Climate Change Adaptation in Austin's Community Forest and Natural Areas

November 6 - 7, 2019

Expanded Agenda + Meeting Notes

Expanded Agenda

Day 1 (Nov. 6): Preparing for Climate Change

This session is open to a broad audience that is interested in learning more about climate change impacts and adaptation in Austin's community forests and natural areas. This session will:

- Provide information on the current and anticipated effects of climate change on the Austin metro and its urban forests and natural areas
- Describe resources and tools that can be used to integrate climate change into urban forest and natural areas management
- Outline adaptation concepts and strategies
- Identify actions that enhance the ability of urban forests and other ecosystems in the Austin region to adapt to changing conditions
- Highlight real-world examples of adaptation projects, and engage participants in a variety of interactive activities to identify climate change issues and potential adaptation actions.

Agenda: Day 1

8:30 **Registration & Coffee**

9:00 **Welcome & Introduction**

Zach Baumer - Climate Program Manager, Office of Sustainability

Leslie Brandt, Northern Institute of Applied Climate Science and US Forest Service

9:30 **Changing Climate in the Austin Region**

Speaker: Cait Rottler, USDA central plains climate hub

Purpose: familiarize everyone with what impacts we are preparing for in the region

10:15 **Break**

10:30 **Vulnerability and Adaptive Capacity of Trees in the Austin Region**

Leslie Brandt, Northern Institute of Applied Climate Science and US Forest Service

Purpose: talk about how trees and natural areas are vulnerable and what species may be more/less vulnerable to anticipated impacts

11:30 Engagement Activity (local observations)

12:00 **Lunch on site (included in registration fee)**

12:45 **Adapting Urban Forests to Climate Change: Approaches for Action**

Leslie Brandt, Northern Institute of Applied Climate Science and US Forest Service

1:15 **Real-world Examples of Forest Adaptation-panel**

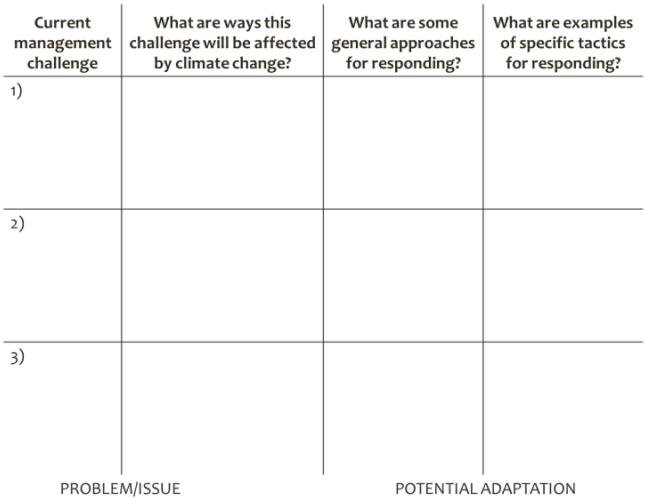
Panel presentations (10 minutes per presenter)

Panel Q&A (open to participants but if they are slow, Leslie will ask these)

1. What are some specific climate change impacts your project is facing or addressing (e.g. extreme temperature, changes in precipitation, storms, drought, changes in pests and diseases)?
2. Is your work more focused on resisting climate change (keeping things the way they are), building resilience (allowing disturbances to occur, but helping the system to bounce back), or facilitating transitions to future conditions?
3. What are some of the specific adaptation strategies and approaches) that your project is implementing (see urban strategies and approaches chapter in Forest Adaptation Resources for ideas)?

2:30 **Break**

2:45 **Activity: Integrating Climate Change into Your Work**



Work time – 10 min

Take about 10 minutes to fill out the worksheet. Be sure to complete at least one management challenge, and feel free to do up to three.

- What major management challenges do you deal with at work?
- What are some ways that this will be affected by climate change?
- What are some general ways to respond to this?
- What are some really specific tactics (really really specific) examples of how to respond?

3:00 Group Rounds and Discussion – 30 min

3:30 **Discussion of Breakout**

Discussion – 20 min

What were some of the commonalities in terms of climate change challenges amongst your group?

What were some examples of adaptation actions?

Did your adaptation actions tend to focus on resistance, resilience, or transition?

3:50 **Closing Comments**

Leslie Brandt

4:00 **Adjourn**

Meeting Notes

- "I'm excited for this, not because we have to talk about it but because it's being talked about"
- Climate Change Adaptation in Austin's Community Forest and Natural Areas
- Zach Baumer
    - "Is climate change happening?" Room raises hands, yes
    - Atmosphere has warmed 1 degree C
    - Haven't been successful at dramatically reducing emissions
    - Scientists not sure how fast global climate system was going to react to GHG emissions
    - Has reacted fast, will continue to react
    - 1.5-2C without significant action in next 30 years
    - We need ecosystems for oxygen, clean water, etc.
    - Expected changes
        - Increased drought
        - Changes in precipitation and temperatures
        - Increased temps in summer and winter
        - Same precipitation annually but spread out in shorter bursts, increased rainfall
        - Flash flooding
        - Wildfires
- Planning committee working for over a year to bring us here today
- Leslie Brandt - Northern Institute of Applied Climate Science - chartered by USDA Forest Service, universities, nonprofits, and tribal conservation organizations
    - Climate Change Response Framework
        - 2009: Wisconsin pilot
        - 2010: Northwoods expansion
        - 2011: Central hardwoods
        - 2012: Central Appalachians
        - 2013-14: New England Mid-Atlantic Urban
    - 3 Main Components of Urban Forestry Climate Change Response Framework: 1. Regional assessment of impacts and tree species vulnerabilities, 2. Local vulnerability assessments, 3 Adaptation projects and planning
    - Objectives: 1. Learn more about current and anticipated effects of climate change on Austin's developed and natural green spaces, with an emphasis on trees and forests, 2. Understand concepts of climate change vulnerability and adaptation and how to apply these concepts fo their work, 3. Share tools and approaches for incorporating climate change into managing Austin's natural and developed green spaces
- Cait Rottler - Changing Climate in the Austin Region, USDA Southern Plains Climate Hub

