Bobcat	*Lynx rufus*		E	G5	S1
Bog turtle	*Clemmys Muhlengerii*	LT	E	G3	S2
Marbled salamander	*Ambystoma opacum*		D	G5	S3
Veery	*Catharus fuscescens*		S/S	G5	S3B

The tiny 4" bog turtle pictured below is a federally threatened species that occurs in a variety of locations in New Jersey.

Plants:

Common Name	**Scientific Name**	**Federal Status**	**State Status**	**Global Rank**	**State Rank**
Green Violet	*Hybanthus majus*		E	G5	S1
Slender Mountain Rice Grass	*Oryzopsis pungens*		E	G5	SH.1
Robbin's Pondweed	*Potamogeten robinsii*		E	G5	S2

At first glance the coded information included in the two lists above may seem like gibberish, but the NJ Natural Heritage Program always includes the following tables with their data lists.

Even a cursory review of these tables shows the complexity involved in determining the exact status of a particular species in a state, the entire country, or globally.

Federal Code Status	**Description**
LE	*Taxa formally listed as endangered
LT	*Taxa formally listed as threatened
PE	*Taxa already proposed to be formally listed as endangered
PT	*Taxa already proposed to be formally listed as threatened
C	*Taxa for which the US Fish & Wildlife Service has on file sufficient information on biological vulnerability and threats to support proposals to list as either an endangered or threatened species
S/A	Similarity of appearance species

*For the purposes of this course the term taxa can be thought of as equivalent to a species. In actuality taxa (singular: taxon) can represent a species, a subspecies, or some other biologically-definable group of organisms.

In the list above, only the Bog turtle is assigned a federal status. According to the table, this species is listed as "threatened" by the federal government.

State Code Status	**Description**
D	Declining species.
E	Endangered species.
EX	Extirpated species – a species that formerly occurred in New Jersey but is not now known to occur in the state.
I	Introduced species – a species that is not native to New Jersey that could not have established itself in the state without the assistance of humans.
INC	Increasing species.
T	Threatened species.
P	Peripheral species – a species whose occurrence
S	Stable species.
U	Undetermined species – a species about which there is not enough information to determine its status.

Naturally, all of the species listed in the heritage database are assigned a state status.

The following ranking systems, which are included in all NJ Natural Heritage data lists, were developed by the Nature Conservancy.

Global Element Rank	**Description**
G1	Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor or combination of factors making it especially vulnerable to extinction.
G2	Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor or combination of factors making it very vulnerable to extinction throughout its range.
G3	Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g. a single US state, a physiographic region) or because of other factors making it vulnerable to extinction throughout its range, with the number of occurrences in the range of 21 to 100.
G4	Apparently secure globally, although it may be quite rare in parts of its range, especially at the periphery.
G5	Demonstrably secure globally, although it may be quite rare in parts of its range, especially at the periphery.
GH	Of historic occurrence throughout its range (i.e. formerly part of the established biota, with the expectation that it may be rediscovered).
GU	Possibly in peril range-wide but status is uncertain; more information is needed.
GX	Believed to be extinct throughout its range with virtually no likelihood that it will be rediscovered.
G?	Species has not been ranked.
GNR	Same as G? Species has not yet been ranked.

The Bog turtle is the only species that appeared on the hypothetical species list above which is not demonstrably secure globally.

State Element Rank	**Description**
S1	Critically imperiled in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres). Species with this rank are often restricted to very specialized conditions or habitats and/or are restricted to an

extremely small geographic area of the state. This ranking also includes species that were formerly more abundant, but because of habitat destruction or some other critical factor of its biology, they have become demonstrably reduced in abundance. Therefore, these are species for which sizable additional occurrences are unlikely to be discovered even with intensive searching.

S2 Imperiled in the state because of rarity (6 to 20 occurrences). Historically many of these species may have been more frequent but are now known from very few extant occurrences, primarily because of habitat destruction. Diligent searching may yield additional occurrences.

