Climate Vulnerability Assessment of Obtawaing Biosphere Region

Climate Change Impacts in OBR

1. **Temperatures will increase by 4 to 10 degrees fahrenheit by 2100, with increased warming during winter**
    1. Northern Michigan has already warmed more than 1.5 degrees fahrenheit since 1950.
    2. This is one of the fastest rates of warming in the US
2. **Winter snowpack will be reduced by 30-80% by 2100**
    1. More winter precipitation delivered as rain
    2. More snow melt between snowfall events
    3. Snowpack is not as deep or consistent
    4. Lake-effect snowfall may increase in short term, but greater temperatures will convert to rain
3. **30 to 50 fewer days of frozen ground sufficient for management during winter by 2100**
    1. The duration of frozen ground has shortened by 2-3 weeks in the pas 70 years
    2. Cold season soil projected to increase by 1.8 to 5.4 degrees fahrenheit by 2100
    3. Frost depth to decline by 40 to 80% by 2100 which will lead to greater water in soil and less runoff or greater loss of water in soil because of increased evapotranspiration

    4. Less snow cover and frozen soil will affect management and ecosystem processes like decomposition and nutrient cycling.

4. **Growing Season will increase by 30 to 70 days by 2100**
    1. Spring arrives earlier and fall arrives later, so phenology may shift for plant species that rely on temperature ot cue development
    2. Greater productivity of trees and other vegetation, but only if balance with water and nutrients.
5. **Intense precipitation events will become more frequent**
    1. Heavy precipitation events will increase in severity and frequency
    2. Storms in 99th percentile have increased by 42% from 1958- 2016
    3. Increases in runoff afer heavy precipitation could lead to increased soil erosion
    4. Large storms to deliver greater rainfall, 20 year return storm to deliver 11-20% more rainfall by 2100
6. **Soil moisture patterns will change**
    1. Drier soil conditions later in growing season
    2. Changing precipitation (increased precipitation in the spring and winter and less in the summer) will lead to changing soil moisture regimes
    3. Longer growing season and warmer temperatures will lead to greater evapotranspiration losses and less availability of soil water later in the growing season
7. **Climate conditions will increase fire risks by 2100**

    1. Fire risk will increase by 20 to 30% due to increased summer temperature
    2. Increased probability of wildfires by 2100, especially in boreal, temperate coniferous, and temperate broadleaf forests
    3. Increased fuel loads from pest induced mortality and blowdown events could increase fire risk.
8. **Many invasive species, pest, and pathogens will increase or become more damaging by 2100**
    1. Increased temperature and moisture stress will exacerbate stress from invasives, pests, and pathogens
    2. Warmer temperatures may allow pests, invasives, and pathogens to expand their ranges further north
    3. These stressors are more damaging in environmentally stressed forests, thus there is potential for synergistic interactions with climate change
9. **Boreal species will face greater stress**
    1. They will experience reduced suitably habitat and biomass
    2. They will be less able to take advantage of warm temperatures and longer growing seasons than temperate species.
10. **Southern or temperate species will be favored**
    1. They will experience more suitable habitat and biomass
    2. Longer growing season and warmer temperatures will lead to greater productivity for these species.
    3. Natives like American Basswood, Black Cherry, and White Oak

4. Also suitable habitat for species not currently in Michigan
5. Such as Black Hickory, Hackberry, and Sycamore

1. **Forest productivity will increase by 2100**
    1. Warming temperatures are expected to speed nutrient cycling and increase photosynthetic rates for most trees
    2. A longer growing season will lead to greater growth and productivity if sufficient water and nutrients available
    3. Lower productivity in localized areas through disturbances like fires, wind events, pests, and droughts
2. **Low diversity systems are at greater risk**
    1. Diverse systems have greater resilience to extreme environmental conditions and greater potential to recover from disturbance
    2. Less diverse communities inherently more susceptible to future changes and stressors
    3. Diversity of response of a system to environmental change is critical to ecosystem resilience, less diverse systems have less diverse responses
3. **Species in fragmented landscapes will have less opportunity to migrate**
    1. Habitat fragmentation hinders the ability of trees to migrate to more suitable habitat, especially if surrounding area is non forested
    2. Mean centers of suitable habitat for trees will migrate 60 to 350 miles by 2100 under high emissions and 30 to 250 miles under lower emissions