- Current Austin Temperature - Trend: Iincrease 0.4 degrees F per decade, some notable periods of cold temperatures
- Minimum temperature has also increased by ~+0.3 degrees F/decade
- Precipitation trend of +0.7" per decade, precipitation whiplash - crazy floods to hardly any rain (dipoles or rollercoasters)
- Variable temperatures, hard to pinpoint increases in precipitation
- RCP 4.5 (low emissions)
    - 2010-2039: days wit heat index >105F 20
    - 2040-2069: days wit heat index >105F 33
    - 2070-2099: days wit heat index >105F 43
- RCP 8.5 (high emissions)
    - 2010-2039: days wit heat index >105F 38
    - 2040-2069: days wit heat index >105F 86
    - 2070-2099: days wit heat index >105F 122
- Increase in temperature no matter which scenarios we're using, question is by how many degrees?
- Scattered percent increases in mean precipitation
- Sometimes increases in runoff, decreases elsewhere
- Soil moisture content remains relatively consistent - ***why?***
    - Wondering why model used shows this
- **Physical Impacts**
- Heat and Cold Tolerance and Growing Season
    - Heat tolerance: Increase from 9 to 12 by end of the century
    - Hardiness Zone: 8b to 9a by end of the century
    - Growing Season Length: Longer, 278 to 359, but doesn't account for heat tolerance zones, etc.
- Heat Stress
    - Austin's current average is 13 days/year over 100F
    - Business as usual predictions add an additional 30-60 days over 100F by the year 2100
    - Urban areas warm faster and worse than rural areas (urban heat island effect)
- Drought Stress
    - Austin is in the belt separating the arid southwest from the humid midwest
    - Belt called "100th meridian" has shifted approximately 140 miles east
    - Austin may become part of the arid southwest if the belt keeps migrating east
    - Past severe droughts have drastically affected Austin trees; ~10%
    - Expect Austin to become more like Laredo in next 50 years
- Severe Weather
    - Hurricanes, which can encroach inland and drop large amounts of rain are expected to become more intense as the ocean continues to warm
    - Unclear how climate change will affect windstorms and the likelihood of wind damage to the urban forest

        - Heavy rain events are expected to increase with climate change, leading to more frequent occurrences of so-called 100-year flood events
    - Central Texas has seen 3 100-year floods in 5 years
    - Every year supposed to have a 1% chance of "100-year floods"
    - Carbon Cycling
        - Austin's trees current sequester about 92,000 tons of CO2 a year, making them a carbon sink
        - Climate change and related aridification may cause them to become carbon sources
        - Structure of tree communities that are not intensively managed may change with increasing CO2, as some trees are better able to capitalize or excess CO2 than others
    - Fire
        - Drought, dry days and days over 100F will make more ideal conditions for large catastrophic fires
    - **Biological Impacts**
    - Phenological Shifts
        - Timing of leafout, flowering, fruiting, and senescence will shift as temperatures increase
        - Effect of increased temperature on tropical v. temperate trees will vary depending on the factors influencing phenological cues
        - Dividing line between temperature-influenced cues and other cues is typically an average temperature of 45F in january, projections for Austin predict average January temperatures excess of this
    - Invasive Plants
        - Invasive plants typically have high adaptive capacity, while man natuve plants do not
        - Ranges of current invasive plants may increase or shift northward
        - However, some recent models suggest that increasing temperatures may actually decrease the number of invasive species in Texas
    - Insect Pests and Pathogens
        - Increased temperatures and drought are expected to stress trees and make them more susceptible to infection
        - Oak wilt, hypoxylon, wood-boring beetles, and bacterial leaf scorch can more easily infect stressed trees
        - Oak wilt and bacterial leaf scorch may benefit directly from warmer, drier conditions, in addition to more easily attacking stressed trees
    - Tree and Forest-dependent Wildlife
        - Some wildlife, such as the federally endangered golden-cheeked warbler, will likely experience a reduction in suitable habitat with climate change (nearly all of the warbler's habitat is expected to disappear in the coming decades)
        - Populations of white-tailed deer may experience shifts in breeding season
        - Suitable range for invasive feral hogs expected to increase

    - Nutrient Cycling
        - Rates of nutrient cycling are likely to change in response to climate change
        - Rates tend to increase with temperature, but decrease with aridity, both of which are expected in the Austin area
        - Nutrient cycling depends on numerous factors, some of which are more affected by climate change than others
        - Overall effect on nutrient cycling is unclear, and different nutrients may respond in different ways to climate change in the Austin area
- Leslie Brandt - Vulnerability and Adaptive Capacity of Trees in the Austin Region
    - How trees and natural areas are vulnerable and what species may be more/less vulnerable to anticipated impacts
    - Vulnerability: The degree to which system is susceptible to, and unable to cope with, adverse effects of climate change, influencing variability and extremes
    - Function of Adaptive Capacity + Potential Impact — Vulnerability
    - Climate Change Tree Atlas - species distribution models helps us understand impacts on individual trees
    - Used updated data to create summary area 1x1 grid, summaries provided in 30 year periods
    - Tree Atlas Results
    - Losing Habitat
        - Black walnut
        - Eastern redcedar
        - American sycamore
        - Bur oak
        - Post oak
        - Black oak
    - Gaining Habitat
        - Pecan
        - Sugarberry
        - Blackjack oak
        - Water oak
    - Post Oak - suitable habitat shifts, less favorable than it had been
    - Impacts: non-native, less common species, shrubs, and cultivars
        - Compared species tolerance to projected changes in heat and hardiness zones for Austin region
            - Heat/hardiness zone projection exceeds species tolerance: potential negative effect
        - Examined species ranges
            - South, west end of range: potential negative effect
            - Center of range: no effect
            - North/east end of range: potential positive effect
    - Current Hardiness Zones - Louis Iverson created based on downscaled climate data

- Future hardiness zone: mid-century, shifting to hardiness zone 9 under low or high emissions
- Bur Oak - Hardy in zones 4-8
- National Plant Atlas - look at species ranges
    - E.g. white ash losing suitable habitat
- Difference in adaptive capacity in individual trees
- Adaptive capacity factors
    - Disturbance factors
        - Pest, disease, fire, drought, flood, pollution, heat, herbivory, invasive species, salt resistance
    - Biological factors
        - Shade tolerance, edaphic specificity, propagation, pruning needed, establishment, establishment, rooting conditions
    - Weighted by potential climate effects
    - -3 to 3
- 2 Separate Scores
    - Plant/developed
        - Species that are or could be planted in yards, boulevards, parks, campuses
        - Greater emphasis on pollution and heat tolerance
        - Fire tolerance, invasive species, competition, natural regeneration not factors
        - Includes nursery propagation, restricted rooting conditions, maintenance, planting site
    - Natural
        - Species that are native or naturalized to the area
        - Less emphasis on pollution, heat, but still factors
        - Includes invasive species competition, fire tolerance, and post-fire regeneration
        - Greater emphasis on shade tolerance
        - Includes dispersal, seedling establishment, vegetative reproduction
- Adaptive Capacity Examples
    - Low: little walnut - narrow habitat requirements, can neither tolerate drought nor extensive flooding
    - High: Chinese tallowtree - invasive = adaptable
- Rank species for vulnerability
    - Assessed 104 species
        - 59 currently present
    - Canopy, sub-canopy trees native to Austin region
    - Non-native species and many cultivars of trees that are currently present
    - Invasive tree species
- Vulnerability matrix
- Number of species in each vulnerability category-based on natural areas score
    - Pretty close to normal distribution