S3 Rare in the state with 21 to 100 occurrences (plant species and ecological communities in this category have between 21 and 50 occurrences). Includes species which are widely distributed in the state but with small populations or acreages with restricted distribution, but locally abundant. Not yet imperiled in the state but may soon be if current trends continue. Searching often yields additional occurrences.

S4 Apparently secure in the state.

S5 Demonstrably secure in the state.

SA Accidental in the state, including species (usually birds or butterflies) recorded only once or twice or at very great intervals, hundreds (or even thousands) of miles outside their usual range. A few of these species may even have bred in the state on one or two occasions.

SE Species that are clearly exotic including those that are not native to North America (known as introduced taxa) or species deliberately or accidentally introduced into the state from other parts of the continent (known as adventive taxa). These species are not a conservation priority (although viable introduced occurrences of species ranked G1 or G2 may be exceptions).

SH Species of historic occurrence in New Jersey. Despite some searching of historical occurrences or potential habitat, no extant occurrences are known. Since not all of the historical occurrences have been field surveyed, and unsearched potential habitat remains, species with this ranking are considered possibly extant, and remain a conservation priority for future field work.

SP The species has the potential to occur in New Jersey, but no occurrences have been reported.

SR Species that have been reported from New Jersey, but without persuasive documentation which would provide a basis for either accepting or rejecting the report. In some instances documentation may exist, but as of yet its source or

	location has not been documented.
SRF	Species that have erroneously been reported as occurring in New Jersey.
SU	Species that are believed to be in peril but the degree of rarity is uncertain. Also included in this classification are species of uncertain taxonomical rank. More field work is required to clarify the species status.
SX	Species that have been determined or are presumed to have been extirpated from New Jersey. All historical occurrences have been searched and a reasonable search of potential habitat has been completed. Extirpated species are not a current conservation priority.
SXC	The species is presumed extirpated from New Jersey, but native populations collected from the wild still exist in captivity.
SZ	These species are not of practical conservation concern in New Jersey, because there are no definable occurrences, although the species is native and appears regularly in the state. An SZ rank will generally be used for long-distance migrants whose occurrences during these migrations are too irregular (in terms of repeated visitations to the same locations), transitory, and dispersed to be reliably identified, mapped and protected. In other words, the migrant passes regularly through the state, but enduring, mappable occurrences cannot be defined. An SZ rank may in a few instances also apply to a breeding population, for example certain Lepidoptera (i.e. butterflies) which die out every year with no significant return migration.
B	Refers only to the breeding population of the species in the state.
N	Refers only to the non-breeding population of the species in the state.
T	This indicates that the species is globally secure, but the subspecies occurring in New Jersey has a different status.
Q	The species is of questionable or uncertain taxonomic standing (e.g. some authorities regard it as a full species, while others treat it as a subspecies or a hybrid). The Red Wolf discussed earlier in the course would be an example.
.1	A species that has been documented from a single location.

Once the list of species is received from the US Fish & Wildlife Service or the New Jersey Natural Heritage Program, it is a good idea to have it analyzed by a qualified expert. Often, species are erroneously assigned to a region or habitat in which they do not occur. If this takes place, the expert can question the findings and, possibly, change the status of the property. There are several methods that an expert can utilize to question the finding of one or more threatened or endangered species on a property. A field survey is the most comprehensive. However, this is

not always possible or definitive. Some species are difficult to detect in the field and might not be found even if they are present on the site. This is especially true if the species is not vocal – for instance some bird species away from the nesting season. Therefore, there are other means that can be used.

For some species there are published Habitat Suitability Index (HSI) models, which allow for an analysis of the site itself. Habitat Suitability Index Models are tools that are commonly used to predict habitat quality and species distributions. Of course, there are no HSI models for a majority of species. However, several have been published and the United States Geologic Survey, National Wetlands Research Center maintains a list of them that can be found at the following website: https://www.nwrc.usgs.gov/wdb/pub/hsi/hsiintro.htm

Using an HSI can give a preliminary indication of the suitability of the habitat but it is not a substitute for an on-site species survey, which can only be undertaken by a qualified wildlife biologist.

