Draft planning

BIOD59 Topics

Edward choices: (Although I’m okay with any topics)

1. [Option 7. Host-parasite cycles in a warning climate]

2. [Option 4. Population viability of northern right whales]

3. [Option 5. Fish farms, climate change and sex ratio of American Crocodile].

Pranav choices (copied from the email conversations and pasted here by Edward) :

1. **[Option 8. Controlling a mysterious killer: white-nose syndrome in bats.]**

2. [Option 5. Fish farms, climate change and sex ratio of American Crocodile].

3. [Option 4. Population viability of northern right whales]

“Although I am tied between option 4&5, I just think I want to explore other uses of models than just population dynamics. That’s why I chose to put 5 over 4. But, yes, 8 is my first preference.”

Joey, Pranav said to let you see what your opinions are on the currently chosen options, before emailing Juan. If you’re okay with any topics, we could send in Pranav’s 3 choices to Juan by tonight (I would prefer if you or Pranav email Juan the group and 3 topic choices before 11:59pm), but if you’re really got your heart set on something else, let us know as well. Also since you did mention that you use your utmail more frequently, you could cc the email conversations that was cced to your gmail to your utmail as well.

-Edward

I’d prefer it utmail or Facebook

-Pranav

**Hey guys,**

**Our topic for the BIOD59H Research Project is [Option 8] Controlling a mysterious killer: white-nose syndrome in bats.**

**Apologies for such a long email!**

**Firstly, since communication has been a bit of a problem right now. I would like to make this our official email thread to communicate about the project. I have added all the emails that I have for both of you. If you use another email that you use more often, when you reply to this email please CC that email too, so you are up to date with anything that happens. If I am ever unresponsive, you can message me on facebook: facebook.com/pranav.sadana07**

**Secondly, we will be use the google doc for literature review and typing up the final paper. When you want to share an article please add a citation and a link. It would just make it easier for us to read the article's title to figure out where we can use it in our paper (instead of having to go out and opening every link to find one article).**

**Thirdly, but most importantly, yesterday, I got a chance to talk to both Juan and Peter and they have give us some pointers for the project:**

**Juan (these are not hard quotes):**

**A good starting point would be to look at the literature to explore the causes and transmission of the disease. It is essentially a disease transmission model. HOWEVER, there is an added layer of complexity required to make this an actual research project: Metapopulation modelling. We will have to incorporate our disease transmission model into the metapopulation model. How do we do that? - that is going to be one of the challenges with the project. But before we begin any of the modelling, we would have to come up with a clear and focused research question that would lead to an outline of the paper too. Some of the things we could look into: disease control strategies, population viability analyses, etc. It would be interesting (and imperative) to account for reproduction strategies of these bats.**

**Peter:**

**He basically re-emphasized a lot of the same stuff. He has given us some pointers for the metapopulation models: We would have to modify Levin's model (apparently taught in BIOB50, I never took that course so I don't really know), by adding some terms. Also, since it is a complex modeling paper, he has asked us to read up more on it and take the weekend to decide if we want to do this. Nonetheless, he thinks that we are a good group for this project and we should be able to do well on the paper. He also should also use the kind of figure we are going to use to get an outline for the paper which would also help us direct our research. Moreover, he has send me an email today (quoted below) that which gives us a direction to look into.**

**"Only emailing to you for now as I don't have the list of groups from Juan yet. But please forward to your group mates, too.**

**The challenge of the bat project is that there are both disease dynamics within each colony and that they are also linked between colonies via immigration/emigration. There are many ways to approach this problem, but one starting point that you could look into is Hess 1996 (Disease in metapopulation models: implications for conservation), Ecology 77, 1617-1632, which is the classic paper for disease in metapopulations as it builds on Levins' classic model for metapopulations without disease."**

**I have attached the paper Peter has recommended, so it is easier for us to access it.**

**Let me know if you need any clarifications on anything. Or if you're confused, it is all right. We will figure this out together. If we are ever so lost, we can always reach out to Juan and Peter for help.**

**I am actually pretty excited to start working on this with you guys! Have a nice long weekend!**

**Best,**

**Pranav**

**Since we are focusing on the Little Brown Bat, here’s some summaries about it from the Canadian wildlife Federation**

[**http://cwf-fcf.org/en/resources/encyclopedias/fauna/mammals/little-brown-bat.html**](http://cwf-fcf.org/en/resources/encyclopedias/fauna/mammals/little-brown-bat.html)