        - Moderate = highest
    - Most vulnerable species that are common in natural areas
        - Bastard oak
        - Buckley oak / Texas red oak
        - Cedar elm
        - Durand oak
    - Least vulnerable species - natural areas
        - Paper mulberry
        - Mexican redbud
        - Texas persimmon
        - Japanese privet
        - Chinese privet
        - Mexican sycamore
        - Chinaberry
        - Honey mesquite
        - Fragrant sumac
        - Prairie sumac
        - Evergreen sumac
        - Texas hercules club
        - Lotebrush
    - Number of species in each vulnerability category-developed areas score
        - More in moderate-high
    - Number of trees (based on urban FIA) in each vulnerability category based on developed area score
        - More vulnerable trees on public land
        - ***Why?***
    - Vulnerability of Austin's top 20 most common trees
        - See a range
    - Key points
        - SPpcies at southweatern extent of their ranges expected to lose habitat
        - Species that are heat, drought, and flood-adapted and pest-disease resistant are least vulnerable
        - Austin's most common trees represent a range of vulnerability, with some of its native oaks being among the most vulnerable
        - Vulnerability of individual species can vary greatly between natural and developed areas
    - Community/natural area vulnerability assessment
    - Vulnerability assessment workshop - June 2019, 25 participants
    - Potential impacts - developed sites
        - Direct and indirect climate change effects
        - For each ecosystem, how will climate change affect…
            - Conditions (e.g. soil or site conditions, disturbance dynamics)
            - Dominant/important species
            - Stressors/threats (e.g. invasive species, pests, diseases, fragmentation)

            - Interactions
    - Adaptive capacity - developed sites
        - Ability of human-ecological system to cope with changes
        - For each forest system, how resilient is it based on…
            - Dominant species response to environmental shifts (phenotypic plasticity)
            - Diversity (e.g. species, functional, genetic)
            - Response to enhanced disturbances
            - Social, economic, organizational capacity
    - Potential impacts - natural areas
        - Direct and indirect climate change effects
        - For each ecosystem, how will climate change affect…
            - Drivers (e.g. soil or site conditions, disturbance dynamics)
            - Dominant/important species
            - Stressors/threats (e.g. invasive species, pests, diseases, fragmentation)
            - Interactions
    - Adaptive capacity - natural areas
        - Ability of ecosystem to cope with changes
        - For each forest system, how resilient is it based on…
            - Dominant species response to environmental shifts (phenotypic plasticity)
            - Diversity (e.g. species, functional, genetic)
            - Response to enhanced disturbances
        - Rate adaptive capacity (low <--> high)
    - Vulnerability determination
        - Vote with sticky dots
    - Confidence determination
        - Consider evidence and agreement to rate your level of confidence in that vulnerability rating (individually)
    - Systems we considered
        - For each, considered current drivers, dominant/important species, stressors and threats, adaptive capacity
        - Then considered likely changes over the next 80 years
        - Systems:
            - Developed Areas: Urban Core, West Austin, East Austin
            - Natural Areas: Upland Forests, Upland Woodlands, Upland Mixed Shrublands, Floodplains and Low Terraces
    - Summary of vulnerability for Austin's regions and natural areas
        - Most found relatively moderate vulnerability but factors contributing to that were different
    - Urban Core: Moderate-high vulnerability
        - Key characteristics - low canopy cover, high impervious surface, high development, high population density
        - Dominant/important species

            - Vulnerable: pecan, eastern cottonwood, post oak, American sycamore, Texas red oak, cedar elm, green ash
            - Adaptable: Texas mountain laurel and Mexican white oak
        - Key stressors - urban heat island, stormwater runoff/localized flooding, air pollution, development, restricted rooting conditions
    - Urban Heat Island
        - Increased
    - West Austin - moderate vulnerability
        - Low-medium density developed areas west of mopac/on Edwards plateau
        - Key characteristics - higher canopy cover, some impervious surface, low-medium development, medium population density
        - Dominant/important species
            - Ashe juniper is the most dominant species in Wst Austin and is considered to be moderately vulnerable
            - Moderate-high vulnerability: pecan, cedar elm, velvet ash, southern magnolia, and Mexican plum
            - Adaptable: yaupon, Eve's necklace, Mexican white oak, Texas mountain laurel
        - Key stressors - development. herbivory/wildlife, wildland-urban interface
    - East Austin - moderate vulnerability
        - Low-medium density developed areas east of Mopac/on Blackland prairie
        - Key characteristics: lower canopy cover, some impervious surface, low-medium development, medium population density
        - Dominant/important species:
            - Vulnerable: pecan, black walnut, eastern cottonwood, post oak, black willow
            - Adaptable: live oak, yaupon, Mexican white oak, Texas mountain laurel, Jerusalem thorn, Texas persimmon, Mexican sycamore
        - Key stressors: urban heat island, stormwater runoff/localized flooding, air pollution, development, restricted rooting conditions
    - Upland Forests: moderate-high vulnerability
        - More closed canopy areas within the Edwards Plateau/Balcones Canyonlands
        - Drivers: closed canopy, fire resistant, mesic conditions, topographic relief
        - Dominant/important species:
            - Vulnerable: Texas red oak, white shin oak, Arizona walnut, cedar elm, Mexican plum
            - Adaptable: evergreen and fragment sumac, Texas persimmon, Texas madrone, Texas mountain laurel
        - Key stressors: wildfire, drought, oak wilt, invasive plants
    - Wildland-Urban Interface - Housing density & tree cover (wisc.edu)
    - Upland Woodland and Savanna: Moderate vulnerability
        - Moderate canopy cover with herbaceous and graminoid layer
        - Drivers: fire-adapted, topographic relief in some areas, dry-mesic