A detailed description of a Habitat Suitability Index Model is beyond the scope of this course (and beyond what an engineer could be reasonably expected to know). However, for illustrative purposes a typical HSI will be briefly described below.

The HSI that we will consider assesses potential habitat for the Pine Marten, *Martes Americana*, which is a relatively large weasel that is found in coniferous forests in the northern part of the United States and is also present in Canada. It is not presently listed as an endangered species by

the USFWS, but their population is threatened and declining in many parts of their range. A photograph of the Pine Marten is shown below:

Many of the Habitat Suitability Models (including the one for the Pine Marten) convert specific habitat requirements of the animal to mathematical formulas. The HSI values will generally range from 0 (not appropriate habitat) to 1.0 (prime habitat). The HSI for the Pine Martin breaks the habitat components into the following four variables:

1. Martens are known to use forests with a closed canopy and to avoid open areas. Therefore, the first variable (V_1) represents to the percentage of tree canopy closure.
2. Martens greatly prefer coniferous forests to deciduous forests. Therefore, the second variable (V_2) is the percentage of canopy closure that is comprised of fir or spruce trees.
3. Martens prefer old growth forests and generally avoid younger stands of trees. Therefore, the third variable (V_3) refers to the successional stage of the forest stand. (Successional stage refers to the age of the majority of trees and in this

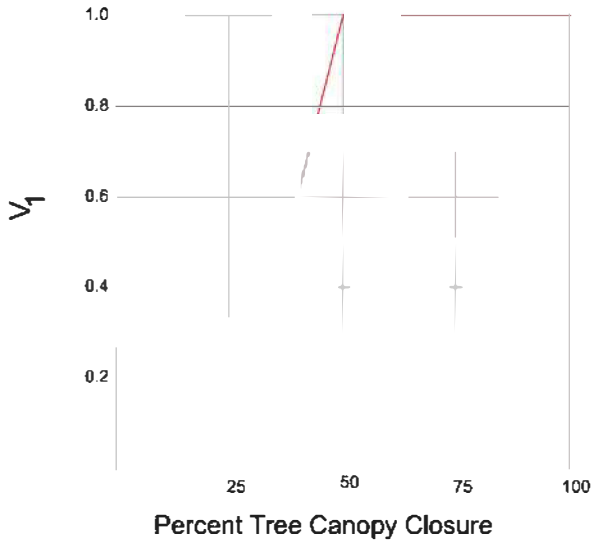
case is subdivided into the following categories (from youngest to oldest): shrub-sapling, pole sapling, young forest, and mature or old growth forest).

4. Researchers have found that Martens require numerous downed tress to survive the winter. Apparently, they use these trees as a means to get under the deep layers of snow which allows them to avoid sever weather and also to hunt the small mammals that take refuge in these areas). Therefore, the fourth and final variable in the model (V_4) is a function of the percent of ground surface covered by downed tress over 3" in diameter.

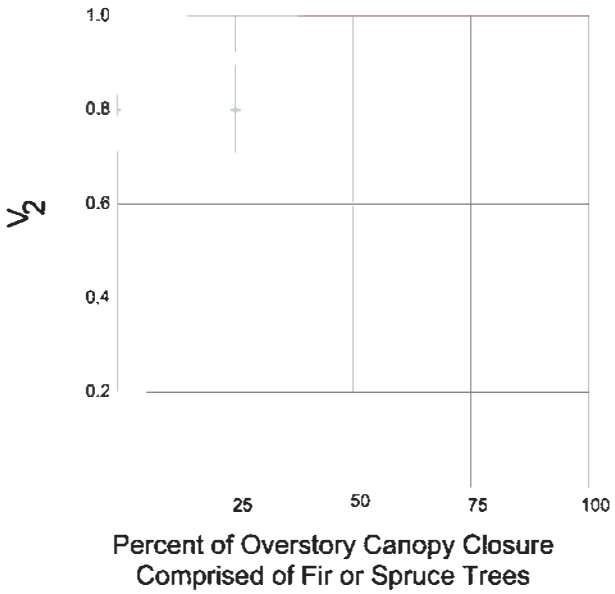
The following photograph represents prime habitat for Pine Martens with mature evergreen trees and relatively closed canopy, and a significant amount of downed timber.