4. **Systems limited to particular environments will have less opportunity to migrate**
    1. Systems confined to particular habitats, like for hydrological regimes, soil types, face barriers to migration
    2. Sugar maple is limited to soils rich in calcium, so it has less available suitable habitat than if predicted by temperature and precipitation alone.
    3. Riparian forests are restricted from upland areas because of dependence on seasonal flood dynamics for regeneration and competitive advantage.
    4. Lowland conifer swamps have a unique mix of species adapted to low pH values, peat soils, and particular water table regimes
5. **Systems more tolerant of disturbance have less risk of declining**
    1. Wildfire, flooding, and pest flooding are expected to increase, so forest adapted to gap-phase disturbance with stand replacing events every 50 to 150 years are less adaptable to change
    2. Forest systems that are more tolerant to drought, flooding, and fire are better able to withstand climate change
6. **The urban heat island effect can exacerbate effects of increasing temperatures**
    1. Urban areas with one million plus people can be 2 to 1 degrees fahrenheit warmer than surrounding rural areas because of heat absorbing infrastructure and waste heat from manufacturing and automobiles

7. **Impervious cover can exacerbate effects of increased heavy precipitation in urban areas**
    1. Increase in impervious cover can dramatically increase size and frequency of localized flooding
    2. Extended flooding can stress trees to the point of mortality
    3. Flooding can lead to secondary attacks by pests and diseases
8. **Forest composition will change across landscape**
    1. Habitat and biomass of tree species will change and ecosystem composition will change with it.
9. **Tree regeneration and recruitment will change**
    1. Seedlings are more vulnerable than mature trees to change in temperature moisture and other seedbad and early growth requirements
    2. But seedlings are more responsive to favorable conditions, so depending on the species, varying results
10. **Surface water temperatures expected to rise due to warming temperatures**
    1. Summer steam temperatures to increase 1.4 to 7.2 degrees fahrenheit by 2100
    2. Temperature in cold water stratified lakes to increase 2.9 to 3.02 degrees fahrenheit
    3. Prolonged warming of surface waters lead to degraded water chemistry, eutrophication, and anoxic conditions

    4. Warming waters can significantly degrade cold water habitats and aquatic communities, which can lead to reduced growth and increased aquatic mortality especially at younger life stages.

11. **Inland lakes are warming and continued warming will decrease seasonal mixing of stratified lakes and reduce available dissolved oxygen**
    1. An average warming of 0.34 degrees fahrenheit per decade
    2. Inland lakes will warm 2.9 to 3.02 degrees fahrenheit by 2100
    3. Warming waters will increase stratification which leads to anoxic conditions and reducing available dissolved oxygen for plants and aquatic organisms
    4. Even less dissolved oxygen when aquatic species increase respiration to cope with warming temperatures
    5. Coldwater fisheries are particularly vulnerable
12. **Seasonal variation in soil moisture and altered precipitation may influence magnitude and duration of floods**
    1. Increased flood risks threaten ecosystems, wildlife, property, infrastructure, human health, and safety
    2. More frequent and longer heavy precipitation events will lead to increased flooding, especially when soils are already saturated
13. **Streamflow events may become more frequent and deliver lower water volumes**
    1. Daily low flows to become more frequent with an annual increase of 17 to 27% by 2100

2. Base streamflows reduced with longer growing season and warmer temperatures
3. Increased water demand and use to maintain public utility water supply and agricultural requirements will lead to reduced streamflow
4. Drier climate conditions alter water balance and reduce baseflow have greatest impact on sensitive systems like head water ephemeral and other small perennial and intermittent systems

Human Vulnerabilities to Climate Change

1. Approximately 40 disadvantaged counties in OBR
2. Michigan is projected to see a fivefold increase in heat wave days by 2050
3. Michigan faces an above average overall summer drought threat
4. Nearly 340,000 people live in Michigan's flood-prone areas.
5. Increased aerosols and particulates
6. Increased pollen
7. Heat related illnesses and deaths.
8. Air pollution
9. Water and food borne diseases like ticks and Lyme disease.

Coastal Vulnerabilities

1. Great Lakes water levels are oscillating abnormally because of erratic precipitation caused by climate change
2. Higher rates of precipitation is causing greater flooding

3. Rain on snow is contributing to greater nutrients in lakes

Climate Change Impacts on Forests

Major stressors and threats to forests in the region include:

- Fragmentation and land-use change
- Fire regime shifts
- Nonnative species invasion
- Forest pests and disease
- Overbrowsing by deer

Some forest types are favored by climate change:

- Most vulnerable- Upland spruce fir
- Moderate vulnerability- Lowland conifer, Red pine/ White pine, and Jack Pine
- Low vulnerability- Aspen birch, northern hardwoods, lowland/ riparian hardwoods
- Favorable- Oak associations, Barrens

https://www.nwf.org/~/media/pdfs/global-warming/climate-smart-conservation/nwfscanningtheconservationhorizonfinal92311.ashx