Introduction (927 of 1000 characters)

The relationship between animal pollinator species and the crops that they propagate is a necessary problem to elucidate due to recent decreasing density of pollinator species. Studying the co-occurrence of origination, ages, and ranges of pollinators and the species they propagate will give information on how vital pollinators are to ecosystems and possibilities for preserving these players in crop cultivation (Connor & Simberloff, 1983). Age of occurrences and species ranges should co-occur between pollinator and crop species. With the examination of correlations, there can be further study of the necessity of animal pollinators for the success of crop species, not just origination. I will collect necessary age and range data from the Paleobiology Database and Neotoma Paleobiology Database of pollinators, *Chiroptera, Anthophila, Lepidoptera,* and crop species *Brassica* and *Rosaceae* to examine these relationships.

Justification (2149 of 2500 characters)

Crop propagation is a growing issue with the earth's rapid change in climate. Not only is it more difficult to maintain crops due to droughts, floods, and soil conditions but is also due to a decrease in density of pollinators. Of chief importance is the predicted disappearance of bees due to climate change (Memmott, 2007). Decreases in bumble bee density has also been due to the introduction of foreign bee species in recent years, increasing the necessity of interventions to manually distribute colonies and monitor the observed change flight patterns of these species (Goulson, 2008). The overall decrease in natural animal pollinators has been correlated to a loss in plant species that depend on animal vectors for seed dispersal (Biesmeijer, 2006; Olesen, 2007). Plant species that rely on animal pollinators have also been shown to experience habitat fragmentation, which is deleterious to the propagation and survival of the species due to edge effects (Aguilar, 2006). Food crops are not the only group at risk of a decline in propagation; a study by Haussmann et. al. has also found a dependence in success of city trees on wild bee pollination, with implications for the preservation green spaces in cities (2016). Current solutions to bee population decline include artificial design of networks for pollinators, manual transportation of pollinators to suffering areas, and creating forage patches (Cane, 2001).

There are some conclusions drawn regarding the robustness of pollinator species compared to pollinator decreases in experimentally simulated studies (Astegiano, 2015; Vieira, 2013; Memmott, 2004). These studies however, focus on present-day relationships, are experimentally designed and controlled, and examines the effects that pollinator loss has on generalized species or on specific regions (Cianciaruso, 2013). Paleontological studies focus on specific time periods and insect species to examine past pollination behaviors in floral communities (Wappler et. al., 2015; Crepet, 1996). The study proposed focuses on more general past relationships to elucidate how present-day relationships can be improved.

Research Plan (1382 of 2500 characters)

Data for this project will be collected from the Paleobiology Database, created by the UW Department of Geoscience, and the Neotoma Paleobiology Database and analyzed using R studio. All occurrences for *Chiroptera* (bats), *Anthophila* (bees), *Lepidoptera* (moths), *Brassica* (cruciferous plants), and *Rosaceae* (flowering fruits) will be collected. These animal species are all pollinators of the two plant species listed so conclusions could be generalized across relationships. I will also travel to the University of Kansas in Lawrence, KS to document their extensive *Apoidea* (bee) fossil collection along with the world's largest collection of bee fossils in Baltic amber from the American Museum of Natural History in New York City, NY. This data will also be examined once documented in the PaleoBioDB. Average age and range will be reported after compiling collections. Then data will be cleaned to account for sampling biases and analyzed for Jaccard similarity indices. Jaccard distances will then be compared to find which pollinator and crop species are most similar. The most similar species are most likely species that heavily rely on that animal pollinator for propagation. Overall, this information can assist with further data collection of occurrences for the preservation of natural habitats or the creation of artificial habitats to maintain pollinator density.

References (2461 of 2500 characters)

Aguilar, R., Ashworth, L., Galetto, L., & Aizen, M. A. 2006. Plant reproductive susceptibility to habitat fragmentation: review and synthesis through a meta-analysis. *Ecology Letters* 9(8), 968-80.
Astegiano, J., Massol, F., Vidal, M. M., Cheptou, P. O. & Guimaraes, P.R. 2015. The Robustness of Plant-Pollinator Assemblages: Linking Plant Interaction Patterns and Sensitivity to Pollinator Loss. *Plos One* 10(2), 16.
Biesmeijer, J.C., et. al. 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science* 313(5785), 351-54. Cane, J. H. 2001. Habitat fragmentation and native bees: a premature verdict? *Conservation Ecology* 5(1), art. No.-3.
Cianciaruso, M. V., Batalha, M. A. & Petchey, O. L. 2013. High Loss of Plant Phylogenetic and Functional Diversity Due to Simulated Extinctions of Pollinators and Seed Dispersers in a Tropical Savanna. *Natureza & Conservacao* 11(1), 36-42.
Connor, E. F. & Simberloff, D. 1983. Interspecific competition and species co-occurence patterns on islands: a null models and evaluation of evidence. *Oikos* 41, 455-465.
Crepet, W. L., 1996. Timing in the evolution of derived floral characters: Upper Cretaceous (Turonian) taxa with tricolpate and tricolpate-derived pollen. *Review of Palaeobotany and Palynology.* 90 (3-4), 339-359.
Goulson, D., Lye, G. C. & Darvill, B. 2008. Decline and conservation of bumble bees. In *Annual Review of Entomology* pp. 191-208. Palo Alto: Annual Reviews.
Hausmann, S. L., Petermann, J. S. & Rolff, J. 2016. Wild bees as pollinators of city trees. *Insect Conservation and Diversity* 9(2), 97-107.
Memmott, J., Craze, P. G., Waser, N. M. & Price, M. V. 2007. Global warming and the disruption of plant-pollinator interactions. *Ecology Letters* 10(8), 710-17.
Memmott, J., Waser, N. M. & Price, M. V. 2004. Tolerance of pollination networks to species extinctions. *Proceedings of the Royal Society B-Biological Sciences* 271(1557), 2605-11.
Olsen, J. M., Bascompte, J., Dupont, Y. L. & Jordano, P. 2007. The modularity of pollination networks. *Proceedings of the National Academy of Sciences of the United States of America* 104(50), 19891-96.
Vieira, M. C., Cianciaruso, M. V. & Almeida-Neto, M. 2013. Plant-Pollinator Coextinctions and the Loss of Plant Functional and Phylogenetic Diversity. *Plos One* 8(11), 10.
Wappler, T., et. al., 2015, Specialized and Generalized Pollen-Collection Strategies in an Ancient Bee Lineage. Current Biology, 25: 3092-3098.