Thesis outline

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1 Introduction

Research from the past two decades have shown increasing evidence that human activity keeps affecting many worldwide environmental processes. This is shown by the increasing impact of invasive species, their corresponding loss of biodiversity which is furthermore affected by its main driver, habitat loss and framentation. That alone raises major concern and actions have been deployed to mitigate these impacts. Human activity, notably their greenhouse gas emissions may have long-lasting consequences, for which predictions by the IPCC have been overwhelmingly alarming since some of their reports have been shown to have been to pesimistic. Climate change currently holds the status of a scientific consensus i.e. scientifics arounds the world, experts in their domain all agree that climate change happens and the speed and the magnitude at which it happens is caused by human activity. However, how climate change impacts thousands of environmental and social processes worldwide is to be discussed with precaution as attribution of its impacts lacks evidence for the most part.

One of the first attribution of climate change impacts on biological systems has been shown in the early 2000s and since then, a lot of ink has been leaked on the impacts of climate change on the phenology of multiple organisms. Bird nesting, tree budburst, fruit ripening, etc., have all been shown to be affected in some ways by climate change. We are still unraveling how the complex nature of climate will affect each organisms and the truth is that at this stage, we have very little idea. The best tool to make projections and predictions that could be useful in climate action and midications is still increasing data quality and availability and developping better model performance. However, we have very few knowledge on how species will react to warmer temperatures and changes of precipitation regimes. For this, better technology may increase observational data availability and quality for a lot of species, but experiments remain a crucial tool where covarying factors can be removed in order to focus on the parameters we want to investigate the most.

Spring and fall phenological events are shifting. These have been shown to happen around the world, but the consequences on spring phenology, while there has been a lot of speculations and hypothesis made, we have no idea of the patern by which these shifts in phenology will affect species around the world. More precisely, spring phenological events have been advancing at a rate of **/decade and autumn phenophases show either a delay or no trend. The former is mainly driven by temperature, for which a lot of research has been conducted. The drivers of the later are far less known for many reasons. Autumn phenophases have attracted less attention, the data is usually much more noisy since meteorological conditions in the fall can drastically influence the quality of the phenological data. E.g. if monitoring canopy leaf drop over a 2 monh period. While trees go through leaf absission, and the separation might not be complete, rain, strong, but even mild winds can advance leaf drop and thus affect data quality. However, the belief is that autumn phenophase, such as budset, leaf colouring and leaf drop are driven by shortening photoperiod and colder temperatures.

1.1 Climate change impacts on tree phenology

Climate change impacts on biological systems and how phenological trends are already shifting with warming temperatures.

1.2 Wildchrokie

1. Common garden from 2015 to 2023
2. Four species within the Betulacea family (Table 2)
3. Data: phenology, height, tree rings
4. Analysis: Hierarchical model to understand how tree ring width relates to GDD

1.3 Treespotters

1. Citizen science project from 2015 to today (Table 3)
2. Tree coring
3. Data: phenology, tree rings
4. Analysis: Hierarchical model to understand how tree ring width relates to GDD

2 References

Table 1: Fuelinex species grouped by tree type, life history, and wood anatomy.

Deciduous Trees			
Common Name (Latin)	**Life History Strategy**	**Wood Anatomy**	**n (approx)**
Bur oak (*Quercus macrocarpa*)	Slow-growth, long life	Ring-porous	87
Bitter cherry (*Prunus virginiana*)	Fast-growth, short life	Diffuse-porous	78
Box elder (*Acer negundo*)	Fast-growth, short life	Diffuse-porous	90
Balsam poplar (*Populus balsamifera*)	Fast-growth, short life	Diffuse-porous	84
Paper birch (*Betula papyrifera*)	Fast-growth, short life	Diffuse-porous	90
Evergreen Trees			
White pine (*Pinus strobus*)	Slow-growth, long life		89
Giant Sequoia (*Sequoiadendron giganteum*)	Slow-growth, long life		54

Table 2: Wilchrokie species grouped by tree type, life history, and wood anatomy.

Deciduous Trees			
Common Name (Latin)	**Life History Strategy**	**Wood Anatomy**	**n**
Paper birch (*Betula papyrifera*)	Fast-growth, short life	Diffuse-porous	8
Yellow birch (*Betula alleghaniensis*)	Moderate-growth, moderate life	Diffuse-porous	21
Grey birch (*Betula populifolia*)	Fast-growth, short life	Diffuse-porous	29
Grey alder (*Alnus incana*)	Fast-growth, short life	Diffuse-porous	31

Table 3: Treespotters species grouped by tree type, life history, and wood anatomy.

Deciduous Trees			
Common Name (Latin)	**Life History Strategy**	**Wood Anatomy**	**n**
American basswood (*Tilia americana*)	Fast-growth, moderate life	Diffuse-porous	5
Eastern cottonwood (*Populus deltoides*)	Fast-growth, short life	Diffuse-porous	4
Northern red oak (*Quercus rubra*)	Moderate-growth, long life	Ring-porous	4
White oak (*Quercus alba*)	Slow-growth, long life	Ring-porous	5
Pignut hickory (*Carya glabra*)	Slow-growth, long life	Ring-porous	4
Shagbark hickory (*Carya ovata*)	Slow-growth, long life	Ring-porous	4
River birch (*Betula nigra*)	Fast-growth, short life	Diffuse-porous	5
Yellow birch (*Betula alleghaniensis*)	Moderate-growth, moderate life	Diffuse-porous	4
Sugar maple (*Acer saccharum*)	Slow-growth, long life	Diffuse-porous	5
Red maple (*Acer rubrum*)	Slow-growth, long life	Diffuse-porous	4
Yellow buckeye (*Aesculus flava*)	Moderate-growth, moderate life	Diffuse-porous	5