

Ecological Dynamics & Climate Vulnerabilities of Sockeye & Kokanee Salmon Re-Establishment in Wallowa Lake

CLIMATE BREAKDOWN Reports audio playlist

<https://soundcloud.com/cliff-crego/sets/climate-breakdown-reports>

Composed with **GEMINI AI**...by **Cliff CREGO** crego@picture-poems.com
X.7.2026

LOSS?

The most insidious
of all losses is the loss
of something vitally important
for which we do not yet
have a name.

Cliff CREGO
The **WALLOWAS, OREGON**

Introduction and Ecological Context

The Pacific salmonid species *Oncorhynchus nerka* exhibits one of the most complex life-history dichotomies in temperate aquatic ecosystems, manifesting as two geographically and behaviorally distinct ecotypes: the anadromous Sockeye salmon, which completes an extensive ocean migration before returning to native freshwater systems, and the landlocked Kokanee salmon, which completes its entire life cycle within freshwater lakes. Wallowa Lake, situated at an elevation of 4,383 feet at the northern base of the Wallowa Mountains in northeastern Oregon, represents a classic oligotrophic, glacier-carved moraine ecosystem. Formed during glacial periods when advancing ice sheets carved deep U-shaped valleys and deposited massive lateral and terminal moraines, the lake naturally created an ideal cold-water lacustrine environment fed by alpine headwaters.

Historically, an estimated 30,000 adult anadromous Sockeye salmon migrated annually to Wallowa Lake, traversing approximately 792 river miles from the Pacific Ocean through the mainstem Columbia, Snake, Grande Ronde, and Wallowa rivers. These returning adult runs served as a vital ecological driver and primary First Food for Indigenous populations, particularly the Nimiipuu (Nez Perce Tribe), whose traditional fishing rights were recognized in the Treaty of 1855. Westward expansion during the nineteenth century brought intense resource exploitation to the basin, including commercial canneries operating on Wallowa Lake that processed up to 60,000 pounds of Sockeye salmon annually.

The complete extirpation of Wallowa Lake's native wild Sockeye run occurred following the construction of the original Wallowa Lake Dam in 1916 and its subsequent expansion in 1929. Built without fish passage structures to store water for downstream agricultural irrigation, the dam severed the migration route between the ocean and the lake. Deprived of access to historical lacustrine rearing habitat, native Sockeye salmon collapsed completely by the early twentieth century. Over the subsequent century, the pelagic niche within Wallowa Lake transitioned to a fishery dominated by non-native resident Kokanee salmon introduced through stocking programs, alongside resident lake trout, bull trout, and rainbow trout.

Kokanee Life-Cycle Dynamics and Trophic Ecology in Wallowa Lake

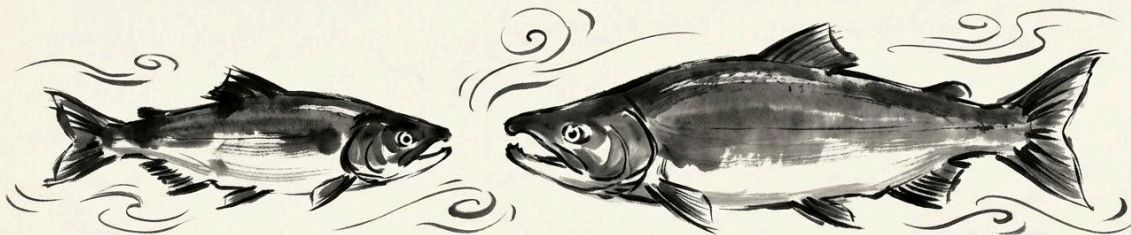
The resident Kokanee salmon (*Oncorhynchus nerka*) in Wallowa Lake completes its life cycle within fresh water over a duration typically ranging from three to five years. The ontogeny begins during late summer and autumn, when mature adults migrate into cold tributary streams, such as the Upper Wallowa River, or assemble along wave-washed gravel shorelines to spawn. Female Kokanee construct nests, or redds, in clean, well-oxygenated gravel substrate, where eggs are fertilized by males and subsequently buried. Embryos undergo incubation throughout the winter months, with hatching occurring between November and January depending on thermal accumulation in the hyporheic zone.

