NO PREP

# Winter on Demand

## Artificial Snow and the Sustainability Tradeoffs

**Includes:** Student reading, case study, differentiated questions, teacher key

Name: Period: Date:

# Winter on Demand: Artificial Snow and the Sustainability Tradeoffs

### Snowmaking Isn't Magic—It's a Resource System

Artificial snow can make a ski run look perfect, but it doesn't appear out of thin air. Snowmaking is a resource system that depends on three major inputs: cold-enough air, water, and energy. When temperatures drop below a workable threshold, snow guns spray tiny droplets that freeze into snow-like crystals. That process is a practical solution for unreliable snowfall, but it comes with environmental costs. In environmental science, we don't evaluate a technology by whether it "works" on the surface. We evaluate its inputs, outputs, and long-term impact on ecosystems and communities. Water is the most obvious concern. Snowmaking uses large volumes of water, often drawn from rivers, reservoirs, or groundwater. In colder,

**Name:** **Period:** **Date:**

# Winter on Demand: Artificial Snow and the Sustainability Tradeoffs

**Snowmaking, Not Magic: A Resource System**

Artificial snow can make a ski run look perfect, but it doesn't appear out of thin air. Snowmaking is a resource system that depends on three major inputs: cold-enough air, water, and energy. When temperatures drop below a workable threshold, snow guns spray tiny droplets that freeze into snow-like crystals. That process is a practical solution for unreliable snowfall, but it comes with environmental costs. In environmental science, we don't evaluate a technology by whether it "works" on the surface. We evaluate its inputs, outputs, and long-term impact on ecosystems and communities. Water is the most obvious concern. Snowmaking uses large volumes of water, often drawn from rivers, reservoirs, or groundwater. In colder, wetter regions, that might be manageable. In warmer or drier regions, it can create conflicts with municipal water needs, agriculture, and wildlife. Water withdrawals can affect stream flow and aquatic habitats, especially during low-water seasons. Even if water is returned later through melt, timing matters. Removing water during critical periods can stress ecosystems. Energy is the second major concern. Snowmaking requires pumps, compressors, and equipment operation, often around the clock during short cold windows. That can raise greenhouse gas emissions if the energy comes from fossil fuels. Hosts may claim renewable power offsets, but the overall footprint depends on local grids and actual usage patterns. And energy demands don't stop at snow guns: maintaining ice arenas, heating buildings, transporting spectators, and running security systems also increase emissions. The third piece is land. Snowmaking often goes hand-in-hand with grading slopes, cutting trails, and building access roads. That can fragment habitats and alter runoff patterns. So the environmental question isn't "Is snowmaking bad?" It's "What are the tradeoffs, and are they managed responsibly?"

**Ecosystems Under Pressure: Water, Habitat, and Timing**

Artificial snow can change how a mountain ecosystem behaves. Natural snow has a different crystal structure and often melts differently than machine-made snow, which can be denser. Denser snow can delay spring melt and change soil moisture timing. That can affect plant growth cycles and the availability of water for animals. It can also change erosion patterns if meltwater runs off in sudden pulses. Habitat disruption is another issue. Building and maintaining Olympic-grade venues may require clearing land, compacting soil, and increasing human traffic in sensitive areas. Wildlife can be affected by noise, lights, and increased vehicle access. Even if the Games last only a few weeks, the infrastructure can alter ecosystems for decades. The sustainability challenge can look like it's just about the event, but it is really about the long-term footprint. Water use becomes especially sensitive in regions where winter is warming. If a host relies heavily on snowmaking, it may increase withdrawals during periods when ecosystems are already stressed. This can trigger ethical and political debates: should a global sports event receive priority access to water? Environmental science emphasizes that resources are shared systems, not isolated choices. Students should also notice that sustainability is not only about nature. It includes people. Water allocation decisions can affect local communities, especially if tourism-driven spending competes with everyday needs. Sustainability means meeting present needs without harming future capacity. That's a framework for evaluating tradeoffs, not a slogan.

