Adapting to and Mitigating Climate Change

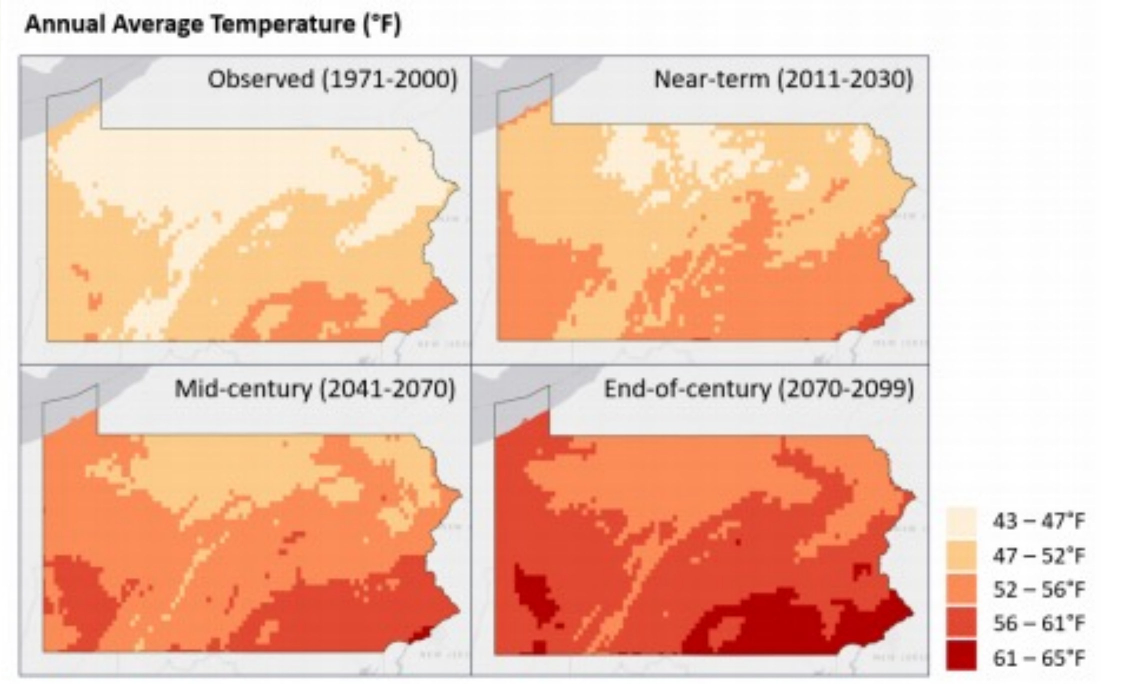
Greg Czarnecki

Director of Applied Climate Science

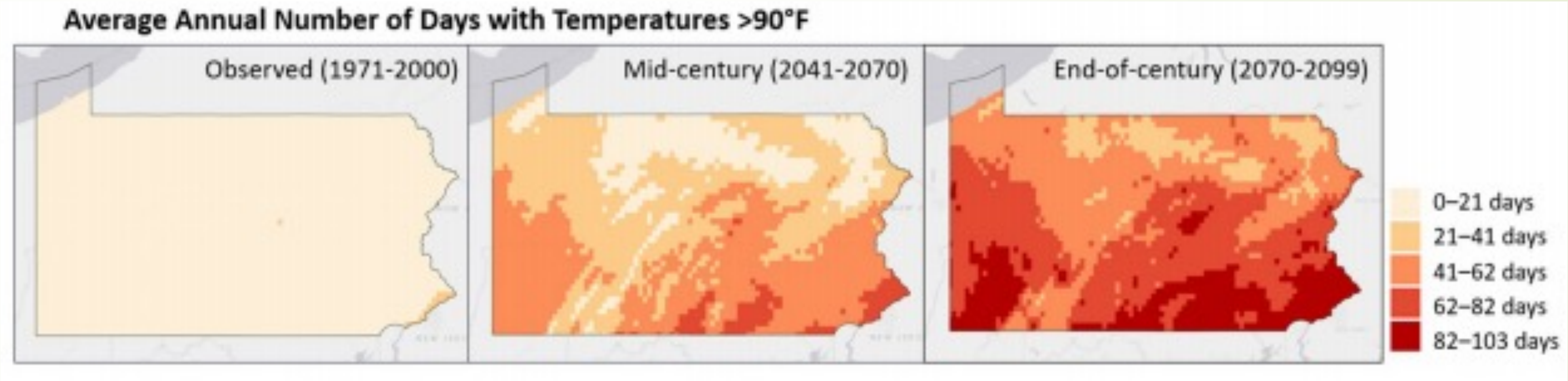
pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Temperatures are Rising

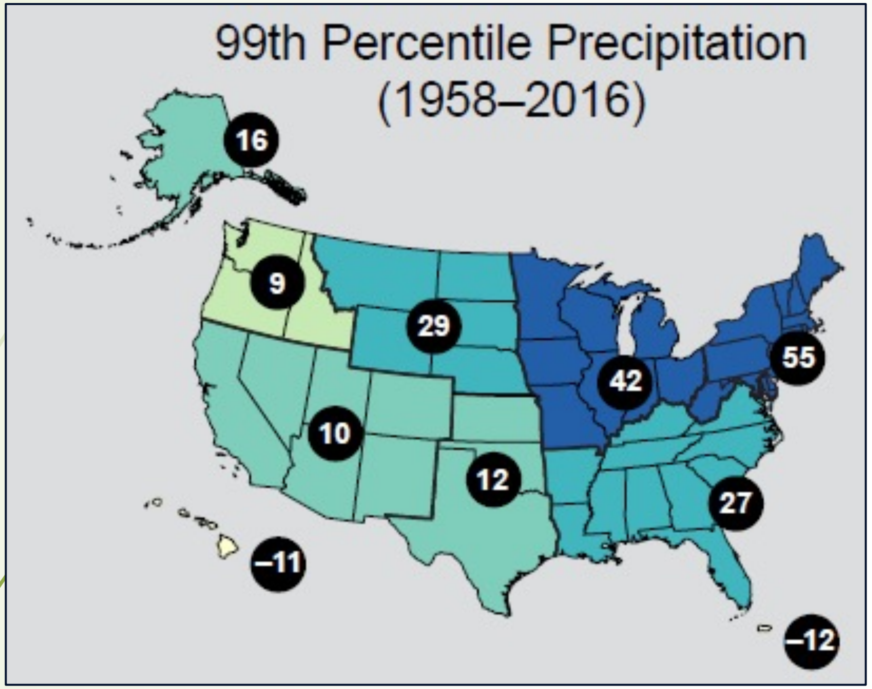
- 1.8 F increase already.
- Temperatures rising nearly twice as fast at night as during the day.
- Winters are warming faster than summers.