        - Dominant/important species:
            - More vulnerable: cedar elm and sugarberry
            - Adaptable: yaupon, fragrant and evergreen sumac, Texas persimmon, honey mesquite, catclaw mimosa, Texas mountain laurel
        - Stressors - wildfire suppression, overgrazing, drought, oak wilt
    - Upland Mixed Shrubland: Moderate-high vulnerability
        - Shrub-dominated systems within the Edwards Plateau and Blackland Prairie
        - Drivers: Xeric sites and shallow soils, grassland-woodland transition, fire-driven
        - Dominant/important species:
            - Adaptable: prairie flameleaf and evergreen sumac, lotebrush, honey mesquite, Texas persimmon, Texas mountain laurel, Lindheimer silktassel, catclaw acacia
            - Moderate-high vulnerability: Ashe juniper, escarpment live oak and white shin oak, Texas kidneywood, Texas redbud, Mexican buckeye are considered less drought tolerant
        - Stressors: overgrazing, wildfire suppression, feral hogs
    - Floodplains and Terraces: Moderate vulnerability
        - Forested floodplain and riparian areas within the Blackland Prairie and Edwards Plateau ecoregions
        - Drivers: flooding, erosional processes
        - Dominant/important species:
            - Vulnerable: sugarberry, possumhaw, Chinese tallowtree, boxelder, American elm, black willow, green ash, American sycamore, eastern cottonwood, western soapberry
            - Adaptable: desert willow, yaupon, invasive chinaberry
        - Stressors: emerald ash borer, changes in flood regime, water use/withdrawal, invasive species, development
    - Question: In MN/Midwest, is there an indication that flooding is strictly due to rainfall, or other factors? Heavy precipitation, snowmelt
- Engagement Activity - Local Observations
    - What climate impacts are you seeing?
    - Write down your biggest climate change impact you've observed in your work or personal life here in Austin
    - Changes in habitat suitability
        - Loss of habitat
        - Loss of Karst species
        - Increased non-native invasive species - some provide habitat value and hold stream banks
        - Range expansion of southern and western species
        - Increase in desert-adapted species, decline in others
    - Tree mortality
        - Post oak loss - East Austin

        - Ashe juniper die-off
        - Texas red oak decline
        - Heat and drought killing trees
        - Hypoxylon more prevalent
        - Whenever there's a windy day I have to worry about where I stand now, which I didn't have to do before
    - Seed production
        - Mini acorns
        - Evergreen sumac - Handful instead of bucket full of berries
        - Coming up to surface and floating
    - Increased storms and severity, flooding
        - Water can only go 3 places - runoff, soak in, evaporate out
        - Sedimentation, erosion problems
        - Flooding out lowlands
        - Depositions of silt/sand
        - Evergreen sumac develops root rot easily
    - Impacts to vegetable gardening - more variable than it used to be
        - When to install fall garden?
        - Idea of planting in general
        - Big deal for farmers - acres of produce they have to sell, flash freezes kill them all
        - Community gardens - rotten vegetables
    - Increased wildfire severity
        - Seeing it now, 2011 fire season unprecedented, haven't seen this type of fire behavior before
        - Combination of intensity, low frequency, happens in extreme conditions
        - Burn ban - not safe to pull it off, in November
        - Used to remove it August/September
        - Risk
    - Human Health
        - Seasonal allergies
        - Mold expanding throughout the year
        - Pollen used to have fairly distinct seasons
        - Blurring of seasons - pollen seasons longer
        - Extreme heat, humidity
        - Heat leading weather-related cause of human mortality
        - More hot days over 100F
    - Heat Stress & Drought
        - Privet and chinaberry experiencing heat stress
        - Had to water native vegetation in personal yard, never had to before
    - Hypoxylon increase
        - Drought stress
    - Killer algae in LBL
        - Waterways in Austin
    - **List from Sticky Notes:**

- Interaction between land use change and climate
- Polar vortex
- Population increase and development to infrastructure
- Bigger storms happening with greater frequency
- Tree mortality
- Increased number and severity of drought/flood events
- Bulldozing hillsides plowing agricultural fields
- More frequent big floods
- Loss of habitat for endangered Karst species Cave bone harvest man gadella reyesi
- Post oak loss
- More hot days over 100 into the late summer
- Increased mortality in tx red oak die to hypoxylon
- Population increase and development to infrastructure
- The limited ability to tether climate change to land use regulations
- Bulldozing hillsides
- Plowing agricultural fields
- Impact: increased heat and more intense precipitation events x decreased adaptive capacity among low income households to bounce back, result = single policies not set up to address interaction/Dynamics SILOES not effective
- Heat stressed trees and drought
- Heat stress on trees
- Heat stress
- Increased in temps - summer months
- Arctic incursions
- Increased impervious cover
- Heat and drought on trees
- Severe drought impacts
- Hypoxylon increase
- Killer algae in LBL
- Little relief from seasonal allergies especially as mold in expands throughout the year
- Increasing heat and its affect on people's health
- Perceived increase in humidity
- Increased wild fire occurrence and severity
- Impacts to vegetable gardening - when to plant seasonal plants seems much more variable than it used to
- Increase in extent and severity of urban stream erosion
- Vegetation stress from drought - plant death
- Increase in storms and storm severity
- Increased number
- Increased non-native invasive species
- Range expansion of southern and western species
- Increase in desert-adapted species

        - Decrease in native populations
        - So many dead trees from 2011 drought
        - Trees we thought were bullet proof (Ashe juniper, ligustrum, crape myrtle) succumbing to heat and drought
        - Tree mortality in shallow, rocky soil areas of Hill Cemetery following 2011 extreme drought - and subsequent shifts in golden-cheeked warbler territories
        - Ashe juniper die-off
        - Seed production - sporadic/timing
        - Increase in extent and severity of urban stream erosion
        - Vegetation stress from drought —> plant death
        - Drought, wildfires, drought
        - More intense storms and hurricanes - Harvey, Irma, Maria, Matthew, Florence...
        - Bigger storms, greater frequency
- Leslie Brandt - Adapting Urban Forests to Climate Change: Approaches for Action
    - Adaptation is the adjustment of human or natural systems in response to climate change
    - Adaptation activities can build on sustainable management, conservation, and restoration
    - Adaptation options: Spectrum - Resistance (persistence) <-> Resilience (autonomous change) <-> Transition (directed change)
    - Adaptation option 1: Resistance
        - Improve the defenses against effects of climate change
            - Short-term
            - High-value
        - Desired future condition of that system matches current condition
        - E.g. using structures to control flooding
        - Preventing spread of invasive species
        - Preventing herbivory
        - Protect at-risk species and sures (e.g. identify refugia)
    - Adaptation option 2: Resilience
        - Accommodate gradual change, usually returning to a prior condition after disturbance
        - System allowed to fluctuate a bit, but ultimately bounce back
        - Resilience is very trendy term, climb up in media/articles
        - Resilience: Ability of a system to maintain or return to a particular ecological state following a disturbance
        - E.g. restoring disturbance-adapted ecosystems such as a floodplain
        - Increasing species and genetic diversity
    - Adaptation option 3: Transition
        - Intentionally encourage change, help ecosystems/communities respond in a targeted fashion
        - Desired future condition of that system is different and transformed over time