Following hatching, the young salmon remain within the gravel bed during the alevin phase, deriving all essential nutrition from an attached yolk sac while cardiovascular and anatomical

development continues. Upon complete yolk sac absorption in early spring, the fry emerge from the substrate and are swept downstream into the pelagic zone of Wallowa Lake. During their multi-year juvenile phase, Kokanee occupy the open water, where they exhibit pronounced diel vertical migration patterns. To minimize metabolic costs and reduce visual predation by apex predators, juveniles inhabit deep, cold waters between 15 and 90 feet below the surface during daylight hours, ascending toward surface layers at dawn and dusk to feed.

As Kokanee approach sexual maturity at age three, four, or five, hormonal surges initiate rapid somatic and physiological changes. Both sexes absorb their silver guanine epidermal coatings and synthesize intense red skin coloration derived from stored carotenoid pigments. Males undergo pronounced structural modifications, developing humped backs, elongated jaws with hooked kypes, and enlarged teeth. Spawning represents the final act of their semelparous life history; following egg deposition and fertilization, all adult Kokanee undergo rapid senescence and die within days, transferring vital nutrients back into the lacustrine and riparian food webs. Kokanee are obligate zooplanktivores that filter small aquatic organisms from the water column using fine, closely spaced gill rakers attached to their branchial arches. Their primary diet consists of cladocerans, particularly *Daphnia* species, as well as copepods, aquatic insect larvae, and terrestrial insects that fall onto the water surface. Trophic conditions in Wallowa Lake were altered by the historical introduction of the non-native opossum shrimp (*Mysis diluviana*). In many western lakes, *Mysis* compete directly with Kokanee by consuming *Daphnia* while remaining largely inaccessible to juvenile fish due to their deep daytime benthic residence, causing Kokanee growth stunting. In Wallowa Lake, however, mature adult Kokanee adapted to prey heavily upon *Mysis*, creating an exceptionally energetic forage base that allowed individual fish to reach record proportions, ultimately yielding the IGFA world-record Kokanee weighing 9 pounds 10 ounces in 2010.

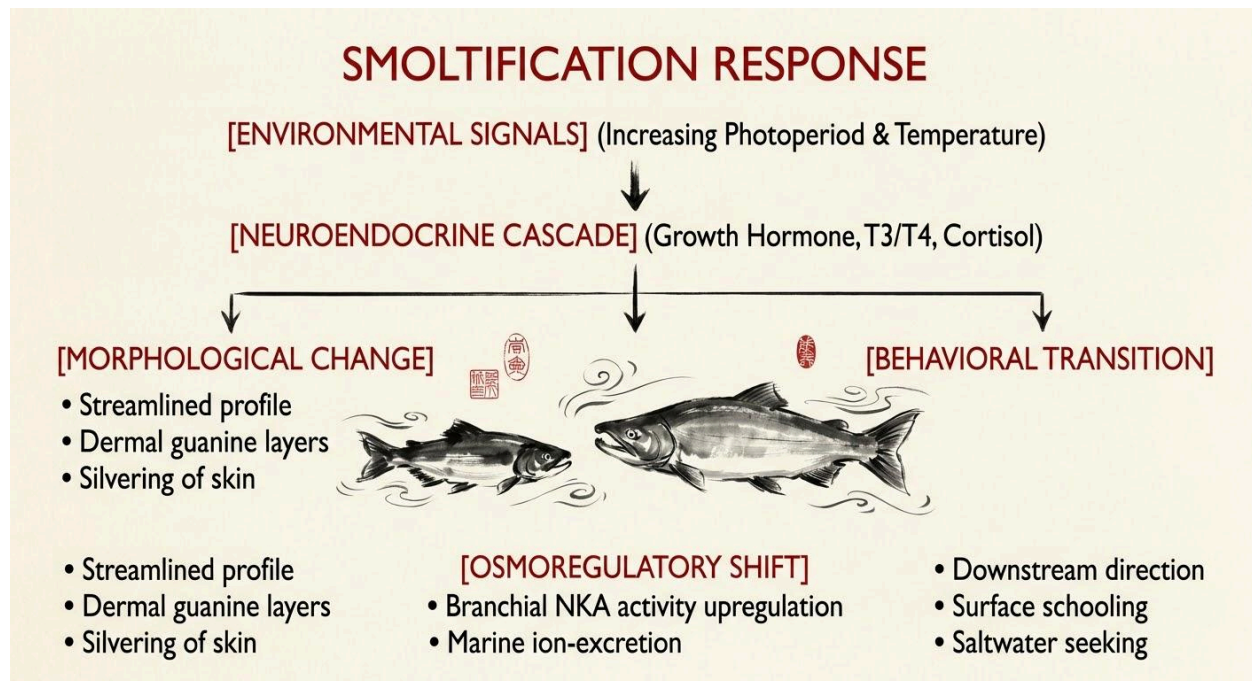
LIFE-HISTORY PARAMETER:	RESIDENT KOKANEE SALMON (<i>O. nerka</i>)	ANADROMOUS SOCKEYE SALMON (<i>O. nerka</i>)
PRIMARY LIFE HABITAT:	Freshwater lakes exclusively (landlocked)	Ocean-going; lacustrine rearing + marine environment
TYPICAL LIFESPAN:	3 to 5 years	4 to 5 years (1–2 yrs fresh water; 2–3 yrs ocean)
ADULT SIZE AT MATURITY:	23–30 cm (9–12 in); 0.5–2 lbs (rarely up to 9+ lbs)	60–84 cm (24–30 in); 5–15 lbs
OSMOREGULATORY ADAPTATION:	Hyposmotic fresh water throughout life cycle	Preadapted smoltification for hyperosmotic marine life