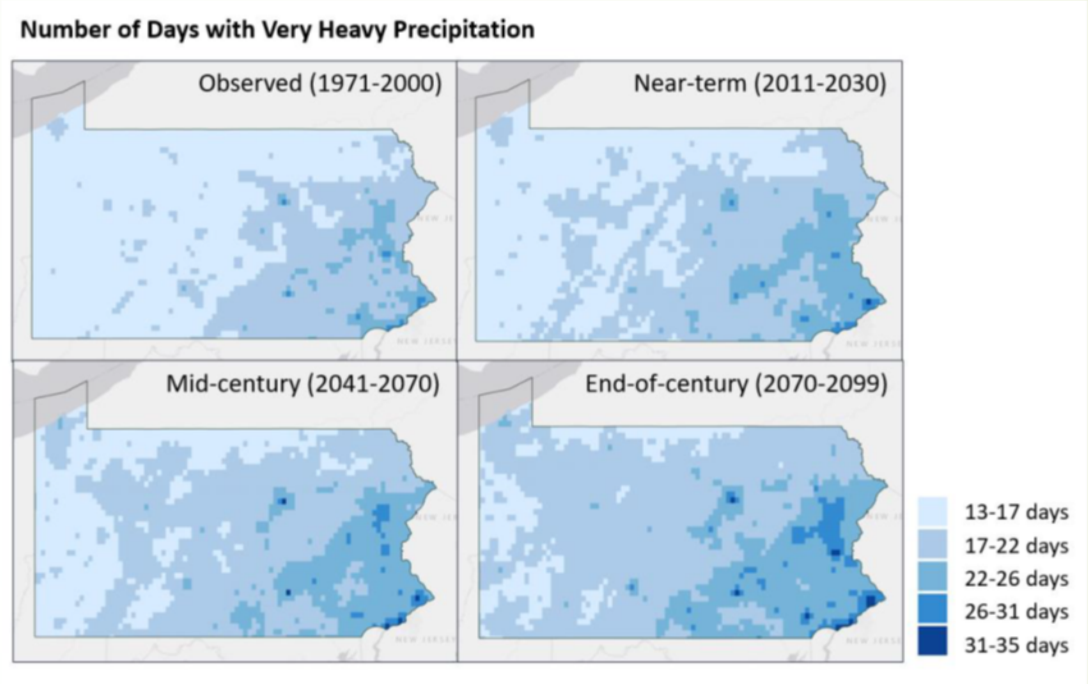
2021 PA Climate Impacts Assessment



Rainfall Patterns are Changing



Fourth National Climate Assessment



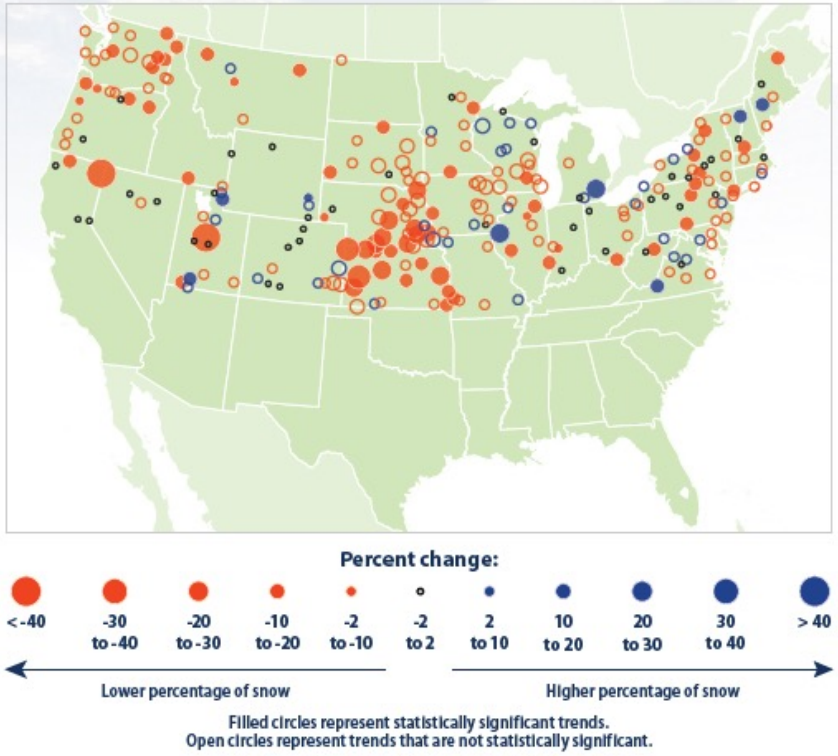
Pennsylvania 2021 Climate Impacts Assessment

www.dcnr.pa.gov

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Winter Precipitation is Changing