- Assisted migration
  - Assisted population migration, assisted range expansion, assisted species migration
  - Policies that may limit what you can do
- Forest Adaptation Resources
  - Adaptation Workbook
  - Define goal, assess vulnerabilities, evaluate objectives, identify adaptation strategies, monitor effectiveness
- Urban Forestry Adaptation Menu
  - Urban sites such as yard trees, parks, cemeteries, school grounds, corporate campuses, and unmanaged green spaces
  - Natural areas such as forest preserves and larger parks
  - Mennu contains: 10 strategies, 35 approaches, infinite tactics
- Adaptation Strategies and Approaches
  - Option (3) —> Strategy —> Approach —> Tactic (infinite)
- Online Workbook
  - Free to use
  - Adaptationworkbook.org
  - Can develop your own adaptation plan
  - Pull-down menu for adaptation strategies
- Demonstration Project Summaries
  - forestadaptation.org/adapt/demonstration-projects
  - Filter by urban forests
  - E.g. natural areas conservancy and NYC department of parks and rec
    - Prioritize and maintain sensitive or at-risk species or communities
    - Use seeds, germplasm, and other genetic material from across a greater geographic range
  - E.g. Goshen, IN
    - Prioritize and maintain sensitive or at-risk species or communities
    - Realign urban ecosystems after disturbance
  - E.g. Bloomington, IN
    - Maintain and create habitat corridors through reforestation or restoration
    - Introduce species that are expected to be adapted to future conditions
  - Hennepin County, MN
    - Use seeds, germplasm and other genetic material across a greater geographic range
    - Introduce species that are expected to be adapted to future conditions
- Adaptation: Key Points
  - Adaptation options are on a spectrum from managing for persistence to managing for change

        - Adaptation workbook and menu provide an organizing framework to select adaptation options that will reduce vulnerability while achieving your management goals
        - Other cities are using the workbook and menu
            - One size does not fit all
            - Managers can pick and choose from the menu
            - Can be a mix of resistance, resilience, and transition strategies
- Real-world Examples of Forest Adaptation: Panel
    - Wendy Gordon - Introduced panel
    - Lisa O'Donnell - Biologist, City of Austin, Balcones Canyonlands Preserve
        - Facilitation: Cooling strategies in a warming climate
        - Traditional view: trees as solitary individuals competing for resources
        - Emerging view: forests as interconnected "superorganisms" (facilitation)
        - Mycorrhizal fungi: "wood wide web"
            - The social network of trees and fungi
            - Dr. Suzanne Simard
            - Mycorrhizal = "fungus roots"
            - Fungi grows in and around the roots
            - Extension of the root system
            - Provides sugars they get from photosynthesis
            - Fungi increases surface area and allows for greater absorption
            - All things we can't see
            - Fungi connects trees to the earth and to each other
            - Can provide carbon through network to support seedlings
        - Benefits of Mycorrhizal Fungi
            - Enhance water and nutrient uptake
            - Increase drought resistance
            - Increase pathogen resistance
            - Increase plant health and stress tolerance
            - Promote carbon sequestration and storage in soil
        - Working with Dr. Brian Pickles
        - Soil organic carbon increases with stand age in Ashe juniper-oak forest Balcones Canyonlands Preserve
        - "Nurse trees" (and roots)
            - Ashe juniper motte (dark brown rich soil, has 5x organic matter) vs. adjacent eroded slope
        - Importance of shade for oak regeneration
            - August 2019: under tree canopy vs. August 2019: no shade (stressed)
            - Canopy is critical for seedling survival of oak
        - Texas red oak seedlings planted as acorns in fall 2017 - caged with shade = more survival, all do okay until August
        - Nurse trees can be living or dead
            - Sapling growing under living tree vs. sapling growing under dead tree

        - Endophytes
            - Bacteria or fungi that live within a plant (e.g. bark, leaves) without causing apparent disease
            - May enhance host plant's growth, nutrient acquisition, ability to tolerate abiotic stresses (e.g. drought), and resistance to insects, pathogens, and herbivores
            - As with mycorrhizae, endophytes receive carbon
        - Some cooling strategies (from soils to canopy)
            - Promote building of rich carbon sponges
            - Habitat restoration and substrate for fungi
    - Pete Van Dyck - Small business owner, regenerative land, drought-proof Texas, soil and water conservation
        - Climate destabilization
        - Increased land use degradation = degraded climate
        - Most dangerous product of fossil fuels is power
        - Irresponsible humans = the problem
        - 50 years = limestone desert in hill country
        - Characteristics of a desert - climate extremes, hot, can be very cold, very dry, can be very wet very fast
        - As earth's land surface area becomes more desertified, we're going to continue to experience these extremes
        - To prevent Texas becoming a desert, start with farming
        - Old Growth Forests - cool, moist, comfortable
        - Change from desert to forest
        - Forest protecting soils from erosion, strong winds
        - Stable ecosystems are great moderators. More we lose these, more everything becomes more erratic
        - Soil health in ecosystems we live in is like our immune system, for the plants and for humans
        - Lost 6 feet of top soil before the year 1860
        - How can we incorporate moderating effects of ecosystems into our urban areas?
        - Terracing in bioswales, conservation terraces
        - Terraces are level and catch stormwater runoff, detritus, etc.
        - Examples of work in Austin
        - Works with nonprofit Earth Repair Corps - 6 volunteer gardens around Austin
        - Blog at earthrepaircorps.com
        - Pete's website/blog: droughtprooftx.com - goal is to rehydrate entire state of Texas
    - Bryan Hummel - Life Scientist, EPA Region 4
        - Nature-based solutions to flooding, drought
        - Annual average precipitation
        - U.S. Drought Monitor - least amount of drought they've ever seen. Other times there are massive amounts of red.