PRIMARY FORAGE BASE:	Freshwater zooplankton (<i>Daphnia</i>), <i>Mysis</i> shrimp	Marine zooplankton, krill, squid, small forage fish
SPAWNING MIGRATION DISTANCE:	Short stream-to-lake or shoreline movement	Long-distance riverine migration (~792 miles to ocean)

Physiological and Genetic Transition Mechanisms: Resident Kokanee to Wild Anadromous Sockeye

The physiological metamorphosis that prepares a freshwater juvenile salmonid for oceanic entry is known as smoltification. Driven by seasonal environmental triggers, smoltification requires coordinated endocrine, morphological, and biochemical shifts. Increasing spring photoperiod and rising water temperatures stimulate the neuroendocrine axis, elevating circulating levels of growth hormone, thyroid hormones (triiodothyronine T₃ and thyroxine T₄), and cortisol. These hormonal cascades induce bodily streamlining, decreasing the fish's condition factor to optimize hydrodynamics for sustained swimming. Concurrently, purine synthesis deposits guanine and hypoxanthine crystals within dermal iridophores, concealing dark parr marks under a brilliant silver coating designed for open-ocean camouflage. Osmoregulatory preparation for hyperosmotic marine entry requires reshaping the branchial epithelium. Hormonal signaling upregulates sodium-potassium adenosine triphosphatase enzyme activity within specialized gill ionocytes. Elevated NKA activity powers the active secretion of excess sodium and chloride ions across gill membranes, protecting the fish from lethal dehydration upon entering salt water. While resident Kokanee retain a seasonal window of elevated NKA activity and partial silvering inherited from their anadromous ancestors, generations of landlocked evolution have attenuated the intensity and duration of this smoltification response.



Genome-wide sequencing and single-nucleotide polymorphism (SNP) analyses demonstrate significant genetic divergence between resident Kokanee and anadromous Sockeye ecotypes. Key quantitative trait loci (QTL) governing age at maturity, body size, freshwater residency, and migratory restlessness differ between the forms. Because resident Kokanee smolts suffer elevated mortality during long migrations due to smaller body sizes,

reduced swimming capacity, and mismatched ocean-entry timing, relying on resident Kokanee to spontaneously re-establish a self-sustaining wild anadromous run is biologically unfeasible. Consequently, restoration initiatives led by the Nez Perce Tribe, in partnership with the Oregon Department of Fish and Wildlife (ODFW), incorporate an active reintroduction strategy using genetically compatible anadromous donor stocks. Lineages originating from Snake River and Columbia River basin Sockeye runs (such as Redfish Lake or Lake Wenatchee stocks) possess the genetic architecture required to navigate the 792-mile migration route, survive marine rearing, and home back to Wallowa Lake.

Infrastructure Modernization: Wallowa Lake Dam Rehabilitation and Fish Passage Design

For over a century, the 35-foot-high concrete gravity dam at Wallowa Lake operated without fish passage facilities, maintaining a physical blockade between the Wallowa River and the lake. In 1996, state dam safety officials classified the aging structure as a high-hazard dam due to concrete deterioration, structural weakness, and insufficient spillway capacity, forcing operational storage restrictions. To address safety concerns and restore migratory connectivity, state and federal entities secured funding for a comprehensive rehabilitation project. Oregon House Bill 5030 allocated \$14 million in state lottery bonds, which was supplemented by federal grants under the Infrastructure Investment and Jobs Act (IIJA) and water storage allocations, bringing the total Phase 1 engineering budget to \$31.6 million.