Change in Snow-to-Precipitation Ratio in the Contiguous 48 States, 1949–2016



This figure shows the percentage change in winter snow-to-precipitation ratio from 1949 to 2016 at 246 weather stations in the contiguous 48 states. This ratio measures what percentage of total winter precipitation falls in the form of snow. A decrease (red circle) indicates that more precipitation is falling in the form of rain instead of snow. Solid-color circles represent stations where the trend was statistically significant. Data source: NOAA, 2016[16]

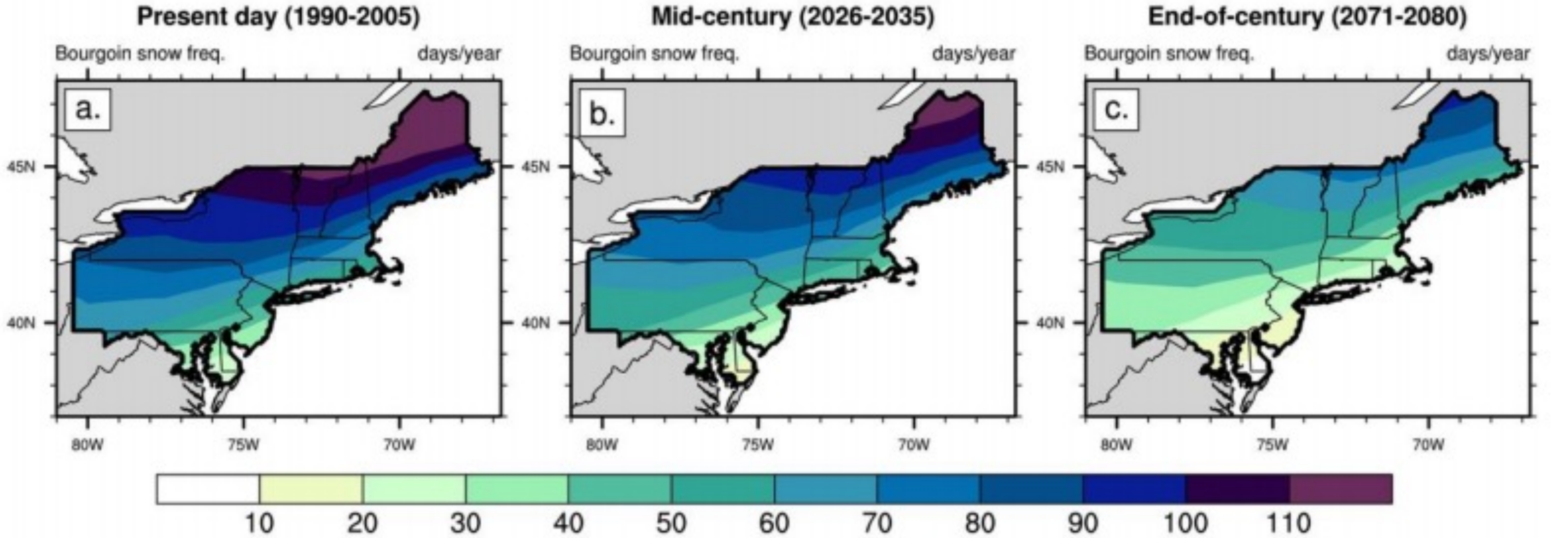


Figure 24. Average number of days per year where snowfall could occur, present-day, mid-century, and end-of-century.

Values for present day represent all years 1990–2005, values for mid-century represent all years 2026–2035, and values for end-of-century represent all years 2071–2080. Source: Zarzycki, C.M., 2018. Projecting changes in societally impactful Northeastern U.S. snowstorms.