The actual value of the HSI is then calculated as: $HSI=(V_1 \times V_2 \times V_3 \times V_4)^{1/2}$.
Values for each of the variables in the model are taken from the following charts.

V1 can be taken from the following: (Note that prime Marten habitat includes at least 50% canopy closure).

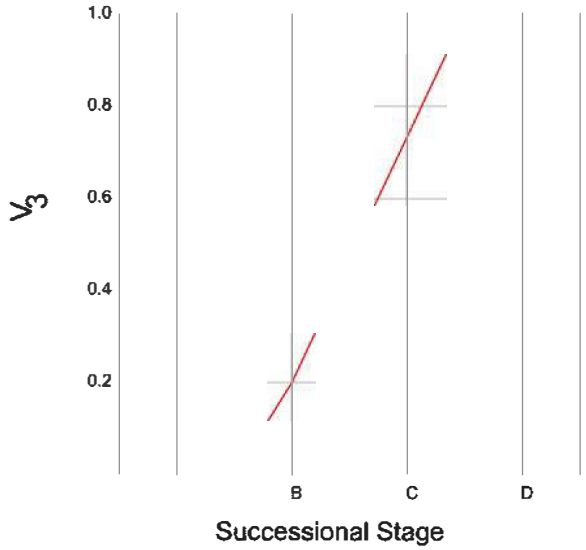


V2 can be taken from the following: (Prime habitat requires that at least 40% of the canopy trees be spruce and/or fir).

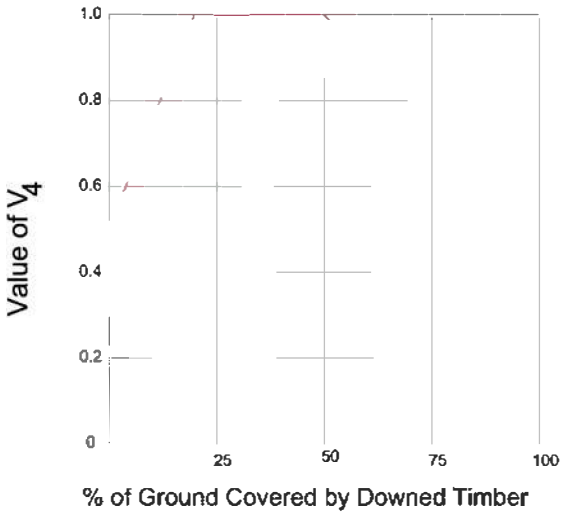


V3 can be taken from the following:

A: Shrub-sapling
B: Pole sapling
c: Young forest
D: Mature or old growth forest



V4 can be taken from the following: (Prime habitat has between 20% and 50% of the ground covered by downed timber).



Therefore, let us analyze a sample coniferous forest to see if it represents suitable habitat for this declining species. As an example, consider a 4 square mile relatively young coniferous forest in northern Montana. Field investigations have shown that the canopy closure is approximately 75% and that nearly all of the canopy trees are either fir or spruce. Approximately 10% of the forest floor is covered by relatively large, downed timber. Based on these descriptions, we can assign the following values to the four variables that make up the model:

1. V1 is 1.0
2. V2 is 1.0
3. V3 is 0.75
4. V4 is 0.5

The overall HSI value is: $(1.0x1.0x0.75x0.50)^{1/2}=0.61$.
Recall that HSI values can range from 0 to 1 with 1 being prime habitat for pine Martens. The value calculated here is somewhat intermediate, which means that his forest probably represents Pine Marten habitat but it is sub-optimal.

