

1. How are ecosystems changing?	2. Why are ecosystems changing?	3. How are ecosystem services affected?	3a. Specific Ecosystem Services Impacted	4. How is society responding to changes?
alterations in soil microbial activity	climate-induced - changes in climate (temp, moist, snow)	GHG source - climate regulation	Regulating: Climate	potential changes in emissions scenarios for reduced GHGs
spatio-temporal changes in vegetation form and function	climate and disturbance	climate regulation	Regulating: Climate	Disturbance mitigation/management; changes in policies regulating GHGs
permafrost thaw; plant distribution & process dynamics; Rh	warming; albedo changes from deposition; changes in precipitation	infrastructure vulnerability; increased vegetation productivity;	Regulating: Climate; Provisional: infrastructure, natural resources	reactive vs. proactive responses? (infrastructure, vegetation management, soil C management / policy)
changes in vegetation composition, structure, and function	climate and disturbance	impacting services dependent on vegetation - climate regulation, wildlife habitat, subsistence	Regulating: Climate; Provisional: Wildlife Habitat; Cultural: Subsistence	altered policies wrt hunting, trapping and/or biofuel harvesting
changes to permafrost soils and associated vegetation	global-scale climate and local-to-regional-scale disturbance	impact ecosystem vulnerability		affects local, regional and global society
Land surface subsidence, hydrologic re-organization, and deeper unfrozen soils	permafrost thaw and ground ice melt	unreliable infrastructure; soil C sink weakened; changing freshwater resources	Supporting: Infrastructure: Regulating: Climate, Hydrologic Cycle	infrastructure planning, construction & maintenance; GHG regulation; water use policy

<p>Rapid high latitude permafrost thaw, increases in surface inundation and methane emissions</p>	<p>Rapid climate warming at high latitudes, combined with subsequent precipitation increases resulting in thaw-induced topographic disturbance, e.g. thermokarst landscapes. Albedo and emissions in drying landscapes may be altered by fire disturbance.</p>	<p>High latitude ecosystems are and have been are weak carbon sink for 18000 years storing 1500 Pg carbon. Warming has potential to reverse this valuable service and add substantially and rapidly to atmospheric GHG concentrations.</p>	<p>Supporting: Infrastructure: Regulating: Climate, Hydrologic Cycle</p>	<p>Developing mitigation policy, including setting goals and incentivizing strategies for reduction of atmospheric GHG concentrations.</p>
<p>disrupt biogeochemical cycles of C,N, Hg, and other system elements; redistribution of Hg and other potentially toxic elements</p>	<p>climate and permafrost thaw</p>	<p>threats to water quality and food chains ranging from primary producers to humans</p>	<p>Provisioning: fresh water; Regulating: ecosystem health (air and water quality)</p>	
<p>changes that directly and indirectly affect people</p>	<p>local to regional disturbances: permafrost thaw, increased erosion, flooding, increased wildland fire</p>	<p>cascading effects on cultural / non-material services</p>	<p>Provisioning: Wildlife habitat; Cultural: Subsistence</p>	<p>adaptation, migration; resilience; preservation; communication & planning</p>

Post-fire changes in vegetation recovery	Variations in burned area and fire severity	Subsistence and non-subsistence resources; Climate regulation	Provisioning: Wildlife habitat; Cultural: Subsistence; Regulating: Climate	Changes in subsistence practices; wildlife & wildfire management policies; policies regulating GHGs
Increased abundance of early successional species; decreased ecosystem nutrient retention; decreased carbon storage at landscape-scale	Increasing abundance of early-successional ecosystems on landscape (the latter sensu Turner 2005 ARES) - changes in fire frequency, severity	Decreasing water quality; changes in subsistence resources	Regulating: Water Quality; Provisional: Wildlife Habitat; Cultural: Subsistence	fuel management, prescribed burning, changing fire suppression tactics
changes in forest productivity	increase atmos. CO2, temperature and precipitation	changes in availability of wood fiber, products and bioenergy; changes in forest C balance - provisional services, climate regulation	Provisioning: Wood and Fiber; Regulating: Climate	changes in forest management policy and practices
Mobilization of old soil carbon	Permafrost , disturbance?		Regulating: Climate	
changing land C sink	warming climate & local disturbances	weakening C sequestration - regulating service (climate)	Regulating: Climate	GHG emissions policy; adaptation

Redistribution of water resources alters ecosystem structure	changing amount, quality, and phase distribution of water affects all ecosystem processes	plant, fish, and wildlife communities available for subsistence and non-subsistence economies; infrastructure	Regulating: Hydrologic Cycle; Provisioning: Fish and Wildlife Habitat; Provisioning: Infrastructure	implement, plan, and regulate current and future land management practices, based in part on water resources
distribution of low and high canopies (changes in vegetation)	feedbacks in soil-permafrost-vegetation-energy exchange	landscape transitions impact human transportation and societal systems	Provisioning: Wildlife Habitat; Cultural: Subsistence; Regulating: Climate	regulatory and human activity reactions to landscape changes
Exchanges of CO ₂ /CH ₄ with the atmosphere	Warming of permafrost, changes in vegetation, changes in hydrology		Regulating: Climate	
post-thaw changes in climate forcing (GWP of GHGs, albedo)	thaw-induced ecosystem change	climate regulation, wildlife habitat; water and resource availability	regulating: climate and hydrologic cycle	changes in resource management policy
changes in active layer, thermokarst and thaw lake dynamics	thermal state of permafrost, hydrology and topographic change	Hydrology; freshwater quality; sediment and nutrient load; fish habitat; contaminant transport; climate regulation	Regulating: Climate, Hydrologic Cycle; Provisional: Fish Habitat	changes in resource management (water, wetlands and fisheries); GHG regulation policy