Stress In Nature Outline

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**Introduction**

1. Pose the problem

* Climate change: The potential effects, how will warming affect species? What species are at most risk? Is there a better way to make predictions of how warming will affect species?
* Should I mention Hsp’s in the first paragraph? No, go from broad to specifc; also, 1 big concept/idea per paragraph

Models ofclimate change predict global temperature increases for terrestrial ecosystems (Deutsch et al. 2008).

Ecotherms, such as ants, are particularly vulnerable to warming because they acquire heat from their external environment, linking temperature to many of their physiological functions (Deutsch et al. 2008). (maybe rephrase, just talk about threats to ectotherms and how that may affect ecosystems?)

Species experiencing temperatures above their optimum for too long may avoid unfavorable conditions by migrating to cooler regions or adapting to new warm conditions, but whether either of these is possible depends on the variation of physiological mechanisms organisms utilize to cope with temperature and the connectivity of the landscape to the severity of thermal stress experienced (Walther et al. 2002). (paragraph 2?)

Current predictions of species response to climate change depend on measures of their lethal thermal limits, yet organisms experience costs to their physiological functions far before reaching their ecological death (Evans & Hoffman 2012).

For better-informed predictions of how keystone species will react to warming, we need to include measures of sub-lethal heat stress

1. Address the Problem/ How has the problem been addressed \*\* prob talk about ants somewhere in this section or between section 2 nd 3

* Experimental warming studies: These are a good way to study the long-term effects of warming to asses which species/locations may be most negatively impacted from potential climate change.
* \* Mention differences in thermal tolerance? ok
* \*what specifically are the impacts?

Experimental warming studies are a good way to observe the long-term effects of warming on keystone species that inhabit diverse thermal environments to assess their response to warming given their natural thermal environments.

(talk about thermal adaptation/ species potential plasticity to heat stress?)

The effects of experimental warming in a northern and southern deciduous forest showed foraging abilities of ant species were more negatively impacted by warming in the southern forest, where species generally display lower critical thermal maxima (Stuble et al. 2013).

Warmer-adapted ectotherms live near their optimal temperature and can tolerate relatively narrow temperature fluctuations, suggesting southern species may experience more thermal stress and negative physiological consequences from warmer temperatures (Deutsch et al. 2008).

Another study comparing historic and experimental data on the effects of warming on ant assemblages in southern forests revealed physiological differences, such as thermal tolerance, are difficult to use alone when assessing species response to climate change over a longer period of time (Resasco et al. 2014).

1. What is a novel way to address the problem?

* Can experimental warming studies to be used to measure sub-lethal stress?
* Hsp’s: Highly conserved molecular chaperones induced by unfavorable temperature to cope with protein damage. Highly responsive to thermal perturbation
* Has been used as a proxy for sub-lethal stress in other systems. Has shown plastic response/ clinal variation in responsiveness to thermal stress

(start with an example of hsps as a biomarker for stress?) no, cite papers that say they’re a good biomarker

When environmental factors − such as temperature − inflict protein damage, organisms utilize the cellular stress response (CSR) to cope with heat stress (Morris et al. 2013).

In response to sub-lethal stress the CSR induces transcription of molecular chaperones called heat shock proteins (Hsps) to assist with the refolding or denaturing of unfolded proteins (Li & Srivastava 2004).

Heat shock experiments in the field and laboratory show ectothermic marine species acclimatized to diverse thermal conditions display clinal variation in Hsp expressionand demonstrate *hsp70, hsp40,* and *hsp83* to be inversely associated with sub-lethal stress (Jost et al. 2015; Oksala et al. 2014; Tomanek & Somero 2000).

The inducible nature of *hsp70* in response to unfavorable temperature and the assistance provided from *hsp40* and *hsp83* co-chaperones to stabilize, denature, or refold damaged proteins makes these three heat shock proteins potential proxies for sub-lethal stress invoked by unfavorable temperature.

(something to link part 3 and 4?)

1. Why/How will we answer the problem? Suggest an Answer

* Objective, study system, hypothesis, predictions

Our overall objective was to assess the potential impacts of warming in wild populations of the ant genus *Aphaenogaster* using Hsps as a proxy by long-term exposure to experimental warming chambers located at a northern (Harvard Forest, MA) and a southern (Duke Forest, NC) site.

The common woodland ant genus, *Aphaenogaster,* are a good model to study species responses to climate change because they occupy temperate deciduous forests from Maine to Florida, where they serve as primary seed dispersers and experience very diverse thermal environments (Warren & Chick 2013). The upper thermal limits of *Aphaenogaster* are inversely associated with latitude, but these limits do not shift as fast as environmental temperatures, suggesting that southern *Aphaenogaster* populations survive closer to their lethal limit and may face greater heat stress than northern populations (Diamond et al. 2013).

Ants experiencing unfavorable temperatures due to experimental warming will up-regulate Hsp transcription indicating an increase in protein damage and the degree to which these ants are stressed when exposed to warmer temperature from a northern and southern location.

We predict Hsp expression will increase with experimental temperature for colonies at the southern site (Duke Forest, North Carolina), their narrow range of thermal tolerance will cause southern populations to survive closer to their critical thermal maxima and experience more sub-lethal stress from warmer temperature (Deutsch et al. 2008; Diamond et al. 2013). However, we predict Hsp expression in *Aphaenogaster* from the northern site (Harvard Forest, Massachusetts) will remain relatively constant across temperatures because they survive below their optimal temperature, so an increase in temperature may push colonies closer to their optimum reducing levels of sub-lethal stress (Deutsch et al. 2008; Diamond et al. 2013)