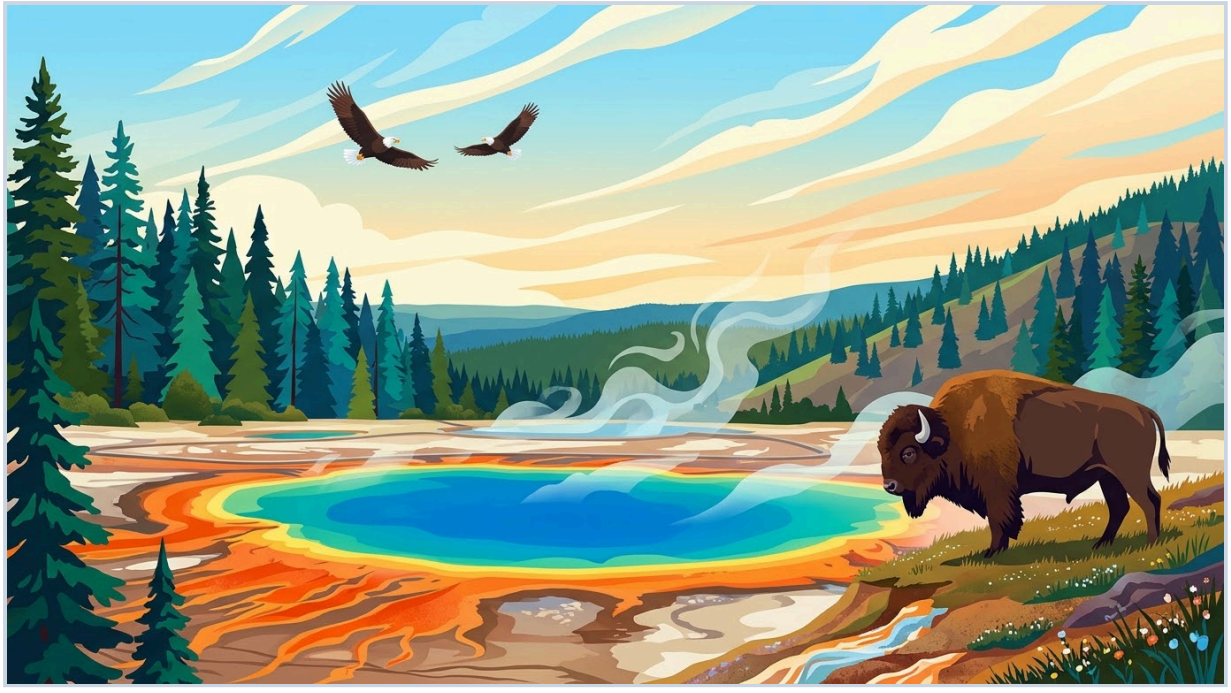
APPLESEED EXPEDITIONS

EDUCATIONAL STUDENT TRAVEL & FIELD SCIENCE

GREATER YELLOWSTONE ECOSYSTEM

Yellowstone Science & Wildlife Field Journal

Plate Tectonics, Supervolcanism, Trophic Cascades, Watershed Stewardship & Species Key



NGSS-ALIGNED EXPEDITION CURRICULUM

Designed for middle and high school field expeditions. Includes Next Generation Science Standards alignment, geological inquiry logs, service-learning reflections, and a 12-species wildlife identification guide.

STUDENT RESEARCHER	SCHOOL / EXPEDITION GROUP
EXPEDITION DATES	LEAD EDUCATOR / INSTRUCTOR

Next Generation Science Standards (NGSS) Alignment

This field journal is structured around three-dimensional learning—integrating **Science and Engineering Practices (SEPs)**, **Disciplinary Core Ideas (DCIs)**, and **Crosscutting Concepts (CCCs)** across Middle School (MS) and High School (HS) grade bands.