Pennsylvania 2021 Climate Impacts Assessment

www.dcnr.pa.gov

pennsylvania DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

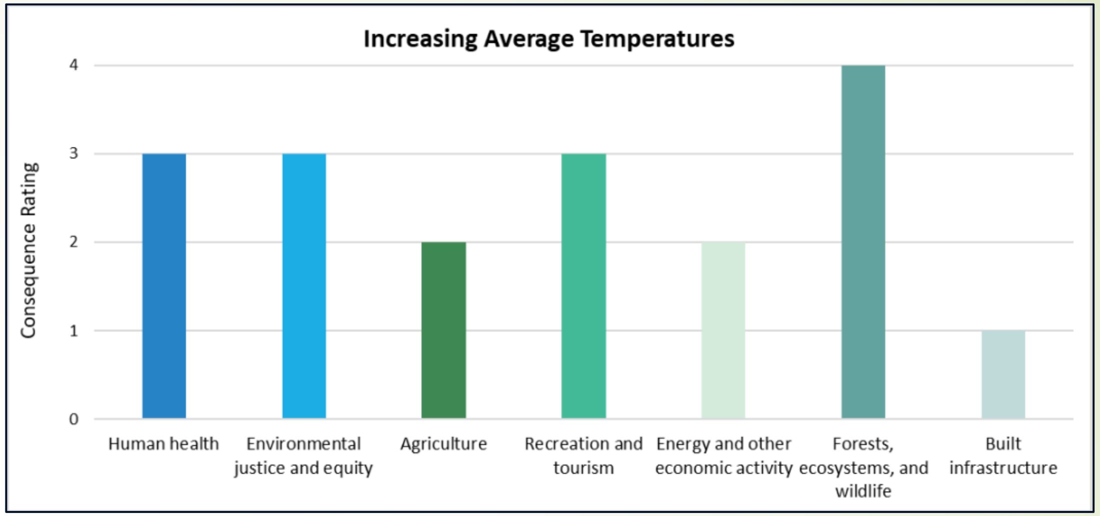
Union of Concerned Scientists

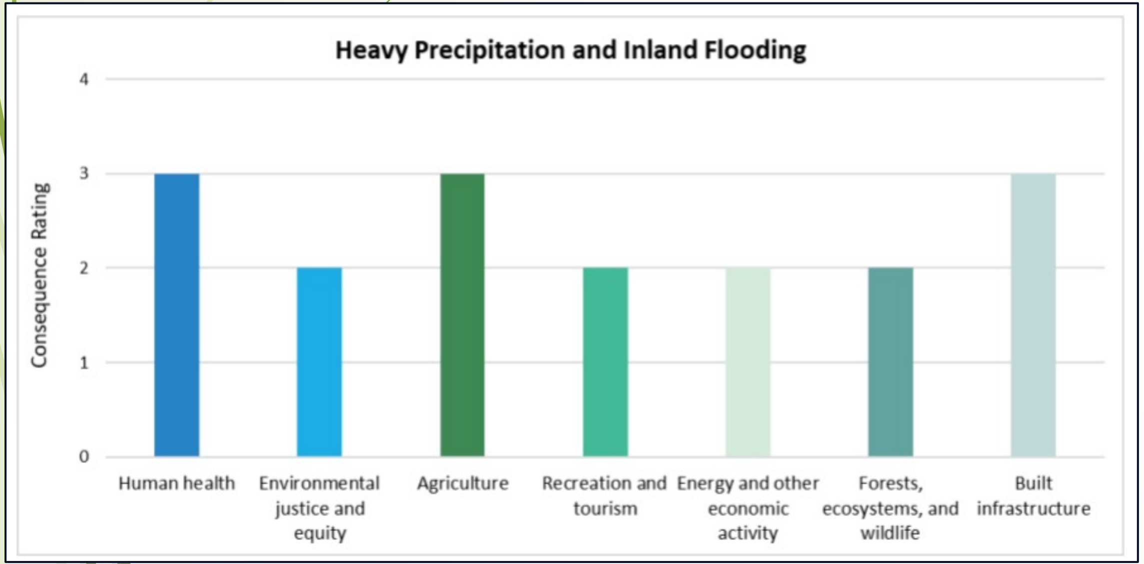
What are the Consequences?

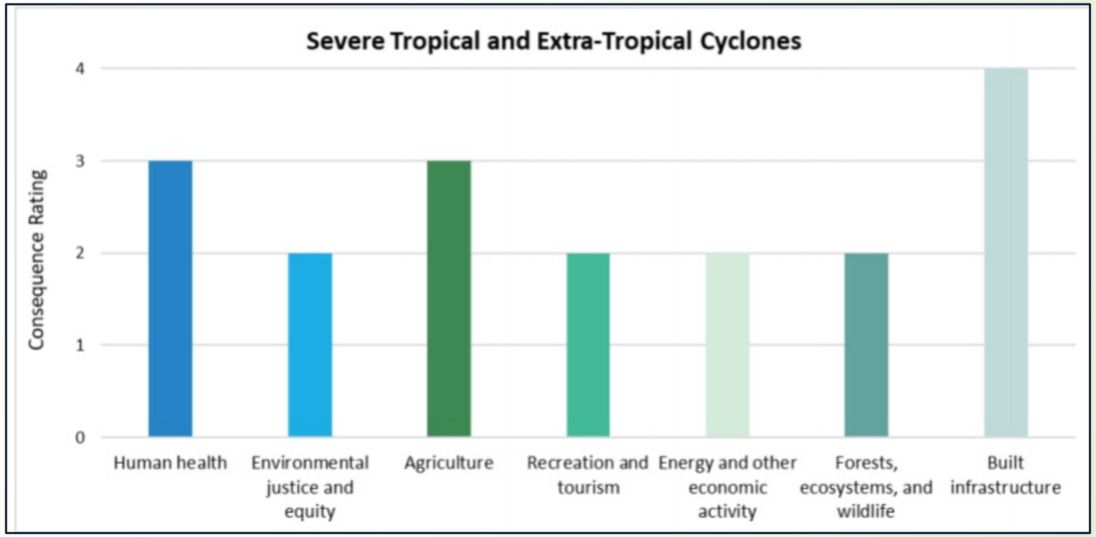
2- Limited

3 – Critical

4- Catastrophic





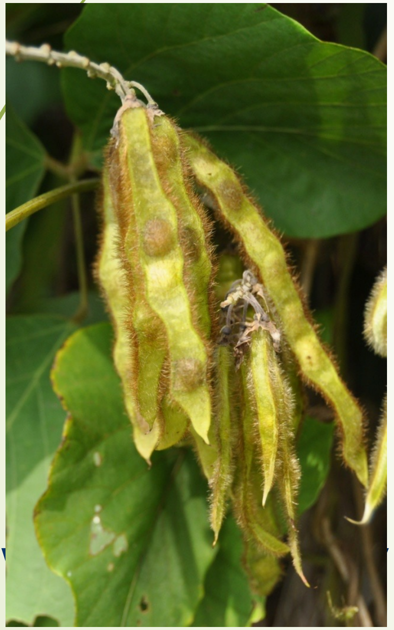


www.dcnr.pa.gov

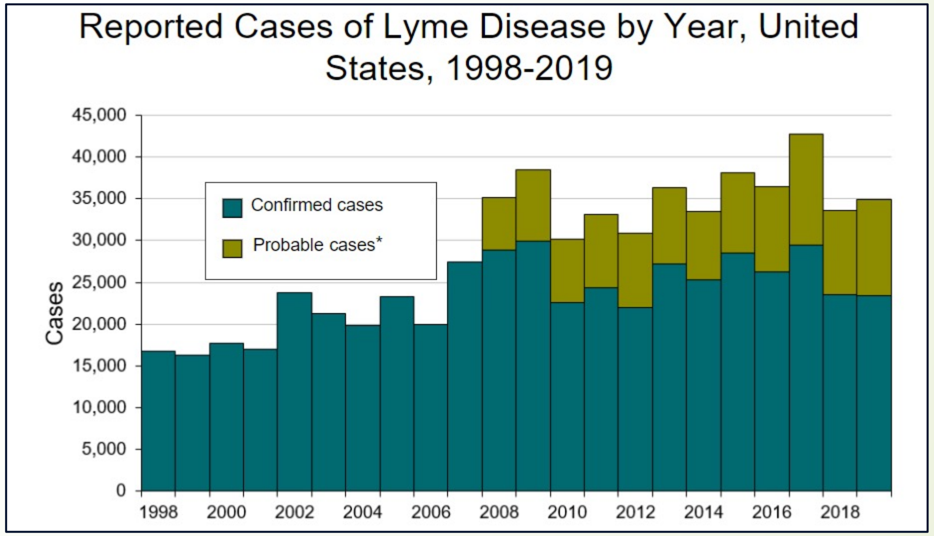
Pennsylvania 2021 Climate Impacts Assessment

pennsylvania DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Invasive Species & Pests

