2019

Buggin Out: Entomology 101 for High School Juniors and Seniors

Jonathan Wischmeyer
University of Nebraska-Lincoln

Jonathan Wischmeyer
Ento888
Fall 2019

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Introduction

I have been teaching Biology and Environmental Science for the past 20 years here at Summit High School. Over that time I have incorporated insects into some of my teaching practices where it was appropriate. As I have worked my way through the Entomology program at UNL I have found myself wanting to utilize insects more as educational tools.

Materials, Methods and Discussion

The purpose of this final project is to design a semester worth of entomology curriculum for high school juniors and seniors attending Summit High School in Breckenridge Colorado. This class would be an elective with the prerequisite of general biology. The length of the semester is 16 weeks and since we are on a modified block schedule the class would meet 3 days per week. Therefore, the curriculum has been designed for a total of 44 days which allows for Thanksgiving break. The course has been designed to be taken during the fall semester to insure that the field projects can be conducted before it starts to snow. These field projects can be conducted locally on public land within walking distance of the high school. The semester has been broken into 8 units of varying length and aligned with Colorado state standards for life science. All materials are linked to each unit and sources are cited at the end of each unit plan.

Results

Unfortunately the current curriculum does not allow for an in depth study of the insect world so my hope is to design this elective and then work toward getting it approved by the school board as an elective option for students.

Acknowledgments

Thank you to my wife and son for putting up with me for the last 4 years as I dragged dead insects into the house and sacrificed family time for papers projects and tests.

References

All references can be found at the end of each unit.

Thank you for considering my project. I have enjoyed the program and the process of completing this project.

Unit Plan

Unit/Topic: Introduction to Insects **Date: Fall**

Standard : 2.9 **Year Level: 11-12**

Outcomes: **Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (HS-LS4-1) (Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.)**

LESSON OUTCOME:

1. **Students will be able to label the major body parts of insects and their function**
2. **Students will be able to explain how and when insects invaded land**
3. **Students will be able to label and explain the life cycle of meal worms**
4. **Students will set up and maintain a habitat for raising crickets that can be used for food.**

LESSON STRUCTURE:

Time	Main Content	Materials
3 days	**Introduction to Insects ppt** **Grasshopper Worksheet** - **Color each word a different color** - **Cut and paste the words on the appropriate body part** - **Color the body part the same color as the word.** **Life Cycles** - **Have the students compare and contrast the three different insects life cycles on the worksheet. Discuss with the class.** **Mouth Parts** - **Have the students write out how they think each mouth part design is used to acquire food. Discuss with the class.**	Why Insects Why Insects? ppt Grasshopper Body parts Grasshopper Body Parts Worksheet Grasshopper Body part vocab Grasshopper body part vocab Different insect life cycles Insect Life Cycles Mouth Parts Mouth Parts
1 day	**Life in the Undergrowth "Invading Land" movie** - **Watch this portion of Life in the Undergrowth and talk about what challenges these organisms must have faced moving out of the ocean onto land.**	Land invasion intro Land Invasion

1 day	**Mealworms Eating Styrofoam** - **Read the article as a class and discuss the potential importance of this discovery. How could this help the environment and humans?** - **Have the students each set up a mason jar with 10-20 meal worms and a small block of Styrofoam. Over the course of the semester the will need to tend their meal worms and observe their life cycle.**	Styrofoam eating mealworms article. Mealworms eat Styrofoam Each student will need a jar with a lid, a small block of styrofoam and 10-20 mealworms. Mealworm Care Instructions Mealworm Care Instructions
2 days	**Set Up Crickets As Food** - **The class will create a cricket farm based on the instructions provided. Students will be responsible for upkeep throughout the semester so the crickets can be used as food in unit 8.**	Instructions for building and maintaining a cricket farm. Cricket Farm Instructions

SAFETY CONSIDERATIONS/MATERIALS

The main safety concern for this unit would be the raising and eventually eating of crickets. Food allergies should be taken into consideration and release forms should be used before students consume the crickets.