The selection of the fish passage strategy involved extensive technical evaluation and regulatory debate among engineers, agricultural water users, state agencies, and tribal governments. Initial designs prepared by engineering contractors proposed a mechanical "trap-and-haul" facility rather than a continuous volitional fish ladder. Designers argued that significant water level drawdowns caused by agricultural irrigation deliveries during late summer made a traditional ladder hydraulically unstable. Under the trap-and-haul proposal, returning adult Sockeye would be captured below the dam, loaded into tank trucks, and hauled around the structure for release into Wallowa Lake.

The proposal to omit a permanent volitional fish ladder drew legal challenges from the Nez Perce Tribe and conservation partners. Opponents argued that mechanical collection and trucking impose severe handling stress, migratory delay, and operational failure risks on migrating salmonids, conflicting with treaty rights and restoration goals. Legal decisions affirmed the necessity of continuous passage infrastructure, culminating in a revised design-build plan that incorporates full volitional fish passage. Construction commenced in September 2026 under a multi-phase framework:

Phase 1 focuses on structural dam safety, enclosing the existing concrete dam inside a reinforced concrete shell, installing new outlet conduit liners, constructing upgraded spillway gates, erecting a modern control facility, and installing back-up power generation. Phase 2 constructs a multi-stage volitional fish ladder featuring an entrance pool, regulating gates, operational piping, and a low-level downstream bypass constructed across the spillway.

To prevent out-migrating juvenile Sockeye smolts and Kokanee from entering irrigation canals

that serve over 16,000 primary agricultural acres in the Upper Wallowa Valley, the new intake facility includes advanced fish screens. Automated mechanical wiper systems sweep the screen surfaces continuously to prevent debris accumulation, maintaining approach velocities below 0.4 feet per second to prevent fish impingement. A surface bypass collector routes downstream migrants away from irrigation intakes, guiding them safely over the spillway or through smooth bypass conduits into the lower Wallowa River.