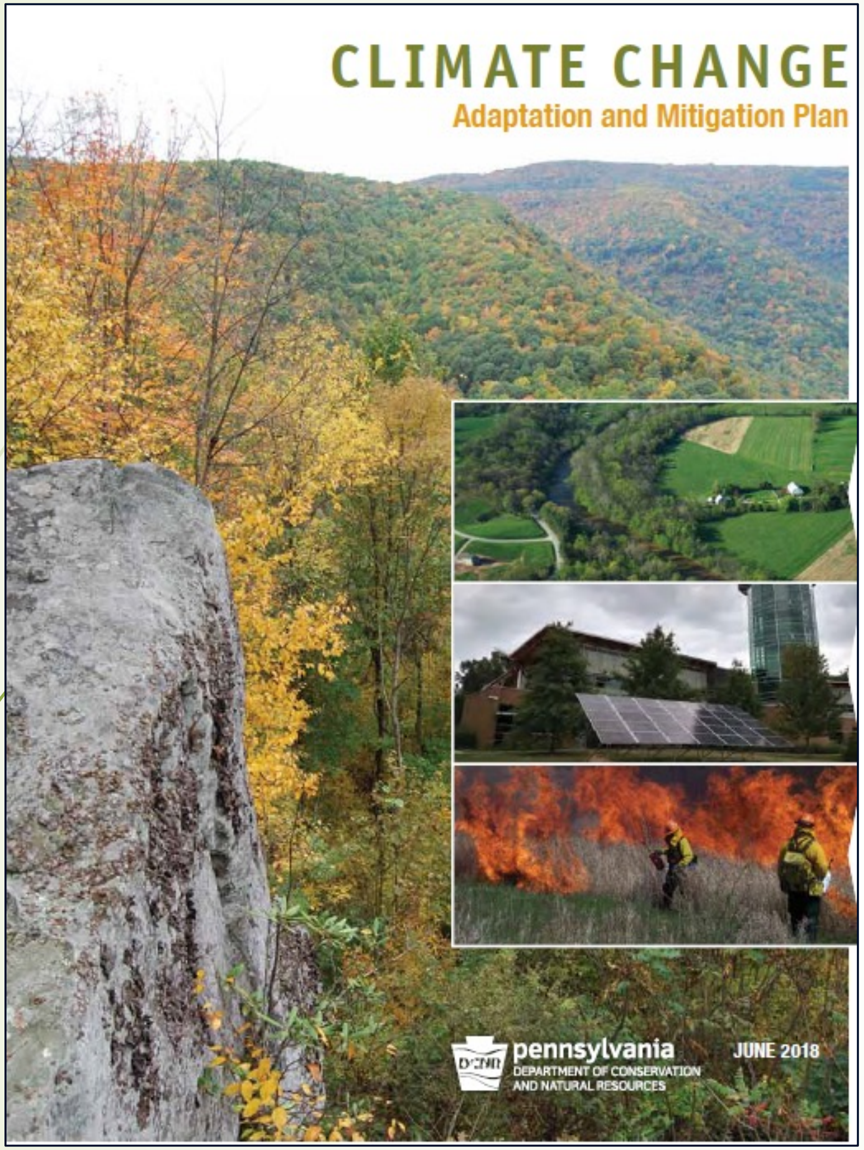


Kudzu is reproducing in Pennsylvania (photo from Lebanon County)



CDC.gov

pennsylvania DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

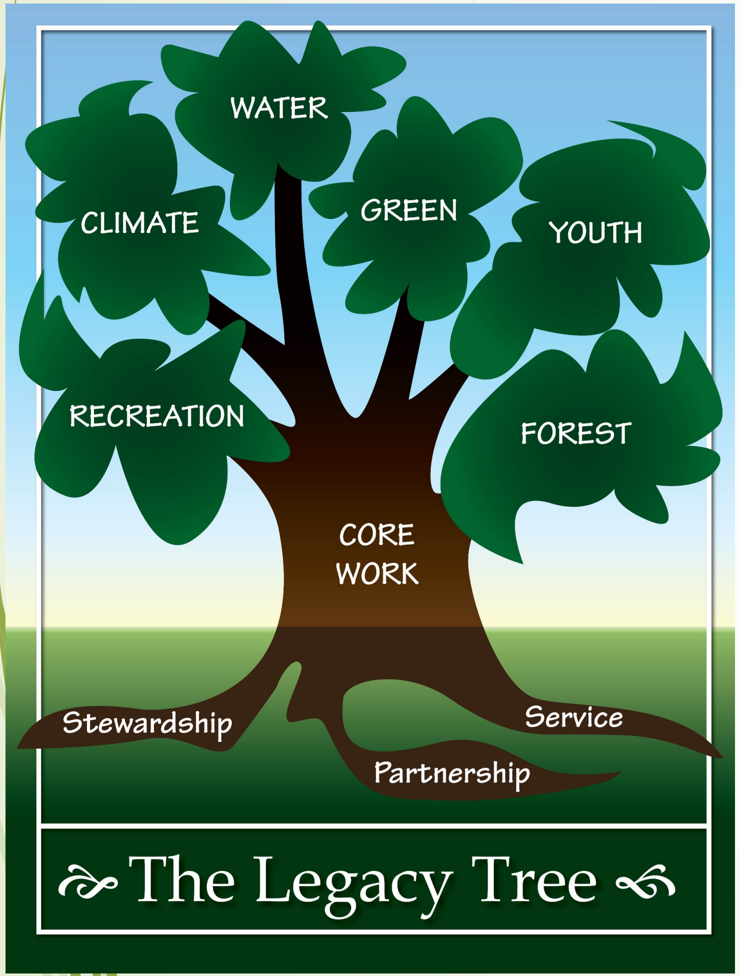


CLIMATE ADAPTATION LEADERSHIP AWARD
for natural resources

www.dcnr.pa.gov

pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DCNR's Climate Change Position Statement