ASSESSMENT

Students will be tested on the basic structure of insects and their life cycle.

Citations

Antenna (biology). (2019, September 4). Retrieved from https://en.wikipedia.org/wiki/Antenna_(biology).

Hadden, J. (2014, January 22). Retrieved from http://www.delawareriverguide.net/insects/mayflycyc.html.

Life in the Undergrowth. (n.d.). Retrieved from https://www.bbc.co.uk/programmes/b007y9sd.

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Plastic-eating worms may offer solution to mounting waste, Stanford researchers discover. (2015, September 29). Retrieved from https://news.stanford.edu/pr/2015/pr-worms-digest-plastics-092915.html.

Skrobonja, E. (2019, April 26). Cricket farming: The ultimate DIY guide. Retrieved from https://www.eatcrickster.com/blog/cricket-farming.

Unknown. (1970, January 1). Complete and Incomplete Metamorphosis. Retrieved from http://gilbreath5thgrade.blogspot.com/2014/06/welcome-my-5th-grade-scientist.html.

Welcome to Enchanted Learning! (n.d.). Retrieved from https://www.enchantedlearning.com/.

Unit Plan 2

Unit/Topic: Insect Anatomy **Date: Fall**

Standard: 2.9 **Year Level: 11-12**

Outcomes: **Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (HS-LS4-1) (Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.)**

LESSON OUTCOME:

1. Students will be able to use the Linnaean system of classification to classify both humans and the European honey bee.
2. Students will complete the process of dissecting a lubber grasshopper while learning anatomy and adaptation.

LESSON STRUCTURE:

Time	Main Content:	Materials
1day	**1. Classification of Humans vs Honey Bee** - **Do the human classification matching with the whole class as an example.** - **Have the students attempt the bee classification on their own.** - **Discuss how and why these levels of classification were created.**	Classification worksheet Classification Worksheet
2 days	**2. Grasshopper Dissection** - **Follow the instructions found in the dissection packet.** - **Be sure to have the class move through the process together and discuss the functions of the body parts.** - **This is a great place to compare and contrast human anatomy and insect anatomy.**	Dissection Packet Dissection Packet Lubber Grasshoppers Dissecting tools Rubber Gloves Goggles Microscopes

SAFETY CONSIDERATIONS/MATERIALS

There is always safety concerns when it comes to dissections. Students must wear protective eyewear and gloves at all times. Dissecting tools are sharp and can cause harm so students should be instructed as to how to use them properly.

ASSESSMENT

Test over the Linnaean classification system and the anatomy of the grasshopper, both form and function.

Citations

The grasshopper dissection packet was put together by a previous teacher so I am not sure where all the resources came from. It looks like they are from bits and pieces from all over the internet.

Unit Plan: Insect Collection

Unit/Topic: Insect Collection and ID **Date: fall**

Standard:2.10 **Year Level: 11-12**

Outcomes: **Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (HS-LS4-1) (Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.)**

LESSON OUTCOME:

1. Students will learn methods for collecting insects.
2. Students will practice the proper method of pinning insects for collection.
3. Students will use a dichotomous key to identify and label collected insects.

LESSON STRUCTURE:

Time	Main Content:	Materials
1 day	**1. Collect insects around school property** - **Provide groups of two with a net and a prepared kill jar.** - **Demonstrate the proper method of sweep netting and discuss any safety issues related to insect collection.** - **Spend the period walking around the school grounds collecting insects.**	Butterfly nets Kill jars Non-acetone nail polish remover Cotton pads

2 days	**2. Pin the collected insects** - **Instruct the students on the proper methods for pinning and labeling their specimens based on the instruction sheet. Sometimes it helps if they have some practice before they pin the insects collected. Japanese beetles can be collected ahead of time and used for this purpose.**	Styrofoam pinning pads Insect pins Pinning blocks Spreading board Instructions for pinning and labeling Pinning and Labeling Instructions
1 day	**3. Identify to the order level the collected insects using a dichotomous key and label.** - **Have the students use the key provided to identify their collected specimen down to order.** - **Use the card stock to make labels and attach them.**	Insect dichotomous key Order Key Card stock for labelling

SAFETY CONSIDERATIONS/MATERIALS

Collecting insects is generally safe but attention should be paid to those insects such as bees and wasps that could sting students. All allergies to bee stings should be identified before collecting begins.