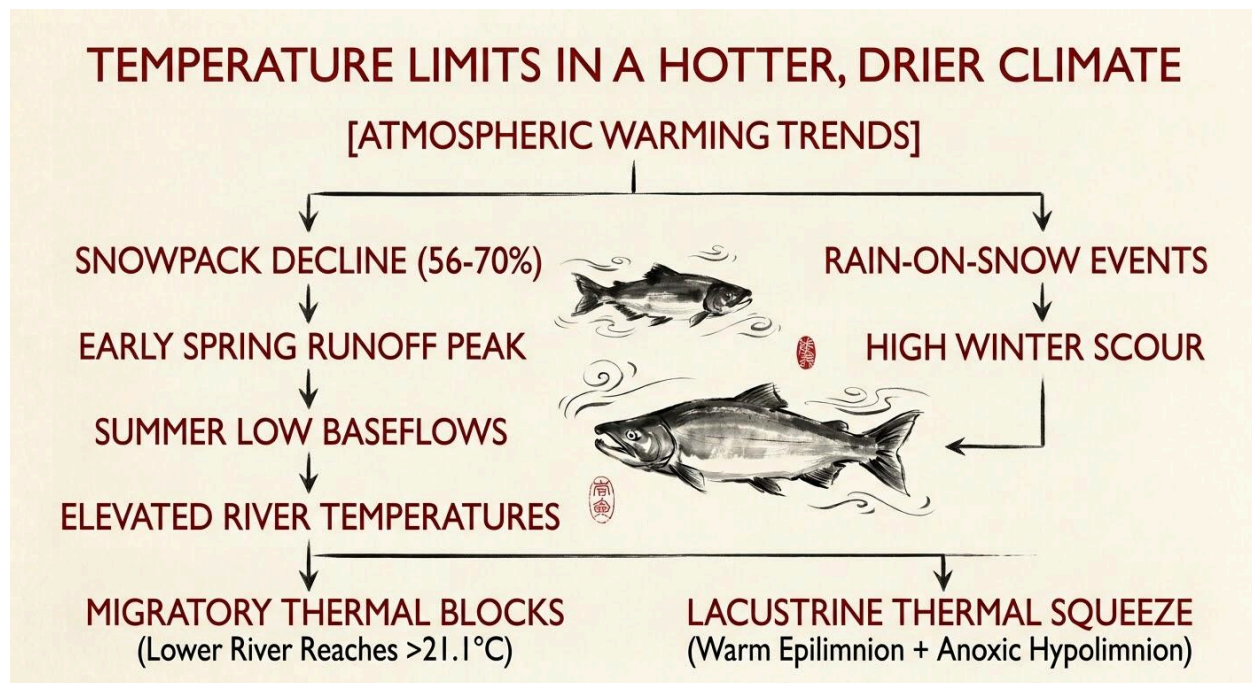
FEATURE / SPECIFICATION

TECHNICAL AND ENGINEERING DETAIL

PROJECT LEAD & DELIVERY MODEL: McMillen Inc. (Progressive Design-Build) PHASE I FINANCIAL ALLOCATION: \$31.6 Million (State Lottery Bonds + Federal IIJA Funds) CONSTRUCTION ONSET: September 2, 2026 DAM SAFETY MODIFICATIONS: Structural reinforced concrete shell encasement, new spillway gates, outlet liners UPSTREAM FISH PASSAGE: Volitional fish ladder with entrance pool, regulating gates, and piping DOWNSTREAM SMOLT PROTECTION: Screened intake with AGRICULTURAL DELIVERY NETWORK: 16,000 primary acres (Upper Valley); INSTREAM FLOW PROTECTIONS: 21,000 unfur valley); 21,000 secondary acres (Lower Valley) Dedicated baseflow releases reserved downstream and downstreaa for fish habitat enhancement	 Screened intake with automated wiper cleaners and surface surface bypass channel
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Macro-Scale Climate Breakdown: Hydrological, Thermal, and Limnological Stressors

Climate breakdown across northeastern Oregon presents severe hydrological and thermal challenges to salmonid survival. Pacific Northwest stream temperatures have increased at an average rate of 0.22°C per decade, while mountain snowpacks are shrinking rapidly. Projections indicate that average spring snowpack across regional watersheds could decline by 56% to 70% by the 2080s. Warmer winter air temperatures elevate the freezing level in the Wallowa Mountains, causing winter precipitation to fall increasingly as rain rather than snow. This hydrographic transition causes spring runoff to peak weeks earlier in the season, depleting alpine snowpack before the onset of summer. Consequently, summer baseflows in the Wallowa and Grande Ronde rivers are projected to drop significantly, exacerbating stream warming during critical migratory periods.



Sockeye and Kokanee salmon depend on narrow thermal windows for survival and migration. When water temperatures exceed 18°C (64°F), migrating salmon experience sub-lethal thermal stress, elevated metabolic rates, depleted energy reserves, and increased susceptibility to disease. Water **temperatures surpassing 21.1°C (70°F) create lethal thermal blockades** that halt adult migration entirely. Returning adults forced to hold in warm lower river reaches suffer high pre-spawning mortality. The vulnerability of Snake River Sockeye to mainstem river warming was demonstrated during the 2015 heatwave, when excessively warm water in Columbia and Snake river reservoirs killed nearly 90% of returning adult Sockeye. Reintroduced Sockeye bound for Wallowa Lake must navigate nearly 800 miles of river corridor, where summer water temperatures in the Grande Ronde and lower Wallowa rivers frequently approach critical thresholds.

Within Wallowa Lake, atmospheric warming alters vertical thermal stratification and limnological health. During hot summer months, surface waters (the epilimnion) heat beyond preferred salmonid temperatures, forcing Kokanee and juvenile Sockeye into deeper layers. However, as organic matter decays along the lake bottom, dissolved oxygen in the deepest zones (the hypolimnion) becomes depleted. Cold-water fish become confined to a narrow vertical band within the metalimnion where water remains cool and oxygenated—a phenomenon known as the "thermal squeeze".

Simultaneously, earlier spring warming alters the timing of primary and secondary lacustrine production. If warmer spring temperatures cause zooplankton blooms (*Daphnia*) to peak earlier while salmon fry emergence timing remains constrained by hyporheic winter temperatures, young fish experience a trophic mismatch that reduces early survival. Increased irrigation demand during hot, dry summers further aggravates lake drawdowns, reducing total lake

volume, compressing pelagic habitat, and desiccating shoreline gravel beds used by spawning Kokanee.

Synthesis and Ecological Conclusions

The restoration of anadromous Sockeye salmon to Wallowa Lake while sustaining resident Kokanee represents an important milestone in Pacific Northwest ecological restoration. Overcoming a century of habitat fragmentation caused by the Wallowa Lake Dam requires structural modernization that combines dam safety with continuous, volitional fish passage. While landlocked Kokanee retain ancestral physiological mechanisms associated with smoltification, establishing a self-sustaining wild anadromous population necessitates the reintroduction of anadromous Sockeye stocks equipped with the genetic traits required for long-distance river migration, ocean survival, and natal homing.