www.dcnr.pa.gov

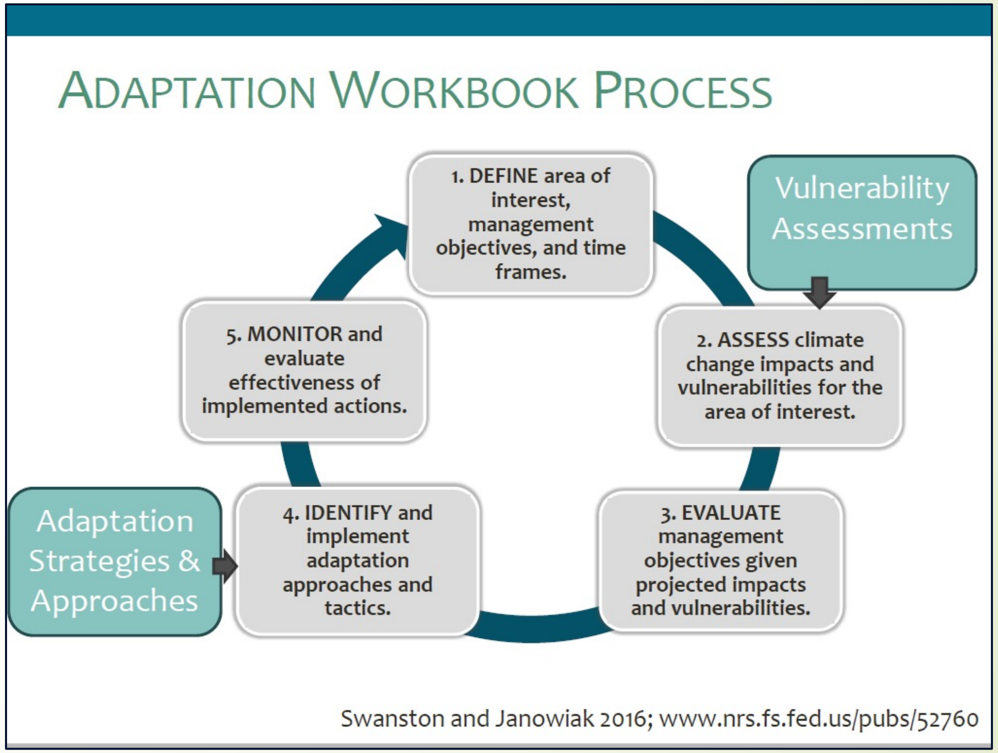
Climate change is real and is impacting the Commonwealth's ecological and recreational resources. As the state's leading conservation agency, DCNR will use the best available science to develop and implement climate change adaptation and mitigation strategies within each of its bureaus to minimize these impacts and serve as a role model for the citizens of Pennsylvania.

pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Climate Adaptation Planning Process

- More than 80 DCNR staff
- Bureaus:
  - Forestry
  - State Parks
  - Facility Design & Construction
  - Recreation & Conservation
  - Geologic Survey
- Topical areas:
  - Riparian buffers
  - Emergency management
  - Communications

NIACS
Northern Institute of
Applied Climate Science



pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Risk Assessment

Risk Matrix for Bureau Impacts and Vulnerabilities

Likelihood \ Severity of Impacts	Negligible	Minor	Moderate	Major	Severe
Very Likely	Med. Low	Medium	Med. High	High	High
Likely	Low	Med. Low	Medium	Med. High	High
Possible	Low	Med. Low	Medium	Med. High	Med. High
Unlikely	Low	Med. Low	Med. Low	Medium	Med. High
Very Unlikely	Low	Low	Med. Low	Medium	Med. High

What is the severity of the impact if it does happen? Think about the bureau and agency missions

Negligible (there is little visible, functional, or economic consequence)

Minor (there is some visible, functional, or economic consequence, but within the range of normal variability)

Moderate (visible, functional, or economic consequence is outside the range of normal variability)

Major (visible, functional, or economic consequence is detrimental to operations and must be addressed)

Severe (visible, functional, or economic consequence that results in mission failure and requires intervention by other state or federal agencies)

What is the likelihood of the listed impact or vulnerability?

Very likely (it's already beginning or has already happened)

Likely (it's imminent that it will happen)

Possible (there's evidence to support it happening, but the event depends on assumptions)

Unlikely (there's evidence predominately suggesting it won't happen)

Very unlikely (it would be against all odds to see it happen, but it's still possible)

State Park Vulnerabilities

- Shortage of knowledgeable personnel
- Forests not being managed for climate change
- Warming waters threaten native fish and coldwater streams
- Increased flooding threatening infrastructure and recreational and ecological resources
- Increase in invasive species and pests

State Park Vulnerabilities

- More variability in lakes levels and discharges
- Longer recreation season leading to increased visitor impact on natural resources
- Changing forest composition
- Reduced winter recreation opportunities