Journal Unit	NGSS Performance Expectations	Field Application & Learning Objectives
Unit 1: Earth Systems & Volcanism	MS-ESS2-2 HS-ESS2-1	Construct explanations based on evidence for how geoscience processes (mantle plumes, plate drift, caldera eruptions, and hydrothermal circulation) have changed Earth's surface over varying time and spatial scales.
Unit 2: Glacial & Fluvial Geomorphology	MS-ESS2-1 HS-ESS2-5	Analyze the cycling of Earth's materials and the properties of water—comparing U-shaped glacial valley carving in Lamar/Hayden Valleys with V-shaped hydrothermal canyon erosion along the Yellowstone River.
Unit 3: Wildlife & Elevation Niches	MS-LS2-1 HS-LS2-2	Analyze and interpret field data to provide evidence for the effects of abiotic resource availability (elevation, snowpack, thermal gradients) on organisms and populations across distinct ecological zones.
Unit 4: Predator-Prey & Trophic Cascades	MS-LS2-4 HS-LS2-6	Construct an empirical argument supported by field evidence that changes to physical or biological components (1995 gray wolf reintroduction) trigger top-down trophic cascades affecting riparian vegetation, beavers, and stream morphology.
Unit 5: Jackson Hatchery Stewardship	MS-ESS3-3 HS-LS2-7	Design, evaluate, and participate in hands-on conservation engineering solutions at Jackson Fish Hatchery to mitigate human impacts, protect native cutthroat trout genetics, and sustain aquatic biodiversity.

Three-Dimensional Field Assessment Note for Teachers:

Each unit features embedded **Field Observation Logs** and **Synthesis Prompts** designed to assess students in *Constructing Explanations (SEP-6)*, *Analyzing and Interpreting Data (SEP-4)*, and recognizing *Stability and Change (CCC-7)* within the Greater Yellowstone Ecosystem.

Welcome to the Greater Yellowstone Ecosystem

Welcome to your field journal and scientific key for the **Appleseed Expeditions Yellowstone Expedition**! Yellowstone National Park, established in 1872 as America's first national park, spans over 2.2 million acres across Wyoming, Montana, and Idaho. It sits at the core of the **Greater Yellowstone Ecosystem (GYE)**—one of the largest intact temperate wildlands remaining on the planet.

This expanded field notebook combines geological inquiry, trophic ecology studies, watershed stewardship reflection, and a comprehensive field identification key for key wildlife species—from high-alpine mammals and raptors to lowland ungulates and aquatic predators.

Field Manual Units:

- **Unit 1: Earth Systems & Volcanism** (Plate tectonics, hotspots, hydrothermal dynamics)
- **Unit 2: Ecosystems & Habitats** (Elevation zones, valley carving, river systems)
- **Unit 3: Wildlife Identification Guide** (Marmots, pikas, otters, eagles, ungulates, bears)
- **Unit 4: Trophic Cascades & Wolves** (Apex predator impact on streams & forests)
- **Unit 5: Conservation Stewardship** (Jackson Fish Hatchery & native trout)

Pre-Expedition Inquiry Question:

Before entering the park, write down one hypothesis about how Yellowstone's underground volcanic heat influences the plants and animals living on the surface:

Plate Tectonics & the Yellowstone Supervolcano



Figure 1: Grand Prismatic Spring displaying vibrant bacterial mats structured by thermal gradients over the mantle plume.

The Yellowstone Hotspot

Unlike most volcanoes formed along tectonic plate boundaries, Yellowstone is fed by a **mantle plume** (hotspot)—a stationary source of deep thermal energy. As the North American Tectonic Plate drifts southwest over this heat source at roughly 1 inch per year, it leaves a volcanic trail across southern Idaho to Northwestern Wyoming.

Three Super-Eruptions

Over the last 2.1 million years, Yellowstone experienced three caldera-forming eruptions: Huckleberry Ridge (2.1M yrs ago), Mesa Falls (1.3M yrs ago), and Lava Creek (640,000 yrs ago), which formed the 30x45-mile **Yellowstone Caldera**.

Field Observation Log:

Record your observations of caldera topography and visible volcanic rock layers:

Hydrothermal Features & Thermophiles

Yellowstone houses over 10,000 hydrothermal features—more than half of the world's active geysers. Precipitation seeps miles underground, where magma heats it under extreme pressure before returning to the surface.

Feature Type	Mechanism	Key Example
Geysers	Constricted underground channels trap steam until violent eruptions occur.	Old Faithful, Steamboat Geyser
Hot Springs	Unobstructed channels allow superheated water to circulate continuously.	Grand Prismatic Spring
Fumaroles	Steam vents where thermal water boils away beneath the surface.	Roaring Mountain
Mudpots	Acidic steam dissolves volcanic rock into thick, bubbling clay pools.	Fountain Paint Pot

Microbial Life in Extreme Heat

The brilliant orange, yellow, and red rings surrounding thermal springs are formed by **thermophiles**—heat-adapted microorganisms. Different species thrive at distinct temperature zones, serving as living biological thermometers.