Climate breakdown introduces long-term vulnerabilities through altered streamflows, river warming, and altered lake dynamics. Countering these impacts requires watershed-scale habitat protection, riparian restoration, thermal refugia preservation, and flow management. Integrating traditional tribal ecological knowledge with modern hydraulic engineering and fisheries science offers a viable path toward restoring anadromous Sockeye salmon to Wallowa Lake.

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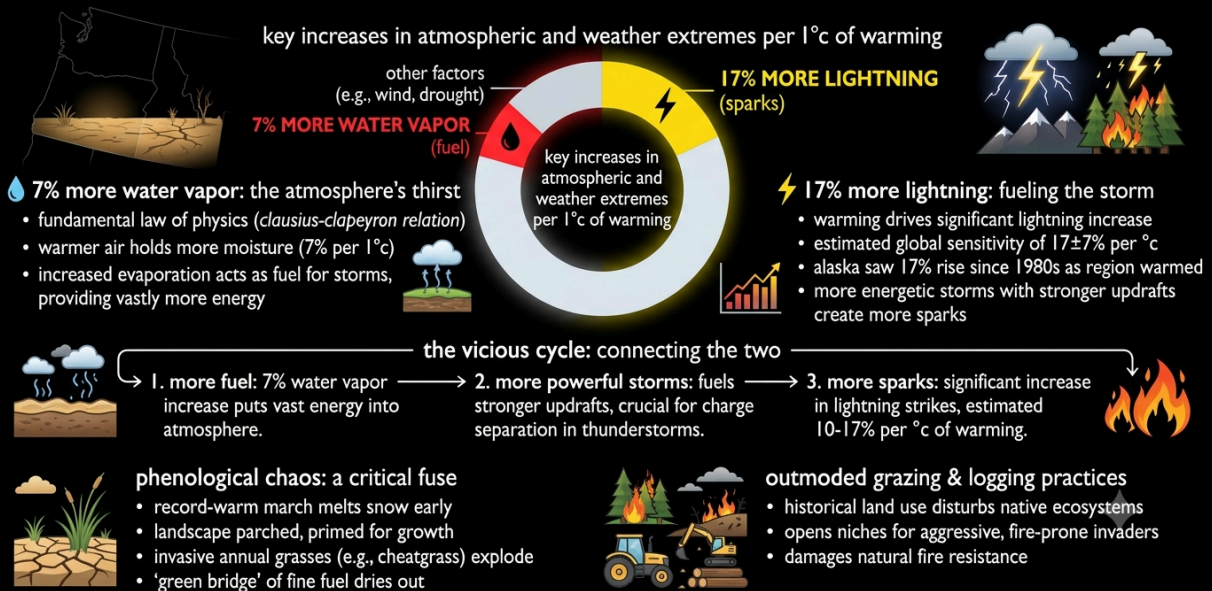
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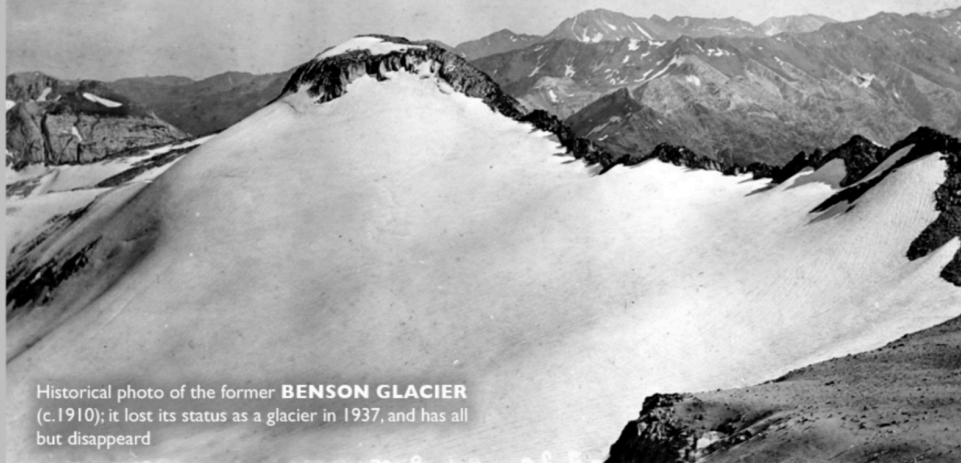
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CLIMATE BREAKDOWN AND WILDFIRE 2.0: THE 7% & 17% FEEDBACK LOOP