The model also makes use of the following assumptions:

1. It is for use in boreal, coniferous forests and is mainly applicable to the western United States.
2. It mainly represents the Marten's habitat use during the winter season (because this is the season where these animals experience the greatest mortality).
3. Martens require large areas of contiguous forest. Therefore, if the forested area is less than 1 square mile the HSI is assumed to be equal to zero (i.e. the area is not at all suitable for Pine Martens).

It should also be noted that most Habitat Suitability Index Models are based on published information about a particular species habitat, but that they have not been verified in the field. In addition, the fact that a particular species is using a specific habitat does not, in itself, necessarily mean that the species is benefitting from that habitat. Some areas are populations "sinks"; areas where a species routinely attempts to breed but is not successful. These sink areas are populated by individuals that were raised in areas known as population "sources".

Options for Landowners:
Although the presence of endangered species often can jeopardize the economic value of a tract of land by limiting what can be done on it, the federal government does provide the following options for landowners:

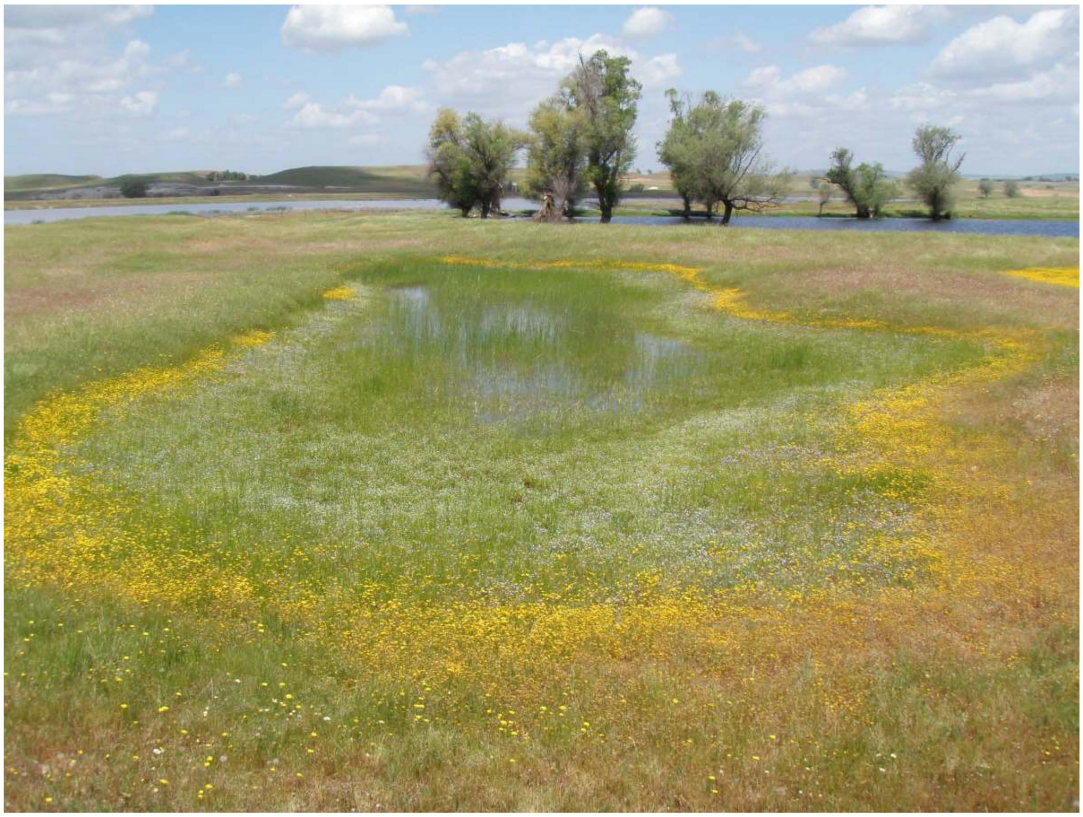
1. Habitat conservation plans: A habitat conservation plan (HCP) outlines ways of maintaining, enhancing , and protecting a particular habitat type needed to protect specific threatened or endangered species. It usually includes measures

to minimize impacts, and may include provisions for permanently protecting land, restoring habitat, and relocating plants or animals to another area. An HCP is required before an incidental take permit can be issued by the federal government.