* **“ Even though Little Brown Bats do not usually migrate to destinations outside of Canada, individuals can move up to 1000 km from summer roosts to winter roosts where they hibernate” (Hibernating places are called hibernacula) (Possibly maximal distance)**
* **“Most Little Brown Bats of more than one year old will mate in the fall when great groups swarm together. Individuals can mate several times with different kmpartners.” (Age of Reproductive age = 1+)**
* **“Females will store the males’ sperm throughout the winter until they ovulate in the spring.” (Breed in Fall/Winter, Birth in Summer)**
* **“After a gestation of 50 to 60 days, depending on the condition and age of the female, a single pup is born in June or July.” (1 female = 1 pup; litter size = 1)**
* **Little brown bats form a strong attachment to their maternity site and will return year after year to the same location. (High preference for 1 cave = metapopulation idea)**

**The sources of this could be used for basic data for designing our models parameters**

[**https://www.registrelep-sararegistry.gc.ca/virtual\_sara/files/plans/rs\_LittleBrownMyotisNorthernMyotisTricoloredBat\_e\_proposed.pdf**](https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_LittleBrownMyotisNorthernMyotisTricoloredBat_e_proposed.pdf)

* **Little Brown Myotis appear to derive energetic and water conservation benefits from clustering while hibernating. (Population survival/persistence shows Allee effect)**
* **A mark-recapture study in Manitoba and northwestern Ontario found only 4% of marked individuals relocated to an alternate hibernaculum within the study period (Norquay et al. 2013). (4 percent migration rate to other caves)**
  + **Female Little Brown Myotis show a relatively high degree of philopatry8 (Frick et al. 2010b). Roosting areas are generally used annually and individual natural roost sites can be used for upwards of 10 years (M. Brigham, pers. comm.). Little Brown Myotis are particularly loyal to anthropogenic structures and sites may be used for 50 years or more (M. Brigham, pers. comm.). (4 % may only refer to females)**
  + **Males roost individually or in small groups and periodically switch roosts. In Quebec, males switched roosts approximately every 2 days (Fabianek et al. 2015). (Males more likely to move between alternative roosts = carrier of WNS more likely)**

**- Little Brown Myotis, Northern Myotis, and Tri-colored Bat are considered short-distance migrants, radiating annually from overwintering areas to summering areas in any direction (Fraser et al. 2012, COSEWIC 2013). In Manitoba and Ontario, Little Brown Myotis migrated regionally 35 to 554 km (median 463 km) (Fenton 1970, Dubois and Monson 2007, Norquay et al. 2013). (More prefered distance)**

**-As noted above, swarming sites may serve as migratory stopover locations (Fenton 1969) and are likely used annually (Rydell et al. 2014). (Intermediate roosting patches between caves)**

* **In addition, yearling survival is low (0.23 to 0.46) (Frick et al. 2010b). In a recent pre-WNS study from New Hampshire, the annual population growth rate of Little Brown Myotis over 16 years was estimated to be 1.008 (Frick et al. 2010b). In 22 subpopulations in the northeastern U.S, the population growth rate was estimated to be 0.98-1.2 (Frick et al. 2010a). (2010 growth rate = 0.98-1.2)**
* **Predicted population growth rates for Little Brown Myotis in the northeastern U.S. post-WNS was 0.95 (Maslo et al. 2015). (Growth rate might drop to 0.95 in a 5 year span)**

**-WNS**

* **almost all of the identified mortality associated with WNS has been during hibernation when the immune functions of bats are reduced (Cryan et al. 2010). Additionally, Fuller et al. (2011) tracked individual Little Brown Myotis and found wing damage caused by WNS healed to some degree 10 Fungi that can cause infections of the skin, hair, and nails due to their ability to utilize keratin. Recovery Strategy for Little Brown Myotis, Northern Myotis, and Tri-colored Bat 2015 28 throughout the summer.**
* **Prevalence decreases during the summer months, likely as a result of body temperatures above that required for P. destructans (Langwig et al. 2015b).**
* **In eastern Canada and the northeastern United States, WNS mortality rates are typically low (i.e., 20%) in the first year of detection, followed by high levels (i.e., >70%) within two years (Frick et al. 2010a). (20% mortality first year, 70+% by the second year) (Fungus is time-delayed)**
* **Transmission of P. destructans does not appear to be associated with winter colony sizes or influx of susceptible individuals after the mating season (Langwig et al. 2015b). (Transmission rate is constant regardless of how large colony is or how many individuals are susceptible; may be frequency dependent)**