KNOW YOUR MOUNTAIN CLIMATE FACTS



Historical photo of the former **BENSON GLACIER** (c.1910); it lost its status as a glacier in 1937, and has all but disappeared

With the *Climate Crisis*, ice world-wide is disappearing at an ever-accelerating rate. If *Lewis & Clark* would have entered the Wallowas just 200 years ago, they would have seen small, vestigial glaciers and ice fields in many of the high cirques and hanging valleys. Since the end the Little Ice Age (c. 1850), these ice fields have all but vanished. Over the same period: (1) the average temperature has increased by, in round numbers, 1 C [1.8 F]; (2) snowpack has decreased by 50%, begins to build about three weeks later, and melts three weeks earlier; (3) and most importantly, atmospheric CO₂ has risen by 30% from 250 to over 395 ppmv. Increase of CO₂, because it holds warmth, is like adding more and more layers of insulation to a down blanket. The other important fact that should be remembered is that the effects of climate change increase greatly with both altitude and latitude, largely because of loss of snow reflectivity.

THE SPIRIT OF SCIENCE in an Age of Denial...

SCIENCE is not its content;
SCIENCE is a way of being,
the willingness to drop a way
of seeing, an idea, a theory,
if contradicted by fact.

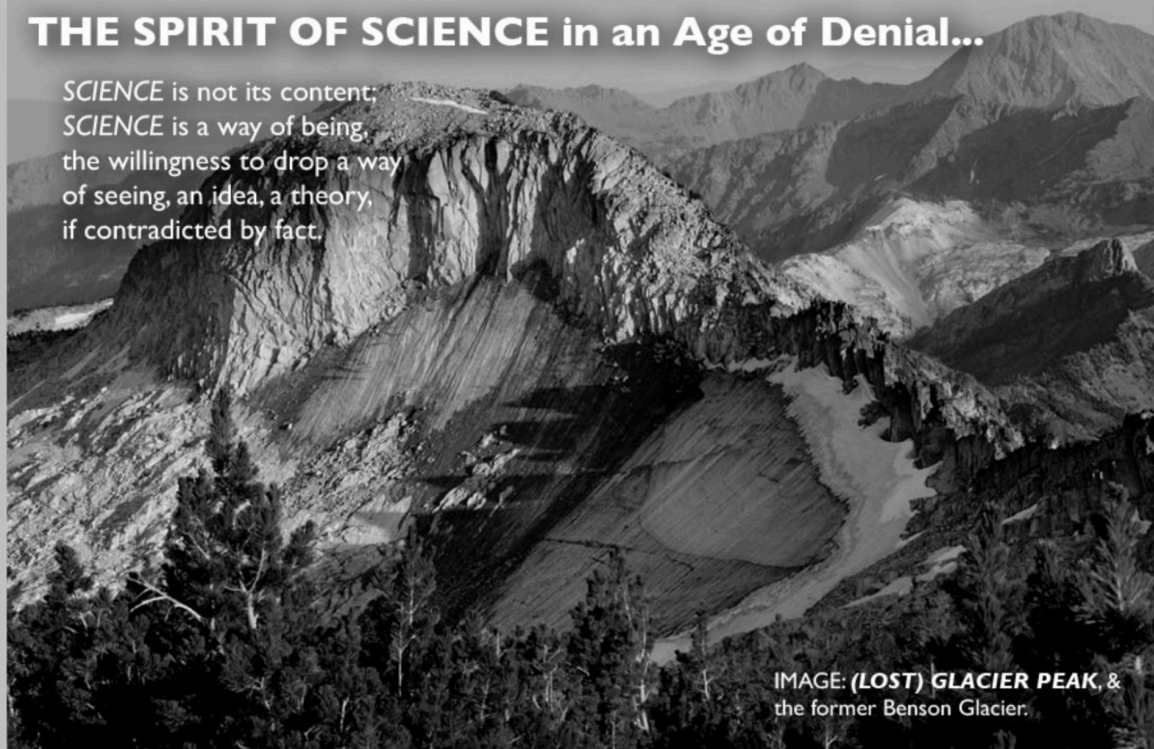
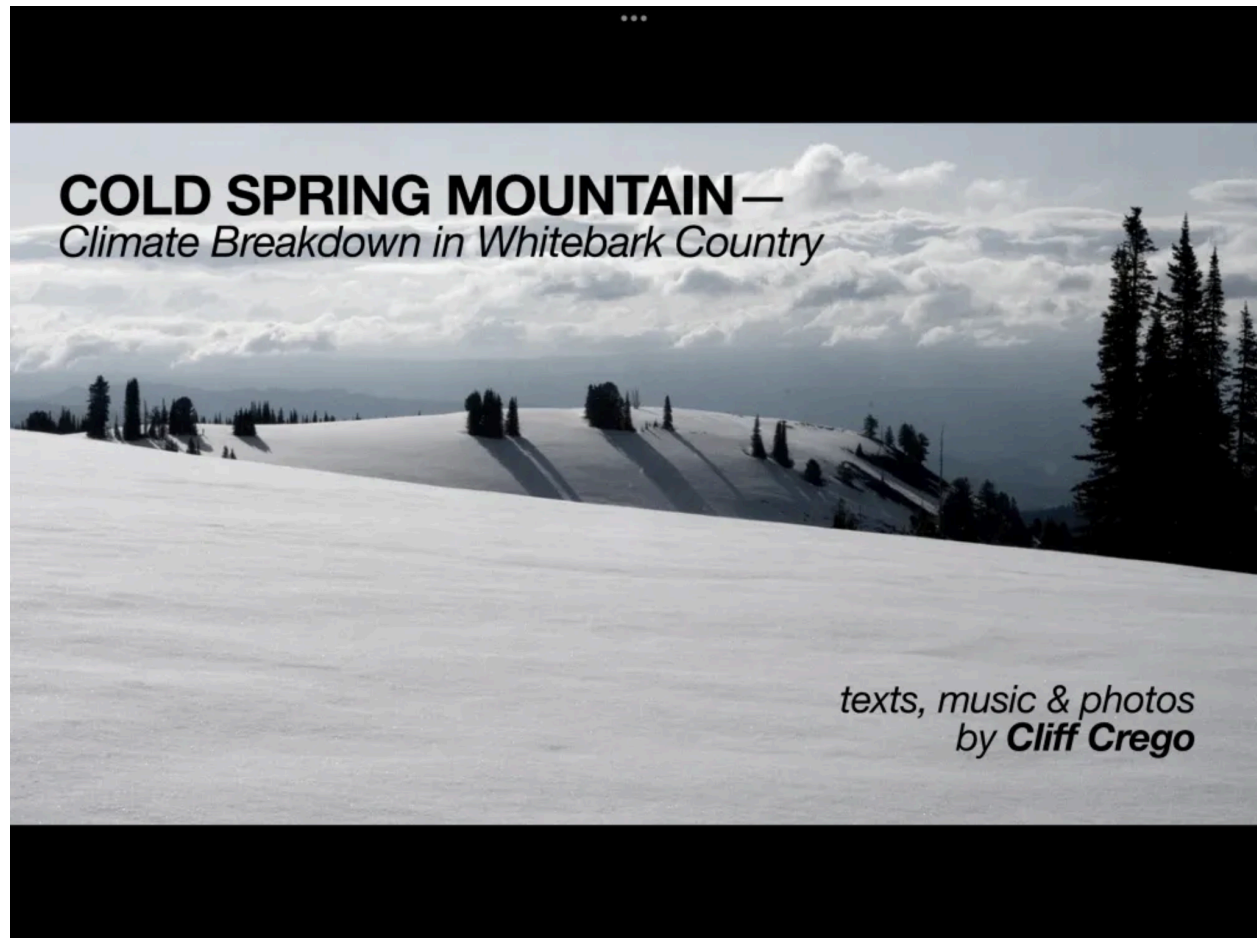


IMAGE: **(LOST) GLACIER PEAK**, &
the former Benson Glacier.



COLD SPRING MOUNTAIN —

Climate Breakdown in Whitebark Country

texts, music & photos
by **Cliff Crego**

COLD SPRING MOUNTAIN, book one, the TEACHING TREE & LIVING WATER sequences
<https://vimeo.com/860227400>

#foto **COLD SPRING MOUNTAIN**, the slideshow philosophical #poetry reading I'm doing this summer on #bikepacking 🚲 tour. View pdf [356Mb]
http://www.picture-poems.com/pdfs/cold-spring-mountain_book-one.pdf

My preferred format is
the **SYMPOSIUM**, modeled on
Plato's dialogue of same name
= all nite drinking party
= soon to be banned in #IDAHO