Direct Climate Effect

Current Condition:

- High temps = increased stress
- Open water ponds increase thermal loading
- Isolated coldwater populations, difficult to transit through salt water connections – loss of eelgrass
- Poor connectivity associated with thermal barriers

Increase in CO_2:

Increased vegetation growth?

Longer growing season may be increasing evapotranspiration rates

Increase in Temperature:

- Δ competitive interactions
- ↑ decomposition rates
- ↓ organic matter accretion
- Reduced suitable habitat
- Increased cool season growth and decreased summer growth
- Decreased survival in smaller tributaries
- Decreased reproduction
- Shrinking habitats especially at headwaters and valley bottoms
- Increased temps can cause reduced year class strength
- Increase in local extinctions
- Change in migration and spawning timing
- Decreased osmoregulation in salters

Change in Precipitation:

- Seasonal Δ timing/duration influences ground water flows
- Δ precip. = increase in sediment
- Loss of tree cover wth freq./more severe drought
- Increased precipitation and groundwater levels could increase summer flows from warm headwater ponds resulting in decreased habitat for coldwater species

Change in Sea Level:

- Raise groundwater level = increased flows?
- Raise groundwater level = increased refuge habitat?
- Raise groundwater level = reduce stream temps?
- Increased saltwater intrusion to groundwater
- Land subsidence

Increase in Extreme Climate Events:

- ↑ extr. disturbance favors input of CWD?
- Change in riparian vegetation
- Large storm from November to February could scour redds
- Storms from Feb –March could wash fry into poor habitats
- Displacement of adults and juveniles from favorable habitats

Invasive/Nuisance Species

Current Condition:

- Many invasive plants in riparian corridor
- Many non native warm water species in ponds
- Increased defoliation associated with forest pests
- Asian clams in John's pond
- Small jellyfish (toxic?) in lower Childs
- Southern pine beetle already here and could become much more damaging
- Mosquito fish in Quashnet

Increase in CO_2:

Increase in Temperature:

- ↑ temp. may encourage range expansion of southern species (animals quicker, plants)
- Increased temperature may allow warm water species to increase
- Increased amount of riparian vegetation made up of invasive
- Increased disease in fish
- Insect pest may not be killed by cold winters anymore

Change in Precipitation:

- May cause species, to spread
- Native plants and animals vulnerable to flooding may experience negative impacts
- Multiple stressors (abiotic + biotic) may act synergistically with ↑ precip.
- Increase in freshwater ponding in marshes
- Increased flows from headwater ponds may cause warm water species to be washed into streams

Change in Sea Level:

Increase in Extreme Climate Events:

- Variable impacts on species, disease, vectors, etc.
- Range expansion likely
- More disturbances could ↑ vulnerability to invasion

Nutrients

Current Condition:

- Increased vegetation in streams = slower flows = increased sediment deposition
- Increased algae blooms in headwater pond and estuary
- Decrease in eelgrass beds
- Sources primary septic, lawns, golf course

Increase in CO_2:

- Changes to veg. communities affects N pools
- Changes to structure/function of microbial N transformers

Increase in Temperature:

- ↑ temp. = ↑ nutrient cycling
- Increase anoxic conditions increased fish kills (greater impact in the Childs)
- Increased temps can increase algae blooms

Change in Precipitation:

- Changes in water levels could influence nutrient availability/circulation
- ↑ in wet deposition of nutrients
- Increased input of fertilizers and pesticides

Change in Sea Level:

Increased sea level can result in increased septic system failure (high ground water)

Increase in Extreme Climate Events:

- May cause more frequent combined sewer overflows
- May cause more input of nutrient from paved areas

Sedimentation

Current Condition:

- Historically high loads of sediment from agriculture (bogs) still in systems
- Sediment trapped in systems due to structures
- Sediment trapped in vegetation

Increase in CO_2:

Increase in Temperature:

- Increased risk of wildfire and associated sediment from windblown debris or erosion
- Increased plant growth

Change in Precipitation:

- Increased sedimentation movement in streams due winter streams

Change in Sea Level:

- Increased sea level can cause increased sediment deposition in inter tidal zone

Increase in Extreme Climate Events:

- storms a major factor in defining short-term variability in sedimentation rates
- More intense precipitation and increased sedimentation

Erosion

Current Condition:

- Increased erosion from disturbed sites (roads, berms, ditches)
- Vegetation loss leads to widening of stream banks
- Soil type and geographical setting are most important factors when comparing erosion rates among sites
- There is a generally recognized low erosion potential around Cape Cod Rivers

Increase in CO_2:

Increase in Temperature:

- ↑ temp = ↑ belowground decomposition = ↑ erosion (maybe)
- Increased temp and decreased precip could dry soil and lead to wind erosion
- Although the above is true- neither may be significant

Change in Precipitation:

- With increased rainfall, there may be an increase in erosion
- Redd scour could be plus or minus for spawning – see sedimentation
-

Change in Sea Level:

- Related impacts – openings in barriers could increase tidal flushing in esturary

Increase in Extreme Climate Events:

- ↑ storms = more erosion of disturbed sites
- Large storms could result in deposition in lower tidal portions of rivers

Environmental Contaminants

Current Condition:

- There is a presumed tolerance to historic and persistent levels of exposure; however "cost" may be reduced ability to tolerate climatic stress
- Certain legacy pollutants are decreasing, but other emerging contaminants are increasing and it is unknown how these 'new' contaminants will affect stream biota
- CC will stress communities through shifting them into non-optimal areas, ↓ resiliency, ↓ diversity, ↑ stress
- Little knowledge of synergistic impacts of multiple contaminants
- Little knowledge of impact of endocrine disrupters
- Methyl –mercury, heavy metals, pesticides all present and concern

Increase in CO_2:

- ↑ CO_2 can alter key ecosystem processes by altering contaminant mobility

Increase in Temperature:

- May increase contaminant uptake and stress plant/animal community
- May see ↑ use of pesticides ; ↑ temp. may alter uptake and physiological response
- Increase in toxicity of organophosphates and heavy metals to fish

Change in Precipitation:

- ↑ precip = ↑ runoff = ↑ contaminants delivered to streams
- ↑ precip = ↑ wet deposition

Change in Sea Level:

- Sea level affects infrastructure which alters contaminant delivery if infrastructure fails or is flooded

Increase in Extreme Climate Events:

- Can cause ↑ flooding of infrastructure / landfills, ↑ contaminant delivery

Degree of Fragmentation

- Fragmentation exacerbates vulnerability as harder to move and ↓ genetic diversity
- Many mutualisms hindered by fragmentation
- Edge effects

Barriers to Migration

- Migration is greatly limited in these systems
- Thermal barriers reduce interchange of genetics between population (in stream, between streams)
- Lack of cover could impact survival of trout moving through estuary

Recovery/Regeneration

- Speed of recovery / regeneration depends on severity of disturbance
- Must be careful w/ restoration targets (i.e. is it likely that historic targets not going to be possible in future) Consensus building and permitting take time
- Legacy impact of past activities still dominate these streams
- Slow growth of large trees

Diversity of Functional Groups

- Dependent on disturbance level / stress
- Biogeographical shifts of community already occurring and will continue
- Low diversity of macro invertebrate functional groups
- Reduced phenotypic plasticity/flexibility of life history traits (i.e. salter behavior)
- Probable low genetic diversity of remnant brook trout populations

Management Actions

- Current supportive habitat extent is a relic of historic land-use change; facilitate restoration through removal of barriers, development of mature riparian habitat, and improvement in hydrology
- Need better water management (groundwater withdrawals, sustained flows, limited releases from ponds in warm months)
- Removal of culverts and other barriers improve fish passage, remedy fragmentation issues as well as reduce sediment buildup upstream of barriers.
- Consider more assisted migration artificial supplementation

Institutional/Human Response

- Water demands usually take precedent over natural system needs