Thermal Log:

Record temperature readings, pH estimates, or color zones observed at Norris or Upper Geyser Basin:

Glacial Carving & Valley Formation

While volcanism created the plateau, glaciers and rivers carved the dramatic valleys and canyons that host Yellowstone's wildlife today.

Glacial Sculpting of Lamar & Hayden

During the Pinedale Glaciation (~20,000 years ago), ice caps up to 4,000 feet thick covered the region. Moving glaciers gouged out broad, flat U-shaped valleys such as **Hayden Valley** and **Lamar Valley**, depositing fertile silt that supports vast grasslands.

Grand Canyon of the Yellowstone

In contrast, the 1,000-foot-deep Grand Canyon of the Yellowstone was cut by running water where hydrothermal steam had softened the rhyolite lava rock, enabling rapid river erosion into steep V-shaped cliffs.

Geological Key Concept:

Glaciers create wide, rounded **U-shaped valleys** (ideal for grazing herds), whereas fast-flowing rivers cut sharp **V-shaped canyons** into soft hydrothermally altered rock.

Field Analysis: Valley Comparison

Contrast Hayden Valley and the Yellowstone Canyon in terms of formation agent, shape, and animal usage:

Ecological Elevation Zones

Yellowstone's drastic elevation changes (5,200 to 11,000 feet) produce distinct ecological zones, each supporting specialized wildlife communities and plant life.

Zone	Elevation	Key Vegetation	Representative Wildlife
Valley Floors	5,500 – 7,000 ft	Sagebrush, sedges, willow banks	Bison, Elk, Gray Wolves, Pronghorn
Mid-Forest	7,000 – 8,000 ft	Lodgepole pine, quaking aspen	Black Bears, Mule Deer, Red Squirrels
Subalpine	8,000 – 9,500 ft	Whitebark pine, alpine fir	Grizzly Bears, Bighorn Sheep, Mountain Goats
Alpine Tundra	9,500+ ft	Low alpine herbs, talus slopes	Yellow-Bellied Marmots, Pikas, Golden Eagles
Riparian Corridor	River Basins	Cottonwoods, wetland willows	Moose, River Otters, Bald Eagles, Cutthroat Trout

Elevation Rule:

Higher elevations experience colder temperatures, shorter growing seasons, and harsher winters, forcing alpine animals like marmots and pikas to evolve special survival adaptations.

Species Key: High-Alpine Small Mammals



Figure 2: Yellow-bellied marmot basks on boulders in subalpine talus fields to absorb solar heat.

Yellow-Bellied Marmot

Marmota flaviventris

Size: 5–11 lbs | Heavy-bodied rodent

Habitat: Alpine talus fields & rocky outcrops

Diet: Grasses, seeds, flowers, roots

Key ID: Yellowish chest, grizzled brown fur

Adaptation: Marmots hibernate for up to 8 months per year in deep subterranean burrows beneath snowpack, losing up to 50% of their body mass during winter stay.

American Pika

Ochotona princeps

Size: 5–6 oz | Egg-shaped lagomorph (rabbit relative)

Habitat: Cold high-elevation boulder fields

Diet: Alpine grasses, sedges, mosses

Key ID: Small round ears, no visible tail, high squeak

Adaptation: Pikas do not hibernate. Instead, they harvest alpine grasses during summer, curing them in sunlit "haypiles" among rocks to feed on during snowbound winters.

Species Key: Alpine Pikas & Forest Rodents



Figure 3: Pikas are temperature-sensitive indicators of climate shifts across high Rocky Mountain peaks.

American Red Squirrel

Tamiasciurus hudsonicus

Size: 7–9 oz | Small tree squirrel

Habitat: Coniferous forests (Lodgepole pine)

Diet: Pine cone seeds, mushrooms, bird eggs

Key ID: Reddish fur, white belly, noisy chatter

Ecological Role: Red squirrels construct massive seed-storage piles called *middens* beneath forest canopy. Grizzly bears frequently raid these middens to feast on cached pine nuts.

Pine Marten (American Marten)

Martes americana

Size: 1.5–3.5 lbs | Slender mustelid

Habitat: Dense mature coniferous forests

Diet: Voles, squirrels, pikas, birds

Key ID: Golden-brown fur, orange throat patch

Adaptation: Agile tree climbers with semi-retractable claws that allow them to pursue red squirrels through the upper canopy and navigate deep winter snowpack.