ASSESSMENT

Students will be assessed on the use of proper technique in pinning and labelling insect specimens.

Citations

(n.d.). Retrieved from https://www.amnh.org/learn/biodiversity_counts/ident_help/Text_Keys/arthropod_keyA.htm.

Search OSU Extension. (n.d.). Retrieved from https://extension.oregonstate.edu/search?search=pinning+insects.

Unit Plan: Insect Ecology

Unit/Topic: Insect Ecology **Date: Fall**

Standard: 2.6 **Year Level: 11-12**
Outcomes:Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. (HS-LS2-6)

LESSON OUTCOME:

1. Students will be able to explain the role that mountain pine beetles play in the ecosystem and why they have been so successful in recent history.
2. Students will understand the importance of species and age diversity in maintaining a balanced ecosystem.
3. Students will be able to explain the 6 different types of symbiotic relationships found in all ecosystems using specific named insect examples.

LESSON STRUCTURE:

Time	Main Content:	Materials
2 days	**1. Introduction to the mountain pine beetle outbreak in Colorado.** **- Watch the three short videos on pine beetle research, pitch pipe entry and the map of historical spreading.** **-Discuss the methods used to study the outbreak and the potential explanations for the beetles recent success. This is also a good time to discuss the future of the outbreak.** **2. The introductory discussion should lead naturally into questioning how this whole process works.** - **The students will read the pine beetle cartoon and draw out the life cycle of Bufford and Burnedett.** - **After they have mapped the life cycle of Bufford real life examples of larva, pupa and adult from the mealworm colony can be used to model these stages.**	Pine Beetle Researcher (video)Pine Beetle Research Pine Beetle Pitch Pipe (video)Pitch Pipe Entry Pine Beetle Spread in Colorado (video)Spread of Mountain Pine Beetle Colorado Pine Beetle Life Cycle Cartoon (pdf) Pine Beetle Life Cycle Cartoon

3 days	**2. Forest Survey (species and age diversity)** **- Over the next few days students will travel to a forest that has been heavily impacted by mountain pine beetles. Students will collect data on species and age diversity by identifying trees using the key and measuring DBH. They will then travel to a forest plot that has not been impacted by the beetle and do the same. The data will then be processed and the two sites compared.** **-The following discussion should focus on the similarities and differences between the two sites and how this could contribute to the success of the beetle.**	Data collection sheet Tree Survey Worksheet Local tree dichotomous key Tree Key Tape measures
2 days	**3. Symbiotic Relationships (Insect Specific)** - The relationship between the beetle and the lodgepole pine is parasitic/herbivory. This local issue is a great jumping off point for introducing other symbiotic relationships that insects have with organisms in other ecosystems. - The butterfly example is a great introduction and then the students will watch the other videos independently and attempt to identify which type of symbiotic relationship they are watching. - In class we will watch "Queen of Trees" and the students will fill out the worksheet while they watch trying to identify as many symbiotic relationships as they can.	Intro: Blue Butterfly Blue Butterfly example Symbiotic Relationship worksheet Symbiosis Worksheet Definition of Symbiotic relationships 6 Types of Symbiosis "The Queen of Trees" Queen of Trees Worksheet QOT worksheet

SAFETY CONSIDERATIONS/MATERIALS

Field trips to the forest can be dangerous. The lodgepole pine forest that will be used has many dead standing trees so caution should be use while walking around so insure that trees do not fall on students. There is also a large amount of dead fall which can be a hazard.