[**https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments/little-brown-myotis-technical-summary-2012.html#\_fig01**](https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments/little-brown-myotis-technical-summary-2012.html#_fig01)

[**https://www.psu.edu/dept/nkbiology/naturetrail/speciespages/little\_brown\_bat.html**](https://www.psu.edu/dept/nkbiology/naturetrail/speciespages/little_brown_bat.html)

**- Emerging males and females mate repeatedly and with multiple partners prior to flying to their summer roosting areas. The pregnant females group together in a nursery roost that is notable for its warm temperatures (pregnant females are not able to thermoregulate very efficiently). After fifty to sixty days gestation each female gives birth to a single pup. (Main focus is on the mothers who group together in the winter for our “caves”)**

**-Females become sexually mature around nine months and males become sexually mature at one year of age. A little brown bat, especially if it survives its first winter, may live twenty or even thirty years. (Average life span = 20-30 years, sexual maturity is 1+)**

# **Long-distance movements of little brown bats (Myotis lucifugus)**

(Travel distances of bats between cave roosting sites)

[**https://www-jstor-org.myaccess.library.utoronto.ca/stable/23488381?pq-origsite=summon&seq=2#metadata\_info\_tab\_contents**](https://www-jstor-org.myaccess.library.utoronto.ca/stable/23488381?pq-origsite=summon&seq=2#metadata_info_tab_contents)

**Body condition explains little of the interindividual variation in the swarming behaviour of adult male little brown myotis (Myotis lucifugus) in Nova Scotia, Canada**

**(Proves that infected males have the same migratory rates from cave to cave as fit males)**

[**https://go-gale-com.myaccess.library.utoronto.ca/ps/i.do?p=CPI&u=utoronto\_main&id=GALE|A419412501&v=2.1&it=r&sid=summon**](https://go-gale-com.myaccess.library.utoronto.ca/ps/i.do?p=CPI&u=utoronto_main&id=GALE%7CA419412501&v=2.1&it=r&sid=summon)

**How to model all of this:**

* **3 roosting sites (circles) arranged in a right angle triangle (top left hand, bottom left hand, bottom right hand)**
  + **Bottom left circle is used as an intermediate migratory site between top left and bottom right (all have the same starting population)**
* **Top left is infected**
* **Run SIR to determine population viability in top left hand circle of “remaining” mothers**
  + **Calculate the amount of pups (“susceptible population”) and divide by 2 (50% male, 50% female) to get amount of susceptible mothers**
* **Assume that every year, a certain amount flies off from the infected colony to other roosting sites**

# **Dynamic, spatial models of parasite transmission in wildlife: Their structure, applications and remaining challenges**

(Edward’s Opinion: This gives a better visual idea of how we could build our metapopulation model than the original paper)

### [**https://besjournals-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/1365-2656.12761**](https://besjournals-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/1365-2656.12761)

**Estimating Extinction Risk with Metapopulation Models of Large‐Scale Fragmentation**

**(Edward’s opinion: We could use this as a modelling example to calculate patch (“caves”) distance and probability of individuals/migrants moving between patches)**

[**https://conbio-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/cobi.12047**](https://conbio-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/cobi.12047)

### **Spatiotemporal Structure of Host‐Pathogen Interactions in a Metapopulation**

<https://www-jstor-org.myaccess.library.utoronto.ca/stable/10.1086/603624?pq-origsite=summon&seq=1#metadata_info_tab_contents>

### 

### **Effect of Humidity on Development of *Pseudogymnoascus destructans*, the Causal Agent of Bat White-Nose Syndrome**

[**https://journals-scholarsportal-info.myaccess.library.utoronto.ca/details/10926194/v24i0001/54\_eohodocaobws.xml**](https://journals-scholarsportal-info.myaccess.library.utoronto.ca/details/10926194/v24i0001/54_eohodocaobws.xml)

# **White-Nose Syndrome fungus introduced from Europe to North America**

<https://www-sciencedirect-com.myaccess.library.utoronto.ca/science/article/pii/S0960982215000792>

# **Host and pathogen ecology drive the seasonal dynamics of a fungal disease, white-nose syndrome**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4286034/?tool=pmcentrez&report=abstract>

# **Resistance in persisting bat populations after white-nose syndrome invasion**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5182440/?tool=pmcentrez&report=abstract>

# **Inoculation of bats with European *Geomyces destructans* supports the novel pathogen hypothesis for the origin of white-nose syndrome**

(Edward opinion) This shows a decrease in mortality of pathogen over a long period of time