Species Key: Aquatic Predators & Riparian Life



Figure 4: River otters thrive along clean, undisturbed river channels like the Yellowstone and Madison Rivers.

North American River Otter

Lontra canadensis

Size: 15–30 lbs | Semi-aquatic mustelid

Habitat: Rivers, lakes, riparian corridors

Diet: Cutthroat trout, amphibians, crayfish

Key ID: Sleek brown fur, webbed feet, long muscular tail

Water Indicator: Otters require clean, unpolluted water with rich fish populations. Their waterproof double coat traps insulating air layers, enabling them to swim in freezing snowmelt.

American Moose

Alces alces

Size: 800–1,200 lbs | Largest deer family member

Habitat: Willow marshes, Moose-Wilson corridor

Diet: Willow twigs, submerged aquatic plants

Key ID: Broad palmate antlers, long snout, bell flap

Feeding Adaptation: Special nostrils can close underwater, allowing moose to submerge up to 18 feet to pull mineral-rich sodium plants from pond bottoms.

APPLESEED EXPEDITIONS UNIT 3: SPECIES GUIDE

Species Key: Apex Raptors of Yellowstone



Figure 5: Bald eagles nest in large trees near rivers and lakes to harvest trout and waterfowl.

Bald Eagle

Haliaeetus leucocephalus

Wingspan: 6.5–7.5 ft | Large fish eagle

Habitat: Lakeshores, river corridors

Diet: Native trout, waterfowl, carrion

Key ID: Bright white head & tail, yellow beak

Aquatic Hunter: Bald eagles use powerful talons to swoop down and snatch cutthroat trout directly from the river surface. They frequently scavenge wolf kill sites during winter months.

Golden Eagle

Aquila chrysaetos

Wingspan: 6–7.5 ft | Apex mountain raptor

Habitat: Open valleys, mountain cliffs

Diet: Marmots, jackrabbits, pikas, fawns

Key ID: Golden nape feathers, dark body, fully feathered legs

Mountain Predator: Golden eagles dive at speeds exceeding 150 mph to strike yellow-bellied marmots and ground squirrels in open alpine meadows and rocky slopes.

Species Key: Ungulates & Large Herbivores

Rocky Mountain Elk (Wapiti)

Cervus canadensis

Size: 500–700 lbs | Herding ungulate

Habitat: Valleys, forest meadows

Diet: Grasses, sedges, aspen bark, willow

Key ID: Tan body, dark brown neck mane, rump patch

Ecological Keystone: Elk are the primary prey species for Yellowstone wolf packs and grizzly bears. Their grazing behavior directly influences riparian plant community structure.

American Bison

Bison bison

Size: 1,000–2,000 lbs | America's largest land mammal

Habitat: Open grasslands (Lamar & Hayden)

Diet: Grasses, sedges, herbaceous plants

Key ID: Dark brown woolly coat, shoulder hump, curved horns

Ecosystem Engineers: Bison wallowing creates shallow depressions that collect rainwater, forming micro-wetlands that foster diverse insect and bird habitat.

Field Observation Log: Raptor & Ungulate Tracker

Record sightings, behavioral notes, and habitat locations observed during field travel today:

Species Key: Bear Identification Guide

Grizzly Bear

Ursus arctos horribilis

Size: 300–700 lbs | Apex omnivore

Habitat: Subalpine forests, high meadows

Key ID: Distinct shoulder hump, dish-shaped face, long light claws (2–4 in)

Diet: Roots, cutthroat trout, army cutworm moths, elk calves

American Black Bear

Ursus americanus

Size: 150–400 lbs | Forest adapted omnivore

Habitat: Lowland forests, Moose-Wilson corridor

Key ID: No shoulder hump, straight facial profile, short curved claws (<2 in)

Diet: Berries, acorns, insects, grasses, carrion

Field Safety & Distance Protocols:

Always maintain a minimum distance of **100 yards (300 feet)** from bears and wolves, and **25 yards (75 feet)** from all other wildlife including bison and elk. Carry bear spray in an accessible location at all times on trails.

Bear Identification Quiz Line:

If you observe a bear with a prominent shoulder hump and short rounded ears in a subalpine meadow, which species are you observing?

Predator-Prey Relationships & Wolf Reintroduction



Figure 6: Reintroducing gray wolves in 1995 initiated a top-down cascade that regenerated river systems.