ASSESSMENT

Students will be tested on the life cycle of the mountain pine beetle and its role in the maintenance of a stable ecosystem along with the 6 different types of symbiotic relationships that involve insects.

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(2018, August 28). Retrieved November 5, 2019, from https://www.pbs.org/video/its-a-goopy-mess-when-pines-and-beetles-duke-it-out-q4ifcw/.

Bonnell, Ann, M., Aguayo, Ingrid, Lisa, Leatherman, … Mason. (n.d.). Year in the life of a mountain pine beetle, A. Retrieved from http://hdl.handle.net/10217/44992.

Life in the Undergrowth. (n.d.). Retrieved from https://www.bbc.co.uk/programmes/b007y9sd.

Queen-of-Trees-Worksheet. (n.d.). Retrieved from https://docs.google.com/document/d/19ehGAzOmA_zX3bfoAFSU_bxEe6qOFm_bufWRXwa5dA4/edit.

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The Queen of Trees. (2015, April 9). Retrieved from https://www.pbs.org/wnet/nature/the-queen-of-trees-introduction/1362/.

Wolfe, E. (2017, April 5). 6 Types of Symbiotic Relationships EXPLAINED (with examples). Retrieved from https://medium.com/countdown-education/6-types-of-symbiotic-relationships-explained-with-examples-2042042fff49.

Unit Plan: Aquatic Insects

Unit/Topic: Aquatic Insects in the Blue River **Date: Fall**

Standard:2.4 **Year Level: 11-12**

Outcomes:Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. (HS-LS2-2) (Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.)

LESSON OUTCOME:

1. **Students will explore the impacts of hard rock mining on the water quality in the Blue River.**
2. **Students will be able to capture and identify local aquatic insects using a macroinvertebrate key.**
3. **Students will be able to use aquatic insects to estimate water quality and species diversity.**

LESSON STRUCTURE:

Time	Main Content:	Materials
1 day	**1. Watch "Poison in the Rockies" to understand mining history in Colorado and the impacts old mines could have on water quality in the Blue river.** **2. Introduce the aquatic insects video showing a mayfly hatch. This is a great review of life cycle and a good introduction to aquatic insects.**	Poison in the Rockies Poison in the Rockies Mayfly Hatch Mayfly hatch
3 days	**2. Field Trip to the Blue river** - **Students will travel to the Blue river over the next 3 days to survey the aquatic insect population along a ¼ mile stretch using waders and a surber net.** **- The students will collect aquatic insects from 3 different sites and separate them with spoons and droppers.** **- using a macroinvertebrate key they will identify and count the individuals.**	Data collection and calculation sheet Data sheet Aquatic Insect Key Aquatic Insect Key
	3. Data Analysis	Simpsons Index Instructions Simpson Index Instructions

1 day	**- In class students will use the data from the population survey to compare species diversity between sites using the Simpson index.** **-They will also use the Biotic Index and the EPT test to estimate water quality. Equations for these calculations are found on the data sheet.**	

SAFETY CONSIDERATIONS/MATERIALS

Field trips can be dangerous. Students should be cautious in and around the river. Samples should be taken in pairs and instructions should be given on how to enter and exit the river safely. Make sure that all students entering the water can swim.

ASSESSMENT

Students will evaluate water quality based on the data collected and the calculations made. This will be done in a written paragraph.

Citations

(n.d.). Retrieved November 5, 2019, from https://www.youtube.com/watch?v=1r1wxLKhE2o.

Home. (n.d.). Retrieved from https://stroudcenter.org/.

MY VALLEY. MY WATERSHED. (n.d.). Retrieved from http://www.roaringfork.org/.