**Carbon Math and "Green" Claims: The Importance of Accounting**

Mega-events often announce sustainability initiatives—carbon neutrality targets, renewable energy purchases, reforestation projects, or efficient building design. Some of these efforts are meaningful. Others are mostly public relations. Environmental science asks for accounting: What is measured? What is ignored? Are offsets verified? Are emissions reduced at the source, or simply balanced on paper? Snowmaking reveals this tension. A host might claim a sustainable Games while still relying on intensive snow production and long-distance travel for spectators. The emissions from flights and transport can dwarf local efficiency improvements. That doesn't mean sustainability efforts are pointless—it means they must be honest and comprehensive. Reducing venue emissions is valuable, but it doesn't erase the full footprint. Another important idea is resilience. A sustainable winter sports system

should function as winters change. That might mean using existing venues more often, limiting new construction, and choosing hosts with naturally reliable winter conditions to reduce snowmaking dependence. It might also mean redesigning events and schedules for safety and reduced resource use. From a classroom perspective, this is a strong lesson: sustainability is not "all or nothing." It's about making better choices under constraints, measuring impacts, and being transparent about tradeoffs.

**Key Information: Sustainability Snapshot: Costs You Don't See on TV**

| Impact Area | What Snowmaking Can Increase | Why It Matters |
|---|---|---|
| Water use | Withdrawals from rivers/reservoirs | Affects habitats and community supply |
| Energy demand | Electricity for pumps/compressors | Links to emissions and grid strain |
| Habitat disruption | Trails, roads, venue footprints | Fragmentation and biodiversity loss |
| Emissions | Travel + operations | Contributes to climate warming |
| Timing changes | Melt patterns and runoff | Alters soils and ecosystems |

**Case Study Excerpt: Snowmaking in a Warmer, Drier Host Region**

**An Olympic planning committee selects mountain venues that are scenic and close to a major city, but the region has experienced warmer winters and periodic drought conditions. To guarantee competition-quality snow, planners expand snowmaking capacity—new pumps, upgraded pipes, and additional snow guns. During a cold window, snowmaking runs overnight for several days, drawing water from a reservoir that also serves nearby communities. Local residents raise concerns about water security, especially during dry years, while venue managers argue that snowmaking water returns in spring melt. Environmental scientists respond that timing matters: withdrawing water during low-flow periods can stress aquatic ecosystems, and denser machine-made snow can shift melt timing. The committee announces sustainability commitments, including renewable energy purchases and habitat restoration plans, but critics ask for clear accounting of water withdrawals and emissions from increased snowmaking. The debate becomes the central question of the host plan: is guaranteeing "winter on demand" worth the resource tradeoffs, or should hosting priorities shift toward naturally colder regions and existing venues?**

1. What are two environmental concerns raised in the excerpt, and how are they connected to resource systems?

2. Why does "the water returns during melt" not automatically solve the sustainability problem?

**Multiple Choice**

1. Which input is most essential for snowmaking to function at all?

    a) Cold-enough air so sprayed droplets can freeze

    b) Warm air above freezing

    c) Saltwater from oceans only

    d) Direct sunlight on the slope to warm the snow guns

2. Why can dense artificial snow affect ecosystems differently than natural snow?

    a) It reduces plant growth by removing all of the soil permanently

    b) It can melt on a different schedule and alter runoff timing

    c) It contains no water at all

    d) It always melts instantly

3. What is one reason sustainability "claims" should be evaluated with careful accounting?

    a) Because only athletes create emissions

    b) Because environmental impacts are always imaginary and invented by paid activists

    c) Because offsets and measurements can ignore major emissions sources like travel

    d) Because snowmaking uses zero energy

**Matching**

Write the letter of the correct definition on the line next to each term.

| Term | Definition |
|---|---|
| 1. ___ Sustainability | A) Choosing one benefit while accepting environmental costs elsewhere |
| 2. ___ Greenhouse gas emissions | B) Splitting ecosystems into smaller pieces through roads/clearing |
| 3. ___ Habitat fragmentation | C) Gases that trap heat in the atmosphere and contribute to warming |
| 4. ___ Carbon offset | D) Meeting present needs without harming future capacity |
| 5. ___ Resource tradeoff | E) A claim of balancing emissions through projects elsewhere, with verification issues |

**Fill-in-the-Blank**

1. Snowmaking increases _____ demand through pumps and compressors.

2. A project used to "balance" emissions is a carbon _____.

3. Breaking habitats into smaller, separated areas is habitat _____.

**Short Answer**

Answer each question in 2-4 complete sentences.

1. Explain how snowmaking can create conflicts over water use in some regions.

_____

_____

_____

2. Describe one strategy organizers could use to reduce the environmental footprint of Winter Games.

3. Why is it important to consider timing (when resources are used) in sustainability decisions?