- Sometimes way too much rain - Hurricane Harvey
- Matter of WHEN we're going to get hit again and again
- Flash flood liability
- 3 places water goes - runoff, soaks in, evaporation
- More of Barton Springs flow vs. coffee-colored water
- Rainfall enters rivers
- Same type of groundwater resources but because it's out of sight out of mind people don't pay as much attention to it
- Saltwater intrusion massive threat to all coastlines in the world
- Groundwater declines are a threat to inland aquifers
- Another way to look art USA
    - Urban - northeast
    - What we eat - midwest
    - Cow/pasture - midwest
    - Vast majority of land use is agricultural
    - Focus in big chunks (cow/pasture, food we eat, livestock feed)
- Bad land management
    - Leads to drought, soil erosion, desertification
- Ecosystem restoration
    - Restores soil and water cycles and reverses desertification
- We live in a closed-loop system, can make it worse or better
- Should be putting carbon into the soil
- Microdetritus berms post rain
    - Imagine this as an ant vs. as a human
    - Change your perspective
    - Can mimic this exact process through beaver dams
    - Several hundred beaver removed
- Donut of mulch around trees - when water comes down, goes around this donut and prevents tree from getting the water, a donut is not very healthy for you!
- Plenty of CO2 and sunlight, need soil and water
- Make this into a banana instead, not a donut, same exact amount of mulch
- Can do this in residential rain gardens, backyard bioswale with "swale plume"
- Volunteer learning opportunity
- Stonebrook Estates; Houston
- Clear Lake Stormwater Wetland. TAMU. - prevented flooding of homes during Harvey
- Straight line is almost never going to be level when plowing - inviting water to rush off landscape
- David Bamberger - water from stone
    - Slows, spreads, and sinks water and turns into groundwater asset
    - Just mimicking nature
- Beaver biomimicry

        - What is there a lot of after a storm? Debris, what do we do with it? Turn it into wildflowers
            - Mulch v. no mulch
            - Turn wood mulch into wildflowers
            - Keep water on the land, not shed it off the land
        - Contour mulch
            - 800 acres of mulch on contour, no runoff, catches and slows and sinks - flood speedbumps
            - Brought springs back to life
            - Military secured stable water supply
            - Groundwater wars are coming
            - Military can say they're putting more in than taking out, part of the solution, not part of the problem
        - Young Farmer Grants - USDA
            - Won 2017 green infrastructure award
            - Swales get dug, covered with vegetation, free gravity powered irrigation
        - Turning desert to a forest in 20 years
    - John Clement - City of Austin / Watershed Protection
        - Urban floodplain health - stressors and strategies
        - Health floodplains = riparian areas
        - Stressors - Development
            - Loss of vegetation and soil function
        - Stressors - Mowing
            - Mow areas to death so very little function, compaction of soil, reduced vegetation
        - Power and energy going through these streams
        - Stressors - Urban Stream Syndrome, see it at road crossings and parks
            - Volume comes through with energy and tears out particles of soil and moves them around
            - No longer have overland flow coming through areas and no infiltration with all the pavement, water table getting lower, lower saturated areas getting torn up
        - Stressors - Climate Change
            - Increased drought, flooding, heat, etc.
        - Strategies - Stabilization
            - Austin's creeks are unraveling, downcutting, getting wider, channels enlarging, need to stabilize physically
        - Grow Zone program
            - Benefits of a creekside forest:
                - Improves natural and beneficial functions of the floodplain
                - Prevents streambank erosion
                - Filters stormwater runoff, removing pollutants before they reach creek
                - Etc.

        - www.austintexas.gov/watershed/creekside
    - Strategies - Grow Zones
    - Strategies - Green Infrastructure
        - Harvest rainwater and store rainwater
    - Strategies - Re-engaging Floodplains
    - Strategies - Restoration
        - Microsites
- Panel Q&A
    - Reaching across scales
    - Pete - trying to build the market for this stuff - basic engineering, everything is about drainage to protect building and roads. We need that but it needs to be balanced with infiltration areas around project. Education, inspiration to do better things.
    - Bryan - big demand for people to use rain gardens, limestone sponge can open this up to an asset
    - John - access/equity issues with grow zones around city? So far its been opportunity-based, benefits of enhanced natural areas
    - Green infrastructure - nobody has mentioned green roofs. How could these be incorporated into green infrastructure in Austin?
    - Pete - doesn't like green roofs, thinks water should run off roof and into rain tanks
    - Bryan - places like Chicago have done well with them, depends on location and cost, amazing tool in highly urban places to bring food/nature back, but from water management standpoint it doesn't pencil out.
    - USDA pushing annual cover crops - cocktail mix - all about diversity
    - Need benefits of planting multiple things
    - Dung beetle does great by sequestering carbon underground
- Activity: Integrating Climate Change into Your Work
    - Help you think about what you're currently working on at your job and how to integrate climate change into that.
    - What major management challenges do you deal with at work?
    - What are some ways that this will be affected by climate change?
    - What are some general ways to respond to this?
    - What are some really specific tactics examples of how to respond?
- Group Rounds and Discussion
    - **Anna's notes**
    - Increased urban edge effects
    - Increased risk of fire and public concerns of fire Drying effect of less canopy
    - Tree die off due to drought and increase with climate change
    - Managing one unique colony of species and drought effects
    - Starting to lose big canopy
    - Ideas of what we can do to help existing colony and to create other congregations
    - Creating resilient core preserve
    - How do you reduce impacts to forest ecosystems?

- NNP invasion
- Flooding
- Equity - low income/communities of color more impacted by cc, can't relocate, etc.
- Long term care of trees
- Opportunities for transitioning strategies for management
- Shaded fuel brakes along neighborhoods
- Brush dumping, anticipate dumping
- Maintain first canopy by boundaries
- Invasive species
- Soil fertility degradation
- Deer destroying everything - don't feed deer! Herd management, hunting, habitat restoration, erosion control
- Decreasing animal species
- Runoff pollution
- Limited species diversity
- Cultural understanding of trees, misunderstanding of restoration
- How do we get people to be supportive of the approaches that are needed?
- Demonstration sites are important to change public perceptions and gain support, e.g. demonstration of the mulching concept talked about earlier
- Putting sign up that says there's a fine
- Creating bananas instead of donuts
- Leadership issues
- Need for public education overheard several times
- Common issues heard include drought, floods, heat stress, wildfires, tree mortality, species diversity, invasive species all exacerbated by climate change
- Treating land under wind farms
- Public education
- **Cait's Notes**
  - Non-native/invasive species
  - Species diversity
  - Improving native habitat/survival
  - Tree mortality
  - Establishing natives
  - Survival of plantings
  - People choose bad trees
  - People hammer already-stressed areas that are nice
  - Human values and what people do and don't care about
  - How and why people make decisions

- Discussion of Breakout
  - What were some of the commonalities in terms of climate change challenges amongst your group?
  - What were some of the examples of adaptation actions?
  - Did your adaptation actions tend to focus on resistance, resilience, or transition?