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Young, L. J. (n.d.). Simpsons Index

Unit: Medical Entomology

Unit/Topic: Medical Entomology **Date: Fall**

Standard: 2.7 **Year Level: 11-12**

Outcomes: **Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1) (Clarification Statement: Does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.)**

LESSON OUTCOME:

1. Students will be able to explain basic Mendelian genetics and how they apply to CRISPR.
2. Students will be able to explain how CRISPR could be used to create a gene drive that could be part of an integrated pest management strategy for combating Malaria.
3. Students will apply knowledge of vector borne diseases and integrated pest management stratagies to another vector borne disease other than malaria.

LESSON STRUCTURE:

Time	Main Content:	Materials
2 days	**1. Vector Borne Disease/ Integrated Pest Management** **-introduce vector borne diseases and their impacts on human health using malaria as an example.** **-introduce the concept of Mendelian genetics using the Mendel Notes** **-Have students complete the punnett square worksheet after the notes.** **- introduce CRISPR/cas9 as a genetic engineering tool by watching the CRISPR video.** **- introduce the concept of a gene drive to combat malaria carrying mosquitos by watching the gene drive video.** **-Both videos can be used to engage in classroom discussion about the moral and ethical issues surrounding CRISPR and gene drives. Even if we have the ability to do this should we? Is this a real option for pest management?**	Vector Borne Disease WHO List of Vector Borne Diseases CDC Malaria Life Cycle Mendel Notes Mendel Notes Mendel Worksheet Punnett Square Worksheet Vector Borne Disease Notes Intro to CRISPR CRISPER Intro Gene Drive and Malaria Gene Drive

3 days	**2. Research paper** - **The students will write a 5 paragraph essay a vector borne disease of their choosing.** **-Have the students identify a vector borne disease other than malaria** **-Have them research the life cycle of the disease and the impact on human health.** **- Research current pest management strategies used to combat the disease.** **- Propose other pest management strategies that could be used.**	Integrated Pest Management WHO Integrated Pest Management

SAFETY CONSIDERATIONS/MATERIALS

No safety concern exist for this unit.

ASSESSMENT

Students will be assessed on their research papers.

Citations

(n.d.). Retrieved November 5, 2019, from https://kurzgesagt.org/portfolio/crispr/.

(n.d.). Retrieved from https://www.who.int/docstore/water_sanitation_health/pesticides/ch5.htm.

CDC - Malaria - About Malaria - Biology. (2018, November 14). Retrieved from https://www.cdc.gov/malaria/about/biology/index.html.

Kahn, J. (n.d.). Gene editing can now change an entire species -- forever. Retrieved from https://www.ted.com/talks/jennifer_kahn_gene_editing_can_now_change_an_entire_species_forever?language=en.

Vector-borne diseases. (n.d.). Retrieved from https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases.

Unit: Insects as Food

Unit/Topic: Insects as Food **Date: Fall**

Standard: 2.12 **Year Level: 11-12**

Outcomes: **Biodiversity and Humans: Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.**

LESSON OUTCOME:

1. Students will learn how to care for insects in captivity and potentially use them as a food source.
2. Students will be able to compare and contrast the environmental impacts of traditional food productions systems and the production of insects as an alternative food source.

LESSON STRUCTURE:

Time	Main Content:	Teaching Approaches
	1. Colony creation and up keep throughout the semester. (This was started in Unit 1)	Instructions for colony construction and care. Cricket Farm Instructions
4 days	**2. Research** - **The students will write a 5 paragraph essay comparing traditional agriculture with insect farming .** **- Start this unit by investigating pros and cons of traditional food production systems focusing on environmental impacts and sustainability. The Food Inc. movie is a good place to start and helps to bring up the many issues surrounding industrial farming.** **-Have the students investigate the pros and cons of insect production as an alternative to traditional protein sources focusing on environmental impacts and sustainability. The two videos are good for getting the conversation started.**	Food Inc. Food Inc. Movie The Future of Food The Future of Food Eating Insects Eating Insects

2 days	**3. Research recipes for crickets and potentially try one depending on the success of the cricket colony. Could also order prepared insect food items like Chirp Chips and chocolate-covered ants.** - **Have a little party where the students can have a chance to try and maybe cook insects. This can vary depending on the interest of the students. The attached websites are good places to start.**	Chirps Chirps Website Edible Insects Edible Insect Website Cricket Recipes Chili Lime Crickets Cricket Tacos

SAFETY CONSIDERATIONS/MATERIALS

The biggest safety concern for this unit would be the consumption of insects. All food allergies should be taken into consideration and release forms should be signed by parents before students consume insects.