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3344949/?tool=pmcentrez&report=abstract>

# **Temperature-dependent growth of Geomyces destructans, the fungus that causes bat white-nose syndrome.**

<https://doaj.org/article/d115b7c2a828400cb7bbd8868cb66585>

# **Sociality, density‐dependence and microclimates determine the persistence of populations suffering from a novel fungal disease, white‐nose syndrome**

<https://onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/j.1461-0248.2012.01829.x>

# **Pan-European distribution of white-nose syndrome fungus (Geomyces destructans) not associated with mass mortality.**

<https://doaj.org/article/80bd4703ad0c497d9494f799348c03d1>

# **Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology**

(Edward opinion) How this fungus “kills” bats

<https://bmcbiol.biomedcentral.com/articles/10.1186/1741-7007-8-135>

# **Pathophysiology of white-nose syndrome in bats: a mechanistic model linking wing damage to mortality**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3730627/?tool=pmcentrez&report=abstract>

# **Destructin-1 is a collagen-degrading endopeptidase secreted by *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4475985/>

# **Multiscale model of regional population decline in little brown bats due to white‐nose syndrome**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6686297/>

# **A review of bat hibernacula across the western United States: Implications for white-nose syndrome surveillance and management**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6209190/>

**The Antifungal Properties of Epidermal Fatty Acid Esters: Insights from White-Nose Syndrome (WNS) in Bats**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6222711/>

**Determinants of Pseudogymnoascus destructans within bat hibernacula: implications for surveillance and management of white-nose syndrome**

[**https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5877478/**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5877478/)

**Resistance in persisting bat populations after white-nose syndrome invasion**

[**https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5182440/**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5182440/)

**Deconstructing the Bat Skin Microbiome: Influences of the Host and the Environment**

[**https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5112243/**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5112243/)

**The Effects of Cutaneous Fatty Acids on the Growth of Pseudogymnoascus destructans, the Etiological Agent of White-Nose Syndrome (WNS)**

[**https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4829186/**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4829186/)

**Host persistence or extinction from emerging infectious disease: insights from white-nose syndrome in endemic and invading regions**

**(Edward’s opinion: This could be the main direction for why are we constructing a model)**

[**https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4810858/**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4810858/)

**Efficacy of Visual Surveys for White-Nose Syndrome at Bat Hibernacula**

**(All this shows is that fungus persists at cave location once introduced despite whether bats are present or not)**

[**https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4509758/**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4509758/)

# **Invasion Dynamics of White-Nose Syndrome Fungus, Midwestern United States, 2012–2014**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4451901/?tool=pmcentrez&report=abstract>

# **The resistance of a North American bat species (Eptesicus fuscus) to White-nose Syndrome (WNS).**

(Edward opinion) Shows that resistance can be developed in North America

<https://doaj.org/article/3af6c8a7d5aa419ba0d026d2b41ccc07>

# **Effects of white‐nose syndrome on regional population patterns of 3 hibernating bat species**

<https://conbio-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/cobi.12690>

# **White-nose syndrome without borders: *Pseudogymnoascus destructans* infection tolerated in Europe and Palearctic Asia but not in North America**

(Edward opinion) Introduce the idea of fungal load to density relationship

<https://www.nature.com/articles/srep19829>

# **Pathogen dynamics during invasion and establishment of white‐nose syndrome explain mechanisms of host persistence**

<https://esajournals-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1002/ecy.1706>

# **Conservation implications of ameliorating survival of little brown bats with white-nose syndrome**

<https://www-jstor-org.myaccess.library.utoronto.ca/stable/24700332?pq-origsite=summon&seq=1#metadata_info_tab_contents>

# **Distribution and Environmental Persistence of the Causative Agent of White-Nose Syndrome, *Geomyces destructans*, in Bat Hibernacula of the Eastern United States**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3568617/?tool=pmcentrez&report=abstract>

# **A review of bat hibernacula across the western United States: Implications for white-nose syndrome surveillance and management.**

<https://doaj.org/article/d2388c82db5843258b50ab80d8163142>

# **Spread of white-nose syndrome on a network regulated by geography and climate**

<https://www-nature-com.myaccess.library.utoronto.ca/articles/ncomms2301>

# **Fungal disease and the developing story of bat white-nose syndrome** (Edward opinion) Basics of history of fungus

[https://go-gale-com.myaccess.library.utoronto.ca/ps/i.do?p=CIC&u=utoronto\_main&id=GALE|A304466727&v=2.1&it=r&sid=summon](https://go-gale-com.myaccess.library.utoronto.ca/ps/i.do?p=CIC&u=utoronto_main&id=GALE%7CA304466727&v=2.1&it=r&sid=summon)