The Reintroduction of 1995

When wolves were eradicated in the 1920s, the loss of an apex predator allowed elk populations to explode. Elk overgrazed riverbank willows and aspens, causing severe stream erosion and loss of habitat for aquatic birds and beavers.

In 1995, gray wolves were reintroduced to Yellowstone, restoring the primary predator and initiating a profound **trophic cascade**.

The Cascade Effect:

1. **Behavior Shift:** Elk avoided exposed riverbanks to reduce predation risk.
2. **Plant Recovery:** Willow and aspen saplings grew taller and denser along rivers.
3. **Hydrological Restoration:** Beavers used willows to build dams, slowing water flow and cooling stream channels.

Aquatic Webs & Native Cutthroat Trout



Figure 7: Appleseed Expeditions students conducting native fish management and aquatic habitat analysis.

Keystone Aquatic Species

Native **Yellowstone Cutthroat Trout** and **Snake River Fine-Spotted Cutthroat Trout** provide critical energy transfer from aquatic insect communities to terrestrial mammals and birds. Over 16 species—including grizzly bears, river otters, bald eagles, and ospreys—rely on spawning trout.

Threats to Native Trout

Invasive non-native lake trout prey directly on native cutthroat fry, while warming summer temperatures and legacy siltation degrade spawning gravels. Active biological management is essential to prevent species collapse.

Aquatic Food Web Connection:

Explain how restoring riverbank willows through wolf reintroduction directly improves cutthroat trout spawning success:

Service Learning: Jackson Fish Hatchery

Hands-on service learning is a core component of Appleseed Expeditions. At the **Jackson Fish Hatchery**, students work alongside conservation biologists to protect native trout genetics and re-establish wild fish populations across regional watersheds.

Why Volunteering Matters

The Jackson Fish Hatchery rears native fine-spotted cutthroat trout, stocking regional rivers to offset environmental pressures and habitat loss. Student volunteer hours directly support critical facility operations:

> **Student Field Responsibilities:**
>
> - **Raceway Cleaning:** Removing waste to prevent fungal and bacterial disease outbreaks in young fry.
> - **Fish Marking & Tagging:** Assisting biologists in clipping adipose fins to identify stocked vs. wild trout.
> - **Stocking Logistics:** Preparing oxygenated transport tanks to stock high-mountain streams.

Stewardship Service Reflection:

Reflect on your experience volunteering at the hatchery. How does maintaining healthy fish populations safeguard mammals and birds throughout the entire Greater Yellowstone Ecosystem?

Master Species Checklist & Sightings Log

Use this field checklist to log wildlife sightings during your expedition. Check off each species observed, and record the location and elevation:

Obs.	Species Common Name	Location / Habitat	Behavior / Notes
[ ]	Yellow-Bellied Marmot	Talus / Alpine slope	
[ ]	American Pika	Rocky boulder field	
[ ]	American River Otter	Riverbank / Stream	
[ ]	American Moose	Willow bog / Lowland	
[ ]	Rocky Mountain Elk	Valley meadow	
[ ]	American Bison	Grasslands	
[ ]	American Black Bear	Forested edge	
[ ]	Grizzly Bear	Subalpine meadow	
[ ]	Bald Eagle	Riparian tree perch	
[ ]	Golden Eagle	Mountain cliff / Valley sky	
[ ]	American Red Squirrel	Conifer canopy	
[ ]	Pine Marten	Mature pine forest	

Most Memorable Field Observation:

Expedition Summary & Final Reflection

Expedition Day	Field Destinations & Activities	Key Science Focus
Day 1	Arrival, transfer through Lava Hot Springs	Plate tectonics & mantle plume
Day 2	Grand Teton Bear Trek, Jenny Lake hike	Glacial uplift & alpine habitats
Day 3	Lamar & Hayden Valley, Yellowstone Canyon	Trophic cascades & raptor ID
Day 4	Jackson Fish Hatchery, Norris Geyser Basin	Hatchery service & thermophiles
Day 5	Moose-Wilson corridor, Departure	Lowland moose/bear habitat niches

Final Synthesis Reflection:

Reflecting on your 5-day expedition across Yellowstone—from supervolcano geotherms and wolf cascades to hands-on trout conservation at Jackson Hatchery—how has your understanding of ecological interconnectedness changed, and what environmental stewardship habits will you commit to in your local community?