ASSESSMENT

The assessment for this unit will be a research paper covering the pros and cons of traditional agriculture in comparison to the pros and cons of insect agriculture.

Citations

(2017, October 10). Retrieved November 5, 2019, from https://www.cbc.ca/news/thenational/the-future-of-food-eating-bugs-1.1913694.

Alymoore. (2017, October 2). Cricket Tacos Recipe. Retrieved from https://bugible.com/2016/04/12/cricket-tacos-recipe/.

Chile Lime Crickets. (2017, September 28). Retrieved from http://marxfood.com/cricket-snack-recipe/.

Chips Made with Cricket Flour - As Seen on Shark Tank. (n.d.). Retrieved from https://eatchirps.com/.

Entomophagist. (2019, October 5). Edible Insects For Sale. Retrieved from https://www.edibleinsects.com/edible-insects-for-sale/.

Everything You Need to Know About Eating Insects. (n.d.). Retrieved from https://www.youtube.com/watch?v=95UGrXKDYL0.

Food, Inc. (n.d.).

Skrobonja, E. (2019, April 26). Cricket farming: The ultimate DIY guide. Retrieved from https://www.eatcrickster.com/blog/cricket-farming.

Unit: Insect Conservation

Unit/Topic: Insect Conservation **Date: Fall**

Standard: 2.6 **Year Level: 11-12**

Outcomes:Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic Engagement)

LESSON OUTCOME:

Students will be able to identify and evaluate the the threats that insects face using examples from the Monarch migration and the decline of honey bees.

Students will evaluate the challenges faced by a named endangered insect and be able to develop a conservation strategy based on the specific challenges that species faces.

LESSON STRUCTURE:

Time	Main Content:	Teaching Approaches
1 day	**1. Monarchs** - **Students will research an endangered insect based on the Red List and write a proposal for its conservation. The proposals will be judged by a panel of fellow teachers and a winner will be selected.** **- Start the discussion about conservation by introducing the migration of monarch butterflies and challenges they face.**	The Incredible Journey of the Monarch Butterfly Monarch Migration

2 days	**2. Insect Decline** - **The decline of insects world wide could have major impacts on all ecosystems. The issue of the honey bee decline is one example of these far reaching impacts** **- discuss the decline of pollinators worldwide using honeybees and sudden colony collapse as an example.** **- Have the students read the two articles on insect decline and discuss the decline of insect biomass worldwide and the potential impacts of this decline on the stability of all ecosystems.**	Who Killed the Honey Bee Who Killed the Honey Bee Insect Apocalypse Article Insect Apocalypse Insect Apocalypse Counter Article Counter Article
4 days	**3. Endangered Species Proposal** **- Using the "Red List" have the students identify an insect that is currently endangered and create a proposal for its conservation based on the UNESCO conservation guidelines provided.**	IUCN Red List IUCN Red List UNESCO Conservation Stratagies UNESCO Conservation Stratagies

SAFETY CONSIDERATIONS/MATERIALS

There are no safety concerns for this unit

ASSESSMENT

Students will be assessed based on their conservation proposals.

Citations

EOLSS is the Largest On-line Encyclopedia. (n.d.). Retrieved from https://www.eolss.net/.

IUCN Red List of Threatened Species. (n.d.). Retrieved from https://www.iucnredlist.org/.

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Yong, E. (2019, February 19). Is the Insect Apocalypse Really Upon Us? Retrieved from https://www.theatlantic.com/science/archive/2019/02/insect-apocalypse-really-upon-us/583018/.