# **Efficacy of Visual Surveys for White-Nose Syndrome at Bat Hibernacula.**

(Edward opinion) How data is limited in collection methodology

<https://doaj.org/article/a434c7e289374db78cfc5b80541a957f>

# **Conservation implications of physiological carry‐over effects in bats recovering from white‐nose syndrome**

(Edward Opinion) Shows how the fungus infects all bats in the same cave simultaneously and all bats that “recover/survive death” “gets rid of pathogen within couple of weeks”

<https://conbio-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/cobi.12841>

# **Host persistence or extinction from emerging infectious disease: insights from white-nose syndrome in endemic and invading regions**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4810858/?tool=pmcentrez&report=abstract>

### **Predicting bat colony survival under controls targeting multiple transmission routes of white-nose syndrome**

(Edward’s Opinion: We could follow this paper for deciding on model design, it uses a variation of S.I.R. modelling)

<https://journals-scholarsportal-info.myaccess.library.utoronto.ca/details/00225193/v409icomplete/60_pbcsucmtrows.xml>

# **Galleria mellonella as an insect model for P. destructans, the cause of White-nose Syndrome in bats.**

<https://doaj.org/article/b8054dd0842b4d93a3709442cafab0f1>

# **Investigating and Managing the Rapid Emergence of White-Nose Syndrome, a Novel, Fatal, Infectious Disease of Hibernating Bats**

<https://www-jstor-org.myaccess.library.utoronto.ca/stable/27976455?pq-origsite=summon&seq=2#metadata_info_tab_contents>

# **Tree roosts of northern long‐eared bats following white‐nose syndrome**

(Edward Opinion) How bats choose roosting sites

<https://wildlife-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1002/jwmg.21411>

# **Higher fat stores contribute to persistence of little brown bat populations with white‐nose syndrome**

<https://besjournals-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/1365-2656.12954>

**MODELING THE ENVIRONMENTAL GROWTH OF *PSEUDOGYMNOASCUS DESTRUCTANS* AND ITS IMPACT ON THE WHITE-NOSE SYNDROME EPIDEMIC**

**(Edward opinion: Shows models on persistance of diesease and gives an example of a model that shows how susceptible gets disease)**

<https://bioone-org.myaccess.library.utoronto.ca/journals/Journal-of-Wildlife-Diseases/volume-51/issue-2/2014-06-157/MODELING-THE-ENVIRONMENTAL-GROWTH-OF-PSEUDOGYMNOASCUS-DESTRUCTANS-AND-ITS-IMPACT/10.7589/2014-06-157.full>

# **The potential impact of white-nose syndrome on the conservation status of north american bats.**

<https://doaj.org/article/edb7769e1c9b497b98fa5c500cacd6fd>

# **Determinants of *Pseudogymnoascus destructans* within bat hibernacula: Implications for surveillance and management of white‐nose syndrome**

<https://besjournals-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/1365-2664.13070>

# **Host, pathogen, and environmental characteristics predict white-nose syndrome mortality in captive little brown myotis (Myotis lucifugus).**

<https://doaj.org/article/574ce0e8259a49e78bee75fff3215bb2>

# **White-nose syndrome dramatically altered the summer bat assemblage in a temperate Southern Appalachian forest**

(Edward Opinion) How fungus affects summertime population sizes

<https://www-sciencedirect-com.myaccess.library.utoronto.ca/science/article/pii/S1616504719300394>

**Estimating the short-term recovery potential of little brown bats in the eastern United States in the face of White-nose syndrome**

[**https://www-sciencedirect-com.myaccess.library.utoronto.ca/science/article/pii/S0304380015003221**](https://www-sciencedirect-com.myaccess.library.utoronto.ca/science/article/pii/S0304380015003221)

# **White-nose syndrome detected in bats over an extensive area of Russia**

(Edward Opinion) fungus very prevalent but infection is low

<https://doaj.org/article/b05c5ba00d6049b282ed51d351bfc26a>

# **White-nose syndrome survivors do not exhibit frequent arousals associated with *Pseudogymnoascus destructans* infection**

(Edward’s opinion: Shows that survivors may have lower mortality rates)

<https://frontiersinzoology.biomedcentral.com/articles/10.1186/s12983-016-0143-3>