Adaptation Options - Infrastructure

www.dcnr.pa.gov

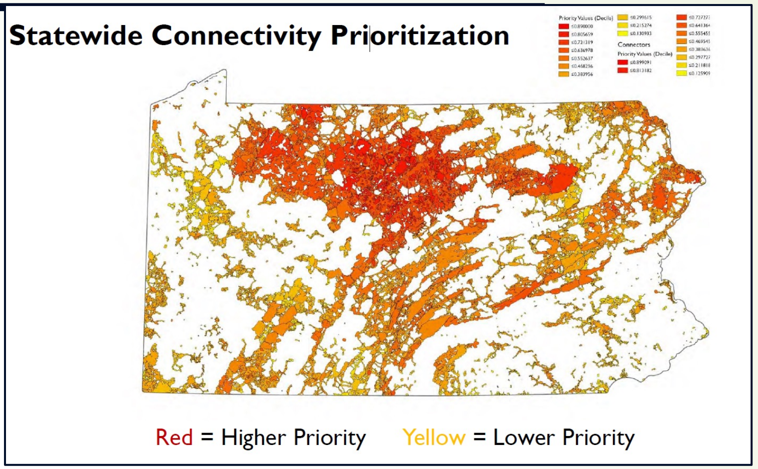
- Evaluate trends in 50-year, 100-year, and 500year floods
- Design infrastructure to be more resilient to flooding
- Avoid rebuilding in flood prone areas
- Reroute roads and trails out of floodplains when possible
- Retrofit lakeshore infrastructure to better adapt to changing water levels
- Remove unneeded dams
- Evaluate the hydraulic capacity of dams and adjust where needed.
- Replace undersized culverts

DCNR pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Adaptation Options - Recreation

- Determine recreational and resource carrying capacities
- Limit some types of recreation in high-use or sensitive areas.
- Adjust seasonal employment.
- Consider other options for water-based recreation such as swimming pools and splash areas.
- Match recreational opportunities with changing site conditions.

Adaptation Options - Conservation



- Conserve key tracts of land that increase connectivity and provide migration corridors.
- Prioritize grant funding that addresses climate change impacts on species, natural communities, and connecting parcels that facilitate the movement of species.
- Conserve biological legacies and unique ecological sites.
- Plant trees that will be better adapted to future conditions.

Planting Trees Better Adapted to Future Climatic Conditions

CLIMATE CHANGE PROJECTIONS FOR INDIVIDUAL TREE SPECIES
RIDGE AND VALLEY (PENNSYLVANIA SUBREGION 4)

Pennsylvania's forests will be affected by a changing climate during this century. A team of forest managers and researchers created an assessment that describes the vulnerability of forests in the Mid-Atlantic region (https://forestadaptation.org/mid-atlantic/vulnerability-assessment). This handout is summarized from the full assessment, but focuses on one region in Pennsylvania. Model results for additional regions can be found online at (https://forestadaptation.org/PA-DISTRIB).

TREE SPECIES INFORMATION:
The DISTRIB model of the Climate Change Tree Atlas uses inputs of tree abundance, climate, and environmental attributes to simulate current and future species habitat under two climate scenarios. Results for "low" and "high" climate scenarios can be compared on page 2 of this handout.

Remember that models are just tools, and they're not perfect. Output from DISTRIB does not consider many biological or disturbance factors which favor or limit tree establishment, growth, or mortality. For example, the susceptibility of ash species to emerald ash borer is causing widespread mortality and it will likely do even worse than the model suggests. For the 30 most common species, we present such factors not included in the model that may cause species to do better or worse than models suggest.

Despite their limitations, models provide useful information about future expectations. It's important to think of these projections as indicators of potential change in the amount of suitable habitat for a species, but that human choices and other factors will continue to influence tree distribution, movement, and forest composition at individual sites.

SPECIES	ADDITIONAL CONSIDERATIONS
LIKELY TO DECREASE	
American basswood	Tolerates shade, susceptible to fire
American beech	Susceptible to beech diseases, very shade tolerant
American mountain-ash	Requires specific habitat, intolerant of fire and shade
Atlantic white-cedar	Requires specific habitat, intolerant of fire and drought
Balsam poplar	Vegetative resprout following fire
Bigtooth aspen	Early-sucessional colonizer, susceptible to drought
Black ash	Narrow requirements; Emerald ash borer causes mortality
Black spruce	Prone to sawfly and budworm attacks, drought-sensitve
Butternut	Prone to butternut canker, drought-sensitive
Chokecherry	Shade intolerant, sensitive to browsing and competition
Eastern hemlock	Hemlock woolly adelgid causes widespread mortality
MAY DECREASE	
Black cherry	Susceptible to insects and fire, somewhat drought-tolerant
Chestnut oak	Establishes from seed or sprout, adapted to fire
Cucumber tree	Susceptible to fire topkill
NO CHANGE	
Black locust	Early colonizer, but susceptible to locust borer & heart rot
MIXED MODEL RESULTS	
American chestnut	prone to chestnut blight; intolerant of fire
American hornbeam	Tolerates shade, susceptible to fire and drought
Black willow	Intolerant of shade, fire, and drought
Bur oak	Drought-tolerant, fire-resistant, adaptS to a variety of sites
Eastern cottonwood	Intolerant of shade, fire, defoliators and cankers
MAY INCREASE	
American elm	Grows on a variety of sites, Dutch elm disease
Black oak	Drought tolerant, susceptible to insect pests and diseases
Boxelder	Widespread and tolerant of drought and shade
Chinkapin oak	Tolerates a gradient of temperatures, very adaptable species
Eastern hophornbeam	Grows across a variety of sites, tolerates shade
LIKELY TO INCREASE	
Bear oak: scrub oak	Shade intolerant, susceptible to fire topkill and flood
Bitternut hickory	Drought-tolerant, susceptible to insects and fire topkill
Black walnut	Good disperser, but intolerant of shade and drought
Blackgum	Shade tolerant, fire adapted
Persimmon	Shade tolerant

CONTACT:
Greg Czarnecki (gczarnecki@pa.gov)
Climate Change & Research Coordinator,
PA Department of Conservation and Natural Resources.