    - Management challenge: cash flow, depletion of natural resources (e.g. rainfall, soil fertility lowered), ideas to respond - diversify business model (stack business), deer eating plants and hunters on land
    - Current management challenge: invasive plants, effect = some of the dead zones from the 2011 drought being colonized by exotic plants, replace dead forest with shrubland suitable for endangered birds, switch to manage for shrubland species, invasive eradication searches need to switch to examine dead zones, plant native seeds suitable for vireos, knock down dead trees and use for erosion runoff
    - Different management challenges, some of the same tactic, which was demonstration gardens. How can we decrease water flow? Public education via neighborhood associations, replicate things we do in the park.
    - Getting people to let us do these things! Don't look attractive, etc. trying to get lots of awards and put them up everywhere for cool projects, do things in areas of campus nobody really sees and take photos of it, get students involved for service learning, etc.
    - Challenge: Revegetating formally eroded but not stabilized banks, species choice, how to water plants we put in, heat affecting them, timing of planting, invasive species that pop up. General approach: use material from across greater geographic area, specific examples - long-term approach to revegetation, monitoring projects for years at a time.
    - Non-native plants: issues is a lot of residential neighbors with invasive plants, can't do anything on their side of the fence, native plant exchange program, education, reach out to suppliers of invasive plants and get cooperation to switch to native.
    - Unequal distribution of tree canopy in West and East Austin, general approaches for east = resistance and resilience and west = resilience and transition. East = wide range of ideas, increasing tree diversity that comes off of vulnerability list, increasing soil health, partnerships.
    - Overlap in solutions, trended toward resistance and resilience, talk about soil and importance of good planning, AISD projects promoting saving of good native top soil of construction, biodiversity and creating behavior in acceptance, linking between strategies and implementation, prove return on investment.
    - Challenge: dealing with impacts of recreation activities, exacerbated by climate change, general approaches = alternative locations, prioritizing where access is allowed, etc.
- Leslie Brandt - Closing Comments
    - Have step 1 done tomorrow
    - Better is project isn't directly related to climate change, will incorporate later in the process

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<u>Day 2 (November 7): Adaptation Planning and Practices</u>

Adaptation Planning and Practices is an active, hands-on training, to assist urban forest and natural areas managers in incorporating climate change considerations and identifying actions for adaptation into their own real-world forest management projects. This training is available for a limited number of participants who have a specific project in mind. Participants are highly encouraged to attend Day 1 as a foundation for this more advanced training. Through this training, participants will be able to:

- Describe regional and local effects of climate change on urban forests and ecosystems
- Understand adaptation concepts and principles in the context of sustainable urban forest management
- Use Forest Adaptation Resources in real-world management projects to:
    - Identify challenges and opportunities for management
    - Develop actionable steps to adapt forests to changing conditions
    - Create their own climate-informed forest management project

We ask that participants develop a project idea and gain familiarity with key resources prior to the training, which helps make the best use of time at the in-person training. Examples of projects that may be a good fit:

- Developing or updating a planting list for street, park, or residential trees
- Updating or developing a master plan or other planning effort for a municipality, park, or natural area
- Selecting species for tree sales or nursery production
- A restoration project in a natural area
- Landscaping or green infrastructure projects

Agenda: Day 2

8:30 **Introduction – Leslie**
/
9:00 **Step 2: Climate change vulnerability on your project area – ACTIVITY**
10:00 **Break**

10:15 Adaptive Capacity

10:45 Vulnerability Determination
11:00 **Step 3: Challenges/Opportunities for Meeting Management Objectives – Overview**

11:15 **Step 3: Challenges/Opportunities for Meeting Management Objectives – Breakouts & Activity**
Draft/complete Step 3.

Transition: Now that you've identified challenges and opportunities, identify potential solutions.
12:15 Lunch

1:00 **Step 4: Identifying Forest Adaptation Approaches and Tactics – Overview**

1:30 **Step 4: Identifying Forest Adaptation Approaches and Tactics – Breakouts**
Groups work on Step 4.

2:15 **Step 4: Identifying Forest Adaptation Approaches and Tactics – Discussion**

2:45 **Step 5: Monitoring**

3:15 Work time for making final poster presentations

3:45 Poster presentations from each group

4:15 **Next Steps & Wrap-up**

4:30 **Adjourn**

Notes:

- Introduction - Leslie Brandt
    - Define, Assess, Evaluate, Identify, Monitor
        - Adaptation will be driven by individual goals, forest conditions, and site characteristics
        - One of the benefits – putting the whole thought process together
        - Documentation and opportunities to be creative, identify win-win opportunities as well as new ideas on adaptation
    - Step 1: Define area of interest, management goals and objectives, and timeframe
        - Goal more broad (e.g. increase urban tree species diversity)
        - Objective more specific, quantitative
    - Group Introductions
        - City of Austin: Make good choices on own private properties, influence decisions made on public property regarding trees, project is to make sure all info presenting to public helps people make responsible decisions related to their trees and supports forest health/best practices - public information angle
        - Vireo Preserve: Restoring preserve
        - Travis County: BCP, maintaining habitat for birds, ecosystems to protect, focus on Karst environments, 6 endangered Karst invertebrates, species of concern, how can we manage these protected areas?
        - Riparian: Urban creeks, riparian forests functional but also serving community goals
- Step 2: Climate change vulnerability on your project area - complete adaptation workbook step 2
    - Purpose: consider how climate change may specifically impact project area
    - How might the area be uniquely affected by climate change? How might regional impacts be different in your project area?