**BATS RECOVERING FROM WHITE-NOSE SYNDROME ELEVATE METABOLIC RATE DURING WING HEALING IN SPRING**

<https://bioone-org.myaccess.library.utoronto.ca/journals/Journal-of-Wildlife-Diseases/volume-54/issue-3/2017-08-195/BATS-RECOVERING-FROM-WHITE-NOSE-SYNDROME-ELEVATE-METABOLIC-RATE-DURING/10.7589/2017-08-195.full>

# **Winter Activity of Coastal Plain Populations of Bat Species Affected by White-Nose Syndrome and Wind Energy Facilities.**

<https://doaj.org/article/61c9ff423a20471bb4d5419f47f5931f>

# **Ectoparasites may serve as vectors for the white-nose syndrome fungus**

<https://parasitesandvectors.biomedcentral.com/articles/10.1186/s13071-016-1302-2>

# **Could localized warm areas inside cold caves reduce mortality of hibernating bats affected by white-nose syndrome?**

<https://www-jstor-org.myaccess.library.utoronto.ca/stable/20696435?pq-origsite=summon&seq=1#metadata_info_tab_contents>

# **Population genetic structure of a common host predicts the spread of white‐nose syndrome, an emerging infectious disease in bats**

<https://onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/mec.13396>

# **Phenotypic Divergence along Geographic Gradients Reveals Potential for Rapid Adaptation of the White-Nose Syndrome Pathogen, Pseudogymnoascus destructans, in North America**

<https://aem-asm-org.myaccess.library.utoronto.ca/content/84/16/e00863-18>

# **A case study of bats and white‐nose syndrome demonstrating how to model population viability with evolutionary effects**

(Edward opinion: Paper gives some Reproduction rates and survival rates)

<https://conbio-onlinelibrary-wiley-com.myaccess.library.utoronto.ca/doi/full/10.1111/cobi.12485>

# **Changes in body condition of hibernating bats support the thrifty female hypothesis and predict consequences for populations with white-nose syndrome.**

(Edward Opinion) How fungus decrease weight decreases reproductive success

<https://doaj.org/article/39b24b81cfdb4f34a99dc3bb8f5be064>

# **Environmental conditions associated with bat white-nose syndrome mortality in the north-eastern United States**

<https://www-jstor-org.myaccess.library.utoronto.ca/stable/23259065?pq-origsite=summon&seq=1#metadata_info_tab_contents>

# **Range-Wide Genetic Analysis of Little Brown Bat (Myotis lucifugus) Populations: Estimating the Risk of Spread of White-Nose Syndrome.**

<https://doaj.org/article/a57c959758eb46cd9f7427b488e7ca8e>

# **Multi-scale model of epidemic fade-out: Will local extirpation events inhibit the spread of white-nose syndrome?**

(Edward opinion: Model Simulation of Little bat populations under white nose syndrome)

<https://www-jstor-org.myaccess.library.utoronto.ca/stable/24432039?pq-origsite=summon&seq=1#metadata_info_tab_contents>

# **Going, going, gone: the impact of white-nose syndrome on the summer activity of the little brown bat (*Myotis lucifugus*)**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3097845/?tool=pmcentrez&report=abstract>

# **White-nose syndrome has almost completely wiped out some North American bat colonies**

<https://www-sciencemag-org.myaccess.library.utoronto.ca/news/2015/02/white-nose-syndrome-has-almost-completely-wiped-out-some-north-american-bat-colonies>

**Economic Importance of Bats in Agriculture**

[**https://science-sciencemag-org.myaccess.library.utoronto.ca/content/332/6025/41/tab-pdf**](https://science-sciencemag-org.myaccess.library.utoronto.ca/content/332/6025/41/tab-pdf)

### **Enhanced Surveillance for White-Nose Syndrome in Bats**

(Edward Opinion) limitations on data collection

<https://wwwnc.cdc.gov/eid/article/18/3/11-1751_article>

### **Bats in Southwest Wisconsin During the Era of White-Nose Syndrome**

<https://journals-scholarsportal-info.myaccess.library.utoronto.ca/details/10926194/v26i0001/168_biswdteows.xml>

### **White-Nose Syndrome Disease Severity and a Comparison of Diagnostic Methods**

<https://journals-scholarsportal-info.myaccess.library.utoronto.ca/details/16129202/v13i0001/60_wsdsaacodm.xml>

# **Multiscale model of regional population decline in little brown bats due to white‐nose syndrome**

<https://doaj.org/article/361ead2204ee48f786a4019b826727d3>