Patricia Leopold (pleopold@mtu.edu)
Mid-Atlantic Climate Change Response Framework Coordinator, NIACS.

NIACS

SOURCE: Prasad, AM; Iverson, LR; Peters, MP; Matthews, SN. 2014. Climate change tree atlas. Northern Research Station, U.S. Forest Service, Delaware, OH. http://www.nrs.fs.fed.us/atlas.

www.forestadaptation.org

FUTURE PROJECTIONS
The DISTRIB model uses Forest Inventory and Analysis (FIA) data to calculate an Importance Value (IV) for each species on the landscape in order to evaluate potential IV's at the end of this century (2070 – 2099). Those changes are classified in the table below as:

- ▲ INCREASE — *Projected increase of >20% by 2100*
- ● NO CHANGE — *Little change (<20%) projected by 2100*
- ▼ DECREASE — *Projected decrease of >20% by 2100*
- ★ NEW HABITAT — *Tree Atlas projects new habitat for species not currently present*

ADAPTABILITY
Factors not included in the Tree Atlas model, such as the ability to respond favorably to disturbance, may make a species more or less able to adapt to future stressors. Specific considerations are provided on page 1 for the 30 most abundant species.

- + high — *Species may perform better than modeled*
- o medium
- – low — *Species may perform worse than modeled*

SPECIES	FIA IV	MODEL RELIABILITY	LOW CLIMATE CHANGE (PCM B1)	HIGH CLIMATE CHANGE (GFDL A1FI)	ADAPT
American basswood	98	M	▼	▼	o
American beech	286	H	▼	▼	o
American chestnut	55	M	▲	●	o
American elm	87	M	●	▲	o
American hornbeam	56	M	▼	▲	o
American mountain-ash	1	M	▼	▼	-
Atlantic white-cedar	1	L	▼	▼	-
Balsam poplar	2	H	▼	▼	o
Bear oak; scrub oak	111	L	▲	▲	o
Bigtooth aspen	123	H	▼	▼	o
Bitternut hickory	27	L	▲	▲	+
Black ash	1	H	▼	▼	-
Black cherry	1129	H	●	▼	-
Black locust	217	L	●	●	o
Black maple	1	L	▼	▼	-
Black oak	361	H	●	▲	o
Black spruce	4	H	▼	▼	o
Black walnut	90	M	▲	▲	o
Black willow	4	L	▼	▲	-
Blackgum	352	H	▲	▲	+
Boxelder	79	M	●	▲	+
Bur oak	2	M	▼	▲	+
Butternut	15	L	▼	▼	-
Chestnut oak	1160	M	●	▼	+
Chinkapin oak	2	M	●	▲	o
Chokecherry	57	L	▼	▼	o
Cucumbertree	13	L	●	▼	o
Eastern cottonwood	367	H	▼	▲	-
Eastern hemlock	134	M	▼	▼	+
Eastern hophornbeam	26	M	●	▲	o
Eastern redbud	49	M	▲	▲	o
Eastern redcedar	274	H	▲	▼	o
Eastern white pine	203	H	●	▼	o
Flowering dogwood	59	M	▲	▼	o
Gray birch	51	M	●	●	o
Green ash	23	M	●	▲	+
Hackberry	2	L	●	▲	+
Honeylocust	2	H	●	▲	o
Jack pine	114	H	▼	▼	+
Mockernut hickory	2	H	▲	▲	+
Northern red oak	881	H	●	▼	+
Osage-orange	1	M	●	▲	+
Paper birch	11	H	▼	▼	o
Pawpaw	5	L	●	●	o
Persimmon	2	M	▲	▲	+
Pignut hickory	128	H	▲	▲	o
Pin cherry	43	M	▼	▼	o
Pin oak	17	L	●	▲	-
Pitch pine	96	H	●	●	o
Quaking aspen	54	H	▼	▼	o
Red maple	2021	H	●	▼	+
Red mulberry	6	L	●	▲	o
Red pine	40	M	▼	▼	o
Red spruce	9	H	▼	▼	-
River birch	7	L	●	▲	o
Sassafras	449	H	▲	●	o
Scarlet oak	187	H	▲	▲	o
Serviceberry	166	M	●	▼	o
Shagbark hickory	45	M	●	▲	o
Shellbark hickory	1	L	▼	▲	o
Shingle oak	4	M	●	▲	o
Shortleaf pine	2	H	●	▲	o
Silver maple	27	M	▼	▲	+
Slippery elm	94	M	●	▲	o
Sourwood	0	H	★	★	+
Southern red oak	1	H	●	▲	+
Striped maple	220	H	●	▼	o
Sugar maple	515	H	●	▼	+
Swamp white oak	12	L	●	▼	o
Sweet birch	826	H	●	▼	-
Sweetgum	1	H	●	▲	o
Sycamore	38	M	▲	▲	o
Table mountain pine	7	M	▼	●	+
Tamarack (native)	16	H	●	▼	-
Virginia pine	117	H	●	▲	o
White ash	844	H	●	▼	-
White oak	502	H	●	▲	+
White spruce	17	M	●	●	o
Yellow birch	81	H	▼	▼	o
Yellow-poplar	224	H	▲	▼	+

www.forestadaptation.org

ylvania
F CONSERVATION
AND NATURAL RESOURCES

Pennsylvania Climate Leadership Academy

Climate Leadership Activator Series

ACCO
ASSOCIATION OF CLIMATE CHANGE OFFICERS

Session #1	Session #2	Session #3
Climate Fundamentals & Implications for Pennsylvania and Mid-Atlantic USA	Climate Implications for Health, Equity & Economic Vitality	Risk Management & Enterprise Readiness
August 24, 2021 (*9:30am – 12:00pm*)	August 31, 2021 (*9:30am – 12:00pm*)	September 7, 2021 (*9:30am – 12:00pm*)

- Climate training offered to all DCNR staff
- Will be required for all new employees

Thank You