2. Safe harbor agreements: A safe harbor agreement (SHA) is a voluntary agreement signed by the US Fish and Wildlife Service or the NOAA Fisheries and a property owner (or any cooperator) that provides for the following:
    a. It sets forth specific management activities that the non-Federal property owner will undertake (or forgo) to provide a net conservation benefit to species covered by the agreement and,
    b. It provides the property owner with the Safe Harbor assurances described within the agreement and authorized in an enhancement of survival permit.
3. Recovery credits and tax deductions: The US Farm Bill includes provisions for tax deductions for farmers who are engaged in activities that benefit federally listed endangered and threatened species.
4. Conservation banking: This is a method used to offset impacts occurring elsewhere to the same listed species. A "bank" consists of non-Federal land containing natural resource values conserved and managed in perpetuity. Often, these banks are created with a specific endangered species, or suite of species, in mind.

The area pictured below is part of the 765 acre Van Vleck Conservation Bank in Sacramento County, California. This bank has created a vernal pool (visible in the foreground) and is preserving native grassland. The following two endangered species should benefit from this bank including:

- Vernal Pool Fairy Shrimp, *Branchinecta lynchi*, which is already present on the site.
- Swainson's Hawk, *Buteo swainsonii*, which has been found in the immediate vicinity of the bank.



Success Stories:

At this point it might be worthwhile to take stock of the outcomes associated with the Endangered Species Act. After all, the Act was (as still is) intended to prevent species from becoming extinct and to ensure that they will have viable populations in the future. The question that has to be asked is: Is it working? The answer to this is a resounding "yes". Many species have been saved from extinction by the Endangered Species Act. Perhaps most notably on August 8, 2007 the Bald Eagle was officially removed from the endangered species list by the US Department of the Interior, because its continental population has rebounded to a healthy level and because it is reproducing successfully in many parts of the country. In addition consider just a few of the many hundreds of the other success stories:

1. The Kirtland's' Warbler, *Setophaga kirtlandii*, a small bird which nests only in a very restricted habitat in a few counties in Michigan and Wisconsin, was on the brink of extinction several decades ago. However, due in large part to protection received under the Endangered Species Act, the population has grown from only 210 breeding pairs in 1971 to over 2000 pairs in 2012.
2. The Southern Sea Otter's, *Enhydra lutris nereis*, population in California has increased from 1789 individuals in 1976 to 2735 in 2005. This is important

because the Sea Otter is a keynote species in the California marine ecosystem helping to keep it in balance.

3. The Black-footed ferret, *Mustela nigripes*, was thought to be extinct in the wild in 1980. Now, however, due to a reintroduction program there are 400 ferrets running wild in 6 western starts and another 400 in captive breeding programs.

The photograph below shows a Kirtland's Warbler, one of the rarest songbirds in North America. Because of its restricted habitat requirements, this species will probably always be rare. It nests only in young (5 to 23 year old) stands of jack pines on nutrient-poor, sandy soils. However, its future looks brighter because of the protection of the Endangered Species Act.

In addition, research has shown that:

1. Less than 1% of protected species have gone extinct since the Endangered Species Act was passed in 1973.
2. The longer a species remains under protection, the better its chances of establishing a recovering population.
3. Listed species fare better if there is a formal recovery plan in place.

4. The more money that is spent on a species, the better its chance of recovery.

Concluding Remarks:

It can be seen by the information presented in this course that issue of endangered species can be quite complex. However, the engineer should be aware of endangered species and know when to call in an expert to determine if they are present. By planning ahead and checking for the presence of these species, an engineer can make an informed decision for his or her client and for the public about whether a particular project can move forward, whether it needs to be modified, or whether it must be abandoned altogether. Finding out this information in the very early planning stages can save time and effort in the long run.