    - How might this area be uniquely affected? Think about presentations from Day 1!
    - Example: Regional impact = extreme precipitation events; an individual area may be more prone to flooding given slope and water table.
    - Pages 82-83 of FAR2
    - Regional projected climate change effects on ecosystems
    - Location specific information that may help assess impacts: soils, hydrology, habitat type or past management
    - Regional climate change impacts and vulnerabilities - from regional vulnerability assessments
- Adaptive Capacity - how systems can adapt to these impacts
- Vulnerability Determination
    - Adaptive Capacity (low-high) + Impacts (supportive-disruptive)
- Impacts - Votes
    - Increase in extremely hot days: 11
    - Increase in heavy rain events and flooding: 11
    - Shifts in heat/hardiness zones: 3
    - Shifts in phenology: 0
    - Changes in nutrient cycling: 2
    - Invasive plants/ants: 5
    - Pests/pathogens: 0
    - Changes in wildlife habitat: 0
    - Changes in tree species habitat: 10
    - Wildfire risks: 2
    - Soil erosion: 7
    - Human health impacts: 3
- Adaptive Capacity - Votes
    - Species diversity: 6
    - Habitat connectivity: 5
    - Genetic diversity: 1
    - Structural/age class diversity: 1
    - Ecosystem condition/health: 7
    - Staffing: 9
    - Inventory: 1
    - Disaster response plan: 0
    - Policy flexibility: 3
    - Tree care/maintenance: 7
    - Risk assessment: 0
    - Funding: 7
    - Public support: 5
    - Adaptive capacity for humans to change the “environment of the mind” and adjust practices to work with nature instead of against it: 1
    - *Note: Some looked at this the opposite way* (e.g. more staff would HELP system, but don’t currently have enough staff)
- Vulnerability - Group Project Areas/Systems

    - Generally all “moderate”
    - Disruptive impacts, moderate adaptive capacity
- Step 3: Challenges/Opportunities for Meeting Management Objectives - Overview
    - Purpose: realistically assess the ability to meet goals and objectives under current management
    - Can current management achieve goals?
    - Given these challenges and opportunities, who changed their management objectives? What did you keep the same?
    - Which ones might change in the future and why?
    - Ecosystem type of management topic - from step 1
    - Challenges to meeting management objective with climate change - things that will make it harder to achieve the management objective due to climate change
    - Challenges by CLIMATE CHANGE, not other challenges
    - Focus on challenges within control of your management (not global markets, policies, etc.)
    - Opportunities to Meeting Management Objective with Climate Change – Things that will make it easier to achieve the management objective due to climate change.
        - **Feasibility** – Can you meet your management objectives using **current** (business-as-usual) management actions? Consider short- and long-term feasibility.
            - **High:** We can do it!
                - Opportunities > Challenge
            - **Low:** We’ll need more resources or effort
                - Challenges > Opportunities
    - Other Considerations – Social, financial, or other factors that also affect your ability to meet objectives.
    - *Are you going to continue with these management objectives? If not, re-evaluate starting with step 1.*
- Step 3: Challenges/Opportunities for Meeting Management Objectives - Breakouts & Activity
- Step 4: Identifying Forest Adaptation Approaches and Tactics - Overview
    - What actions can enhance the ability of the ecosystem to adapt to anticipated changes
      and meet management goals?
    - Will future managers know what we were trying to do?
    - **Approach** – Select from the menu. Pick any that seem to make sense and help address the challenges.
    - **Tactic** – Describe a specific action you can take.
    - These details should ideally answer what, where, and how you will implement the actions.
    - **Timeframe** – Specify when you will implement the tactic
        - For example:
            - Summer 2016
            - Winter 2016-7

            - Within 3 years of…
            - After…
    - **Benefits** – Describe why the tactic is good
        - For example:
            - addresses biggest or multiple challenges
            - is cheap and easy
            - has co-benefits
            - is likely to succeed
    - **Drawbacks and Barriers** – Describe why it's not so good
        - For example:
            - it may have negative side effects
            - requires high cost or effort
            - may not be successful
            - has social, financial, or other barriers
    - **Practicability** – Is it both ***effective*** (will meet desired intent) and ***feasible*** (capable of being implemented)?
        - **High:** Yes to both!
        - **Moderate:** Yeah, but it will take some additional effort or planning…
        - **Low:** No, the barriers/drawbacks seem too big or the benefits too small.
    - **Recommend Tactic**– Given all this, is this tactic likely to be helpful?
    - Also consider: trade-offs, urgency, likelihood of success, cost, and effort…
        - **Yes:** look to integrate into plan, prescription, or other activities
        - **No:** not useful at this time
- Step 4: Identifying Forest Adaptation Approaches and Tactics - Breakouts
- Step 4: Identifying Forest Adaptation Approaches and Tactics - Discussion
    - What are some examples of tactics you discussed in your groups?
    - Overall, were the strategies you selected geared toward resisting climate change, transitioning to align with future conditions, or somewhere in between/a mix?
        - Groups had a mixture
    - Do the strategies you selected help reduce the biggest impacts you identified?
    - Do the strategies you selected help enhance your adaptive capacity?
    - Do your strategies address the challenges you identified, capitalize on opportunities, and help you meet your goals and objectives?
- Step 5: Monitoring
    - Purpose: Practice adaptive management
    - How do we know if the selected actions were effective?
    - What can we learn from these actions to inform future management?
    - Be VERY CLEAR about your information needs and the kind of monitoring that might help you get that information:
        - **Implementation monitoring** = Did we do the action?
        - **Surveillance/impact monitoring** = What change is occurring over time?
        - **Effectiveness/adaptation monitoring** = Did our action actually have the desired effect?
    - Be VERY CLEAR about your information needs and the kind of monitoring that

might help you get that information:
        - **Implementation monitoring** = Did we do the action?
        - **Surveillance/impact monitoring** = What change is occurring over time?
        - **Effectiveness/adaptation monitoring** = Did our action actually have the desired effect?
        - **Scientific research** = Is this outcome statistically significant compared to a control? Could we expect similar results elsewhere?
    - Climate change monitoring
        - Are you going to monitor climate change? Nope.
        - Are you going to monitor climate change impacts? Not necessarily.
        - Are you going to monitor the success of your management? That's the ticket!
        - You're already doing that (or trying).
        - "Climate change monitoring" is not climate science
    - **Adaptation Monitoring Variable** – What you will measure
    - **Criteria for Evaluation** – a value or threshold that is meaningful for assessing effectiveness or informing future decisions
    - **Monitoring Implementation** – How you will gather the information
    - What are some things you could monitor from your projects to assess the effectiveness of your adaptation actions?
- Poster Presentations
    - Tell your story! Place and purpose —> Key risks from climate change —> Adaptation actions to address key risks —> Outcomes and benefits
    - Who is your audience?
- Next Steps & Wrap-up